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RICE CONSUMPTIVE USE COMPONENTS IN NORTH MIDDLE NILE DELTA

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ABSTRACT

Two tank experiments were carried out at Sakha Agricultural Research Station during the two successive growing seasons 2006 and 2007 in the North Middle Nile Delta region to find out the different components of rice consumptive use, in addition to, down deep percolation. In the two growing seasons, data showed that evaporation (E), down deep percolation (P), transpiration (T) and evapotranspiration (ET) are increased with increasing depth of water applied. Mean values of (P) were the highest (50.5 and 65.38 cm) under the high level of water status till 7.5 cm above soil surface in comparison with (T) and (E). Under all irrigation depths, the values of (E) were higher than that of (T). Therefore, the values of consumptive use components and (P) can be arranged in descending order as follows: P > E > T in the two growing seasons. Values of E, T and ET can be also descended in this order during the growth stages as follows; vegetative > reproductive > ripening. Generally, the same trend was obtained for down deep percolation.

INTRODUCTION

Rice is considered as the second largest crop in water consumption following to sugar cane. Water needs for the two crops are about one third of the total water allocated to irrigation sector, which equaled to about 85% from the national water supply in Egypt. Irrigated agriculture is the dominant type of cultivation. In other words, no economical rainfed agriculture in Egypt due to the arid conditions which facing the country. Moreover, Egypt has a unique source for the conventional water, that it is the River Nile with a constant allocation of its water supply. This situation leads to the capita share of water at present which is decreasing to less than the water poverty level. Therefore, tremendous efforts are presently implemented towards effective irrigation management at farm level. One potential way to achieve this goal is through minimizing water losses especially for irrigated rice. In general, one feddan (0.42 ha) of rice needs more water in average with 3,000 m^3 than any other summer crops. Down deep percolation from irrigated rice is the main component of water losses. Therefore, determination and analysis of components for rice consumptive use i.e. evaporation (E) and transpiration (T), in addition to, the losses via deep percolation (P) is urgent to specify the keys of rationalize rice irrigation.

Hence, the objective of this study is to compute evaporation (E), transpiration (T) and evapotranspiration (ET) during rice growing season as well as the corresponding values of down deep percolation (P).

MATERIALS AND METHODS

To achieve the target of the present study, two tank experiments were conducted at Sakha Agricultural Research Station, Kafr El-sheikh Governorate in the North Middle Nile Delta region during the two successive growing seasons 2006 and 2007. The soil texture of the experimental site is heavy clay which is more suitable for rice cultivation as it has a high water holding capacity.

The consumptive use (CU) or crop evapotranspiration (Etc) is the sum of the depths of water used by the vegetative growth of given area in transpiration (T), building plant tissues and evaporation from adjacent soil (E) **(Israelsen and Hansen, 1962)**.

Rice consumptive use (Cu) components were estimated for the rice cultivar Sakha 101 by tank experiment as shown in Fig. (1). Three groups of tanks were installed in filed each with three tanks with the same diameter of 95 cm. While, depth for tanks 1 and 2 and 30.3 cm for number 3. Tanks I and II for each group were filled with soil which was taken from the adjacent field with the same sequences of different soil layers in order to be similar, as possible, to the natural soils and were buried about 20 cm into the soil to the same level with the tank number 3 as clearly shown in Fig. (1). In the first growing season the tanks were transplanted with Sakha 101 rice cultivar seedlings on 15th June, 2006, while in the second growing season 2007, the tanks were transplanted with the seedlings at same rice cultivar on 1st July, 2007. Harvesting process was occurred on 7th October in the two growing seasons 2006 and 2007.

Each group were irrigated till a specified watering depth during the two growing seasons. Irrigation depth was adjusted at 2.5, 5.0 and 7.5 cm above the soil surface for first, second and third group, respectively. The irrigation till 7.5 cm above soil surface considers as the traditional watering by the local farmers in the area. The water level in each tank was recorded daily to find out the consumed water in the last 24 hours. Each tank was re-watering every 6 days till the static specific head of water above soil surface was obtained. Meaningfully, irrigation interval was the same for all groups.

Readings from tank (1) gave the sum of the two components (E) and (T), while readings of tank (2) gave values of E, T and P and tank (3) only recorded (E) losses. Therefore, it is easy to find out the role of each component on rice consumptive use, which ultimately affected the ways to rationalize rice irrigation via reducing evaporation or minimizing down deep percolation losses.

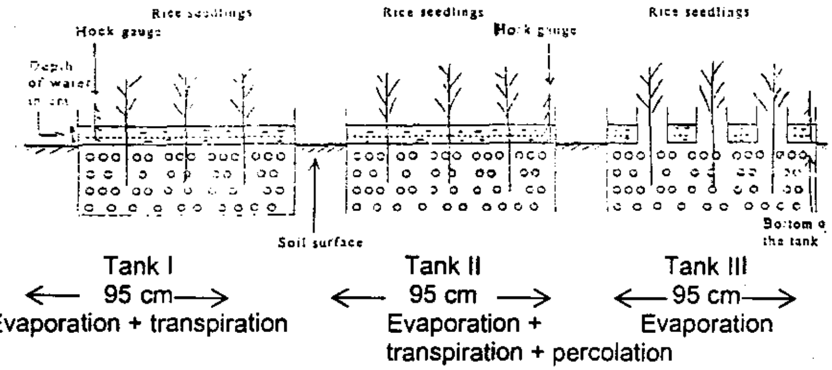

Fig. (1): Tank experiment system.

The number of plants in each tank in all groups was fixed according to the area of tanks to be 18 plants in each tank.

Table (1): Climatological data for the site during the experiments.

Climatic parameter	2006						2007					
	May	Jun.	Jul.	Aug.	Sept.	Oct.	May	Jun.	Jul.	Aug.	Sept.	Oct.
Temperature												
T_{max} °C	28.5	31.7	31.3	33.0	33.0	29.0	30.0	33.0	32.6	32.5	32.0	29.2
T_{min} °C	11.6	17.0	17.5	18.6	16.8	13.4	12.0	16.5	17.3	17.2	15.0	12.0
Solar radiation Rs cal./cm²/day	22.8	23.0	20.4	22.3	20.3	15.2	22.0	No data recorded				
Relative humidity %												
7.30	79.3	81.4	85.1	91.6	89.0	76.0	76.3	82.4	83.0	83.0	74.5	75.0
RH. 13.30	45.0	47.0	58.0	59.0	52.0	49.5	45.0	56.0	54.0	56.5	55.7	54.7

Data obtained from Sakha Meteorological station
Where
T_{max} : Maximum temperature °C
T_{min} : Minimum temperature °C
Notes: All values in this table are accumulated through the whole month.

RESULTS AND DISCUSSION

1. Components of rice consumptive use:

Under the two irrigation depths 2.5 and 5.0 cm above the soil surface, data for the first growing season indicated that the values of evaporation (E) was the highest followed by down deep percolation (P) and transpiration (T). For the 2.5 cm depth values are; 16.0, 12.3 and 10.3 cm, while they are 27.6, 24.6 and 17.8 cm under 5.0 cm, respectively On the contrary, under the traditional irrigation depth 7.5 cm above the soil surface, the highest value was recorded for (P) followed by (E) and finally (T) with values of 50.5, 36.7 and 17.8 cm, respectively.

Table (2): Some calculated percentages of E, T, ET and P for applied water depths in the two growing seasons 2006 and 2007.

Calculated parameters	2.5 cm			5.0 cm			7.5 cm		
	1	2	3	1	2	3	1	2	3
	2006								
E/applied water	3.70	2.84	8.56	5.94	3.71	11.20	7.39	3.82	13.32
T/applied water	2.36	1.81	5.45	3.83	2.39	7.22	3.54	1.83	6.39
ET/applied water	5.25	4.03	12.14	9.77	6.10	18.42	10.98	5.68	19.78
P/applied water	2.85	2.18	6.58	5.30	3.31	9.98	10.78	5.26	18.33
	2007								
E/applied water	6.06	4.95	14.01	7.47	4.66	14.08	7.82	4.04	14.09
T/applied water	8.08	6.19	18.66	6.63	4.14	12.49	6.28	3.25	11.32
ET/applied water	14.12	10.83	32.62	14.10	8.80	26.57	14.10	7.29	25.41
P/applied water	4.26	3.27	9.84	8.50	5.31	16.02	13.17	6.81	23.73

Where:

1. **Under all treatments means tank (1) which measures evaporation and transpiration.**
2. **Tank (2) measures evaporation, transpiration and down deep percolation.**
3. **Tank (3) measures evaporation only.**

Table (3): Evaporation (E), transpiration (T), evapotranspiration (ET), percolation (P) and their percentages of the evapotranspiration at different stages of rice cultivar Sakha 101 in the growing season 2006 with irrigation depth 2.5 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	1.5	*	0.5			2.0	
	1.7	0.4	2.1			0.4	
	1.8	*	1.5			1.0	
	1.5	0.7	1.6			0.9	
	1.5	1.5	2.0			0.5	
	1.5	1.7	2.1			0.4	
	1.5	1.9	2.2			0.3	
Total water consumed (cm)	11.0	6.2	12.0	92.0	52.0	45.8	0.46
Reproductive stage	1.2	1.1	1.8			0.7	
	1.0	0.1	1.3			1.2	
	0.6	0.3	1.4			1.1	
Total water consumed (cm)	2.8	1.5	4.5	62.0	33.0	3.0	67.0
Ripening stage	0.5	0.1	1.3			1.2	
	0.6	*	1.2			1.3	
	0.5	1.3	1.9			0.6	
	0.6	1.1	1.8			0.7	
Total water consumed (cm)	2.2	2.5	6.2	35.0	40.0	3.8	61.0
Seasonal water consumed (cm)	16.0	10.2	24.1	70.4	44.9	12.3	54.2

Table (4): Evaporation (E), transpiration (T), evapotranspiration (ET), percolation (P) and their percentages of the evapotranspiration at different stages of rice cultivar Sakha 101 in the growing season 2006 with irrigation depth 5.0 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	1.1	1.2	2.3			2.7	
	2.1	1.5	3.6			1.4	
	2.4	0.9	3.3			1.7	
	3.0	0.8	3.8			1.2	
	3.0	0.5	3.5			1.5	
	3.3	1.4	4.7			0.3	
	2.9	0.9	3.8			1.2	
Total water consumed (cm)	17.8	7.2	25.0	71.2	28.8	10.0	40.0
Reproductive stage	1.9	1.8	3.7			1.3	
	1.5	1.8	3.3			1.7	
	1.9	1.0	2.9			2.1	
Total water consumed (cm)	5.3	4.6	9.9	53.54	46.46	5.1	51.52
Ripening stage	1.0	1.5	2.5			2.5	
	1.4	0.6	2.0			3.0	
	1.1	1.9	3.0			2.0	
	1.0	2.0	3.0			2.0	
Total water consumed (cm)	4.5	6.0	10.5	42.86	57.14	9.5	90.48
Seasonal water consumed (cm)	27.6	17.8	45.4			24.6	

Table (5): Evaporation (E), transpiration (T), evapotranspiration (ET), percolation (P) and their percentages of the evapotranspiration at different stages of rice cultivar Sakha 101 in the growing season 2006 with irrigation depth 7.5 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	1.6	0.4	2.0			5.5	
	2.7	0.7	3.4			4.1	
	2.7	0.8	3.5			4.0	
	2.7	0.8	3.5			4.0	
	2.7	0.7	3.4			4.1	
	2.7	2.9	5.6			1.9	
	2.7	2.1	4.8			2.7	
Total water consumed (cm)	17.8	8.4	26.2	67.94	32.06	26.3	100.38
Reproductive stage	2.7	2.3	5.0			2.5	
	2.7	1.3	4.0			3.5	
	2.7	0.8	3.5			4.0	
Total water consumed (cm)	8.1	4.4	12.5	64.8	35.2	10.0	80.0
Ripening stage	2.7	0.9	3.6			3.9	
	2.7	1.3	4.0			3.5	
	2.7	1.3	4.0			3.5	
	2.7	1.5	4.2			3.3	
Total water consumed (cm)	10.8	4.8	15.8	68.4	30.38	14.2	89.87
Seasonal water consumed (cm)	36.7	17.6	54.5			50.5	

Table (6): Evaporation (E), transpiration (T), evapotranspiration (ET), down deep percolation (P) and their percentages of the evapotranspiration at different growth stages of rice cultivar Sakha 101 in the growing season 2007 with irrigation depth 2.5 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	2.7 2.8 2.8 2.7 2.5	2.4 3.0 1.9 3.0 2.6	5.1 5.7 4.7 5.7 5.1			1.2 0.5 1.2 1.9 1.7	
Total water consumed (cm)	13.5	12.9	26.3	51.3	49.0	6.5	24.71
Reproductive stage	2.5 2.7	4.7 4.4	7.2 7.1			0.9 1.6	
Total water consumed (cm)	5.2	9.1	14.3	36.36	63.64	2.5	17.48
Ripening stage	2.5 2.5 2.5	4.3 1.4 7.2	6.8 3.9 9.7			3.4 3.7 2.3	
Total water consumed (cm)	7.5	12.9	20.4	36.76	63.24	9.4	46.08
Seasonal water consumed (cm)	26.2	34.9	61.0			18.4	

Table (7): Evaporation (E), transpiration (T), evapotranspiration (ET), down deep percolation (P) and their percentages of the evapotranspiration at different growth stages of rice cultivar Sakha 101 in the growing season 2007 with irrigation depth 5.0 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	4.7 3.2 3.0 4.4 2.5	0.2 2.5 1.8 2.6 3.2	4.9 5.7 4.8 7.0 5.7			5.9 2.5 4.2 3.2 4.5	
Total water consumed (cm)	17.8	10.3	28.1	63.35	36.65	20.3	72.24
Reproductive stage	3.8 3.2	2.0 4.0	5.8 7.2			5.6 3.0	
Total water consumed (cm)	7.0	6.0	13.0	53.85	46.15	8.6	66.15
Ripening stage	3.0 2.5 4.4	4.8 4.6 5.1	7.8 7.1 9.5			3.6 3.1 3.9	
Total water consumed (cm)	9.9	14.5	24.4	40.57	59.43	10.6	43.44
Seasonal water consumed (cm)	34.7	30.8	65.5			39.5	

Table (8): Evaporation (E), transpiration (T), evapotranspiration (ET), down deep percolation (P) and their percentages of the evapotranspiration at different growth stages of rice cultivar Sakha 101 in the growing season 2007 with irrigation depth 7.5 cm.

Growth stages	Components of consumptive use (C.U)						
	E	T	ET	E/ET %	T/ET %	P. cm.	P/ET %
Vegetative growth stage	5.20 4.79 2.68 3.81 3.10	6.22 0.92 3.24 1.9 1.69	11.42 5.71 5.92 5.71 4.79			1.84 6.84 5.93 6.98 8.47	
Total water consumed (cm)	19.58	13.97	33.55	58.36	41.64	30.06	39.60
Reproductive stage	3.38 3.17	2.19 4.73	5.57 7.90			7.12 7.33	
Total water consumed (cm)	6.55	6.92	13.47	48.63	51.37	14.45	107.28
Ripening stage	4.44 2.54 5.70	3.46 2.68 4.17	7.90 5.22 9.87			7.33 8.18 5.36	
Total water consumed (cm)	12.68	10.31	22.99	55.15	44.85	20.87	90.78
Seasonal water consumed (cm)	38.81	31.2	70.01			65.38	

In the second growing season 2007, the highest value was recorded for (P) followed by (E) and (T) under the two irrigation depths 5.0 and 7.5 cm above the soil surface. The values are 39.5, 34.7 and 30.8 cm, under the 5.0 cm depth treatment, while under the 7.5 cm depth irrigation treatment the values are 65.38, 38.8 and 31.20 cm. On the other hand, for the lowest irrigation depth till 2.5 cm above the soil surface, the highest value was recorded for (T) followed by (E) and finally (P) with values of 39., 26.2 and 18.4 cm, respectively.

The mean values of the two growing seasons, showed that increasing irrigation depth leads to increasing values of (P), (E) and (T). Where the highest values were recorded under 7.5 cm irrigation depth and the values are; 57.94, 37.755 and 24.5 cm, respectively. Data also indicated that the values of (P) were the highest in comparison with the values of (E) and (T). The values can be descended in this order P > E > T.

Data for the two growing seasons also clearly showed that the values of evapotranspiration (ET), which also so-called consumptive use (CU) are increased with increasing irrigation water depth up to 7.5 cm above the soil surface. The values in the first growing season are 22.7, 45.4 and 54.5 cm and in the second growing season, the values are 61.0, 65.5 and 70.01 cm. at 2.5, 5.0 and 7.5 cm above the soil surface, respectively. Data presented in the same tables clearly indicted that the values of evapotranspiration (ET) i.e. Cu are generally higher during the first month of the growing season under the three irrigation treatments till 2.5, 5.0 and 7.5 cm above the soil surface. The same trend was clearly for evaporation (E) with values of 8, 13.8 and 13.8 cm in the first growing season 2006 under the three irrigation status, respectively. Also, in the second growing season 2007, the values of E are 11.0, 15.3 and 16.48 cm. under the stated irrigation treatments, respectively.

This finding of increasing evaporation during the first month of the rice growing season might be attributed to the less foliage cover and high surface wetted irrigated soil exposed to solar radiation and hence increasing losses via evaporation process. Generally, the values of evaporation (E), transpiration (T), evapotranspiration (ET) and down deep percolation (P) were increased with increasing irrigation depth up to 7.5 cm above the soil surface in the two growing seasons 2006 and 2007. The abovementioned parameters E, T, ET and P were higher under vegetative growth stage in comparison with the other growth stages.

Conclusions and Recommendations

After doing this research, data cleared illustrated that increasing irrigation water depth up to 7.5 cm led to increasing water losses either by evaporation or down deep percolation. So, we recommends that, to make lacking of these losses irrigation depth should be decreased without any drastic effect on yield, also, we should take care of wet leveling of the soil (which so-called talweet) to making decreasing for down deep percolation especially, depth of water more than 5.0 cm considers waste water.

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مكونات الاستهلاك المائى لمحصول الارز فى منطقة شمال وسط الدلتا

السيد ابو الفتوح مرسى ، ماهر محمد كساب ، حسن يوسف محمد حسن و محمد عبد الفتاح محمد ابراهيم
معهد بحوث الاراضى والمياه والبيئة ــ مركز البحوث الزراعية

نفدت تجربتان فى تنكات بمحطة البحوث الزراعية بسخا وذلك خلال موسمى ٢٠٠٦ & ٢٠٠٧ فى منطقة شمال وسط الدلتا وذلك بهدف تحليل مكونات الاستهلاك المائى لمحصول الارز بالاضافة الى التسرب العميق فى كلى موسمى الدراسة. البيانات اوضحت ان قيم البخر ، التسرب العميق والنتح وكذلك البخر نتح قد زادت بزيادة عمقه ماء الرى المضاف. كذلك أوضحت النتائج أن متوسط القيم للتسرب العميقة كانت الاعلى تحت العمق ٧,٥ سم بالمقارنة بمتوسط القيم الخاصة بالبخر والنتج والتى كانت ٥٠,٥ ، ٦٥,٣٨ سم على الترتيب تحت كل اعماق الرى. قيم البخر كانت اعلى من قيم النتح. ومن ثم قيم الاستهلاك المائى وكذلك التسرب العميق يمكن ترتيبها تنازليا كالتالى: التسرب العميق > البخر > النتح فى كلى موسمى الدراسة. قيم البخر ، والنتج وكذلك البخر نتح يمكن ترتيبها تنازليا حسب مراحل النمو هكذا ، مرحلة النمو الخضرى > التزهير > النضج بصفة عامة نفس الاتجاه تم ملاحظته للتسرب العميق.