Effect of deficit irrigation on growth and yield of onion, Allium cepa L.

Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia

TECHNICAL REPORT OF EXPERIMENTAL ACTIVITIES

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Implemented by

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About the Project

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Cover foto: Water harvesting pond gradually filled by precipitations during rainy season. Water will be used for deficit irrigation trials during autumn | 15 Aug. 2015 | C. Zucca

About ICARDA

The International Center for Agricultural Research in the Dry Areas (ICARDA) is the global agricultural research Center working with countries in the world's dry and marginal areas, supporting them for sustainable agriculture development to help increase their productivity, raise incomes for smallholder farmer families, improve rural nutrition and strengthen national food security. With partners in more than 40 countries, ICARDA produces science based-solutions that include new crop varieties (barley, wheat, durum wheat, lentil, faba bean, kabuli chickpea, pasture and forage legumes); improved practices for farming and natural resources management; and socio-economic and policy options to enable and empower countries to improve their food security. ICARDA works closely with national agricultural research programs and other partners worldwide in Central Asia, South Asia, West Asia, North Africa, and Sub-Saharan Africa.

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Synthesis

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Report submitted by: Ertiban Wondifraw

Summary Report

The effect of deficit irrigation (DI) on the yield and yield components of onion was studied with financial support from ICARDA. In the study area, irrigation practices are common mainly for two crops, onion and garlic. The sources of water for irrigation is limited (only few small streams) and these cannot support all farmers need in the watershed. On the other hand farmers' irrigation demand is increasing from time to time and their irrigation management is usually poor.

To satisfy many farmers in the watershed, water productivity should be increased in the area, DI is known to increase water productivity with insignificant or minimum yield reduction. Therefore, the experiment was done to evaluate DI on the yield of onion and water productivity. The experiment was implemented at two farmers' plots where rain water harvesting ponds were developed by ICARDA for the purpose of supplemental irrigation. These farmers were fully involved during this experiment. The experiment was laid out in a randomized complete block design (RCBD), and has investigated in the irrigation seasons of the year 2015 and 2016.

There were seven DI treatments, such as farmers practice/control, deficit during initial, development, mid and late stages, deficit throughout the growing stages and full irrigation amounts. Irrigation depth was applied depending on the soil moisture and for full irrigation each irrigation was applied up to field capacity and for DI irrigation was applied at 70% depletion or almost half of the soil field capacity requirement. The amount of water supplied was measured and application time was in 7days interval.

The recommended amount of P2O5 and N fertilizers i.e. 46kg/ha and 87 kg/ha respectively were applied to each plot at transplanting. All the necessary agronomic practices such as weeding, earthing up, row and plant spacing was the same for each plot. Data were analysed for variance and LSD at 5% level of significance. The result showed that, DI irrigation had significant effect on yield and water productivity of onion. Though the two years data couldn't be combined, the result showed that deficit irrigation on mid stage gave relatively better onion bulb yield.

Schematic summary of information

Location:	Abakaliyo and Dezaze Village, Gumara-Maksegnit watershed, Gondar
Easting:	0345765
Northing:	1373988
Elevation:	1994m a.s.l.
Period of implementation:	September, 2014 to April 2016
Duration of trials:	2 years;2 seasons
Activity leader(s):	Ertiban W. (ertiban@yahoo.com), Muuz Gebretsadik
Other researchers involved:	Melkie Desalegni, Atikit, A.

1 Background and rationale

Deficit irrigation (DI) has been widely investigated as a valuable and sustainable production strategy in dry regions. By limiting water applications to drought-sensitive growth stages, this practice aims to maximize water productivity and to stabilize – rather than maximize – yields. Research results confirm that DI is successful in increasing water productivity for various crops without causing significant yield penalty (Raes, 2009; C. FAO, 2002).

Deficit irrigation requires precise knowledge of crop response to drought stress, as drought tolerance varies considerably by genotype and phonological stage. In developing and optimizing DI strategies, field research should therefore be combined with crop water productivity modeling (FAO, 2002). As water supplies decline and the investment of water increases, it is clear that producers are being driven toward deficit irrigation management. The implication of this management system is that some level of plant water stress is unavoidable. The challenge is to define management system that will minimize the negative impact of the expected stress. This irrigation management requires choosing the timing and amount of water to be applied (requires optimizing the timing and degree of plant stress within the restriction of available water). The critical soil water content varies for different crops and different crop stages and is determined by the rooting density characteristics of the crop, evaporation rate and, to some extent, by the soil type (FAO, 1992).

A research was done on effect of DI irrigation on onion production by Rop et al (2016). They found that 'DI at vegetative and late growth stages influence yields in a positive linear trend.' They concluded that onion cultivation with 20% stress optimize water productivity without significantly reducing yields. A similar study by El-Hady et al (2015) stated that it is possible to increase onion yield by applying irrigation less than ET. Studies done by Ayas and Demirtaş (2009) also showed that application of 50% of the ET can increase water productivity significantly and it can be applicable where water resource is a limiting factor.

Therefore, this proposal is initiated to evaluate deficit irrigation scheduling for onion production in Gumara Maksegnit Watershed using direct measurements of moistures condition in the field.

2 Objectives

The main objectives of this research activity were to evaluate the effects of deficit irrigation on onion yield and yield components and to improve water productivity in the area through deficit irrigation scheduling.

3 Experimental Methods

The soil type in the study site comprises mainly Vertisols and the texture of the experiment areas is clay.

Table 1: Soil physical and chemical property of the site at Soil depth from 0-25 cm

Soil depth/cm	Walkley & Black OM %	BD g/cm^3	pH H2O	T.N Kjeldhal %	Exch. P Olsen PPm	Texture			Tex class
						Sand	Silt	Clay	
>100	1.40	1.44	6.89	0.09	2.31	23.84	22.4	53.76	Clay

There were seven irrigation treatments. Irrigation application depths were determined on the basis of soil water storage depletion.

Table 2: Treatment setup of the experiment

Trt code	Treatments	Description of the treatments
1	Farmers practice	Farmers use border irrigation system, no furrow
2	stress during initial stage	In the first 25 days the plots were received deficit irrigation (at 70% depletion) and after this stress the plots received full irrigation based on the moisture content of the soil
3	Stress during development stage	Only from 25 days of transplanting to 75 days was received deficit irrigation, during other time, the plots were received full irrigation
4	Stress during mid stage	Only From 75 days of transplanting to 90 days the plots received reduced amount of water, other stages received full irrigation
5	Stress during late stage	From 90 days to maturity , the plots were applied with deficit
6	Stress in all stages	Throughout the growing stages, the plots were received deficit irrigation
7	optimum irrigation at all stages	Throughout the growing stages, the plots were received full irrigation

The control experiment is farmers practice. In the study area farmers use border and flood irrigation systems. Depending on the availability of water farmers usually use much water beyond the soil field capacity level. This results in runoff and deep drainage of the water exceeding the crops demand. On the other hand farmers irrigate their plots in long intervals. This has its own negative impacts on the crop, because irrigation scheduling should consider the soil, crop type, and the atmospheric demand, but farmers rarely consider these conditions. Finally these poor scheduling practices result in reduced yield, poor quality and low water productivity.

4 Statistical aspects

- Treatments:

The study had 7 treatments with one factor of deficit irrigation.

- Null hypothesis:

Deficit irrigation significantly affects garlic yield and doesn't improve water productivity.

- Statistical design:

Randomized complete block design (RCBD) with three replications was used. The plot size was 3m by 3.2m. Spacing between blocks was 1.5 meter and spacing between plots was 1m. The irrigation system was furrow method and farmers practice for control treatment. Onion (Bombe red variety) was tested; with spacing between row 40*20*10 cm

- The response variables measured were:

bulb diameter, bulb weight Bulb number, bulb yield, Bulb. Each variable was measured from the middle rows to avoid border effects.

- Statistical analysis:

Analysis of variance was carried out with 1-way ANOVA. Means and standard errors were calculated for DI treatments. SAS version 9 statistical software was used for analysis.

5 Results

- As the one year data indicated, highest water productivity was obtained in all stages stress condition and no significant yield difference among stress treatments during late, initial, and development stages
- Optimum irrigation gave a significant higher yield and yield components over the deficit treatments, but no significant difference with stress during initial, mid stages and farmers practice
- Farmers practice gave the lowest water productivity .

Table 3: Effect of DI on the yield and WP of Onion

Treatment	BD (cm)	Bb wt (g)	T Yld kg/ha	Unm yld kg/ha	Ma yld kg/ha	WP kg/m^3
Farmers practice	3.85^{ab}	40^{ab}	13057^{ab}	46	13011^{ab}	2.4^{e}
Stress during IS	3.59^{abc}	42a	12010^{abc}	71	11938^{abc}	3.5^{cd}
Stress during DS	3.51^{bc}	32^{bc}	10151^{c}	32	10119^{c}	4.04^{bc}
Stress during MS	3.68^{abc}	39^{abc}	13599^{a}	53	13546^{a}	4.24^{b}
Stress during LS	3.70^{abc}	33bc	11406^{bc}	20	11386^{bc}	3.35^{d}
Stress in all stages	3.40c	32c	10711^{c}	53	10658^{c}	5.25^{a}
FI in all stages	4.01a	43a	13545^{a}	0.0	13545^{a}	3.7^{bcd}
CV (%)	9.22	16.5	12.82	139	12.88	13.56
LSD (0.05)	0.43	7.77	2757	69.0	1949.1	0.67

Remark; IS= initial stage, DS= development stage, MS= maturity stage, LS= late stage, FI= full irrigation

The result in table 3 has showed that deficit irrigation during all stages and stress during development stage has negatively affected yield of onion while deficit irrigation in the other stages gave comparable onion yield to that of farmers practice and full irrigation in all stages.

Table 4: ANOVA Table, Onion Marketable bulb yield, 2016

Source	DF	Sum of Squares	Mean Square	F Value	F > Pr
Model	8	448043106.1	56005388.3	3.09	0.0386
Error	12	217560815.8	18130068.0		
Corrected Total	20	665603921.9			

Table 5: Effect of deficit irrigation on the yield and water productivity of Onion, 2016

Treatment	BD (cm)	Bb wt (g)	Un m yld kg/ha	Mar yld kg/ha	WP kg/m^3
Farmers practice	$4.03B^{AC}$	36.13^{C}	525.0	8490^{BC}	2.1^{C}
Stress during IS	4.59^{AB}	42.00^{BC}	242.4	8411^{BC}	2.8^{C}
Stress during DS	3.98^{BC}	41.80^{BC}	201.4	6935^{C}	2.7^{C}
Stress during MS	3.68^{C}	43.67^{AB}	350.0	11925^{AB}	5.4^{A}
Stress during LS	4.45^{AB}	49.20^{A}	321.6	12688^{A}	4.5^{AB}
Stress in all stages	4.67^{A}	37.36^{BC}	371.5	7526^{C}	4.1^{B}
FI in all stages	4.6^{BA}	38.70^{BC}	454.9	8672^{Bc}	2.5^{C}
CV (%)	8.4	9.04	50	23	16
LSD (0.05)	0.64	6.66	325	3923	0.9

As shown in table 4, marketable yield of onion is affected with the application of deficit irrigation practice. Accordingly, the mean separation table 5, showed stress during mid-growth stage as well as stress during development stage gave better yield of marketable onion bulb yield.

***NOTE**: The data presented in this report are currently being elaborated for scientific publication, thus some of them are not final. The aim of this report is to summarize the nature and quality of the activities conducted and of the dataset generated, and to illustrate the main results obtained.*

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