American Journal of Science, Engineering and Technology
2021; 6(3): 73-81
http://www.sciencepublishinggroup.com/ /! set
"oi: 10.116#8/ .! set.20210603.1#
$%%&: 2'78-83#' ((rint); $%%&: 2'78-83'3 ( ) nline)

Evaluation of Deficit Irrigation Effect on Water Use Efficiency and Yield Response for Onion and Potato at Ketar Scheme

Bayan Ahmed*, Dinka Fufa, Asnake Tilaye

) romi! *gricultur!l +ese!rch $nstitute, *sell! *gricultur!l -ngineering +ese!rch . enter, *sell!, -thiopi!

Email address:
bayahm@gmail.com (B. Ahmed), dinkfuf@yahoo.com (D. Fufa)
/ . orrespon"ing !uthor

To cite this article:
0!1!n *hme", 2in3! 4u5!, *sn!3e 6il!1e. -7!lu!tion o5 2e5icit $rrig!tion -55ect on 8 !ter 9se -55icienc1 !n" : iel" +esponse 5or) nion !n" (ot!to !t ; et!r %cheme. American Journal of Science, Engineering and Technology. <ol. 6, &o. 3, 2021, pp. 73-81.
"oi: 10.116#8/ .! set.20210603.1#

Received: *ugust #, 2021; Accepted: *ugust 2#, 2021; Pu lished: %eptember #, 2021

A stract: $n the situ!tion o5 impro7ing w!ter pro"ucti7it1, there is incre!sing interest in "e5icit irrig!tion pr!ctice whereb1 w!ter suppl1 is re"uce" below m!=imum le7els !n" mil" stress is !llowe" with minim!l e55ects on 1iel". 4or this !uthori>e, the stu"1 w!s con"ucte" "uring the "r1 se!son 5or three 1e!rs 5rom 2ecember 2017 to ? !1 201@ to stu"1 the e55ect o5 "e5icit on !pplic!tion e55ic!c1, stor!ge e55icienc1, "istribution uni5ormit1 !n" irrig!tion w!ter use e55icienc1 o5 pot!to !n" onion. 6he "e5icit w!ter le7el use" were 7' !n" '0A . 8 + line" with 5ull irrig!tion 100A. 4rom the result, !7er!ge o5 !pplic!tion e55icienc1 (-!), stor!ge e55icienc1 (-s) !n" "istribution uni5ormit1 (2 9) o5 the three w!ter le7els (100A, 7'A !n" '0A) were 60.@7A, 70.27A, 7'.#A, ''.#'A, 62.8#A, 88.68A, 88.2#A, 87.61A !n" 8@.8@A 5or pot!to !n" 60.06A, 70.81A, 8'.6#A, 6'.03A, 60.2#A, 66.02A, 88.#@A, 87.8@A !n" 86.2#A 5or onion respecti7el1. 6he highest ; 1 o5 0.@8 !n" 0.8' w!s !tt!ine" !t '0A . 8 + 5or pot!to !n" onion respecti7el1 !n" the lowest w!s 100A . 8 + 5or both crops. 6his show the highest 1iel" re"uction w!s registere" un"er '0A . 8 +. 6he !pplic!tion e55icienc1, stor!ge e55icienc1, "istribution uni5ormit1 !n" 1iel" response o5 7'A . 8 + is slightl1 low 5rom 5ull irrig!tion w!ter le7el. %o it is recommen"e" to use 7'A . 8 + 5or both crops in s!7ing w!ter !s it h!s low 1iel" re"uction. 6here5ore, to implement "e5icit irrig!tion on 5!rm p!rticip!tor1 tr!ining shoul" be gi7en 5or !pplic!tion o5 right !mount o5 w!ter.

! ey"ords: 2e5icit, (ot!to,) nion, -55icienc1, : iel" +esponse

#$ %ntroduction

4oo" pro"uction !n" w!ter use !re ine=tric!bl1 lin3e". 8 !ter h!s !lw!1s been the m!in 5!ctor limiting crop pro"uction in much o5 the worl" where r!in5!ll is insu55icient to meet crop "em!n". 8 ith the e7er incre!sing competition 5or 5inite w!ter resources worl"wi"e !n" the ste!"il1 rising "em!n" 5or !gricultur!l commo"ities, the c!ll to impro7e the e55icienc1 !n" pro"ucti7it1 o5 w!ter use 5or crop pro"uction, to ensure 5uture 5oo" securit1 !n" !""ress the uncert!inties !ssoci!te" with clim!te ch!nge, h!s ne7er been more urgent B7C.

6he pressure on !griculture is incre!sing "ue to popul!tion growth thereb1 cre!ting ! nee" to impro7e !gricultur!l pro"uction !n" pro"ucti7it1. 8 !ter h!s been i"enti5ie" !s one o5 the sc!rcest inputs, which c!n se7erel1 restrict !gricultur!l pro"uction !n" pro"ucti7it1 unless it is c!re5ull1 conser7e" !n" m!n!ge". 6here is ! growing recognition th!t incre!ses in 5oo" pro"uction will l!rgel1 h!7e to origin!te 5rom impro7e" pro"ucti7it1 per unit w!ter !n" soil B6, 13C.

6he incre!se in w!ter "em!n" h!s resulte" in new metho"s o5 s!7ing w!ter worl"wi"e with !bout 70A o5 w!ter being use" in !griculture glob!ll1; w!ter s!7ing techniDues h!s to be pr!ctice". $rrig!tion technologies !n" irrig!tion sche"uling m!1 be !"opte" 5or more e55ecti7e !n" r!tion!l uses o5 limite" supplies o5 w!ter. 2e5icit irrig!tion is one o5 the metho"s "esigne" to ensure the optim!l use o5 !lloc!te" w!ter. $t m!=imi>es w!ter use e55icienc1 5or better 1iel"s per unit o5 irrig!tion w!ter !pplie" through; e=posing the crops to ! cert!in le7el o5 w!ter stress either "uring ! p!rticul!r perio"

or throughout the growing se!son B1#C.

*t present !n" more so in the 5uture, irrig!te" !griculture will t!3e pl!ce un"er w!ter sc!rcit1. $nsu55icient w!ter suppl1 5or irrig!tion will be the norm r!ther th!n the e=ception, !n" irrig!tion m!n!gement will shi5t 5rom emph!si>ing pro"uction per unit !re! tow!r"s m!=imi>ing the pro"uction per unit o5 w!ter consume", the w!ter pro"ucti7it1. 6o cope with sc!rce supplies, "e5icit irrig!tion, "e5ine" !s the !pplic!tion o5 w!ter below 5ull crop-w!ter reDuirements (e7!potr!nspir!tion), is !n import!nt tool to !chie7e the go!l o5 re"ucing irrig!tion w!ter use. 8hile "e5icit irrig!tion is wi"el1 pr!ctice" o7er millions o5 hect!res 5or ! number o5 re!sons 5rom in!"eDu!te networ3 "esign to e=cessi7e irrig!tion e=p!nsion rel!ti7e to c!tchment supplies it h!s not recei7e" su55icient !ttention in rese!rch.

$n or"er to ensure success5ul "e5icit irrig!tion, it is necess!r1 to consi"er the w!ter retention c!p!cit1 o5 the soil. $n s!n"1 soils pl!nts m!1 un"ergo w!ter stress Duic3l1 un"er "e5icit irrig!tion, where!s pl!nts in "eep soils o5 5ine te=ture m!1 h!7e !mple time to !" ust to low soil w!ter m!tric pressure, !n" m!1 rem!in un!55ecte" b1 low soil w!ter content. 6here5ore, success with "e5icit irrig!tion is more prob!ble in 5inel1 te=ture" soils B'C.

2e5icit irrig!tion h!s been suggeste" !s !n !ltern!ti7e str!teg1 5or m!3ing better use o5 irrig!tion w!ter. 2e5icit irrig!tion pro7i"es ! me!ns o5 re"ucing w!ter consumption while minimi>ing !"7erse e55ects on 1iel". $n this metho", the crop is e=pose" to ! cert!in le7el o5 w!ter "e5icit either "uring ! p!rticul!r perio" or throughout the whole growing se!son B#C.

2e5icit irrig!tion h!s been pr!ctice" in "i55erent p!rts o5 the worl" B2C. 2e5icit irrig!tion is ! str!teg1 which !llows ! crop to sust!in some "egree o5 w!ter "e5icit in or"er to re"uce irrig!tion costs !n" potenti!ll1 incre!se re7enues. -nglish !n" +! ! "escribe" three "e5icit irrig!tion c!se stu"ies in which the re"uctions in irrig!tion costs were gre!ter th!n the re"uctions in re7enue "ue to re"uce" 1iel"s. 2e5icit irrig!tion c!n le!", in principle, to incre!se" pro5its where w!ter costs !re high or where w!ter supplies !re limite". $n these c!se stu"ies, crop 7!lue w!s !ssoci!te" closel1 with 1iel", !n" crop gr!"e !n" m!r3et!bilit1 were not germ!ne.

6he m!in ob ecti7e o5 "e5icit irrig!tion is to incre!se the w!ter use e55icienc1 o5 ! crop b1 elimin!ting irrig!tions th!t h!7e little imp!ct on 1iel". 6he resulting 1iel" re"uction m!1 be sm!ll comp!re" with the bene5its g!ine" through "i7erting the s!7e" w!ter to irrig!te other crops 5or which w!ter woul" norm!ll1 be insu55icient un"er tr!"ition!l irrig!tion pr!ctices B'C. 6here5or to o7ercome irrig!tion w!ter short!ge !n" incre!se w!ter use e55icienc1, this stu"1 w!s con"ucte" with the ob ecti7es o5 "etermining w!ter use e55icienc1 !n" 1iel" response o5 pot!to !n" onion on three w!ter le7els un"er 5urrow irrig!tion.

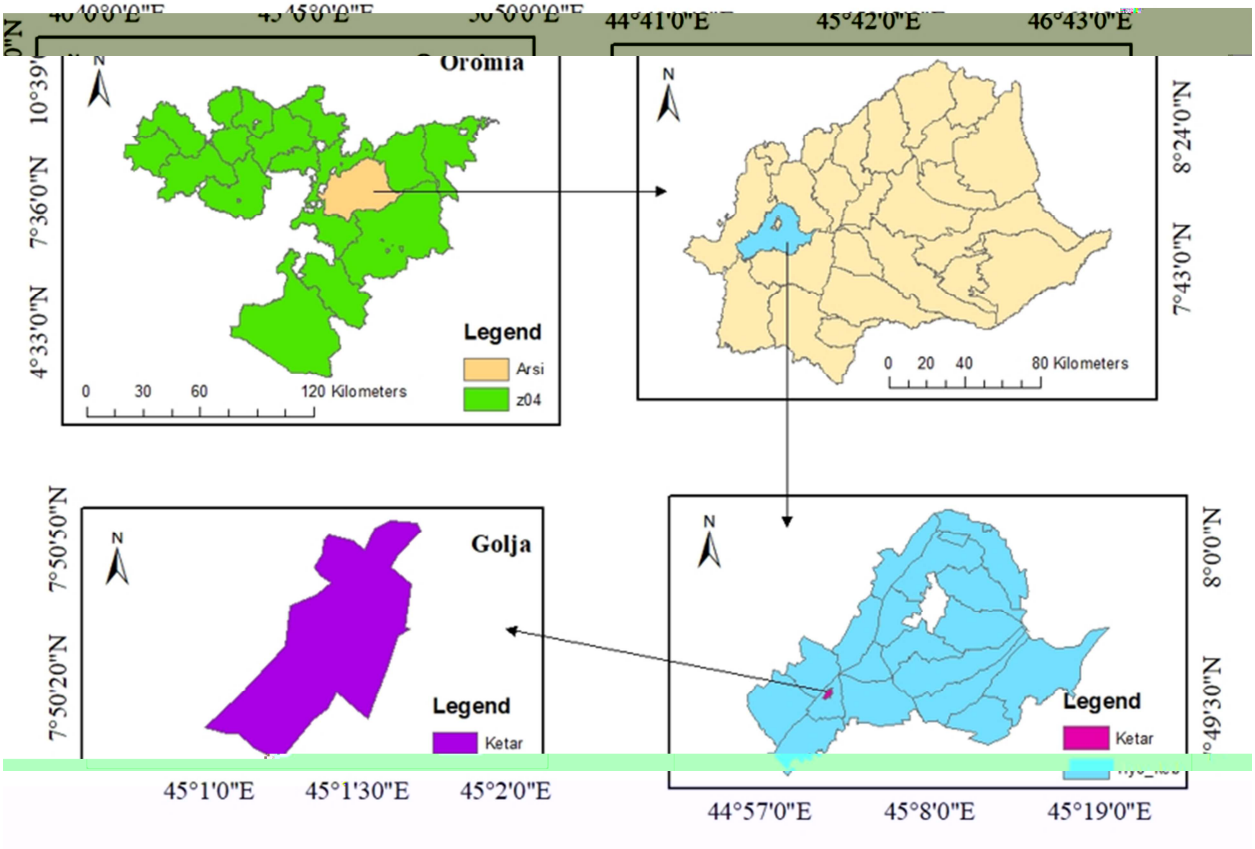

Figure 1. Map of study area.

&$ 'aterials and 'ethods

2.1. Description of the Study Area

6he stu"1 w!s con"ucte" !t 6i1o wore"!, *rsi>one "uring "r1 se!son (2ecember 2017 to ?!1 201@) on ;et!r irrig!tion scheme. 6he "istrict is loc!te" !t longitu"e !n" l!titu"e o5 7F #6G 30H - 7F '#G 0H & !n" 38F ''G 30H-3@F #G 30H -. 6he scheme w!s "esigne" to irrig!te !roun" #30 h! o5 l!n", h!s "isch!rge o5 800 litir/s !n" w!s recommen"e" !s it c!n irrig!te 7@' h! i5 c!n!l is line" (re"uction o5 con7e1!nce loss) !n" re"uce" o7er irrig!tion ("eep percol!tion !n" t!il w!ter runo55 loss) B3C.

6he clim!te o5 the !re! is gener!ll1 w!rm !n" temper!te. 6he !7er!ge !nnu!l temper!ture is 13.8F. !t !n !7er!ge 1'.1F., *pril is the hottest month o5 the 1e!r !t !n !7er!ge 12.7F. !n" "ecember is the col"est month o5 the 1e!r. 6he r!in5!ll here is 1118 mm. (recipit!tion is the lowest in 2ecember, with !n !7er!ge o5 12 mm. $n Eul1, the precipit!tion re!ches its pe!3, with !n !7er!ge o5 187 mm. 6he wore"! h!s !n !ltitu"e o5 2#30m !bo7e se! le7el (!.s.l) B18C.

2.2. Experimental Design and Treatments

6he crops use" 5or this e=periment were pot!to !n" onion. 4or e!ch crop e=periment w!s "one in"i7i"u!ll1 !n" the e=periment w!s !rr!nge" in +!n"omi>e" .omplete 0loc3 2esign (+.02) with three replic!tions. 6he tre!tments consi"ere" 5or the e=periments were three irrig!tion w!ter le7els which !re 100A, 7'A !n" '0A .8+. 6he e=periment w!s con"ucte" on in"i7i"u!l plot si>e o5 ' m = ' m (2' m^2) with @ number o5 such plot 5or e!ch crops. 6he sp!cing between the bloc3s !n" plots were 3ept !s 2 m !n" 1.' m respecti7el1.

2.3. Soil Data

4or soil te=ture, org!nic m!tter, pI !n" -., "isturbe" soil s!mples were use" !n" un"isturbe" soil 5or bul3 "ensit1, moisture content !t 5iel" c!p!cit1 (4.) !n" perm!nent wilting point ((8(). 9n"isturbe" soil s!mples were collecte" b1 core s!mpler !n" "isturbe" w!s b1 !uger 5rom two "epths 0-30cm !n" 30-60cm !t three points "i!gon!ll1 o5 the e=periment!l sites !n" w!s t!3en to l!bor!tor1 5or !n!l1sis.

4or te=tur!l !n!l1sis o5 the soil h1"rometer metho" w!s use" 5or !n!l1>ing p!rticle si>e "istribution !n" 9%2* te=tur!l tri!ngle w!s use" to i"enti51 the te=tur!l cl!ss. 6he org!nic m!tter content o5 the soil w!s "etermine" b1 titr!tion metho". 6he soil w!s o=i"i>e" un"er st!n"!r"i>e" con"ition with pot!ssium "ichrom!te in sulphuric !ci" to "etermine the c!rbon content. 6he st!tus o5 org!nic m!tter content w!s obt!ine" b1 multipl1ing c!rbon content with 1.72# B16C.

6he soil bul3 "ensit1 w!s !n!l1>e" !5ter o7en "r1ing the s!mples 5or 2# hours !t 10'F. !n" weighe" 5or c!lcul!ting "r1 "ensit1 !s gi7en b1 B12C.

$$\rho_b = \frac{M_s}{V_t} \quad (1)$$

8here: ρ_b = soil bul3 "ensit1 (gm/cm^3)

?$_s$Jm!ss o5 "r1 soil (gm) !n"

<$_t$Jtot!l 7olume o5 soil in the core s!mpler (cm^3)

%oil pI w!s "etermine" b1 using w!ter suspension with soil to w!ter r!tio 1:2.' b1 (I meter. -. w!s "etermine" b1 metho" o5 w!ter suspension with soil to w!ter r!tio 1:2.' b1 electro con"ucti7it1 meter.

6he soil moisture content !t 5iel" c!p!cit1 (4.) !n" perm!nent wilting point ((8() w!s "etermine" !5ter soil s!mples were s!tur!te" 5or one "!1 (2# hrs) using the pressure pl!te !pp!r!tus. 4iel" c!p!cit1 w!s "etermine" b1 e=erting ! pressure o5 0.33 b!rs !n" perm!nent wilting point w!s "etermine" b1 e=erting ! pressure o5 1' b!rs until no ch!nge in moisture will be obser7e". 6he 4. !n" (8(7!lues were 5urther use" to "etermine tot!l !7!il!ble w!ter (6*8). 6o un"ert3e the test o5 p!r!meter three soil s!mples 5rom e!ch plot.)nce 4. !n" (8("etermine" 6*8 w!s "etermine" !s st!te" B1C:

$$6*8\,J\,\frac{(FC - \;!\;)}{100}/02/2 \quad (2)$$

8here: TA! "tot!l !7!il!ble w!ter (mm)

FC "5iel" c!p!cit1 (A b1 weight)

! "perm!nent wilting point (A b1 weight)

#""epth o5 root >one (mm)

$#"speci5ic "ensit1 o5 soil

$$+*8\,J6*8\,/\,?*2 \quad (3)$$

8here: +*8 is re!"il1 !7!il!ble w!ter !n" ?*2 is m!n!gement !llow!ble "epletion norm!ll1 7!ries 5rom 0.3 to 0.7 "epen"ing on soil t1pe.

2.4. Climatic Data

6he minimum !n" m!=imum temper!ture, rel!ti7e humi"it1, win" spee" !n" "!il1 sunshine hour 20 1e!rs o5 the stu"1 !re! were collecte" 5rom -thiopi! &!tion!l ?eteorologic!l *genc1 to "etermine me!n "!il1 re5erence e7!potr!nspir!tion (-6o).

2.5. Crop Water Requirement and Irrigation Water Requirement

.+)(8*6 7ersion-8 w!s use" !n" clim!tic "!t! were 5e" to c!lcul!te the re5erence e7!potr!nspir!tion (-6_o) o5 the stu"1 !re!.

$$-6_c J -6_o = ;_c \quad (4)$$

8here: -6_cJcrop e7!potr!nspir!tion (mm/"!1)

-6_oJre5erence crop e7!potr!nspir!tion (mm/"!1)

$;_c$Jcrop coe55icient

&et-irrig!tion reDuirement 5or the crop w!s "etermine"

!ccor"ing to cropping p!ttern. 6ot!l irrig!tion w!ter reDuirement 5or the crop w!s c!lcul!te" using net-irrig!tion reDuirement o5 the crop, irrig!te" !re!s !n" irrig!tion e55icienc1.

$rrig!tion inter7!l w!s c!lcul!te" !s;

$$\% = \frac{d_{net}}{ET_c} \quad (')$$

8 here, $Jirrig!tion inter7!l ("!1s)

2_{net}Jnet-"epth o5 irrig!tion (mm)

-6_cJ"!il1 crop e7!potr!nspir!tion (mm/"!1)

6he "epth o5 irrig!tion !pplic!tion is the "epth o5 w!ter th!t c!n be store" within the root->one between the 5iel"'s c!p!cit1 !n" !llow!ble le7el o5 the soil w!ter "eplete" 5or ! gi7en crop, soil !n" clim!te. $t is eDu!l to the re!"il1 !7!il!ble soil w!ter o7er the irrig!te >one. 6he moisture "e5icit (") in the e55ecti7e root->one is 5oun" out b1 "etermining contents !t the 5iel" c!p!cit1 !n" bul3 "ensities o5 e!ch l!1ers o5 the soil.

$$d = \sum_{i=1}^{n} \frac{(FC_i - \quad !_i)}{100} / \gamma_i / \#_i / \quad (6)$$

8 here: 4.$_i$J5iel" c!p!cit1 o5 the irrig!tion w!ter l!1er on o7en "r1 weight b!sis (A)

(8 ($_i$J!ctu!l moisture content o5 the w!ter l!1er on o7en "r1 weight b!sis (A)

γ_i J!pp!rent speci5ic gr!7it1 o5 the soil o5 irrig!tion l!1er

2_iJ"epth o5 the irrig!tion l!1er (mm)

(J"epletion 5r!ction (A)

nJnumber o5 l!1ers in the root >one

2.6. Soil Moisture Determination

4or soil moisture "etermines gr!7imetric metho" w!s use". 4or this soil be5ore !n" !5ter irrig!tion were collecte" 5rom two soil "epths o5 the 5iel". 6he s!mples were t!3en !t 30 !n" 20 cm "epth inter7!l within the e55ecti7e root >one, which w!s consi"ere" up to 60 cm 5or pot!to !n" #0cm 5or onion crops. 6he moisture st!tus o5 the soil pro5ile 5or e!ch 5iel" w!s me!sure" be5ore !n" !5ter e!ch irrig!tion e7ent. 6he s!mples collecte" 5rom 5iel" using m!nu!ll1 "ri7en soil !uger were pl!ce" in the !ir tight cont!iner !n" weighe" prior to pl!cing in !n o7en "r1 !t 10'F. 5or 2# B17C. 6he o7en "rie" soil s!mples with cont!iner !n" co7er w!s weighe" !g!in. *5ter the soil moisture s!mpler collecte" !n" o7en "rie", the moisture w!s c!lcul!te" !s ! percent!ge o5 "r1 weight o5 the soil s!mple (8) !s

$$! = \frac{M_t - M_s}{M_s} / 100 = \frac{M_\&}{M_s} A / 100 \quad (7)$$

8 here: 8 Jweight o5 soil s!mple (gm)

$?_t$Jweight o5 5resh s!mple (gm)

$?_s$Jweight o5 o7er "rie" s!mple (gm)

$?_w$Jweight o5 moisture (gm)

6o con7ert these soil moisture me!surements into 7olumes o5 w!ter, the 7olumetric moisture content (θ) w!s c!lcul!te" !s

$$\theta = \frac{\rho_b / !}{\rho_\&} \quad (8)$$

8 here: θ J7olumetric moisture content (A)

ρ_b = %oil bul3 "ensit1 (gm/cm^3)

8 Jmoisture content on "r1 weight b!sis (A)

$\rho_\&$ Junit weight o5 w!ter (1gm/cm^3)

2.7. Discharge Measurements at Field

6he 5low o5 w!ter into the e=periment!l 5low w!s me!sure" using 3 (3 inch) si>e p!rsh!ll 5lume to be inst!lle" !t its entr!nce. 2isch!rge me!surement w!s t!3en !t 2/3* (two-thir" o5 length o5 con7erging section). 6hen the 5low "epth obser7e" on the 5lume w!s con7erte" to the correspon"ing "isch!rge using eDu!tion (@) 5or 3 si>e p!rsh!ll 5lume. 6hen the tot!l 7olume o5 w!ter !pplie" ($<_t$) w!s c!lcul!te" using eDu!tion (10) !s st!te" B@C !n" the tot!l "epth o5 !pplie" w!ter w!s c!lcul!te" b!se" on the represent!ti7e plot.

$$' = C_f (( ))^{n_f}$$

4or 3GG p!rsh!ll 5lume, $' = 0.1771)^{1.''0}$ (@)

$$V_a = ' / \Delta t \quad (10)$$

8 here: L J"isch!rge through the 5lume (l/s)

$._5$J"isch!rge coe55icient 5rom r!te" t!bles

; Junit const!nt (; J3.28 5or I in m)

n_5J5low e=ponent 5rom the t!bles

$<_t$Jtot!l 7olume o5 w!ter !pplie" (m^3)

Δt J5low time to the 5iel"

2.8. Determination of Irrigation Efficiency

2.8.1. Application Efficiency

$t is e=presse" !s:

$$E_a = \frac{V_s}{V_f} / 100 \quad (11)$$

8 here: $-_!$J 8 !ter !pplic!tion e55icienc1 (A)

$<_s$J<olume o5 irrig!tion w!ter store" in the root >one (m^3/s or h!-m)

$<_5$J<olume o5 irrig!tion w!ter "eli7ere" to 5!rm or 5iel" (m^3/s or h!-m)

<olume o5 irrig!tion w!ter store" in the root >one w!s "etermine" b1 c!lcul!ting !7!il!ble w!ter in the root >one in either 7olume b!ses or weight b!ses b1 "etermining soil moisture content be5ore !n" two "!1s !5ter irrig!tion b1 gr!7imetric or o7en "r1 metho" 5or the selecte" plots. <olume o5 irrig!tion w!ter "eli7ere" to plot w!s me!sure" !t 5iel" b1 p!rsh!ll 5lume.

2.8.2. Distribution Uniformity

6he "istribution uni5ormit1 is more commonl1 use" to ch!r!cteri>e the irrig!tion w!ter "istribution o7er the 5iel" in sur5!ce irrig!tion s1stems. 6he low-Du!rter "istribution uni5ormit1 (2_u) is "e5ine" !s the !7er!ge "epth in5iltr!te" in the low one-Du!rter o5 the 5iel" "i7i"e" b1 the !7er!ge "epth in5iltr!te" o7er entire 5iel". $t is e=presse" !s:

$$\#_u = \frac{\#_{l*}}{\#_{a+}} / 100 \qquad (12)$$

8 here: 2_uJ 2istribution 9ni5ormit1 (A)

2_{ID}J *7er!ge "epth o5 w!ter in5iltr!te" in the low one-Du!rter o5 the 5iel" (m)

$2_{!7}$J *7er!ge "epth o5 w!ter in5iltr!te" o7er the 5iel" (m)

4or computing !7er!ge "epth o5 w!ter in5iltr!te" o7er the 5iel", moisture content o5 the 5iel" w!s me!sure" be5ore !n" !5ter irrig!tion !n" their "i55erence !n" me!n o5 their "i55erence w!s c!lcul!te". 6he !7er!ge "epth o5 w!ter in5iltr!te" in the low one-Du!rter o5 the 5iel", moisture content o5 the 5iel" w!s me!sure" be5ore !n" !5ter irrig!tion !n" their "i55erence w!s c!lcul!te" 5or the le!st 5our 5rom "escen"ing or"er !n" then me!n o5 their "i55erence w!s compute". 4rom $2_{!7}$!n" 2_{ID} "istribution uni5ormit1 (2u) w!s compute" 5or the three plots (b1 "i7i"ing me!n o5 "i55erence o5 o7er!ll s!mple 5or me!n o5 "i55erence o5 le!st Du!rter).

2.8.3. Storage Efficiency

%oil w!ter stor!ge e55icienc1 ($-_s$) is "e5ine" !s the r!tio o5 the 7olume o5 w!ter store" in root to 7olume o5 w!ter reDuire" 5illing the root >one to ne!r 5iel" c!p!cit1 !n" is e=presse" !s

$$E_s = \frac{V_s}{V_{fc} - V_a} / 100 \qquad (13)$$

8 here: $-_s$J%oil w!ter stor!ge e55icienc1 (A)

$<_s$J<olume o5 w!ter store" in the soil root >ones 5rom !n irrig!tion e7ent (m^3/s)

$<_{5c}$J<olume o5 w!ter !t 5iel" c!p!cit1 in the crop root >one (m^3/s or h!-m)

$<_!$J<olume o5 w!ter in soil root >one prior to irrig!tion e7ent (m^3/s or h!-m)

2.8.4. Water Productivity

6he w!ter utili>!tion b1 crop is gener!ll1 "escribe" in terms o5 w!ter use e55icienc1 (3g/h!, 3g/m3 or D/h!) B11C. 8 !ter use e55icienc1 (8 9 -) !n" irrig!tion w!ter use e55icienc1 ($8 9 -) !re "etermine" b1 "i7i"ing the 1iel" to se!son!l -6 !n" tot!l se!son!l irrig!tion w!ter ($8) !pplie" B1'C.

$$! - E = \frac{\text{'a}}{ET_c} \qquad (1\#)$$

8 here: 8 9 - Jw!ter use e55icienc1 ($3g/m^3$)

: $_!$Jis !ctu!l 1iel" ($3g/m^2$)

- 6_cJse!son!l crop e7!potr!nspir!tion (m^3/m^2)

$$\%! - E = \frac{\text{'a}}{\%!} \qquad (1')$$

8 here, $8 9 -- irrig!tion w!ter use e55icienc1 ($3g/m^3$)

: !J!ctu!l 1iel" ($3g/m^2$)

$8 Jirrig!tion w!ter !pplie" (m^3/m^2)

2.8.5. Yield Response Factor of Crops to Deficit

8 hen w!ter suppl1 "oes not meet the crop w!ter reDuirements, the -6c will "ecre!se. 9n"er this con"ition, w!ter stress will "e7elop in the pl!nt, which will !"7ersel1 !55ect crop growth !n", ultim!tel1, crop 1iel". 6o pre"ict the re"uction in crop 1iel" when crop stress w!s c!use" b1 ! short!ge o5 soil w!ter:

$$(1-\frac{Y_a}{Y_m})JK_y(1-\frac{ET_a}{ET_m}) \qquad (16)$$

where; :!J!ctu!l 1iel" (3g/h!); :mJm!=imum 1iel" (3g/h!); -6!J!ctu!l e7!potr!nspir!tion (mm); -6mJm!=imum e7!potr!nspir!tion (mm), !n" ;1J1iel" response 5!ctor.

2.9. Statistical Analysis

6he results were !n!l1>e" b1 "escripti7e st!tistic!ll1 using ?icroso5t e=cel !n" comp!re" !7er!ges result o5 p!r!meters.

($ Result and Discussion

3.1. Physico-Chemical Properties of Soil

6!ble 1 below shows the ph1sico-chemic!l propert1 o5 the stu"1 !re!. 4rom this soil pI 7!lues were 5oun" in r!nge o5 '.3#-6.03 !n" h!7e !7er!ge o5 '.#@. 6his in"ic!tes mo"er!te !ci"ic soil. -lectric!l con"ucti7it1 (-.) o5 the st!tions w!s in r!nge o5 0.10-0.32 mmhos/cm !t room temper!ture (2'F.). *7er!ge org!nic m!tter contents ()?) o5 the e=periment!l site were 3.'8. %oil te=ture cl!ss o5 stu"1 !re! w!s cl!1 lo!m. 6he !7er!ge 7!lues o5 pI, -lectric!l con"ucti7it1 !n" org!nic m!tter were '.#@, 0.16 !n" 3.'8 respecti7el1. *ccor"ing to .l!sses o5 s!linit1 !n" -. (1 "%/mJ1 mmhos/cm; !s !"!pte" 5rom 9%2*, soil which h!s electric!l con"ucti7it1 0M2 mmhos.cm is non-s!line soil.

Table 1. Soil p), EC, . MC and te/ture determination of e/perimental site.

)ample *o	P+	E, -mmhos.cm at &/0,1	2, 3	2 '	)oil te4ture			
					)and 3	)ilt 3	, lay 3	, lass
1	'.#7	0.1	1.@7	3.#	30	32	38	.N
2	'.3#	0.2#	2.0#	3.'2	26	36	38	.N
3	6.03	0.21	2.1@	3.77	2'	37	38	.N
#	'.3@	0.32	1.@8	3.#1	3#	2#	#2	.
'	'.2@	0.12	1.@#	3.3#	2@	3'	36	.N

)ample *o	P+	E, -mmhos.cm at &/0,1	2, 3	2 '	)oil te4ture			
					)and 3	)ilt 3	, lay 3	, lass
6	'.'7	0.11	2.1'	3.71	30	36	3#	. N
7	'.3#	0.13	2.23	3.8#	32	3'	33	. N
8	'.'1	0.11	2.13	3.67	36	30	3#	. N
@	'.#7	0.1#	2.0@	3.6	3#	22	##	.
*7er!ge	'.#@	0.16	2.08	3.'8	31	32	37	. N

. NJ . l!1 lo!m . J . !l1

3.2. Irrigation Water Requirement

6!ble 2 show the !7er!ge se!son!l irrig!tion w!ter !pplie" 5or pot!to crop. 4or the three w!ter le7els (100, 7' !n" '0A . 8 +) the !7er!ge o5 se!son!l irrig!tion w!ter !pplie" per plot w!s 16.'', 12.#1 !n" 8.27 m^3 respecti7el1. 4rom this the !7er!ge o5 se!son!l irrig!tion w!ter nee" per hect!re o5 pot!to crop 5or the three w!ter le7els (100, 7' !n" '0A . 8 +) were 6620, #@63.6 !n" 330@.2 m^3 respecti7el1. 6he w!ter s!7e" per hect!re using two w!ter le7el which !re (7' !n" '0A . 8 +) were 16'6.# !n" 3310.8 m^3 re5erence to 100A . 8 +. 4rom this result, using "e5icit more w!ter w!s s!7e" to e=p!n" commen" !re! o5 scheme.

Table 2. A+erage Seasonal &ater application of &ater on potato e/perimental plot.

%rri5ation Day	6r$ %rr -mm1	6ross %rri5ation depth -m1	Plot Area -$m^&1$	Avera5e 7olume of) 8 A -$m^(1$		
				-#99 3 , 8 R1	-:/ 3 , 8 R1	-/9 3 , 8 R1
1	37.3	0.0#	2'	0.@3	0.70	0.#7
2	22.1	0.02	2'	0.''	0.#1	0.28
3	27.3	0.03	2'	0.68	0.'1	0.3#
#	37.3	0.0#	2'	0.@3	0.70	0.#7
'	#0.1	0.0#	2'	1.00	0.7'	0.'0
6	'3	0.0'	2'	1.33	0.@@	0.66
7	#6.7	0.0'	2'	1.17	0.88	0.'8
8	#7	0.0'	2'	1.18	0.88	0.'@
@	'3.3	0.0'	2'	1.33	1.00	0.67
10	'3.'	0.0'	2'	1.3#	1.00	0.67
11	'1.1	0.0'	2'	1.28	0.@6	0.6#
12	'6.2	0.06	2'	1.#1	1.0'	0.70
13	6#.#	0.06	2'	1.61	1.21	0.81
1#	72.'	0.07	2'	1.81	1.36	0.@1
1'	0	0	2'	0.00	0.00	0.00
6ot!l				16.''	12.#1	8.28

. 8 +J . rop w!ter reDuirement % 8 *J%ession!l w!ter !pplie"

6he !7er!ge o5 se!son!l irrig!tion w!ter !pplie" 5or onion crop w!s illustr!te" un"er t!ble 3 5or the three w!ter le7els (100, 7' !n" '0A . 8 +). 4rom this t!ble the !7er!ge o5 se!son!l irrig!tion w!ter !pplie" per plot were 1#.@3, 11.20 !n" 7.#7m^3 !n" se!son!l irrig!tion w!ter nee" per hect!re o5 onion crop 5or the three w!ter le7els (100, 7' !n" '0A . 8 +) were '@72, ##80 !n" 2@88 m^3 respecti7el1. 6he w!ter s!7e" per hect!re using two w!ter le7el which !re (7' !n" '0A . 8 +) were 1#@2 !n" 2@8# m^3 re5erence to 100A . 8 +. 4rom this result, using "e5icit more w!ter w!s s!7e" to e=p!n" commen" !re! o5 scheme.

Table 3. A+erage seasonal &ater application of &ater on onion e/perimental plot.

%rri5ation day	6ross %ri5n Depth -m1	Plot Area -$m^&1$	7olume -$m^(1$		
			#99 3 , 8 R	:/ 3 , 8 R	/9 3 , 8 R
1	0.0'	2'	1.32	0.@@	0.66
2	0.03	2'	0.77	0.'8	0.3@
3	0.03	2'	0.87	0.6'	0.##
#	0.0#	2'	0.@7	0.73	0.#@
'	0.0'	2'	1.2'	0.@3	0.62
6	0.06	2'	1.3@	1.0#	0.70
7	0.06	2'	1.'1	1.13	0.76
8	0.06	2'	1.'0	1.13	0.7'
@	0.06	2'	1.61	1.21	0.81
10	0.06	2'	1.'1	1.13	0.7'
11	0.0@	2'	2.2#	1.68	1.12
12	0.00	2'	0.00	0.00	0.00
6ot!l			1#.@3	11.20	7.#7

3.3. Application Efficiency (Ea)

6!ble # shows the !pplic!tion e55icienc1 o5 the e=periment!l site were c!lcul!te" using "epth o5 w!ter store" to crop root >one "i7i"e" b1 "epth o5 w!ter !pplie" to 5iel". 6he !7er!ge o5 !pplic!tion e55icienc1 o5 the three w!ter le7els 5or pot!to !n" onion were 60.@7A, 70.27A, 7'.#A !n" 60.06A, 70.81A !n" 8'.6#A respecti7el1. 6he w!ter !pplic!tion e55icienc1 o5 the two w!ter le7els (7'A !n" '0A) w!s gre!ter th!n the 5ull irrig!tion (100A) e7en though the !mount o5 w!ter !pplic!tion w!s lower. 6his is "ue to properl1 use" w!ter !n" !pplie" to 5iel" without more loss.

6!ble @ show 1iel" response 5!ctor o5 crops to "e5icit w!ter w!s "escribe". 4rom this t!ble !7er!ge ;1 7!lue r!ge were 0 - 0.8' !n" the highest ;1 o5 0.8' w!s !tt!ine" !t '0A . 8 + !n" the lowest w!s 100A . 8 +. 6his show the highest 1iel" re"uction w!s registere" un"er '0A . 8 +. 6he "e5icit b1 2'A or 7'A . 8 + is no more 1iel" re"uction there5or it is recommen"e".

Table 9. ,ield response factor of onion crop to deficit irrigation &ater.

8 ater level - **3** 1	$<_a$ -k**5**.ha1	ET_a	$<_a.<_m$	$ET_a.ET_m$	$\#-<_a.<_m1$	$\#-ET_a.ET_m1$	$!_y>?-\#-<_a.<_m1.-\#=ET_a.ET_m11@$
100	12200	662	0.80	1	0.20	0	-
7'	13000	#@6.'	0.86	0.7'	0.1#	0.2'	0.'8
'0	8'20	331	0.'6	0.'	0.##	0.'	0.88
'0	8#00	331	0.''	0.'	0.#'	0.'	0.8@
100	1'200	662	1.00	1	0.00	0	-
7'	13120	#@6.'	0.86	0.7'	0.1#	0.2'	0.''
7'	13#00	#@6.'	0.88	0.7'	0.12	0.2'	0.#7
'0	@2#0	331	0.61	0.'	0.3@	0.'	0.78
100	13200	662	0.87	1	0.13	0	-

A$,onclusion and Recommendation

4.1. Conclusion

$n this stu"1, !n !ttempt w!s m!"e to e7!lu!te "e5icit irrig!tion "e5icit or three w!ter le7els (100, 7' !n" '0A . 8 +) using !pplic!tion e55ic!c1, stor!ge e55icienc1, "istribution uni5ormit1 !n" irrig!tion w!ter use e55icienc1 o5 the pot!to !n" onion crops. N!bor!tor1 result o5 soil "!t! shows th!t te=ture cl!ss o5 soil in stu"1 !re! w!s cl!1 lo!m. 6he !7er!ge 7!lues o5 pI, -lectric!l con"ucti7it1 !n" org!nic m!tter were '.#@, 0.16 !n" 3.'8 respecti7el1.

4or the three w!ter le7els (100, 7' !n" '0A . 8 +) the !7er!ge o5 se!son!l irrig!tion w!ter !pplie" per plot !n" per hect!re o5 pot!to crop were 16.'', 12.#1 !n" 8.27 m^3 !n" 6620, #@63.6 !n" 330@.2 m^3 respecti7el1. 4or onion were 1#.@3, 11.20 !n" 7.#7m^3 !n" '@72, ##80 !n" 2@88 m^3 respecti7el1. 6he w!ter s!7e" per hect!re using two w!ter le7el which !re (7' !n" '0A . 8 +) were 16'6.# !n" 3310.8 m^3 5or pot!to !n" 1#@2 !n" 2@8# m^3 5or onion re5erence to 100A . 8 + respecti7el1.

6he !7er!ge o5 !pplic!tion e55icienc1 (-!), stor!ge e55icienc1 (-s) !n" "istribution uni5ormit1 (29) o5 the three w!ter le7els (100A, 7'A !n" '0A) were 60.@7A, 70.27A, 7'.#A, ''.#'A, 62.8#A, 88.68A, 88.2#A, 87.61A !n" 8@.8@A 5or pot!to !n" 60.06A, 70.81A, 8'.6#A, 6'.03A, 60.2#A, 66.02A, 88.#@A, 87.8@A !n" 86.2#A 5or onion respecti7el1. 6he irrig!tion w!ter use e55icienc1 c!lcul!te" w!s the highest !t '0A w!ter le7el 5or the two crops !n" the lowest were c!lcul!te" !t 100A . 8 + w!ter le7els.

6he highest ;1 o5 0.@8 !n" 0.8' w!s !tt!ine" !t '0A . 8 + 5or pot!to !n" onion respecti7el1 !n" the lowest w!s 100A . 8 + 5or both crops. 6his show the highest 1iel" re"uction w!s registere" un"er '0A . 8 +. 6he "e5icit b1 2'A or 7'A . 8 + is no more 1iel" re"uction there5or it is recommen"e".

4.2. Recommendation

$t is highl1 recommen"e" to use 7'A . 8 + 5or both crops in s!7ing w!ter !s it h!s low 1iel" re"uction in 5rom w!ter re"uce". 0e5ore implementing ! "e5icit irrig!tion progr!m, it is necess!r1 to 3now crop 1iel" responses to w!ter stress, either "uring "e5ine" growth st!ges or throughout the whole se!son. 6o implement "e5icit irrig!tion on 5!rm p!rticip!tor1 tr!ining shoul" be gi7en 5or !pplic!tion o5 right !mount o5 w!ter. *s this w!ter s!7ing technolog1 ("e5icit irrig!tion) is best 5or w!ter stress !re!s it is strongl1 recommen"e" to con"uct 5urther rese!rch wor3s 5or other schemes p!rticul!rl1 !t highl!n" !re!s !s it h!s less e7!potr!nspir!tion th!n th!t o5 lowl!n"s.

References

B1C *llen, +., (ereir!, N. %, +!es, 2. !n" %mith, ?. 1@@8. .rop -7!potr!nspir!tion (Oui"elines 5or computing crop w!ter reDuirements. 4*) $rrig!tion !n" 2r!in!ge (!per, &o. '6. 4*), +ome, $t!l1.

B2C 0e3ele 6il!hun. 2007. +egul!te" "e5icit irrig!tion sche"uling o5 onion in ! %emi-!ri" region o5 -thiopi!. *gric. 8 !ter ?!n!ge. 8@: 1#8P1'2.

B3C 2in3! 4u5!. 2017. 6echnic!l (er5orm!nce '78 -7!lu!tion o5 ;et!r ?e"ium %c!le $rrig!tion %cheme, %outhe!st o5)romi! +egion!l %t!te, -thiopi!, <ol. @, &o. @, (13-21, .i7il *n" -n7ironment!l +ese!rch, $%%& 222#-'7@0 ((!per) $%%& 222'-0'1# ()nline).

B#C -nglish !n" +!!. 1@@6. 6he -55ect o5 2e5icit $rrig!tion on (ot!to 7!potr!nspir!tion !n" 6uber :iel" un"er .ool %e!son !n" %emi!ri" .lim!tic .on"itions. Eourn!l o5 *gronom1.

B'C 4*) (4oo" !n" *gricultur!l)rg!ni>!tion). 2002. 2e5icit irrig!tion pr!ctices. 4*) 8 !ter +eport &o. 22. +ome, $t!l1.

B6C 4*) (4oo" !n" *griculture)rg!ni>!tion). 200'. +egion!l .on5erence on 4oo" %!5et1 5or *5ric!.

B7C 4*) (4oo" !n" *gricultur!l)rg!ni>!tion). 2012. .rop 1iel" response to w!ter, 4*) irrig!tion !n" "r!in!ge p!per, 66, 4*), +ome, $t!l1.

B8C $rm!3, %.,)"hi!mbo,).N., ;r!n>, N. 8. !n" -isenh!uer, -. 2. 2011. $rrig!tion -55icienc1 !n" 9ni5ormit1, !n" .rop 8!ter 9se -55icienc1. $nstitute o5 *griculture !n" &!tur!l +esources, 9ni7ersit1 o5 &ebr!s3!PNincoln.

B@C E!mes, N. O. 1@88. (rinciples o5 4!rm $rrig!tion 2esign. Eohn 8ile1 !n" %ons, $nc. &ew :or3.

B10C Nesle1, 8. 2002. $rrig!tion -55icienc1. $rrig!tion -55icienc1 -nh!ncement +eport &o ##'2/16!.

B11C ?ich!el, *. ?., 1@@7. $rrig!tion 6heor1 !n" (r!ctice. -7!lu!ting N!n" 5or $rrig!tion .omm!n"s. +eprinte" -"ition, <i3!s (ublishing Iouse (7t Nt", &ew 2elhi, $n"i!.

B12C ?ich!el, *. ?. 2008. $rrig!tion 6heor1 !n" (r!ctice 2n" e"ition. $n"i!n !gricultur!l rese!rch institute, &ew 2elhi.

B13C &+?2 (&!tur!l +esources ?!n!gement 2irector!te). 2011. 6he 4e"er!l 2emocr!tic +epublic o5 -thiopi! ?inistr1 o5 *griculture &!tur!l +esource %ector %m!ll-%c!le $rrig!tion .!p!cit1 0uil"ing %tr!teg1 5or -thiopi!.

B1#C %hree"h!r, +., %hi7!pur, *. <, Q &ith1!, 0. ;. 201'. 2e5icit $rrig!tion ?!n!gement (r!ctice 5or ?! or .rops in ;unig!l .omm!n" *re!, *0* (@), 170P18'.

B1'C 6!nner, .. 0. !n" %incl!ir, 6. +. 1@83. -55icient w!ter use in crop pro"uction: rese!rch.

B16C 8!l3er, *. !n" $. *. 0l!c3. 1@3#. *n -=!min!tion o5 2i55erent ?etho" 5or 2etermining %oil)rg!nic ?!tter !n" ! (ropose" ?o"i5ic!tion o5 the .hromic *ci" 6itr!tion ?etho". %oil %ci. 37: 2@-37.

B17C 8!l3er, 8. +. 2003. %ur5!ce irrig!tion simul!tion, e7!lu!tion !n" "esign. 9ser gui"e !n" technic!l "ocument!tion, 9t!h st!te uni7ersit1, Iug!n, 9t!h, 9%*.

B18C :!>!chew -te5! !n" ;!s!hun 2ib!b!. 2011. (h1sic!l !n" %ocio -conomic (ro5ile o5 *rsi Rone !n" 2istricts, 0ure!u o5 4in!nce !n" -conomic 2e7elopment +egion!l 2!t! !n" $n5orm!tion (rocess, *""is *b!b!, -thiopi!.