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EFFECT OF DIFFERENT DRAIN DEPTHS ON SOIL HYDROLOGY AND CROP PRODUCTION OF RICE AND WHEAT CROPS

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ABSTRACT

The present work was carried out during summer and winter seasons on rice and wheat crops cultivated in an open field at Zankalon area, Sharkia Governorate, Egypt, to study the effect of drain depth on soil hydrology, salinity and crop production of rice and wheat crops**.** Three drainage treatments were used i.e. conventional drainage depth (drain depth 1.20 m, T_{120}), controlled drainage depth (drain depth 0.60 m, T_{60}) and without drainage depth (drain depth 0.0 m , T_0 where the drain outlet was completely blocked) to achieve this target.

The obtained results reveal that, the total amounts of irrigation water applied to different treatments during the growing season were arranged in a descending order: conventional drainage depth (T_{120}) > controlled drainage depth (T_{60}) > without drainage depth (T_0) for both rice and wheat crops. Using T_{60} and T_0 treatments for rice crop saved 32.7 and 49.7 % of the applied water as compared with the T_{120} treatment, respectively. The irrigation intervals were 2.0, 3.0 and 5.0 days for T_{120}, T_{60} and T_0 treatments, respectively. This means that, using T_{60} reduced the number of irrigations by 40 % which reduces the irrigation cost. On the other hand, there is a little difference between the total amounts of irrigation water applied to the different treatments cultivated with wheat crop.

The total amounts of drainage water drained from the soil cultivated with rice crop at T_{120}, T_{60} and T_0 treatments were 2069.6, 1065.0 and 0.0 m^3/fed, respectively, but at wheat crop they were 305.9, 292.1 and 0.0 m^3/fed., respectively.

Concerning the fluctuation of water table for wheat crop, the results emphasized that at T_{120} treatment, 80% of the measured water table levels were fluctuated within the depths of 50-75 cm, to >100 cm below soil surface. While, it never reached the depth of 0-20 cm below soil surface. Under T_{60} and T_0 treatments about 90% of the measurements were fluctuated within the depths of 0-50 cm below soil surface during rice cultivation. On the other hand, 63% of the measured water table during the wheat growing season fluctuated at the depth less than 100 cm at T_0 treatment. While, 85 % and 66 % from measured water table levels during the growing season were fluctuated at depth more than 1.0 m for T_{120} and T_{60} treatments, respectively.

The values of relative ground water depths (RGWD) at rice were 1.3, 0.3 and 0.4 for T_{120}, T_{60} and T_0 treatments, respectively. Whereas, under wheat crop, they were 2.0, 1.8 and 1.4 for the same above mentioned treatments, respectively. It is clear that (RGWD) values were more than one at all wheat treatments, and also in case of T_{120} treatment cultivated with rice. This may be attributed to the fact that the fluctuating water table rises to the soil surface after irrigation but soon it falls down to the drain depth.

The highest grain yield of both rice and wheat were obtained from plant grown under the T_{120} treatment. This means the effect of drain depth on grain yield was positive. Crop water productivity (CWP) values for rice grain were 0.75, 1.34 and 1.68 kg/m^3 for conventional, T_{60} and T_0 treatments, respectively. Whereas, the (CWP) values for the wheat grain, were 1.01, 0.9 and 0.90 kg/m^3 for the above mentioned treatments respectively.

Using the T_{120} treatment, the obtained results proved that more salts were leached from the soil to drainage water followed by T_{60} for both crops under the study. On the other hand, more salts were accumulated in soil layers during the growing season in both crops in the soil of T_0 treatment.

Keywords: conventional drainage, controlled drainage, without drainage, relative ground water and grain yield, drain depth, rice, wheat.

INTRODUCTION

Irrigation water represents a limiting factor for agricultural production. The need to each drop of water for the horizontal and vertical expansion and the yields of field crops is a vital problem in Egypt. Bahaa (2005) reported that, Egypt has reached a stage where the quantity of water is imposing limits on its economic development. The present share is below 1000 m^3/capita/year, and it is expected to drop to 500 m^3/capita/year in the year 2025, which would indicate "water scarcity". In additional a rapid degradation in surface and ground water quality is taking place.

The environmental conditions have changed dramatically in the last decades. In the irrigated lands such as Delta and Nile valley, Egypt, groundwater levels have risen to produce waterlogging. This process has caused excessive salinity build up in crop root zones and created yield reductions or caused land abandonment in severe cases (Deriwrachien and Feddes, 2003). Lee *et al.,* (2004) mentioned that this environmental stress condition is an important factor limiting crop growth and resulting yield loss. It consists of two major factors: stress intensity and stress duration. Salinity stress in general associated with excess or defect of water, where these conditions led to reducing plant roots respiration, absorption of water and essential nutrients, and toxicity of some specific ions and consequently the domination of environmental imbalance (Irshad *et al.,* 2002). Plant needs air such as water. So, subsurface drainage can be used to make it possible to dispose excess irrigation water and prevent waterlogging to allow for the root zone environment that facilitates plant growth and optimizes crop production. Subsurface drainage is a necessary component of irrigated agriculture in arid and semi-arid areas such as in Egypt. The future design of drainage will require that a subsurface drainage system be part of a water management system that includes both irrigation and drainage (Christen and Ayars, 2001) and (Ayars *et al.,* 2003). Many studies showed that the sustainability of agricultural production is directly related to ground water levels, where there is a conventional association between productivity and average groundwater depth (ILRI, 1994), Mohamedin (1995) and El-Araby (2004). Water management techniques may be used to reduce drainage outflow during the growing season of rice. The use of controlled drainage and other water management practices play an important role for reducing the amounts of irrigation water.

Therefore, the present work aims to study the effect of different drain depths on soil hydrology, salinity and crop production of rice and wheat crops.

MATERIALS AND METHODS

To achieve the previous target, a field experiment was carried out on rice and wheat crops cultivated at Zankalon area, Sharkia governorate, Egypt, during summer and winter seasons. Some physical and chemical characteristics of the soil under investigation are given in Table (1).The area served by a tile drainage system, which was adapted to carry out the current study (Fig. 1). It is divided into three treatments each one drained by five laterals connected to subcollector through a manhole and the drain spacing is 20 m. Three drainage treatments were applied in this study i.e.:

a. **Conventional drainage** (T_{120}): drain depth is 120 cm below soil surface.
b. **Controlled drainage** (T_{60}): drain depth is controlled, 60 cm below soil surface.
c. **Without drainage** (T_0): drain depth is zero (closing drainage system).

The measurement program for hydrology impact required installation a set of observation wells at all units to monitor water table level. It is installed down to a depth of 2.0 m, two observation wells were installed in the midway between the lateral drains (at 1/4 and 3/4 of the lateral length) in rice and wheat units, three lateral drains were used in every unit for monitoring the water table levels. Water table depths in the observation wells were measured daily using a sounder and a measuring tape (Cavelaares, 1974).

Drainage Water: Three laterals were chosen in the middle of each treatment. The lateral discharges were measured using a bucket of known volume and a stopwatch. The average lateral discharges were calculated, and in turn the total amount was also calculated.

Relative Ground Water Depth (RGWD):

The relative ground water depth (RGWD) is used to analyze and to evaluate the ground water (**Gupta et al., 1988**). It is given as:

$$\text{RGWD} = \frac{\text{(Average depth to WT in the season)}}{\text{(Intended depth to WT in the season)}}$$

If the intended depth of water table is reached throughout the season the average depth of water table, (RGWT) is equal to unity.

Crop Water Productivity (**CWP**):

Crop water productivity (CWP, kg/m^3) is a quantitative term used to define the relationship between crop produced and the amount of water involved in crop production (FAO, 2003). It can be calculated as follows:

CWP = Grain yield (kg/fed.)/Applied irrigation amount (m^3/fed.)

Soil samples: seventy five samples were collected from fifteen profiles at the three treatments (five profiles from each treatment). Samples were collected from each one profile at fixed depths of 0-25, 25-50, 50-75, 75-100 and 100-125 cm from soil surface at the beginning and at harvest time for determining the soil electrical conductivity (Bower and Wilcox, 1982). Soil bulk density of different layers of soil profile were measured using the core sampling technique described by Camplbell (1994). The amounts of salts in soil layers were calculated according to the method proposed by Van Hoorn(1981) as follows:

S = C * O *Pb * D

Where:

S : amount of salt in kg/fed
C : salt concentration in kg/fed
O : saturation percentage
Pb: bulk density in kg/m^3
D : layer depth in cm

Table (1): Some physical and chemical characteristics of the soil.

Parameter	Value
1- Physical properties :	
- **Particle size distribution (%)**	
Clay	42.2
Silt	25.1
Fine sand	23.4
Coarse sand	9.3
Texture class	Clay
- **Field capacity (%)**	34
- **Wilting point (%)**	18
2- Chemical analysis :	
EC_e (dS/m)	1.00
pH	7.80
- **Soluble cations (meq/l)**	
Na^+	5.95
K^+	0.19
Ca^{++}	2.84
Mg^{++}	1.29
- **Soluble anions (meq/l)**	
CO_3^-	0.00
HCO_3^{--}	1.43
SO_4^{--}	3.48
Cl^-	5.36

Crop samples were collected at harvest time to determine the rice and wheat crops yield. Six crop samples were taken from an area of 25 m^2 to represent each unit at both rice and wheat. The crop yield was carried out according to a standard methodology and procedure suggested by El-Guindi and Nijland (1980).

The current study aimed to study the effect of drain depth on the soil hydrology and crop production of rice and wheat crops.

RESULTS AND DISCUSSION

Irrigation water:

The total amounts of irrigation water applied for different treatments (T_{120}, controlled and without drainage) after transplanting till the harvest of rice crop plus pre-irrigation were 5072.61, 3415.16 and 2551.58 m^3/fed., respectively. It is clear that, the total amounts of irrigation water for different treatments were arranged in a descending order of $T_{120} > T_{60} > T_{120}$. Using T_{60} and T_0 treatments saved 32.7 and 49.7 % of the applied water as compared with the T_{120}, respectively. This is mainly related to drainage condition, because the irrigation water was replenished to maintain the water layer above soil surface, where T_{120} suffer from more water drained.

Number of irrigation water were required for cultivated rice fields over all the growing season, they were 36, 21 and 13 irrigations for T_{120}, T_{60} and T_0 treatments, respectively. They reflect the direction of the total amount of water added to the different treatments. This means that, the frequency of irrigations were arranged in a descending order of $T_{120} > T_{60} > T_0$. The irrigation rates are irrigation every about 2.0, 3.0 and 5.0 days for T_{120}, T_{60} and T_0 treatments, respectively. This means that, using T_{60} reduced the irrigation cost by 40 %.

On the other hand, the total amounts of irrigation water applied for different treatments (T_0, T_{60} and T_{120}) cultivated by wheat crop were 3215.5, 3112.6 and 2802.6 m^3/fed., respectively. There are little different between the total amount of water applied for the different treatments.

Drainage water:

The total amount of drainage water drained from soil cultivated with rice crop for T_{120}, T_{60} and T_0 treatments were 2069.6, 1065.0 and 0.0 m^3/fed, respectively (Fig.2). This means that, by restricting the subsurface drainage system outlet, the drain discharge reduced to zero, while raising the subsurface drainage system outlet to 60 cm below soil surface drainage water reduced the drain discharge by 49 % compared to T_{120} treatment.

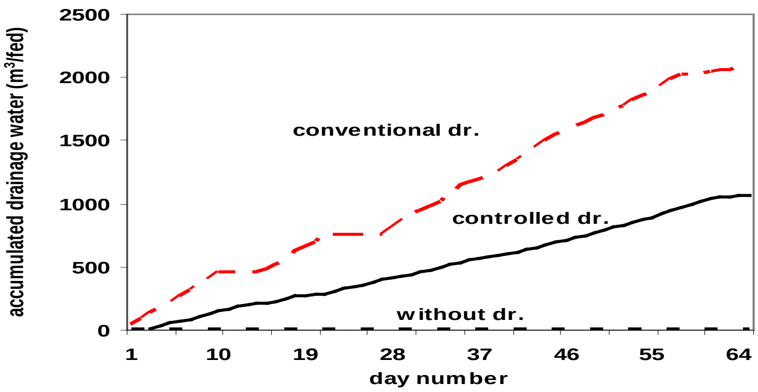

Fig.(2):Accumulated drainage water drained from different treatments during rice growing season.

On the other hand, the total amount of drainage water drained from soil cultivated with wheat crop for T_{120}, T_{60} and T_0 treatments were 305.9, 292.1 and 0.0 m^3/fed., respectively (Fig. 3). This means that no much difference between T_{120} and T_{60} treatments. The differences between the two values were not significant due to the relatively long periods between irrigation and almost the same amounts of irrigation water applied to both treatments.

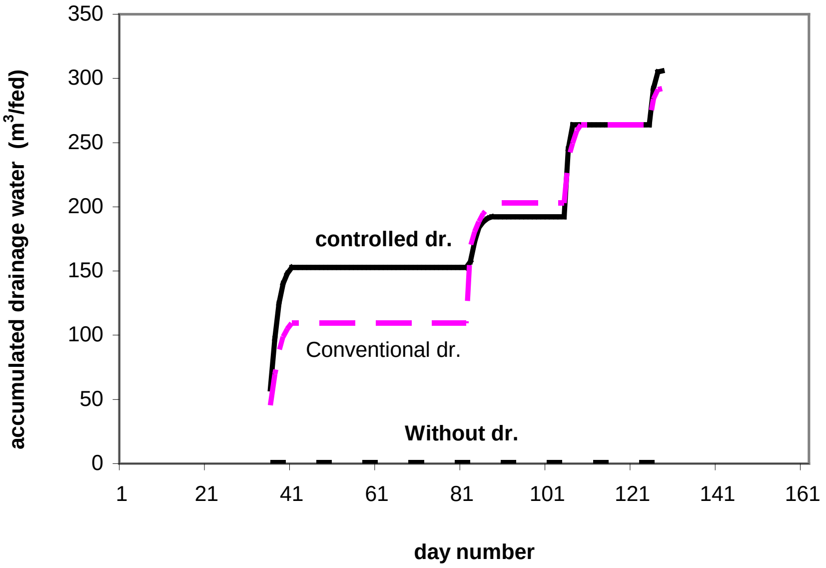

Fig.(3): Accumulated drainage water drained from different treatments during wheat growing season.

Fluctuation of water table in rice cultivated unites:

A program of measurement for watertable depth fluctuation was carried out in the different treatments. The analysis of data was made separately for each treatment to determine the most frequent depth of the water table under the current conditions of subsurface drainage system. At T_{120} treatment, the average watertable depths during the summer growing season ranged from 0.41 to 1.64 m with an average of 0.78 m below soil surface. While at the T_{60} treatment, it ranged from 0.00 to 0.73 m with an average of 0.18 cm from soil surface (Table 2 and Fig. 4). At the same time, water table depths ranged from 0.09 to 0.86 m with an average of 0.24 m from soil surface at T_0 treatment.

Table (2): Minimum, maximum and average watertable depths for rice and wheat crops during growing seasons.

Drainage Treatments	Water table depth (m)			RGWD
	Min	Max	Average	
	Rice crop crop			
Conventional drainage	0.41	1.64	0.78	1.3
Controlled drainage	0.00	0.73	0.18	0.3
Without drainage	0.09	0.86	0.24	0.4
	Wheat crop			
Conventional drainage	0.09	1.89	1.24	2.1
Controlled drainage	0.08	1.89	1.10	1.8
Without drainage	0.01	1.57	0.82	1.4

On the other hand, It could be noticed from Table (3) that 80 % of the measured water table levels under T_{120} treatment below soil surface were fluctuated within the depths of 50-75 cm, to >100cm below soil surface. While, it never reached the depth of 0-20 cm below soil surface. Under T_{120} and T_0 treatments 91% and 89% of the measurements were fluctuated with the depths of 0-50 cm below soil surface during rice cultivation, respectively.

Table (3) Frequency of occurrence percentages of the watertable depths during growing seasons of rice and wheat crops

Drainage Treatments	Water table classes (cm)				
	0-20	20-50	50-75	75-100	>100
			Rice crop		
Conventional drainage	0	20	39	3	38
Controlled drainage	66	25	9	0	0
Without drainage	62	27	11	0	0
			Wheat crop		
Conventional drainage	2	1	3	9	85
Controlled drainage	3	4	8	19	66
Without drainage	10	13	12	28	37

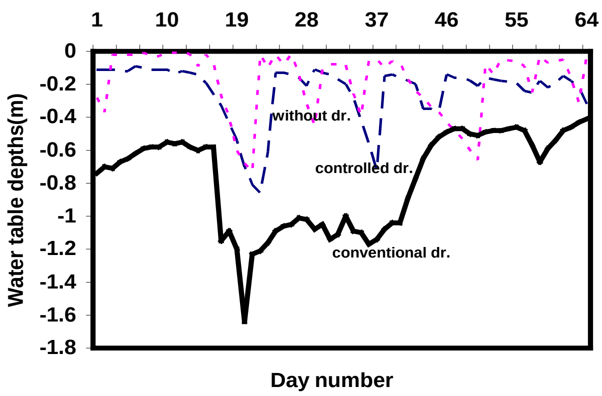

Fig.(4) Water table depths (m) at different treatments treatments during rice growing season.

Fluctuation of water table in wheat cultivated units:

Data in Table (2) presents minimum, maximum and average water table depths in units cultivated with wheat crops during winter season. Water table depths in T_0, T_{60} and T_{120} treatments varied from 0.01 to 1.57 m; 0.08to 1.89 m and 0.09 to 1.89 m below soil surface, respectively (Fig. 5). While the average water table depths during the growing season were 0.82, 1.10 and 1.24 m below soil surface for the abovementioned units, respectively.

Data in Table (3) showed that 63% of the water table during the wheat growing season was less than 1.0 m at the treatments without drainage. While, 85 and 66 % of the measured water table depths during the growing season were more than 1.0 m below soil surface for T_{120} and T_{60} treatments, respectively.

Relative Ground water Depth (RGWD):

The values of relative ground water depth (RGWD) at rice presented in Table (2) showed that at rice these values were 1.3, 0.3 and 0.4 for T_{120}, T_{60} and T_0 treatments, respectively. This means that, T_{60} and T_0 treatments which cultivated by rice crop were affected too much by raising water table, while no affect happened at T_{120} treatment.

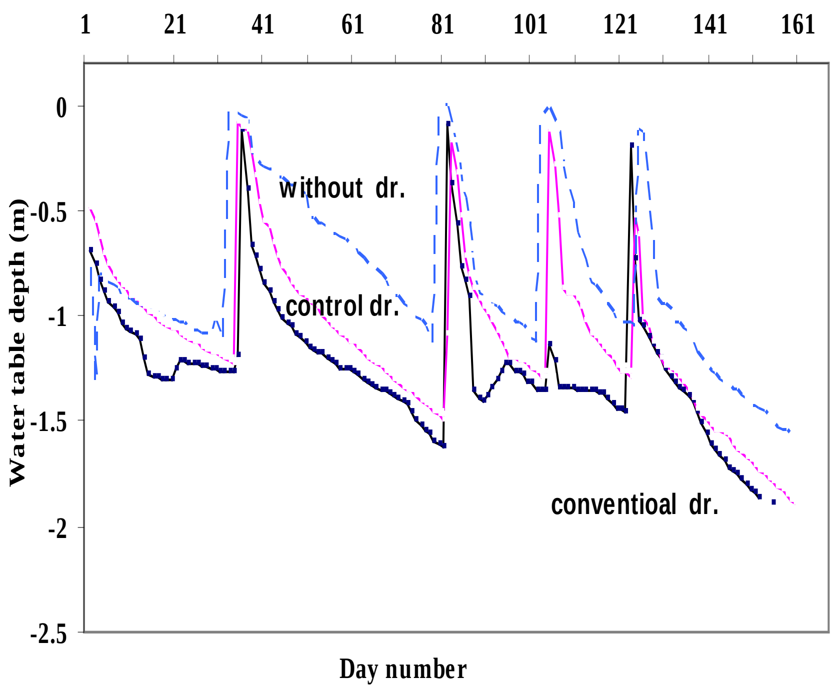

Fig.(5) Water table depths (m) under different treatments during wheat growing season.

Concerning, the values of relative ground water depth at field cultivated with wheat they were 2.0, 1.8 and 1.4 at T_{120}, T_{60} and T_0 treatments, respectively.

From the abovementioned results, it is clear that RGWD values were more than the unit at all wheat treatments and T_{120} drainage treatment cultivated with rice this may be due to the fact that the fluctuating water table rises to the soil surface but soon it falls to the drain depth. Thus, the values of water table frequency of occurrence are more reliable than using the average values to study the effect of water table fluctuation on crop yield.

Crop yield:

Data presented in Table (4) show the rice and wheat crops production (grains and straw) and crop water productivity in different drainage treatments. From the obtained results it is obvious that drain depth affected the grain yield of both rice and wheat. The highest grain yield of rice (3121.6 kg/fed.) was obtained for plant grown on soil provided with 1.2 m drain depth (T_{120} treatment) as compared with rice grain yield grown in the soil provided with 0.60 m and 0.00 m (2874.9 and 2635.2 kg/fed., respectively)

Concerning the wheat grain yield, it takes the same trend of rice grain yield. The highest wheat grain yield (3245.0 kg/fed.) is obtained from T_{120} treatment, followed by soil provided with T_{60} and T_0 treatments (2722.0 and 2514.0 kg/fed., respectively). From the previous results it is clear that, the effect of drain depth on grain yield was opposite. On the other hands, the highest straw yield for rice (6495.9 kg/fed.) was obtained in T_{60} treatment, while the lowest (5321.4 kg/fed.) was at T_{120} treatment.

Crop water productivity (CWP) was calculated for different drainage treatments for both grain and straw yields. The results show that, crop water productivity for rice grain were 0.75, 1.34 and 1.68 kg/m^3 for T_{120}, T_{60} and T_0 treatments, respectively. While they were 1.28, 3.02 and 3.97 kg/m^3 for rice straw at the same treatments, respectively. Crop water productivities (CWP) for wheat grain were 1.01, 0.9 and 0.90 kg/m^3 for the previous treatments respectively, and they were 1.26, 1.34 and 1.62 kg/m^3 for the same treatments, respectively.

Table(4) Rice and wheat crop production (grain and straw) and crop water productivity under different treatments .

Drainage Treatments	Production		Crop water productivity	
	Grain (Kg/fed.)	Straw (Kg/fed.)	Grain (Kg/m^3)	Straw (Kg/m^3)
	Rice crop			
Conventional dranage	3121.6	5321.4	0.75	1.28
Controlled drainage	2874.9	6495.9	1.34	3.02
Without drainage	2635.2	6211.1	1.68	3.97
	Wheat crop			
Conventional dranage	3245.0	4048.0	1.01	1.26
Controlled drainage	2722.0	4025.0	0.90	1.34
Withoutr drainage	2514.0	4533.0	0.90	1.62

Change in soil salinity:

The data obtained in Table (5) show that the initial soil salinity in soil cultivated with rice was higher than the final one, in T_{120} treatment only, while soil salinity in the other two treatments (T_{60} and T_0) was inversed. The soil under the first treatment, showed that salts removed from the different layers during the growing season, while on the other two treatments, the salts accumulated in the soil during the growing season. The total amount of salts removed from soil layer (1.25 m below soil surface) was 1649.8 kg/fed. at T_{120} treatment. At the same time 722.6 and 1246.3 kg/fed. of salts were accumulated in soil layer during rice growing season at T_{60} and T_0 treatments.

The initial soil salinity was lower than the final one at all treatment in soil cultivated by wheat crop. This means that the accumulated salts were occurred at the end of season. They were 884.1, 1271.7 and 2477.5 kg/fed. at T_{120}, T_{60} and T_0 treatments, respectively.

From the above-mentioned results, it could be concluded that in T_{120} treatments more salts were leached with the drainage water followed by T_{60} treatment. Whereas, T_0 treatments revealed that more salts were accumulated in soil layers during the growing season in both crops.

Table (5) The amount of accumulated or leached salts from soil profile under cultivated rice and wheat crops.

Drainage treatments	Depth (cm)	Rice crop: ECe (dS/m) Initial	Rice crop: ECe (dS/m) Final	Rice crop: ECe (dS/m) Δ EC	Rice crop: Bulk density g/cm^3	Rice crop: Δ Salts (kg/fed)	Wheat crop: ECe (dS/m) Initial	Wheat crop: ECe (dS/m) Final	Wheat crop: ECe (dS/m) Δ EC	Wheat crop: Bulk density g/cm^3	Wheat crop: Δ Salts (kg/fed)
Conventional drainage	0-25	1.32	0.88	-0.44	1.49	-338.39	0.82	1.12	0.30	1.49	243.5
	25-50	1.31	0.87	-0.44	1.56	-348.62	0.72	1.10	0.38	1.56	333.4
	50-75	1.29	0.88	-0.41	1.62	-338.80	0.93	1.10	0.17	1.62	157.6
	75-100	1.25	0.88	-0.38	1.66	-318.18	0.69	0.84	0.15	1.66	132.2
	100-125	1.26	0.89	-0.36	1.66	-305.77	0.68	0.70	0.02	1.66	17.3
Total						-1649.8					884.1
Controlled drainage	0-25	0.74	0.92	0.18	1.49	125.73	0.88	1.82	0.94	1.49	759.4
	25-50	0.70	0.88	0.19	1.56	137.19	0.89	1.30	0.41	1.56	345.1
	50-75	0.66	0.88	0.22	1.62	165.64	0.79	0.91	0.12	1.62	104.7
	75-100	0.66	0.85	0.20	1.66	151.06	0.76	0.80	0.05	1.66	43.2
	100-125	0.66	0.85	0.19	1.66	142.97	0.75	0.77	0.02	1.66	19.4
Total						722.6					1271.7
Without drainage	0-25	0.70	1.03	0.33	1.49	256.91	1.88	3.31	1.43	1.49	1184.3
	25-50	0.69	1.02	0.33	1.56	260.76	1.86	2.74	0.88	1.56	724.8
	50-75	0.69	1.03	0.34	1.62	275.94	0.81	1.40	0.59	1.62	549.9
	75-100	0.71	1.00	0.28	1.66	238.29	0.84	0.85	0.01	1.66	7.1
	100-125	0.73	0.98	0.26	1.66	214.37	0.81	0.82	0.01	1.66	11.4
Total						1246.3					2477.5

Conclusion:

From the abovementioned results, it can be concluded that, using the T_{60} and T_0 treatments in rice fields will save large amounts of irrigation water and reduce losses of water. Using T_{120} treatment was not practical solution due to the excessive amount of irrigation water added to rice fields, while T_0 treatment caused raising water table and hazard affect for soil salinity problem. The effect of T_{60} on crop which used normal amount of water was not clear.

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تأثير أختلاف عمق الصرف علي هيدرولوجيا التربة والملوحة وأنتاجية محصولي الأرز والقمح

مني كمال مصطفي عبد الرازق
معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية-الجيزة-مصر

أجريت هذه التجربة الحقلية في منطقة الزنكلون – محافظة الشرقية – مصر خلال الموسم الصيفي والموسم الشتوي وذلك علي محصولين (أرز و قمح)من خلال تجربة حقلية بغرض دراسة تأثير أختلاف عمق الصرف علي هيدرولوجيا التربة والملوحة وأنتاجية محصولي الأرز والقمح. وتم تطبيق ثلاث معاملات صرف بمعني معاملة صرف تقليدي (عمق المصرف 1.2 م) ، معاملة صرف متحكم فيه (عمق المصرف 0.6 م) ، معاملة بدون صرف (تم قفل مصب المصرف تماما- وأعتبر عمق المصرف 0.0 م).

وقد أظهرت النتائج المتحصل عليها أن كميات مياه الري المضافة خلال موسم زراعة الأرز للمعاملات الثلاثة كانت متدرجة تناقصيا من معاملة "الصرف التقليدي" يليها معاملة "الصرف المتحكم فيه" ثم المعاملة "بدون صرف" . وقد وجد أن أستخدام معاملة "الصرف المتحكم فيه" والمعاملة "بدون صرف" أدت الي توفير 32.7 ، 49.7% من كميات مياه الري المضافة مقارنة بتلك المضافة في المعاملة ذات الصرف التقليدي (عمق الصرف 1.2 م) . أما عن فترات الري فكانت رية كل يومين في حالة "الصرف التقليدي" ، ورية كل ثلاثة أيام في حالة الصرف المتحكم فيه ، رية كل خمسة أيام في حالة "المعاملة بدون صرف". هذا يعني أن أستخدام الصرف المتحكم فيه قلل كمية و تكاليف الري حوالي 40 %. من ناحية أخري وجد أن هناك أختلاف طفيف بين كميات المياه الكلية المستخدمة في المعاملات الثلاثة خلال موسم زراعة القمح.

كما وجد أن كمية مياه الصرف المنصرفة من الأراضي المنزرعة بالأرز تحت نظام الصرف التقليدي والمتحكم فيه والمعاملة بدون صرف 2069.6، 1065.0، 0.0 م^3 /فدان علي التوالي ، أما في حالة محصول القمح فكانت الكميات 305.9، 292.1، 0.0 م^3 /فدان لنفس المعاملات السابقة علي التوالي. وقد أثبتت النتائج أنه تحت "معاملة الصرف التقليدي" تكون 80 % من قياسات الماء الأرضي خلال موسم زراعة الأرز واقعة في العمق بين 50-75 سم ، >100 سم تحت سطح التربة ولم تصل أبدا الي مستوي 0-20 سم تحت سطح التربة. أما معاملة "الصرف المتحكم " فيه و"معاملة بدون" صرف" فقد وجد أن 91% ، 89% من قياسات الماء الأرضي تتذبذب في عمق 0-25 ،25-50 سم تحت سطح التربة علي التوالي.

من ناحية أخري وجد أنه في حالة محصول القمح يكون 63 % من القياسات تشير الي تذبذب الماء الأرضي علي عمق 100سم تحت سطح التربة في معاملة "بدون صرف" ، أما في حالة الصرف التقليدي والصرف المتحكم فيه فكان 85% ،66% من قياسات الماء الأرضي يتذبذب في مستوي > 100سم تحت مستوي سطح الأرض.

من جهة أخري وجد أن قيم (RGWD) في أراضي الأرز كانت 1.3 ، 0.3 ، 0.4 لمعاملات "الصرف التقليدي" و"المتحكم فيه" و"المعاملة بدون صرف" علي التوالي. أما في القمح فكانت هذه القيم 2.0 ، 1.8 ، 1.4 لنفس المعاملات السابقة علي التوالي. من الواضح أن قيم (RGWD) كانت أكبر من الواحد في كل معاملات القمح بالاضافة الي معاملة "الصرف التقليدي" في الأرز وذلك راجع الي أن الماء الأرضي يصل لسطح التربة بعد الري ولكنه يهبط بسرعة لمستوي المصرف.

وقد بينت النتائج أن أعلي قيم أنتاجية للحبوب في محصولي الأرز والقمح المتحصل عليها من النباتات المنزرعة تحت معاملة "الصرف التقليدي". مما يعني أن تأثير عمق الصرف علي الأنتاجية كان تأثيرا ايجابيا. أما قيم (CWP) لحبوب الأرز فكانت 0.75 ، 1.34 ، 1.68 كجم/ م^3 وذلك لمعاملة "الصرف التقليدي" و"المتحكم فيه" و"بدون صرف وذلك علي التوالي ، بينما كانت 1.01 ، 0.90 ، 0.90 كجم/ م^3 لنفس المعاملات السابقة علي التوالي.

وقد أثبتت النتائج أنه بأستخدام معاملة "الصرف التقليدي" وجد أن كمية الأملاح المزالة من التربة والتي غسلت مع مياه الصرف كانت بكميات واضحة يليها معاملة "الصرف المتحكم" فيه وذلك في حالة كل من محصولي الأرز والقمح ،من ناحية أخري لوحظ تراكم ملموس للاملاح في طبقات التربة خلال موسم الزراعة وذلك في المعاملة بدون صرف في كلا المحصولين.

قام بتحكيم البحث

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