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THE AMOUNT OF WATER SHOULD BE APPLIED FOR FABA BEAN CROP UNDER DRIP AND DEFICIT IRRIGATION.

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ABSTRACT

A field experiment was carried out during the two successive growing seasons of faba bean 2011/ 2012 and 2012/ 2013.

The aim of this investigation was to find out the impact of water deficit based on differentreference evapotranspiration(ET_o) methods on water applied for faba bean crop.

The field trial was executed at Sakha Agricultural Research Station, which represents the conditions of North Nile Delta region. The field is clay in texture and furnished with drip irrigation system.

Main treatments were ET_o methods;FAO Penman-Monteith, Ibrahim, Doorenbos- Pruitt and Modified Penman. While the subtreatmentswere levels of watering, 60%, 80% and 100% from irrigation water ($IW_.$), IW= crop water needs (Et_c) divided by E_i (E_i = irrigation efficiency = 0.85 for drip irrigation.

The main findings could be summarized as follows:

- Average seasonal irrigation water (IW) was ranged between 476.83and 696.41 m^3 / fed.which recorded under 60% FAO penman- monteith and 100% modified Penman, respectively.
- Mean rainfall (RF) of the two seasons were 405.08 m^3 / fed. (9.65 cm).
- Average of the total water applied (TWA) had the same trend of IW and ranged between 881.92 and 1101.50 m^3 / fed. for the stated ET_o methods, respectively.
- The contribution percentage of RF in WA was between 36.8 and 46% which resulted from 100% Modified Penman and the 60% FAO Penman- Monteith, respectively.
- Generaly, ET_o methods can be arranged in inscending order regarding computation of IW as; FAO Penman- Monteith,Doorenbos&Pruit, Ibrahim and Modified Penman respectively.

Therefore,seasonal rate of water applied is ranged between 5.7 and 7.1 m^3/ fed/ day.Out of them, almost half of it comes from rainfall.

So, more investigations should be carried out to verifying the role of rainfall in North Nile Delta in water applied for cultivated winter crops as wheat, barley and sugar beet under drip irrigation.

Since there is no significant difference in seed yield, then it is advisable to irrigate with 60% FAO Penman- Monteith or Ibrahim depending upon the availability of climatic elements.

Keywords: drip irrigation, reference evapotranspiration (ET_o), rainfall, water applied and faba bean.

INTRODUCTION

Egypt is facing a shortage of water and is expecting a serious decreasing of the availability of water. It is preferableto highlight the status of water in Egypt as follows(Abu-Zeidand Hamdy.2002):

- Egypt is the solely country worldwide that its agricultural land is nearly irrigated of about 98% due to the very dry conditions i.e. no rainfed agriculture from economical point of view is implemented.
- Capita share per annum from water for different purposes is less than the poverty edge of 1000 m^3 and it is continuously decreasing till the water scarcity level of less than 500 m^3 in the few coming decades.
- River Nile is the main resource of renewal water with a fixed allocation of its water.
- Agriculture is the main sector in water consumption withabout 80-85% from total available water supply.
- Moreover, the negative impacts of climate change is expecting which is mainly resulting in increasing crop water needs along with decreasing crop production is expecting.
- Therefore, the strategic procedures of water saving becomes a must.

Furthermore,Phocaides (2007) had pointed out that drip irrigation is an effective way in water saving in specific and in " on- farm irrigation management" in general.

In addition, computation of irrigation water should be applied not less not more than the actual crop- water needs is also important item under the umbrella of " On – farm irrigation management".

In this direction, water deficit technique plays a vital role in rationalize irrigation water, particularly under the shortage of irrigation water.

Faba bean is considered as the main winter legume crop in Egypt. The high seed protein content of 28% gave this crop high value in human cnsumption and at the same time it is alow price source of plant protein.In addition,faba bean increased soil fertility through nitrogen fixation by root nodules.Such feature is amounted with 20- 25 Kg.N/ fed, to be useful for the following summer cultivated crop.(Ashry *et al.,* 2012).

The role of water deficit and drip irrigation on faba bean crop- water needs were investigated by several researchers such as; Ibrahim (1981), Mashari and Naeem (2008), Ali and Talukder (2008), Oweis and Hachuns (2006), Kijne *et al.* (2003) provide several strategies for enhancement of water productivity by integrating varietal improvement and better resources management at plant level, field level and agro climatic level.

So, the objective of this work was to find out the impact of water deficit computed based on different reference evapotranspiration (ET_o) methods for faba bean crop under drip irrigation method, In this direction, the sharing of rainfall in water applied was also taking into consideration.

MATERIALS AND METHODS

Location

A field experiment was conducted during the two successive winter growing seasons of 2011/ 2012 and 2012/ 2013 at the Demonstration Field for Modern Irrigation Systems, Sakha Agricultural Research Station, Kafr EL-Sheikh Governorate. The location is situated at 31º-7' N Latitude, 30º-57' E Longitude with an elevation of about 6 meters above mean sea level and

represents the circumstances and conditions of Middle North Nile Delta region.

Climatic conditions

Climatological elements during the two growing seasons of faba bean (viciafaba L) crop were recorded as monthly averages from Sakha Agro-meteorological Station.(Table 1)

Table(1).Climatic elements; average air temperature (T, Cº), average relative humidity (RH, %), wind speed at 2 meter height (U2, m.sec-1) and rain fall (Rf,mm.) during the two growing seasons, 2011/ 2012 and 2012/ 2013.

Month	2011/ 2012				2012/ 2013			
	T,Cº	RH, %	U2, m.sec-1	Rf mm/day	T,Cº	RH, %	U2, m.sec-1	Rf mm/day
Nov	16.9	70.5	0.76	-	20.40	75.67	0.66	28.2
Dec	13.4	73.6	0.69	14.59	15.96	72.8	0.73	13.15
Jan	9.32	68.95	0.72	32.5	13.42	78.21	0.52	2.54
Feb	10.42	68.81	0.78	32.74	14.78	76.97	0.73	-
Mar	13.17	68.52	1.06	42.75	18.51	65.16	1.03	-
Apr	18.03	63.53	1.16	-	20.96	59.05	1.11	8.5

Soil analysis:

To judge perfectly on the soil physical and chemical properties, these methods were used according to the global standard methods.

- Mechanical analysis for soil was carried out using the pipette method as described by Dewis and Fertias (1970).
- Bulk density was determined by using the undisturbed core samples according to Klute (1986).
- Soil organic matter content was determined by walkley and black method described by Hesse (1971).
- Total carbonates were estimated using modified calcimeter and calculated as calcium carbonate according to Dewis and Feritas, (1970).
- Soil reaction (pH) was measured in (1:2.5) soil: water suspension (Jackson 1967).

Total soluble salts were determined by measuring the electrical conductivity in the extract of saturated soil paste in dSm^{-1}as explained by Jackson ,(1967).

- The amounts of water soluble cations and anions were determined in the extract of saturated soil paste by the methods described by Hesse, (1971).

1- Soluble calcium and magnesium (Ca^{++} and Mg^{++}) were determined by the versenate method.

2- Soluble sodium and potassium (Na^{+} and K^{+}) were determined by using Flamephotometer.

3- Carbonate and bicarbonate (CO_3^{--} and HCO_3^{-}) were determined by titration with standarized sulfuric acid solution.

4- Chloride (CL^{-}) was titrated with silver nitrate.

5- Sulphate was determined by calculating the difference between sum of cations and anions.

- Field capacity and wilting point were measured by using pressure membrane apparatus according to (Garcia 1978).

The experimental soil is clay in texture(Dewis and Fertias, 1970) as presented in Table (2).

Table (2-a).Particle size distribution .

Soil depth, cm	Clay, %	Silt, %	Coarse Sand,%	Fine Sand,%	Texture grade	O.M. %
0-15	41.6	39.8	4.1	14.6	Clay	1.9
15-30	40.0	39.5	4.5	16	Clay	1.4
30-45	39.5	41.3	4.3	14.9	Clay	0.62
45-60	40.3	42.0	4.5	13.2	Clay	0.75

Table (2-b).Soil chemical analysis.

Soil depth (cm)	Cations, meq/l				Anions, meq/l				EC, ds/m	pH	$CaCo_3$
	K^+	Na^+	Mg^{++}	Ca^{++}	SO_4^-	Cl^-	HCO_3^-	CO_3^{--}			
0-15	3.91	21.2	3.79	11.1	5.3	30.1	4.6	-	4.35	8.11	3.5
15-30	2.22	9.3	2.47	3.01	2.29	12.8	1.91	-	1.89	8.19	4.2
30-45	5.12	18.7	4.98	5.2	3.89	24.2	2.91	-	3.4	8.15	3.3
45-60	4.2	20.1	3.6	6.3	2.6	27.9	3.7	-	3.62	7.92	4.1

Soil water constants

Values of soil- water constants; field capacity (FC, %), wilting point (WP, %), available water (AW, %) as well bulk density (D_b, $Kg.m^{-3}$)as descriped by Klute (1986)are tabulated in Table (3).

Table(3):Values of field capacity (F.C., %), wilting point (W.P., %), available water (A.W., %) and bulk density (Db, Kg. m-3).

Depth, cm	F.C,%	W.P,%	A.W,%	D_b ($kg.m^{-3}$)
0-15	47.6	25.9	21.7	1.13
15-30	43.5	23.6	19.9	1.18
30-45	39.2	21.3	17.9	1.24
45-60	37.1	20.2	16.9	1.31
Mean	41.9	22.7	19.1	1.22

The drip irrigation system

The experimental field is furnished with the drip irrigation system.In the drip irrigation, water is applied to each plant separately in a small, frequent, precise quantities through dripper emitters. It is the most advanced irrigation method with the highest application efficiency. The water is delivered continuously in drops at the same point and moves into the soil and wets the root zone vertically by gravity and laterally by capillary action. The planted area is only partially wetted.

Field experiments

A field experiment was conducted usingfaba bean (*Viciafaba L)*as winter crop. Faba bean crop which was grown during the two seasons 2011/ 2012 and 2012/ 2013.

Dates of sowing (S) and harvesting (H) were as follows:

Season 1: S = 22/11/2011, H= 19/4/2012

Season 2: S = 17/11/2012, H= 20/4/2013

All cultural practices including laser leveling were performed as recommended by Agricultural Research Center (ARC) except for the factor of study i.e. effective irrigation management for faba bean crop under drip irrigation system.

Total water applied (TWA)

Total water applied consists of two items; irrigation water (IW) and rainfall (RF). Data of RF is obtained from the agro- climatic station in the site. While IW is computed as follows:

$ET_c = ET_o \times Kc$…… (1)

Where:

ETc= Crop evapotranspiration, $mm.day^{-1}$

Kc= Crop coefficient.

The dimensionless crop coefficient, Kc is the ratio between water consumed by the growing crop (faba bean) to ETo. Values of Kc were quoted fromFAO Irrigation paper No. 56(Allen et al., 1998).

While applied irrigation water through the drip irrigation systems was computed as:

$$IW = \frac{ETc}{Ei} \quad \text{…… (2)}$$

AsE_i is irrigation efficiency under drip irrigation which equals 0.85.

Irrigation water was computed based on Reference evapotranspiration method (ET_0) as Main treatment.

Treatments:-

Main treatments (ET_o , methods):

A. FAO Penman Monteith.
B. Ibrahim.
C. Doorenbos and Pruitt.
D. Modified Penman.

Sub- treatment (Irrigation level).

1. Watering with 100% IW.
2. Watering with 80% IW.
3. Watering with 60% IW.

The investigated irrigation treatments were as follows:

A-FAO Penman-Monteith Method:

The FAO Penman-Monteith method as described by Allen *et al*. (1998) wasused to calculate ETo. The equation is given as:

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

Where:

ETo= 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 ($kPa\ C^{o-1}$)

γ = psychrometric constant ($kPa\ C^{o-1}$)

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°)

B-Ibrahim Equation(1981).

ET_p = 0.1642 + 0.8 Ep

Where:

ETp= Potential evapotranspiration, cm.day¹

Ep= Pan evaporation, cm.day¹

C-Doorenbos- Pruitt method.

Doorenbos- Pruitt (1975)predicted potential evapotranspiration(ET_p) as follows:

$ET_p = BWR_s / L - 0.3$

Where:

ET_p = daily potential evapotranspiration in mm/ day.

B= adjustment factor based on wind and mean relative humidity.

W= weight factor based on temperature and elevation above sea level.

R_s= daily total incoming solar radiation for the period of consideration in cal/ cm^2/ day.

L= latent heat of vaporization of water in cal/ cm^2/ day.

D-Modified penman.

Equation of the modified Penman method contains a radiation term and an aerodynamic term as follows:

ET_0=C "W.Rn+(1-W).F(U).(e_s-e_a)"

Where:

ET_0= referance crop evapotranspiration,

C = adjustment factor to compensate for the effect of day and night weather condition,

W = Weighting factor,

R_n = net radiation in equivalent evaporation (mm./day).

E_a= Actual vapour pressure, (mm.Hg).

E_s= Saturation vapour pressure at air temperature.

$$E_a = E_s \times \frac{RH\ mean}{10o}$$

Data collection

- Irrigation water.
- Rainfall.
- Seed yield.

RESULTSAND DISCUSSIONS

Irrigation water (IW), rainfall (RF) and total Water applied (TWA).

AS stated before in the materials and methods, total water applied (WA) consists of two components e.g. irrigation water (TIW) and rainfall (RF). Therefore, the values of IW, RF and TWA for the two growing seasons 2011/2012 and 2012/2013 of the investigated faba bean crop are tabulated in Table (4). Values are representing in m^3 /fed.and cm (1fed. = 4200 m^2 = 0.38 ha).

Regarding irrigation water (IW), the values can be arranged in descending order in connection with the different reference evapotranspiration (ET_0) methods as; Modified penman, Ibrahim, Doorenbos and Pruit and FAO Penman – Monteith in the first season. While the arrangement in the second season is; Ibrahim, Modified Penman, Doorenbos **- Pruit and FAO Penman-Monteith ET_0 methods.**

Therefore, FAO Penman-Monteith is resulted in the lowest value of IW in the two seasons of faba bean. On the other hand, modified Penman and Ibrahim methods are associated with the highest value of IW in the first and the second season, respectively.

In connection with irrigation level; the amount of IW has the same trend with that of irrigation level. Meaningfully for each ET_omethod, IW under 100% level is the highest followed by 80% and the 60% is the lowest.

As tabulated in Table (4-a-b), seasonal rainfall (RF) in the growing season of faba bean is 411.84 and 398.33 m^3/fed. or 9.81 and 9.48 cm, respectively in the first and second growing season.

So, by adding RF to IW for each stated irrigation level (100, 80 and 60%) under each reference evapotranspiration (ET_o) method, then total water applied (TWA) could be obtained. In general, WA has the same trend with that of IW.

Average values of IW, RF and WA are tabulated in Table (4-c) . Regarding IW, the highest mean values under the 100% irrigation level are ranged between 566.0 and 696.41m^3/fed.which resulted from FAO Penman-Monteith and modified Penman method, respectively. On the other hand, the corresponding lowest mean values 476.83 and 533.55 m^3/fed. is recorded under the 60% irrigation level. Mean values of IW under the 80% level are in between.Mean value of rainfall in the two seasons is 405.09m^3/fed. that it is a reasonable amount in irrigation water in the North Nile Delta, particularly for winter crops such as faba bean.Therefore, total water applied (WA) has the same trend with that of irrigation water (IW). Meanwhile, TWA is ranged between 881.92 and 1101.50 m^3/fed. The stated values are resulted under the 60% irrigation level of FAO Penman-Monteith and the 100% irrigation level of modified Penman.

T4

The obtained results are in the same line with that obtained byMashari and Naeem (2008), Ali and Talukder (2008) and Oweis and Hachuns (2006).

Contribution of rainfall (RF) in total water applied (TWA):

Values of contribution percentages of RF in TWA as tabulated in Table (4- c) cleared out that this percentages have the opposite trend with that of irrigation level. For example, with applied Ibrahim method, the mean contribution percentages are; 37.36, 39.79 and 42.58 under 100, 80 and 60% irrigation level of this method, respectively. The corresponding values for FAO Penman-Monteith are; 41.79, 43.79 and 45.98%. Same findings are obvious with all investigated ET_o methods.

So, in conclusion this finding of sharing rainfall in total water applied should be taking into consideration which is considered as an effective way of water saving in rationalize faba bean watering. Nearly, half of TWA is coming from rainfall. This contribution is mainly depending upon the level of applied irrigation water e.g. 60, 80 or 100%. This finding is in the same direction with that stated by oweis and hachuns (2006).

Rate of water applied:

Seasonal rate of irrigation water applied (WA) as expressed in m^3 /feddan/day under drip irrigation system is tabulated in Table (4-c). Values are ranged between 5.68 and 7.09 m^3 /fed./day which was resulted under the 60% of FAO Penman-Monteith and under the 100% of modified Penman.

This parameter of seasonal rate of water applied is useful in planning effective water management for faba bean crop under drip irrigation system with taking into consideration the availability of irrigation water. Out of the stated values, nearly 50% is coming from rainfall. Meaningfully, average seasonal daily irrigation water applied (IW) is ranged between 2.84 and 3.55 m^3/fed. depending upon the availability of irrigation water and the obtained marketable yield.

Seed yield (ton/ feddan).

Table (5) illustrated that no significant difference among different treatments from seed yield point of view. This result could be attributed to the effect of rainfall which diminishing the role of irrigation water on seed yield.

Table (5). Effect of different ET_o methods and water deficit on faba bean seed yield (ton/ fed).

Season	FAO Penman-Monteith			Ibrahim			Doorenbos-Pruitt			Modified penman		
	100%	80%	60%	100%	80%	60%	100%	80%	60%	100%	80%	60%
1st season	1.93	2.5	2.12	1.82	1.7	1.85	1.99	2.02	1.64	2.35	2.14	1.77
2nd season	1.69	1.74	1.62	1.73	1.68	1.68	1.80	1.57	1.60	1.66	1.79	1.73

Therefore, it is recommended to irrigate faba bean with 60% irrigation water based on FAO Penman – Monteith or Ibrahim methods depending upon the availability of climate elements. This finding could be practiced under drip irrigation only.

REFERENCES

Abu-Zeid, M. and A. Hamdy (2002).Water crisis and food security in the Arab world: where we are and where do we go. 2nd Regional Conference on Arab Water, Cairo, Egypt, 2002, p. 6.

Ali, M. H; and M. S. U. Talukder (2008).Increasing Water Productivity in Crop Production. A Syntheses Agriculture Water Management, pp. 1201-1213.

Allen, R. G; L. S. Pererira; D. Raes and M. Smith (1998).Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56. FAO, Rome, Italy.

Ashry, M.R.K; Farrag, F.R.M; Abdu,S.M.M. and El- Akram,M.F.I (2012). Rationalization of irrigation water use for faba bean (viciafaba L.). FayoumJ.Agric.Res. & Dev., Vol. 26, No.1, January, 2012.

Dewis , J; and F. Fertias (1970).“ Physical and Chemical Methods of Soil and Water Analysis” : Soil Bulletin No. 10 FAO. Rome.

Doorenbos, J., and W. O .Pruitt (1975).Crop water requirements. Irrigation and drainage paper, No. 24, FAO, Rome.

Garcia , G. (1978). Soil Water Engineering Laboratory Manual . Colorado State University .Dept of Agric and Chemical Engineering . Fort Collins , Colorado , USA .

Hesse , P.R (1971).« A Text Book of Soil Chemical Analysis » Juan Murry(publisher) Ltd , London .Ibrahim, M.A.M. (1981). Evaluation of different methods for calculating potential evapotranspiration in North Nile Delta region.ph.D. Thesis,Fac.Agric.Soil, Water Sci., Alex.Univ.

Jackson , M.L.(1967). « Soil Chemical Analysis » Practice Hall of India private limited , New Delhi.

Kijne, J.W.; R. Barker and D. Molden (2003).Water Productivity in Agriculture: Limits and Opportunities for Improvement,Comprehensive Assessment of Water Management in Agriculture Series, No. 1 International Water Management Institute, Srilanka.

Klute , A(ed) (1986). Methods of Soil Analysis . Part 1: Physical and Mineralogical Methods. American Socially of Agron Madison Wisconsin, USA.

Mashari A. Al- Naeem (2008).Effect of irrigation scheduling on growth parameters and water use efficiency of barely and faba bean crops in Al- Asha, Saudi Arabia. American Jornal of plant physiology 3(3): 111-120.

Oweis, T. and A. Hachuns (2006).Water treatments and supplemented irrigation for improved water productivity of dry farming systems in west Asia and Africa. Agric. Water Manage,J. 80: 57-73.

Phocaides, A. (2007). Handbook on pressurized irrigation techniques.FAO. Rome.

كمية مياه الري الواجب إضافتها لمحصول الفول البلدي تحت الري التنقيط وعجز المياه.

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أقيمت تجربة حقلية بمحطة البحوث الزراعية بسخا- شمال وسط دلتا النيل (تربة طينية) خلال موسمي نمو الفول البلدي لعام ٢٠١١ / ٢٠١٢، ٢٠١٢ / ٢٠١٣ بهدف تحديد كمية مياه الري الواجب إضافتها من خلال المعاملات الأتيه:-

أربعة معاملات رئيسية ألا وهي طرق تقدير البخر نتح المرجعي (فاو بنمان مونتيث- إبراهيم- دورنبوس وبروت- بنمان المعدلة)، وتحت كل معاملة من طرق البخر نتح المرجعي ثلاث مستويات من الري: ١٠٠% - ٨٠% - ٦٠%

وقد تمت إضافة مياه الري من خلال شبكة الري بالتنقيط.

وفيما يلي أهم النتائج المتحصل عليها:

- متوسط مياه الري (IW) يتراوح بين ٤٧٦.٨ – ٦٩٦.٤ م^{٣} / فدان والتي تحصل عليها من الـ ٦٠% فاو بنمان مونتيث و ١٠٠% بنمان المعدلة علي الترتيب.
- متوسط الأمطار لموسمي النمو ٤٠٥.١ م^{٣} / فدان (٩.٧ سم).
- متوسط المياه المضافة (الري + الأمطار) لها نفس إتجاه مياه الري والتي تتراوح بين ٨٨١.٩ – ١١٠١.٥ م^{٣} / فدان وذلك للمعاملات السابقة علي التوالي.
- نسبة مساهمة الأمطار في المياه المضافة تتراوح بين ٣٦.٨ و ٤٦% والتي نتجت من ١٠٠% بنمان المعدلة و ٦٠% فاو بنمان مونتيث علي التوالي.
- عموما يمكن ترتيب طرق البخر نتح الموضعي ترتيبا تصاعديا بالنسبة لتقدير مياه الري: فاو بنمان مونتيث- دورنبوس وبروت- إبراهيم- بنمان المعدلة.
- معدل المياه المضافة خلال الموسم يتراوح من ٥.٧ – ٧.١ م^{٣} / فدان / يوم. نصف هذا المعدل تقريبا يأتي من مياه الأمطار.

وحيث أن التحليل الإحصائي أوضح إنه لا يوجد فروق معنوية في نتائج المحصول وعليه يمكن التوصية بالري بمعدل ٦٠% فاو بنمان مونتيث – وفي حالة عدم توفر بيانات الأرصاد الجوية فيمكن الري بمعدل ٦٠% من معادلة إبراهيم (حيث تعتمد فقط علي قراءات وعاء البخر في المنطقة).

كما توصي الدراسة بإجراء المزيد من الدراسات لبيان الأثر المتداخل من الأمطار في تحديد المياه المضافة للمحاصيل الشتوية في منطقة شمال دلتا النيل (مثل القمح – الشعير – بنجر السكر) تحت نظام الري بالتنقيط فقط.

قام بتحكيم البحث

أ.د / أحمد عبد القادرطة — كلية الزراعة – جامعة المنصورة

أ.د / محمد ابراهيم مليحة — مركز البحوث المائية

Table (4). Seasonal irrigation water (I.W), rainfall (RF), total water applied (TWA), Percentage of RF to WA and rate of water applied (m^3/fed/day).

a- 1st season 2011-2012.

parameter	FAO-Penman monteith			Ibrahim			Doorenbos&Pruit			Modified Penman		
	100%	80%	60%	100%	80%	60%	100%	80%	60%	100%	80%	60%
IW,m^3/fed	525.60	487.15	448.15	584.28	534.09	483.91	544.38	502.15	459.95	678.63	552.15	497.45
cm.	12.51	11.60	11.60	13.91	12.72	11.52	12.96	11.96	10.95	16.16	13.15	11.84
. RF,m^3/fed	411.84	411.84	411.84	411.84	411.84	411.84	411.84	411.84	411.84	411.84	411.84	411.84
cm.	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81
WA,m^3/fed	937.44	898.99	860.54	996.12	945.93	895.75	956.22	913.99	871.79	1090.47	963.99	909.29
cm.	22.32	21.40	20.49	23.72	22.52	21.33	22.77	21.76	20.76	25.96	22.95	21.65
RF/WA,%	43.93	45.81	47.86	41.34	43.54	45.98	43.07	45.06	47.24	37.77	42.72	45.29
RateWA,m^3/day/fed	6.29	6.03	5.78	6.69	6.35	6.01	6.42	6.13	5.85	7.32	6.47	6.10

b- **2nd season 2012-2013**.

parameter	FAO-Penman monteith			Ibrahim			Doorenbos&Pruit			Modified Penman		
	100%	80%	60%	100%	80%	60%	100%	80%	60%	100%	80%	60%
IW,m^3/fed	606.40	555.68	504.96	795.48	706.94	618.41	631.26	575.57	519.88	714.19	641.91	569.64
IW cm.	14.44	13.23	12.02	18.94	16.83	14.72	15.03	13.70	12.38	17	15.28	13.56
. RF,m^3/fed	398.33	398.33	398.33	398.33	398.33	398.33	398.33	398.33	398.33	398.33	398.33	398.33
RF cm.	9.48	9.48	9.48	9.48	9.48	9.46	9.46	9.46	9.46	9.46	9.46	9.46
WA,m^3/fed	1004.73	954.01	903.29	1193.81	1105.27	1016.74	1029.59	973.90	918.21	1112.52	1040.24	967.97
WA cm.	23.92	22.71	21.51	28.42	26.32	24.21	24.51	23.19	21.86	26.49	24.77	23.05
RF/WA,%	39.65	41.75	44.10	33037	36.04	39.18	38.69	40.90	43.38	35.80	38.29	41.51
Rate WA,m^3/day/fed	6.20	5.89	5.58	7.37	6.82	6.28	6.36	6.01	5.67	6.86	6.42	5.98

c. Average of the two seasons.

parameter	FAO-Penman monteith			Ibrahim			Doorenbos&Pruit			Modified Penman		
	100%	80%	60%	100%	80%	60%	100%	80%	60%	100%	80%	60%
IW,m^3/fed	566.0	521.42	476.83	689.88	620.52	551.16	587.82	538.86	489.92	696.41	597.03	533.55
WA,m^3/fed	971.09	926.50	881.92	1094.97	1025.60	956.25	992.91	943.95	895.00	1101.50	1002.12	938.63
RF/WA,%	41.79	43.79	45.98	37.36	39.79	42.58	40.88	42.98	45.31	36.79	40.51	43.22
Rate WA,m^3/day/fed	6.25	5.96	5.68	7.03	6.59	6.15	6.39	6.07	5.76	7.09	6.45	6.04