[illegible]

[illegible]

[illegible] 20 [illegible] (20) [illegible] (20) [illegible] Doorenbos [1] [2](&Al-Kassam 1979 .(FAO)

[illegible]

Predicting Yield Response Factors In Jensen Model

Eman Hazim Sheet
University of Mosul
College of Engineering
Water Resources Dept.

Maan Hazim Sheet
Univresity of Dihouk
College of Engineering
Water Resources Dept.

Abstract

The yield response model is very important in irrigation planning and management of irrigation projects. A computerized model for simulating irrigation water requirement for wheat crop at Mosul area has been proposed for (20)years of daily climatological data. The model predict daily actual and potential evapotranspiration, then the relation between relative yield and relative evapotranspiration is put into (20)equations and solved mathematically to find the coefficients for each stage of growing growth period of wheat crop at Mosul area.The yield response factors is found for two cases, the first is for rainfed agriculture practice for wheat for (20)years where an available data for production is available ,and the second is for irrigated practice where four years production data were available[1] .Then the results are compared with the results obtained from (Doorenbos & Al kassam 1979) equation for yield. [2] and show a small variation while the last equation is justified by International Agriculture and Food Organization(FAO).

Keywords: crop water production function ,yield response factor, yield Jensen model, irrigation management.

قبل في 2006/1/2 **أستلم في 2005/2/20**

[illegible]

[illegible] [3,4,5] [illegible] :Hanks

$$Y/Y_{max} = T/T_{max} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

[illegible]:

Y [illegible]

Y_{max} : [illegible]

T: [illegible]

T_{max}: [illegible]

[2,6,7] [illegible]

$$Y/Y_{max} = \prod_{i=1}^{n} (AET_i / CPET_i)^{\lambda i} \quad \ldots\ldots \ \ldots\ldots\ldots..(2)$$

[illegible]:

AET_i = [illegible]

$CPET_i$ = [illegible]

λi = [illegible]

n = [illegible]

[illegible] λi [illegible] λi [illegible] λi [illegible] λi Doorenbos [illegible] [2] (and Al-Kassam 1979 [illegible]:

$$Y/Ymax = \prod_{i=1}^{n} [1 - ky_i(1 - AET_i / CPET_i)] \ldots\ldots\ldots\ldots(3)$$

:ǇƒǇ ŧ ǒơ

ýĂ Ţ ơǆ!ƒ Ăǆǉ ýơƒƧǆ ǇǆŦ ǉơƧǆ ý ŧ! Ŧǒƞ ǴǨǇŬƒ ýǆǴƶǆ :ky $_i$

ǆƒƥƤ k ù ĩ ǴǑ ky $_i$ ǆǒ ù p Ŧ ù 5 Ƨƶǆ Ǉ ù ǆ λi ǆǒp ƥǴƞǒŬ Ŧ ǉǒ Ƨ Ʊ[8] (Kipkorir2002) Ĭ ƱƵƒ

:Ŧ!ƥǴƶǆ!ƒ

λ=0.275 ky³ -0.1351 ky ² +0.8761 ky -0.0187 ……(4)

Ŏ ù 5 ý ǒ ù Ţ Ǵơǆ!ƒ 2 ǈƤǆ! Ă Ŧ ǒǉ ơ ƔƧǴƞ k Ĭ !ƒ ƜǴk ơk Ŧ ǉǒ ƥ!ƒĂ Ŧ ơ ǒ ơ Ţ!ƒ Ƙ ǖǆǴƶǆ!ƒ ǆǒp Ǉƒ

.Ŏ ư ǴǒƧ!ƒ ý ǒ ƥĂǆǉ! ǇǴƞkŬƒ ǆk ƥ l5 Ŧ ǒǉ ơ!ƒ ƔƧǴƞk! ƘǴǒǇǴŧǆƒ Ƨ5Ăk ǆƥƶ! ƒƧƲǇ Ǉŧ!Ă ý Ţ Ăǆ!ƒ Ŧ lƱǇǆ

ƘƟǴǉƐ ơƐǋǅǈǋ 5ƥƯ

: Ĭ ŢƑĭƥǉƐ ŧ ƤǋǅǈǉƐ

Ŧ ù ǒǆĂ ǒ!ƒ Ŧ ù ǒƤǴǇǆ!ƒ ƘǴ ù ǆĂǉƶǆ!ƒ ỳ ù ǆƞ ǆ ù k ŧ ǒơ Ü ǇĬĿ ǒƞ Ŧ!ƥǴƶǆ! Ŏ ư ǴǒƧ ƜƦĂǆǇ ý ǆƵ ǆk

Ŧ ù lƱǇǆ Ŏ ù 5 Ʊ ù l5 ƧǴ ù Ʊǆ Ŭƒ ǇǴ ù ǒǆ Ĭ ù ǉƵ lƥǆkƶǆ!ƒ ŦǇ ĩ 20 lƧk5! ŦƱǇơ!ƒ ƜǴkǇƒ ǇƵ ƘǴǆĂǉƶǆĂ

.ƜƦĂǆǇǉ! Ŏ ǈǴǒ ĩ ǇŬƒ ƱƱƤǆ!ƒ Ơ ư Ă ǒ (1)ýŧ T!ƒĂ.ý Ţ Ăǆ!ƒ

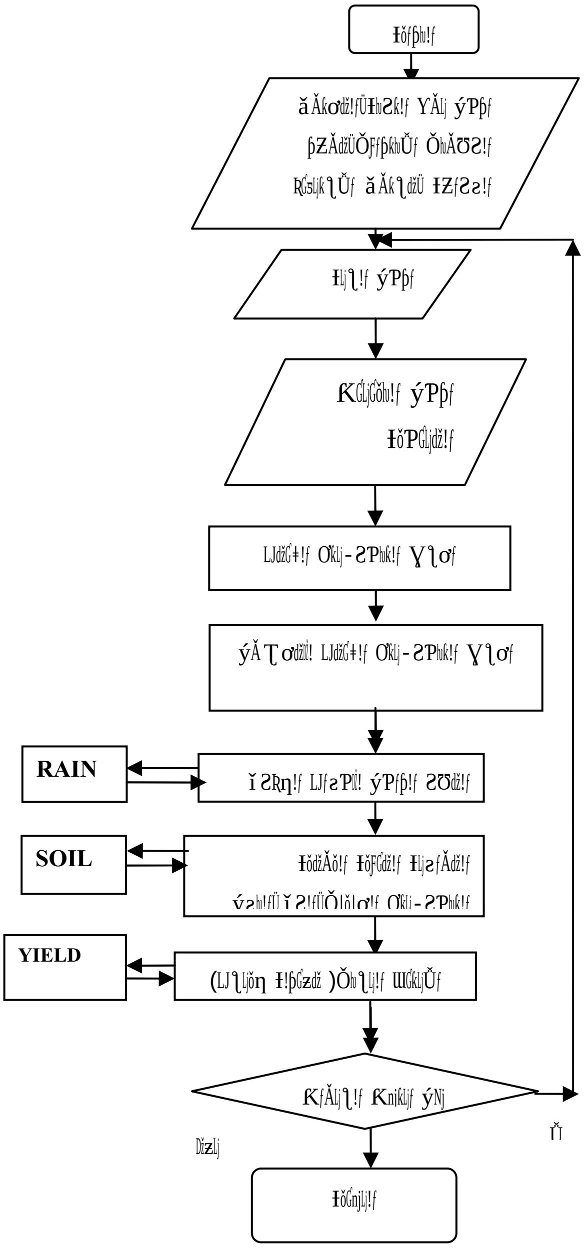
Ŏ ù 5 Ǵ ù ǌǒ!ƒ ǇǴƞkŬƒ ǆk ŧ ǒơ Ü ŧ ǒkǇĂǆ-ǇǴǆǇǒǈ Ŧ!ƥǴƶǆ ǆƒƥƤk ĩ ǴǑ ǇǆǴŧ!ƒ Ơk ǇƧƤǈk!ƒ ƔǴ ĩ ơ ǆk

.[9,10] ă ƧƤŬƒ ƼƧƱ!Ǵǈ ŦǇƧǴlǆ ỳƥƒĂ! ǴǌǇƞƑǴkǇ ŦǈƧǴlǆĂ ǴǌǇkƥƥ! ƒƧƲǇ lƧǒƤŬƒ ƘƒĂǇ ĩ !ƒ

$$ET_{\circ}=\frac{0.408\Delta(R_n-G)+\gamma\frac{900}{T+273}U_2(es-ea)}{\Delta+\gamma(1+0.34U_2)}\quad ……(5)$$

:ǇƒǇ ŧ ǒơ

mm/day	Ŏǆ Ă ǒ!ƒ ǇǆǴŧ!ƒ ƠkǇ ƧƤǈk!ƒ: $ET_{\circ}$
$^{\circ}$c	ŦǒǆĂǒ!ƒ lƧƒƧơ!ƒ ŦƞƧƥ ýƥƶǆ: T
m/sec	ǆ2 ƳǴ5kƧƒ Ĭ ǉƵ Ŧ ĩ Ǵlǆ ƟǴǒƧ!ƒ ŦƵƧ ĩ: U_2
MJ/m^2 day	ƘǴǈǇ!ƒ ƠƱ ĩ ƥǇƵ Ŏ ĩ ǆT!ƒ ƳǴƶTŬƒ Ŏ5Ǵ Ţ: R_n
MJ/m^2 day	ŦǈƧk!ƒ lƧƒƧơ ƼƥƤk Ŧ5ǴƛŦ: G
KPa	ỳǈTk!ƒ ƧǴƤǈ Ʊƺ ư: es
KPa	Ŏǉƶ5!ƒ ƧǴƤǈ!ƒ Ʊƺ ư: ea
KPa	ỳǈTk!ƒ ƧǴƤǈ Ʊƺ ư Ŏ5 ƒ lǇ!ƒ: $es-ea$
KPa /c$^{\circ}$	ỳǈTk!ƒ ƧǴƤǈ Ʊƺ ư ǑǇơǇǆ ýǒǆ: Δ
KPa /c$^{\circ}$	ǑǈĂƱƧ!ƒ ƩǴǒl!ƒ ƘǈǴƛ: γ


RAIN
SOIL
YIELD

: [illegible]

$$CPET=Kc*Eto \quad \ldots\ldots(6)$$

:[illegible]

=CPET [illegible] mm

Kc = [illegible]

[illegible]

:[11] [illegible]

$$AET=CPET*SK \quad \ldots\ldots(7)$$

:[illegible]

=AET [illegible] mm

SK =[illegible]

:[11] [illegible]

$$SK=\log(1+PAW)/\log 101 \quad \ldots\ldots(8)$$

:[illegible]

SK: [illegible]

=PAW [illegible] %

: PAW [illegible]

$$PAW=(AW/TAW)*100 \quad \ldots\ldots(9)$$

:[illegible]

AW: [illegible] mm

TAW: [illegible] mm

: TAW [illegible]

$$TAW=RZ*(FC-PWP) \quad \ldots\ldots(10)$$

:[illegible]

RZ: [illegible] cm

FC: [illegible] mm/cm

PWP: [illegible] mm/cm

ĭƧù!ƒĂ ƧƱdž!ƒ ǉĜödž ǇJdž ǇJƒƨƤ!ĜĂ!ƒ ýƤƥö Ĝdž ǇJöǆ ĭƧƦɳ!ƒ ǇJƒƨƤ!! ƗödžĂö!ƒ ƗöƑĜdž!ƒ ƗǉƨƒĂdž!ƒ ýdžƵ Džķ ĈĜùdž!ƒ ăĂķƖùdž ǇJùdž ƥƵĜƮ!ƒ ĈĜdž!ƒ ýĜdžǋƒ ƴdž ýƨǆ!ƒ ǉĜödžĂ ƠķǉǨ-ƧƤǆķ ǇJdž ǇJƒƨƤ!ƒ ǇJdž ƜƧƤö ĜdžĂ ǇJùƵ ƥöƨķ Ŏķ!ƒ ƧƱdž!ƒ ǉĜödž ǇJdž(20%) ǇJĂƗö ǋǈĜĂƵ ǋǆĜƖơ Džķ ƥl5 ŎơƱƖ!ƒ ƠöƖ!ƒ ĜdžƒÜŎưƧŮƒ [11](10mm) ĭƧƦɳ!ƒ ǇJƒƨƤ!! ƗödžĂö!ƒ ƗöƑĜdž!ƒ ƗǉƨƒĂdž!ƒ ýƛdžķ Ɨö!Ĝķ!ƒ Ɨ!ƥĜƶdž!ƒĂÜ .

AWi+IRR+RAIN = AET+DRAIN+AWe …………………(11)

:ǇJƒ Ɨöơ

ŎƑƒƥķǆŮƒ ŎǆĂƱƧ!ƒ ăĂķơdž!ƒ= AWi	mm
ŎƑĜǌǉ!ƒ ŎǆĂƱƧ!ƒ ăĂķơdž!ƒ= AWe	mm
ĭƧ!ƒ ƘĜödžƗ=IRR	mm
ƧƱdž!ƒ ĈĜdž =RAIN	mm
ýƨǆ!ƒ ĈĜdž =DRAIN	mm

.ƪödžƵ ýƨǆ ǉĜödžƗ ƔǋƦö ĭƧƦɳ!ƒ ǇJƒƨƤ!ƒ Ƨǆƶö Ĝdž ýƗ ǇJƒ ƧǆķƵƒ ƥƿĂ -ƧƤǆķ!ƒ ƔĜƖơ Džķ ÜƗödžöƥ!ƒ ƗƵƒƧƨ!ƒ ĬǈƵ ƗǉƖ 20 ǈƥdž!Ă ĂdžǉJ!ƒ ǈƧķ5 ýĂƱ ĬǈƵ ǊdžĜǉƧǆ!ƒ ýöƷƬķ ǇJdž Ĭ!ĂŮƒ ƗǈơƧdž!ƒÜ ýơƒƧdž ǈƥƵ Ĭ!ƒ ƗƱǉơ!ƒ ýĂƮơdž ĂdžǉJ ǈƧķ5 Ƙdžƈp Džƛ ŎǈöǈơƒĂ ǇJdžĜƗ!ƒ ŎdžĂö!ƒ ƠķǉJ 20)ƧùöǋƨķƒŌ :ƗùƛƒĜƛ!ƒ ƗùǈơƧdž!ƒÜ(DžĂùö 75)ĭƧưùƤ!ƒ ĂdžǉJ!ƒ :ƗöǉĜƛ!ƒ ƗǈơƧdž!ƒÜ(DžĂö 20)ƘĜǆǉŮƒ: DžùƛÜ[2] (DžĂùö 31)ƝưùǉJ!ƒ :ƗƖdžĜƤ!ƒ ƗǈơƧdž!ƒÜ(DžĂö 35)ýĂƮơdž!ƒ ǇJöĂƗķ :ƗƶǆƒƧ!ƒ ƗǈơƧdž!ƒÜ(DžĂö ýĂƮùơdž!! ƠķùǉJ-ƧùƤǆķ!ƒ ýdžƮùķ Ŏķ!ƒĂ (ƗǉƖ 20) ǈƧķ5!ƒ ýƗ!Ă ƗǈơƧdž ýƗ! ƗödžĂö!ƒ Džöǈ!ƒ Ƙƶdžɳ .ŎǈöǈơƒĂ ƠķǉJ-ƧƤǆķ!ƒĂ

ĬùǈƵ ýĂƮùơ!ƒ Džķ ƗöơƒĂ(1998-1995) ƘƒĂǉƖǈ! ƗöĂƧdž!ƒ ƗƵƒƧƨ!ƒ ĬǈƵ ǊdžĜǉƧǆ!ƒ ýöƷƬķ Džķ ĜdžƗ [1] ǇJùdžĂÜ ƗöƵƒƧƨ!ƒ ƗĜơǆű! ĈĜǆƒ ƗƱơdž ǇJdž ƗǈǈơƧ!ƒ ƔƧĜɳķ!ƒ ƯƶǆƒƜĜǉŮƒ ǇJƵ ƗǈöǈơƘĜdžĂǈƶdž :(1) ýĂƥɳ!ƒ Ŏ5 ƠưĂdž ĜdžƗ

(ƧĜķƗǋ/Džƺƛ) ƗƱǉơ!ƒ ýĂƮơdž! ƗöɳĜķǉŮƒ : (1)ýĂƥɳ!ƒ

ǈƑĜdžŰƐ ơǋǋǉƊ	ƥƑƗǈǉ/ !ƺǈ ǆǐƜƑƗdžÜƐ	
	ƒ ƥĜǉ Ŏǈödžƛķ ĭƧ	Ŏùù ùǈödžƛķ ĭƧ ýdžĜƗ
95/11/29	2760	2930
96/1/2	4046	4081
96/2/7	3872	3952
96/12/1	4710	5500
97/1/5	4560	5470
97/2/1	3130	3490
97/12/30	2160	4610
97/2/17	460	1090

ǶǛ ǚ5ǰǆǅǁǁƐǇ ƛǝƑƗǆǁƐ

ǘƛùǆǕƝǆǤǉƧǶ!ƒ ýǒƺƬǩ ǈǆǆ ǤǌǒǁƵ ýǍƮơ!ƒ ǅǩ Ŏǩ!ƒ Ɨƿǘƺ!ƒ ǈǑǶǩ (12) ƘǙƥǤƶǆ!ƒ ƗƵǍǆǦǆ
Ŏ5 ǅǒǁ!ƒ ǤǆƒǕ(0.9) Ŏǁǂ!ƒ ǚǤǨǉǙƒ Ĭǁ Ƶ ǚǤǨǉǙƒ ĭǅǕŎǶǚǉ!ƒ ƗǒǦǤǨǉǙƒ ǈǑǶ Ɨƿǘƺ!ƒ ýƛǆǩ Ĭ!ǍǙƒ Ɨ!ƥǤƶǆ!ƒ
ƴùǒǆǦ! ǈǆǤùǂ!ƒ ƠǩùǇ ƧƤǶǩ!ƒ Ĭ!ƒ Ŏǁǒǁơ!ƒ Ơǩǉ ƧƤǶǩ!ƒ ǈǑǶ ƔǚǇ!ƒ ýƛǆǩ5 Ɨ!ƥǤƶǆ!ƒ ǈǆ ƧƤǙƒ ƻƧƱ!ƒ
.ƘƒǍǉǚ!ƒ ƴǒǆǦ ýƛǆǩ Ɨ!ƥǤƶǆ(20) ŎǇ (12) ƘǙƥǤƶǆ!ƒ ƗƵǍǆǦǆǍǕƗǚǆƤ!ƒ ýơƒƧǆ!ƒ

$$0.90=(0.75)^{\lambda 1}\ (0.91)^{\lambda 2}\ (0.96)^{\lambda 3}\ (0.89)^{\lambda 4}\ (0.91)^{\lambda 5}$$

$$0.99=(0.55)^{\lambda 1}\ (0.90)^{\lambda 2}\ (0.96)^{\lambda 3}\ (0.91)^{\lambda 4}\ (0.97)^{\lambda 5}$$

$$1.00=(0.55)^{\lambda 1}\ (0.90)^{\lambda 2}\ (0.96)^{\lambda 3}\ (0.89)^{\lambda 4}\ (0.91)^{\lambda 5}$$

$$0.97=(0.86)^{\lambda 1}\ (0.90)^{\lambda 2}\ (0.47)^{\lambda 3}\ (0.65)^{\lambda 4}\ (0.89)^{\lambda 5} \quad \ldots\ldots\ldots(12)$$

$$0.95=(0.86)^{\lambda 1}\ (0.90)^{\lambda 2}\ (0.47)^{\lambda 3}\ (0.80)^{\lambda 4}\ (0.90)^{\lambda 5}$$

.
.
.
.
.
.

$$0.97=(0.90)^{\lambda 1}\ (0.90)^{\lambda 2}\ (0.47)^{\lambda 3}\ (0.66)^{\lambda 4}\ (0.25)^{\lambda 5}$$

ƘǙƥǤƶǆ!ƒ ýơ ǅǍ ǈǆǍ ǈǒ5ƧƱ!ƒ ǅǩǒƧǤƹǍ! ƦƤǤǶ ƗǒƱƤ ƘǙƥǤƶǆ Ĭ!ƒ ƘǙƥǤƶǆ!ƒ ýǒǍơǩ ǅǩ
ǅǒùƿ ǈǒùǶǒ(2)ýǍƥǦ!ƒǍ .ƔǘƛǤǆ!ƒ ƝǆǤǉƧǶ ǅƒƥƤǩǚǤǶ λ5Ǖ λ4Ǖ λ3Ǖ λ2Ǖλ1 ǅǒƿ ƥǤǦǒǙ ƗǒƱƤ!ƒ
ǈǂǆǒǍ ƗǒǦǤǨǉǙƒ ǅǒƿ ǈǑǶ Ɨǆǒƿ ĬǁƵƒ ŎǇ Ymax ǈƒ ƧǤǶǩƵǤǶ ǤǌǒǁƵ ýǍƮơ!ƒ ǅǩ Ŏǩ!ƒ ƘǗǆǤƶǆ!ƒ
.[12] Ŏ5 Ǥǆǂ Ɣ!Ǥǚ!Ǥǚ ǅǒǁ!ƒ Ưƶǚ ǈǍǂǩ ǈƒ

ŎǶǍùƱƧ ǎǍùƙơǆ ƴǆ Ɨǒǆǒƥ!ƒ ƗƵƒƧƨ!ƒ ƥǤǆǩƵǤǶ ǚǤǨǉǙƒ ƘǗǆǤƶǆ ǅǒƿ-2-ýǍƥǦ!ƒ

Ɨǒǁǁơ!ƒ Ɨƶǚ!ƒ ƥǉƵ ŎƑƒƥǩǚƒ

λ 1	λ 2	λ 3	λ 4	λ 5
0.76	3.14	0.32	3.84	2.74

ŎƑƒþùƙƒ ŎƕĂƠƧ ăĂƙơƋ ƴƋ ƗŏƋŏþ!ƒ ƗƵƒƧƨ!ƒ þƓƋƙƵƓ ƜƓƙǇŬƒ ƘǕƋƓƶƋ Ɗŏƿ ƝŏƕŏƼ -3- ýĂþƞ!ƒ ƓƋƒ

ƊƑƒþ!ƒ ýĂƕƦ!ƒ ƗƠƖǇĂ Ɨŏǐơ!ƒ Ɨƶƪ!ƒ ƝŏƕƠƪĂƋ

λ1	λ2	λ3	λ4	λ5
0.41	3.07	0.01	-4.58	3.41

ŎùƝ Ymax ƝƒƧƓùƙƵƒ ǏǐƵ ƗŏĂƧƋ!ƒ ƗƵƒƧƨ!ƒ þƓƋƙƵƓ ƜƓƙǇŬƒ ƘǕƋƓƶƋ ƊŏƿƝŏƕŏ (4)ýĂþƞ!ƒ ƓƋƒ

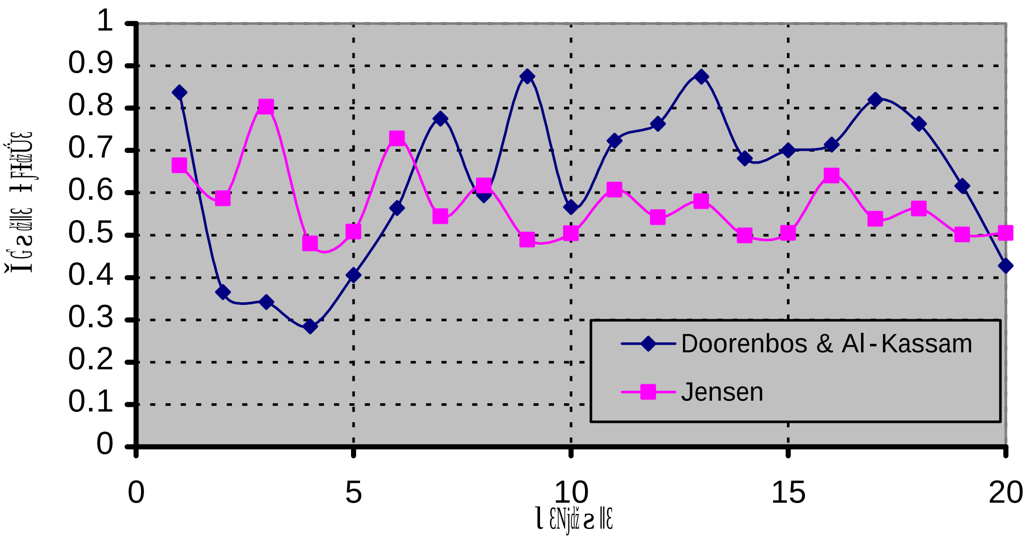
.ƗŏƖŏơ!ƒ ƊŏƖ!ƒ ƝŏƕƗƋŏƿ ǏǐƵƒ

ƗŏĂƧƋ!ƒ ƗƵƒƧƨǐ! ƜƓƙǇŬƒ ƘǕƋƓƶƋ Ɗŏƿ-4-ýĂþƞ!ƒ

λ1	λ2	λ3	λ4	λ5
0.54	-20.2	8.0	2.98	0.37

ƊŏƖ!ƒ ƴƋ ŎƕƪǇ!ƒ ƜƓƙǇŬƒ Ɗŏƿ ƗǇƧƓƖƋ ƘƋƙ ŎƕƪǇ!ƒ ƜƓƙǇŬƒ þƓƞŏƒĂ (2)Ɨ!þƓƶƋ!ƒ Ŏ5 λi ƊŏƖƕ ƯŏĂƶƙ!ƓƕĂ

(2) ýǂT!ƒ Ŏ5 ƓƋǂ (3) Ɨ!þƓƶƋ ƝƋƋ ƓƞŏǐƵ ýĂƮơ!ƒ Ɗƙ Ŏƙ!ƒ



ƜƓƙǇŬƒ Ɨ!þƓƶƋ! ƝŏƞƦĂƋǇ! ƝŏǇƪ!ƒ ƴƋ ŎƕƪǇ!ƒ ƜƓƙǇŬƒ ƧŏƺƘ(2) ýǂT!ƒ [illegible] λ_i [illegible] λ_i [illegible] (1) [illegible] (12) [illegible] (3) [illegible] (3) [illegible]

[illegible]

[illegible] λ_i [illegible] (12) [illegible] (3) [illegible]

[illegible]

(1)Adary et al. "Wheat productivity under supplemental irrigation in northern Iraq" ,ICARDA,2002.

(2)Doorenbos J. & Kassam A.H. "Yield response to water".FAO,Irrigation & Drainage paper No.33,Rome,Italy,1979,p.193.

(3)Hiler E.A. & Clark R.N. "Stress day index to characterize effects of water stress on crop yield". Transactions of the ASAE 14,1971,p.757-761.

(4)Stewart J.I. & Hagan R.M. "Function to predict the effects of crop water deficit".Journal of the irrigation and drainage divisions,ASCE 99,1973,p.421-439.

(5)Hanks R.J."Model for predicting plant yield as influenced by water use".Agronomy journal 66,1974,p.660-665.

(6)Howell,T.A. & Hiler E.A. "Optimization of water use efficiency under high frequency irrigation evapotranspiration & yield relationship,Transactions of the ASAE,99,1975,p.873-878.

(7)Jensen M.E. "Water consumption by agriculture plants,ch.1 in:Kozlowski,Water deficit and plant growth vol II,Academic press New York,1968,p.1-22.

(8)Kipkorir E.C. &Raes D. "Transformation of yield response factor into Jensen sensitivity index". Irrigation & Drainage system,16,2002,p.47-52

(9)Richard G.A. et al.."Crop Evapotranspiration guidelines for computing crop water requirements" FAO,Irrigation & Drainage paper No.56,Rome,Italy,1998.
(9)Richard G.A. et al.."Crop Evapotranspiration guidelines for computing crop water requirements" FAO,Irrigation & Drainage paper No.56,Rome,Italy,1998.
ǑƑƓǜďž!ƒ ǁ ǖǌǩǜƪǛƒ ƔƓƪǜơ! ƚ ǜǒǨǉǍďž ǇƓďžǉǒƜ ǍƓƽ!ƒ Ƚ!ƥƓƶďž Ǆǒǒǀǩ "ǇƓƱǀƪ ƚǀǒƽƬǛ ǐƧǍƜƞ!ƒ(10) ýƨǜƜ!ƒǍ ǐƧǜ!ƒ ƚǜƪƥǉǋǛ ƧǒǩƪƞƓďž Ƚ!ƓƪƧ" ƽƒƧƶ!ƒ Ǒƽ ƚƮƥƓǉǍ ƚǀďžƓƚ ƚǒƤƓǉďž ƘƓǉƓǒƜ ǑƶƞƧďž!ƒ .(2002) ýƮǍďž!ƒ ƚƶďžƓƞǛ
(11)Sheet,E.H.(1987)."Modelling supplemental irrigation water requirements for wheat crop at Mosul area". M.SC.thesis submitted to the college of Engineering,University of Mosul.
(12)Zhang Z. & Pei D. et al "Management of supplemental irrigation of winter wheat for max. profit". http://www.fao.org/Docrep/004/y3655e09.htm,2004.
13)Chahraman,B & Sepaskha A.R. "Use of water deficit & sensitivity index for partial irrigation scheduling of Wheat &Barely".Irrigation science,18,1997,p.11-16.