Water Requirement Components of some Egyptian Rice Varieties in North Nile Delta

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ABSTRACT

Two experiments were conducted at Sakha Agriculture Research Station, during the two successive summer growing seasons of 2012 and 2013 to estimate and analysis water requirements components for some Egyptian rice varieties (*Oryza sativa L*); namely cvs. Giza 178, Sakha 102 and Sakha 104 and to evaluate and compare the estimated rice crop evapotranspiration (ET_c) values computed using Hargreaves, Penmen-Monteith and Class A pan methods used for (ETc) with the measured actual rice evapotranspiration (ETa) using micro- paddy lysimeter used for (ETa) to evaluate the best method for estimating the reference evapotranspiration which suitable with North Nile Delta conditions.

Results showed that evaporation (E) is the highest component of total rice water requirements (WR) during the whole growing season stages for cv. Giza 178 with an average 39.8%, followed by cvs. Sakha 102 and Sakha 104 with an average 38.3 and 38.2%, respectively. However, Transpiration (T) is the lowest part of WR for cvs. Giza 178, Sakha 102 and Sakha 104 with an average 21.0, 20.1 and 21.4%, respectively. For percolation (P) is major for Sakha 102 and Sakha 104 varieties with an average of 41.6 and 40.4%, respectively. Meanwhile, the lowest value of P (39.2%) was lost from Giza 178. Mean values of ET_a for cv. Giza 178, Sakha 102 and Sakha 104 were 6.1, 6.0 and 6.0 mm day^{-1}, respectively. Although mean values of the estimated rice crop evapotranspiration resulted from Hargreaves, Penmen-Monteith and Class A pan methods were underestimated actual rice evapotranspiration, but Hargreaves and Penmen-Monteith methods performed best for North Delta, Egypt because of the least amount of error and least percentage deviation between ET_a and ET_c. Crop water productivity (CWP) were 0.85, 0.86, and 0.87 Kg m^{-3} for rice cvs. Giza 178, sakha 102, and Saka 104, respectively. Also results indicated that the values of crop water use efficiency (CWUE) of rice for cvs. Giza 178, Sakha 102 and Sakha 104 were 1.53, 1.55 and 1.46 Kg m^{-3} respectively. So, Hargreaves and Penmen-Monteith methods could be recommended for saving irrigation water with planting rice cv. Giza 178, which gave higher water productivity.

Keywords: Actual evapotranspiration, reference evapotranspiration, rice varieties, micro-paddy lysimeter, water requirements, crop water productivity, crop water use efficiency.

INTRODUCTION

Since the water resources in Egypt are limited and focused on the river Nile. Egypt water allocation is 55.5x 10^9 m^3 a year and with tremendous increase in the population, production has to be increased and irrigation water has to be well managed and how to find the way for saving more irrigation water becomes essential. There is a clear constraint on reducing water irrigation in Egypt based on the necessity to control salinity in the Northern Delta. The saline aquifer which underlines the Northern Delta will cause soil salinity problems due to upward migration when the hydraulic pressure gradient permits. Periodic flushing with sufficient fresh water is required to reduce this upward migration. There is evidence that rice cultivation has actually improved some of the relatively saline soils in the Northern Delta. So, cultivation of rice is essential to conserve soil fertility and to reduce salinity hazard in particular areas such as Northern Delta (Badawi and Ghanem; 2007).

Rice is highly water consumed specially under the conventional irrigation method, thus saving the water is becoming decisive factor for agricultural expansion. At the same time, a shortage of fresh water for irrigation and a necessity to search for effective on-farm water management strategies are required for increasing the water use efficiency of rice irrigation. Water requirement of the rice crop was to vary from 75 to 250 cm. On an average, tall indica rice require about 1.25 cm of water every day (Dastane et al., 1971). A rice crop of about 150 days duration requires water amounting to 64 cm for raising the nursery, 102 cm for growth from planting to flowering and a further amount of 25 cm for repining making the total to 190 cm (Ramiah and Vachhani, 1951). A great part of the water requirement of rice constitutes the water lost through deep percolation. Vamadevan and Dastane (1967) stated that 120 cm of water was lost through deep percolation and 48 cm only was used by the crop as consumptive use. The percolation loss was greatly reduced under condition of soil saturation more than under continuous soil submergence. As considerable amount of water is lost from rice fields through percolation, attempts have been made to advise ways to reduce or prevent water loss through percolation. Gross irrigation water applied

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were amounted 196.38, 152.05 and 118.21 cm resulted from irrigation every six days intervals with submerged depths of 10, 7 and 4 cm, respectively. Gross amount of water applied for rice cvs. Giza 178 and Giza 177 were found to be 165.20 and 145.86 cm, respectively (El-Bably et al., 2007). Abd El-Hafez (1982) found that mean values of rice consumptive use ranged between 5.88 and 6.25 mm/day. Doorenbos and Pruitt (1984) found that approximate range of seasonal evapotranspiration in mm for rice crop is 500-900. Abo-Soliman et al, (1990) concluded that water requirements for rice was ranged from 161 to 214 cm in North Delta, Egypt under flooding method and the mean values of utilization efficiency ranged from 47 to 54%. Mahrous et al, (1984) found that total rice water requirements was 199, 165, and 141 cm when irrigation intervals were 4, 6 and 8 days respectively. Mean values of actual evapotranspiration for rice cv. Giza 178 was higher than rice cv. Giza 177 by 15.7% because of the longer growth duration (El-Bably et al., 2007).

The determination of crop water requirements is the first step used in project planning and design. The operation commonly involves the estimation of the reference crop evapotranspiration or evaluation of crop evapotranspiration. Better estimates of crop evapotranspiration play important role to accurately determine the crop water requirements. Different methods can be used to determine crop evapotranspiration (ET_c), which is an essential element in crop water use (Attarod et al., 2005). The FAO Penman-Monteith method (Allen et al., 1998) is generally considered to be the best approach for estimating crop evapotranspiration. Crop coefficients are used to estimate evapotranspiration of crops multiplied by calculated potential or reference evapotranspiration (ETo). To determine crop evapotranspiration, crop coefficients must be derived for each crop empirically based on local climatic conditions (Doorenbos and Pruitt, 1977). An estimate of evapotranspiration forms the foundation for the planning and designing of all irrigation projects and efficient water usage, providing a basic tool for computing water balance and predicting water availability and requirement (Humphrey et al., 1994; Pereira et al., 1999). Crop water requirements are directly related to crop evapotranspiration (ET_c) and vary depends on crop grown and its different growth stages. Evapotranspiration involves a highly complex set of processes, which are influenced by many factors depends on the local conditions. These conditions range from precipitation and meteorology factors to soil moisture, plant water requirements and the physical nature of the land covered (Dunn and Mackay 1995). To effectively and efficiently use the available water resources for irrigation supply, studies of crop water requirements for paddy crops based on derived crop coefficient and/or field measurement are crucial. To improve water management practice, experimental data based irrigation management model can be applied for estimation of crop water requirements in rice. On the other hand, evapotranspiration is the one of the important components of the water balance equation in paddy fields.

It is mainly affected by climatic factors and, to some extent, is controlled by physiological functions of rice under submerged conditions (Li and Cui, 1996; Peacock et al., 2004; Tsubo et al., 2007). The worldwide estimate of rice ET ranges between 450 and 700 mm/season, depends on the climate and growing season (Doorenbos and Kassam, 1979).

There are several techniques used in determining evapotranspiration. These techniques include water balance, empirical formulae or micro-meteorological approaches. Field measurements of evapotranspiration are generally not only tedious but also expensive and are therefore, restricted to research plots rather than practical uses in the farms by farmers. On the other hand, micro-paddy lysimeter affords simple and reasonably accurate water accounting device. The micro-paddy lysimeter employed in this study is cheaper and has gained more prominence recently. Abdel-Hafez (1982) used and tested a micro-paddy lysimeter (tanks) for estimating Water requirement and consumptive use of rice were calculated from data obtained from sets of three types lysimeter installed in the rice field. One of these types of lysimeter was designed to measured evapotranspiration (ET), the second to measure evapotranspiration and percolation (ET + P), and the third type to measure evaporation (E). The differences between values of (ET) and (ET + P) yielded to amount of water percolated through the soil (P), while the differences between (ET) and (E) yielded to the amount of water transpired by plants (T). Evapotranspiration of wetland rice, in which the measurements were done with pan evaporation. The ratio of (ETc/Ep) could be used to compare difference between and within varieties, as well as variations in crop water requirement between seasons. However, the FAO Penman-Monteith method is considered as the international standard for predicting crop water requirement and has extensively been used worldwide by irrigation engineers, agronomists and hydrologists (Abdullahi, et.al., 2013). The climatic data usually require using Penman's combination equation, which is not always available and, often, ET, is approximated as a factor (pan coefficient) multiply by the standard evaporation pan reading.

Objective of this study was to estimate and analysis of water requirement components of some rice varieties i.e. evaporation, transpiration to express actual consumption as well as the deep percolation, and to evaluate three reference evapotranspiration (ETo) methods, using the recommended FAO rice crop coefficient (Kc), in North Delta, Egypt.

MATERIALS AND METHODS

Two experiments were conducted at Sakha Agriculture Research Station, during the two successive summer growing seasons of 2012 and 2013 to estimate and analysis water requirements components for some Egyptian rice varieties (*Oryza sativa L*); namely cvs. Giza 178, Sakha 102 and Sakha 104 and to evaluate and compare the estimated rice crop evapotranspiration (ET_c) values computed using Hargreaves, Penmen-Monteith and Class A pan methods used for (ETc) with the measured actual rice evapotranspiration (ETa) using micro- paddy lysimeter used for (ETa) to evaluate the best method for estimating the reference evapotranspiration which suitable with North Nile Delta conditions.

The site lies at Kafr EL Sheikh Governorate (Middle North of the Nile Delta), which located at (31¯ 07° N Latitude, 30¯ 57° longitude) with an elevation of about 6 metres above sea level. Data presented in Table 1 which reveal the meteorological parameters during the studied period, recorded from Sakha Agro-meteorological Station. The meteorological parameters, include; air temperature (T., C°), relative humidity (RH.,%), wind speed (U_2,km day^{-1} at 2 m height) and evaporation pan (E_p, mm). The soil texture of the experimental site is heavy clay which is more suitable for rice cultivation by having a high water holding capacity.

In the first growing season the plants were transplanted with Giza 178, Sakha 102 and Sakha 104 rice cultivars seedlings on 2nd July, 2012, while in the second growing season 2013, the plants were transplanted with the seedlings with the same rice cultivar on 4th July, 2013. Harvesting process was occurred on 20th October in the two growing seasons.

Since evapotranspiration and percolation are the major consumptive components of water budget in a paddy field plot, it is important to measure or estimate these values for calculating the actual water requirement in the plot as establishing a basis for irrigation planning. Actual evapotranspiration can be measured in a plot using a small lysimeter with the bottom set in the top soil, in which some rice plants are growing as shown in Fig.1 (a). Since water in the cylinder is consumed only by evapotranspiration, its rate can be measured as the decrease of water depth in it. If evaporation rate is to be separated from evapotranspiration rate, it can be measured using a similar cylinder without rice plants inside it but the plants distributed outside the cylinder as Fig.1(c). While Fig.1 shows examples of measuring cylinder with only one plant hill, each cylinder in this study contains 18 plants for more accurate measurements; however it may cause some troubles in the placement of the heaviness of the apparatus.

Actual percolation rate can be measured in a plot with the cylinder without a bottom as shown in Fig.1 (b). The rate of decrease of water head inside the cylinder gives the rate of water consumption by percolation and evapotranspiration. Therefore using the evapotranspiration rate measured with the cylinder (Fig.1 (a)), percolation rate can be calculated. Irrigation water depth of each cylinder is set at the traditional watering level of 5 cm. above soil surface immediately after transplanting. Each one was rewatering every 6 days till a static depth of 5 cm. above soil surface.

Water balance in paddy fields

In this study, rainfall, surface drainage, runoff and seepage assumed as negligible since these parameters are not available at the time of the study, and especially in Egypt, Therefore, the consumptive use principally consisted of crop evapotranspiration and infiltration. Watanabe (1999) also reported that, in a plot-to-plot irrigation system, water consumption consisted principally of total evapotranspiration and total infiltration. Hence, supply terms are only irrigation.

Table 1. Climatic data of the site during the experimental seasons

Year	Months	T, (c°)			RH, (%)			U_2,	E_p, mm/day	Rf,mm
		Max.	Min.	Mean	Max.	Min.	Mean	(km/h.)		
2012	July	33.16	25.3	29.23	84.05	53.02	68.53	91.74	6.0	-
	Aug.	34.65	25.02	29.83	84.90	52.14	68.52	90.91	5.7	-
	Sept.	32.28	22.73	27.50	82.87	52.30	67.58	86.33	6.6	-
	Oct.	29.92	20.64	25.28	85.24	55.31	70.27	74.15	4.3	0.2
2013	July	32.32	24.31	28.31	79.57	54.7	67.13	110.99	6.1	-
	Aug.	33.79	24.76	29.27	83.63	60.52	72.07	90.24	5.1	-
	Sept.	32.50	22.93	27.71	81.00	56.60	68.80	87.60	3.8	-

Oct.	27.79	19.42	23.60	76.23	57.36	66.79	108.99	2.8	-

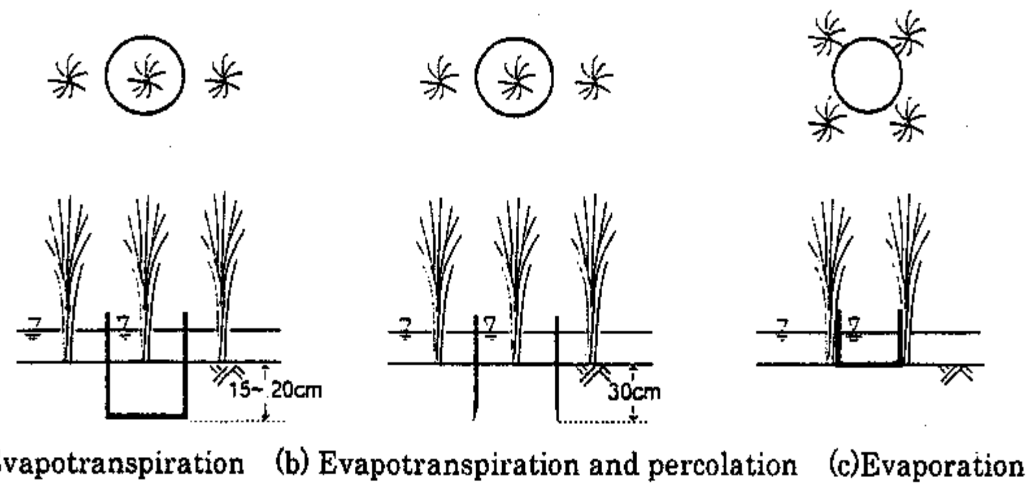

Fig.1 Examples of measuring apparatus for evapotranspiration and percolation rate.

The water balance in a paddy field was calculated by field storage and water volumes entering and leaving the field. The field storage consisted of ponded water (D) and soil moisture (W). The inflow to the field consisted of precipitation (P), irrigation (IR), surface inflow (R_{in}) and seepage inflow (S_{in}), while the outflow was composed of crop evapotranspiration (ET_c), infiltration (I), surface outflow (R_{out}) and seepage outflow (S_{out}). Therefore, the water balance equation was;

Δ (D + W) = (P + IR+ S_{in}+ R_{in}) - (ET_c + I+ S_{out}+ R_{out})

Where, Δ (D + W) is the change of field storage and all terms are expressed either in mm or in m^3. The water balance for the paddy fields was calculated for the whole varieties in both seasons.

Estimating Reference evapotranspiration (ET_o) using climatological data

The ET_o is a measure of the evaporative demand of the atmosphere independent of crop type, crop development and management practices. Only climatic factors affect (ET_o). Accordingly, ET_o is a climatic parameter and can be computed from meteorological data (Allen et al., 1998). Agro-climatological elements during both growing seasons through 2012 and 2013 were collected from the agro-meteorological station in the site.

Values of ETo for different months were estimated using of the four following methods:

1. Hargreaves method:

ETo = 0.0023Ra. TD0.5 (Ta + 17.8)

where:

Ra = absolute radiation, Cal. cm^{-2}-day^{-1}

TD = air temperature difference between max. and min., ^oC

Ta = air temperature average, ^oC

Values of Ra for the area were computed depending upon the local environmental features (Ibrahim, 1995).

2. FAO Penman-Monteith method: as described by Allen *et al.* (1998) was used to calculate ET_o. The equation is given as:

$$ETo = \frac{0.408\ \Delta\ (Rn - G) + \gamma\ [900/(T + 273)]\ U_2\ (es - ea)}{\Delta + \gamma\ (1 + 0.34\ U_2)}$$

Where:

ET_o = Reference evapotranspiration, mm.day-¹

Rn = net radiation (MJ $m^{-2}d^{-1}$)

G = soil heat flux (MJ $m^{-2}d^{-1}$)

Δ = slope of vapor pressure and temperature curve (kPa $^oC^{-1}$)

γ = psychrometric constant (kPa °C^{-1})

U2 = wind speed at 2 m height (ms^{-1})

es-ea = vapor pressure deficit (kPa)

T = mean daily air temperature at 2 m height (°C)

3. Class A pan evaporationmethod:

ETo = Kp * Ep

As:

Kp = pan coefficient, values of Kp affected with the surrounding area, where the pan is located and it was taken as an average value of 0.85.

Ep = daily evaporation rate, mm day^{-1}.

Computation of crop evapotranspiration (ETc):

ETc = Kc * ETo

The dimension less crop coefficient, Kc is the ratio between the water consumed by specific crop to ETo. values of Kc were quoted from FAO No. 56, 1998, and presented in table 3.

Measures of the four methods performance included estemated (ET_c) and measured (ET_a) values components of the mean absolute error (MAE), and the root mean square error (RMSE) (Meyer *et al.,* 1993).

Crop water productivity (CWP):

Irrigation water productivity is commonly calculated according to Michael (1978) as fellow:

$$CWP = \frac{Yield}{Water\ applied}$$

Crop Water use efficiency (CWUE):

Crop water se efficiency is generally defined as the ratio of yield (Y), Kg m^{-2}, to the amount of water depleted by the crop in the process of evapotranspiration (ETa), m^3 m^{-2} $season^{-1}$. It was calculated according to Doorenbos and Pruitt (1977) as fellow:

$$CWUE = \frac{Y}{ETa}$$

RESULTS AND DISCUSSION

Rice water requirements components:

Data of Table 2 represent the results of daily millimeters of evaporation (E), transpiration (T), deep percolation (P), water requirements (WR) which equal the summation of E, T and P and measured ETa from micro-paddy lysimeter in rice plots.

Evaporation (E) was the major at early stages (July) and declined due to shading of plant and climate factors to reach its minimum rate at October. Transpiration (T) rate was high at the early stage of growth and then declined. Percolation (P) was high at the first stage and then decreased due to stability of water table level by time after transplanting (Figure 2). These results are agreed with results that given by Abdel-Hafez (1982) and Moursi (2002).

Data in table 3 indicated Evaporation (E) is the highest portion of total rice water requirements (WR) within the whole growing season stages of Giza 178 with an average 39.8 % (439.5 mm $season^{-1}$). while it comes at the second stage after P of WR for Sakha 102 and 104 with an average 38.3 and 38.2 % (411.3 and 431.6 mm $season^{-1}$), respectively. While, transpiration (T) is the lowest part of WR within the growing season of Giza 178, Sakha 102 and Sakha 104 with average 21.0, 20.1 and 21.4% (232.0, 215.3 and 241.4 mm $season^{-1}$), respectively. Moreover, there is no differences observed between cultivars in transpiration Through adapting the system of irrigation, unproductive water losses such as E and P can be reduced and the level of productive water use then depends mainly on transpiration. Little is known on how such water saving techniques affect transpiration of rice as it is more difficult to observe in the field (Hartmann et al., 2010).

For percolation (P) is major for Sakha 102 and Sakha 104 varieties with an average of 42 and 41% (445.5 and 456.6 mm), respectively. On the other hand, the lowest value of P (39% (384.8 mm)) was lost from Giza 178. Clearly, the P values decreased by increasing E rate which could be interpret that P values of Giza 178 is less than corresponding values of Sakha 102 and 104. In general, the P rate was the high at vegetative stage and then decreased due to stability of water table level by time after transplanting. In average, the highest portion of the water requirements of rice is down deep percolation (P) in average of 40.6% and that could be occurred due to the static head of water during the growing season and the soil permeability.

Actual Evapotranspiration (ET_a):

Result in Table 4 showed that mean values of actual evapotranspiration for Giza 178, Sakha 102 and Sakha 104 was 6.1, 6.0 and 6 mm. day^{-1}, respectively and they are almost the same. According to Tabbal, et al. (2002) typical ET_c rates of rice fields are 4 - 5 mm/day in the wet season and 6 - 7 mm/day in the dry season, but can be as high as 10–11 mm/day in subtropical regions. Data also revealed that the maximum ET_a was in July and then gradually decreased until harvesting. These results may be due to prevailing agronomic and climatic conditions (Abdullahi, et.al., 2013; Sugimoto, 1976; Wickham, 1978; Tomar and Toole, 1980).

Result in Table 3 showed that values of ET_a for rice cv. Giza 178 were 7.9, 6.7, 5.8 and 3.9 mm day^{-1} and 8.1, 6.7, 5.5 and 3.7 mm day^{-1} for rice cv. Sakha 102 and 7.8, 7.0, 5.6, and 6.0 mm/day in July, August, September and October months for cv. Sakha 104, respectively. It can be observed that the maximum ET_a was in July and then gradually decreased until harvesting. These results may be due to prevailing agronomic and climatic conditions (Abdullahi, et.al., 2013; El-Bably et al., 2007; Abd El-Hafez et al., 1982; Tomar and Toole, 1980; Wickham, 1978 and Sugimoto, 1976).

Evaluation of the methods:

Hargreaves method, Penman-Monteith and Class A pan methods were underestimated actual evapotranspiration using Giza 178 by 9.3, 9.8 and 20.8%, respectively (Table 4). Overall, based on criteria of MAE, RMES, and percentage deviation from ET_a, Hargreaves and Penman-Monteith methods performed best for North Delta, Egypt because of the least amount of error

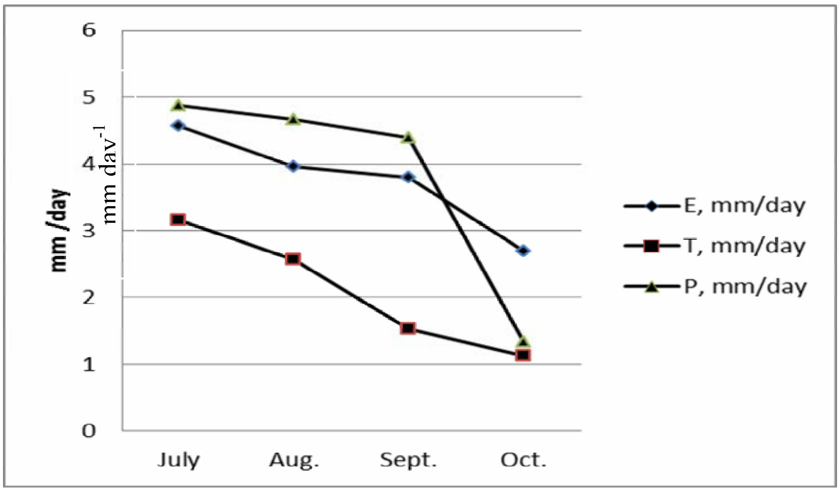

Fig. 2. Rice water requirements components E, T and P for Giza 178, Sakha 102 and Sakha 104 at during the growing season.

Table 3. Components of water requirements (E, T, ETa and P) percentages for some rice varieties (Giza 178, Sakha 102 and Sakha 104)

Varieties	E, %	T, %	ETa, %	P, %
Giza 178	39.8	21.0	60.8	39.2
Sakha 102	38.3	20.1	58.4	41.6
Sakha 104	38.2	21.4	59.6	40.4

Table 4. Monthly references evapotranspiration (ET_o mm day^{-1}), crop coefficient (K_c), measured actual evapotranspiration (ET_a mm day^{-1}) and calculated crop evapotranspiration (ETc) of rice (average of both growing seasons)

Months	Reference evapotranspiration, ET_o mm day^{-1}			FAO rice coefficient (K_c)	Actual evapotranspiration (ET_a), mm day^{-1} of rice cultivars					
	Hargreaves	Penman Monteith	Class A Pan		Giza 178	Sakha 102	Sakha 104	Hargreaves	Penman Monteith	Class A Pan
July	5.7	6.2	5.1	1.07	7.9	8.1	7.8	6.1	6.6	5.5
Aug.	5.4	5.5	4.6	1.16	6.7	6.7	7.0	6.3	6.4	5.3
Sept.	4.9	4.5	4.5	1.19	5.8	5.5	5.6	5.8	5.4	5.3
Oct.	3.7	3.4	3.0	1.04	3.9	3.7	3.8	3.8	3.5	3.1
Average					6.1	6.0	6.0	5.5	5.5	4.8
MAE								-0.57	-0.60	-1.27
RMES								0.85	0.52	2.15
Percentage deviation form ETa values of Giza 178								-9.3	-9.8	-20.8

Table 5. Irrigation water applied, grain yield and crop water productivity of some rice cultivars, over both growing seasons

varieties	Water requirements after transplanting, (W.R), mm	Water requirements during nursery, mm	Applied water, mm/season	Grain yield, Kg m^{-2}	CWP, Kg m^{-3}	CWUE, Kg m^{-3}
Giza 178	1104.9	104.0	1208.9	1.029	0.85	1.53

Sakha 102	1072.1		1176.1	0.971	0.86	1.55
Sakha104	1129.6		1233.6	0.980	0.87	1.46
Mean	1102.5		1206.5	0.993	0.86	1.51

(MAE = -0.57 and 0.60, RMES = 0.85 and 0.52 for both of Hargreaves and Penman-Monteith methods, respectively) and least percentage deviation (-9.3 and -9.8) between ET_a and ET_c. Therefore, values of MAE, RMSE, and percentage deviation from ET_a indicated close agreement between actual evapotranspiration (ET_a) and crop evapotranspiration (ET_c) using one of Hargreaves or Penman-Monteith compared to the other method. The obtained results are agreed with those obtained by El-Bably et al., 2007.

Yield-water relations:

Mean values of both Crop water productivity (CWP) and crop water use efficiency (CWUE) of rice in kg grain per one cubic meter of water applied (table 5) for Giza 178, Sakha 102 and Sakha 104 varieties were 0.85, 0.86 and 0.8 Kg m^{-3} ,respectively. Results showed that rice irrigation water productivity for Giza 178 > Sakha 102> Sakha 104. Meaningfully, one cubic meter of water applied produces 0.8, 0.86 and 0.87 Kg grain yield for Giza 178, Sakha 102 and Sakha 104, respectively.

Data in table 5 also indicated that the values of crop water use efficiency (CWUE) of rice in kg grain per one cubic meter of water depleted by rice crop through the process of evapotranspiration (ETa) for cvs. Giza 178, Sakha 102 and Sakha 104 were 1.53, 1.55 and 1.46 Kg m^{-3} respectively. Results showed that rice irrigation water productivity for Sakha 102 > Giza 178 > Sakha 104. That was due to the low seasonal ETa of cv. Sakha 102 compared with the other varieties. The obtained results are in good agreement with those obtained by Ibrahim et al, 2005.

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الملخص العربي

مكونات الاحتياجات المائية لبعض اصناف الارز المصرية بشمال دلتا النيل

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أقيمت هذه الدراسة خلال موسمي ٢٠١٢م، ٢٠١٣م بمحطة البحوث الزراعية بسخا- محافظة كفرالشيخ بهدف تقدير المقنن المائي وتحليل ومكوناته لبعض أصناف الارز وهي جيزة ١٧٨ وسخا ١٠٢ وسخا١٠٤ وكذا تقدير الاستهلاك المائي(البخر نتح الفعلي) للاصناف المختلفة باستخدام الليزمترات الحقلية بالاضافة الي تقدير البخر نتح القياسي باستخدام طريقة هارجريفز والفاو بنمان مونتيث ومعادلة وعاء البخر القياسي(أ) ومعادلة ابراهيم لتحديد افضل الطرق لاستخدامها في شمال دلتا النيل.

ويمكن ايجاز النتائج كالتالي:

- سجلت قيم البخر(E) أكبر نسبة من إجمالي المقنن المائي لمحصول الأرز(WR) خلال موسم النمو بأكمله وذلك بالنسبة لصنف جيزة ١٧٨ بمتوسط ٣٩,٨٪ من WR. في حين أنه يأتي في الدرجة الثانية بعد التسرب العميق(P) كنسبة من WR للأصناف سخا ١٠٢ و١٠٤ بمتوسط ٣٨,٣ و٣٨,٢٪ على التوالي.
- أظهرت النتائج بأن النتح(T) يشكل أقل جزء من WR خلال موسم النمو بمتوسط نسبة مئوية ٢١ و٢٠,١ و٢١,٤% من المقنن المائي للاصناف جيزة ١٧٨، سخا ١٠٢ وسخا ١٠٤ على التوالي. في حين ان التسرب العميق(P) يشكل النسبة الاكبر من WR للأصناف سخا ١٠٢ وسخا ١٠٤ بمعدل ٤١,٦ و٤٠,٤٪ على التوالي. في حين كانت اقل قيمة للتسرب العميق(٣٩,٢%) من الصنف جيزة ١٧٨.
- وأظهرت النتائج أن متوسط قيم البخر نتح الفعلي للأصناف جيزة ١٧٨، سخا ١٠٢ وسخا ١٠٤ كانت ٦,١ ، ٦,٠ و٦ ملم في اليوم على التوالي.
- واضحت النتائج بأن قيمة جهد البخر نتح المحسوب باستخدام طريقة هارجريفز، بنمان-مونتيث ووعاء البخر القياسي(أ) أقل من االبخرنتح الفعلي المقدر لصنف جيزة ١٧٨ بنسبة٩,٣ و٩,٨ و٢٠,٨٪ على التوالي.
- أظهرت الدراسة أنه يمكن استخدام طريقتي هارجريفز والفاو بنمان مونتيث لتقدير قيمة البخر والنتح لمحصول الأرز بدرجة دقيقة حيث أنها الأقل فى درجة الخطأ والنسبة المئوية للإنحراف بين جهد البخر والنتح النظرى والفعلى.
- كما أظهرت النتائج أن إنتاجية وحدة المياه المضافة لمحصول الأرز للاصناف جيزة ١٧٨ < سخا ١٠٢ < سخا ١٠٤. والقيم المناظرة كانت ٠,٨٥، ٠,٨٦ و٠,٨٧ ٥٥ كجم/م^{٣} على التوالي. وكان صنف سخا ١٠٤ < سخا ١٠٢ < جيزة ١٧٨ في قيمة كفاءة الاستهلاك المائي للمحصول حيث كانت القيم ١,٤٦، ١,٥٣ و١,٥٥ كجم/م^{٣} على التوالي.