# Effect of deficit irrigation on growth and yield of Garlic

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**

ICARDA
Science for Better Livelihoods in Dry Areas

**In collaboration with**

ARARI

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# About the Project

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**Project coordinator**

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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

**Activity type:** Technology generation

**Report submitted by:** Ertiban Wondifraw

**Summary Report**

In the framework of the project 'Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia', the effect of deficit irrigation (DI) on the yield and yield components of garlic was studied at Gumara-Maksegnit watershed with a budget support of ICARDA. In the study area irrigation practices are common 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 by increasing water productivity with insignificant or minimum yield penalty. Therefore, the experiment was done to evaluate DI on the yield of garlic and water productivity.

The experiment was implemented at two farmers' plot 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 92kg/ha and 105 kg/ha respectively were applied to each plot at transplanting. All the necessary agronomic practices such as weeding, earthening up, row and plant spacing were the same for each plot.

Data were analysed for variance and LSD at 5% level of significance. As the one-year result showed that, DI had significant effect on yield and water productivity of Garlic. The maximum yield was recorded at full irrigation applications while, the minimum yield was obtained at application of deficit irrigation throughout the season. All stages deficit gave maximum water productivity and the lower water productivity was recorded at farmers practice. To give a reliable conclusion it will be necessary to include the second year data which is on trial.

**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; 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).

Garlic is one of the known vegetable crops in the world with respect to its production and economic value. It is used as a seasoning in many foods worldwide. It has maximum nutritive content than other bulb crops in addition to containing antibiotics like garlicin and allistatin (Maly L.et al 1998).

Garlic is the most widely used crop next to onion and has a wide range of climatic and soil adaptation (Dessalegn L. and E. Herath. 1994). It can be produced in areas where about

600mm rain is occurred in its growth periods. Moderate climatic condition suits for garlic production. Up to 300c temperature is important for bulb development; high humidity and rainfall affects negatively in both vegetative growth and for bulb formation (Sovovo M. and Sova P.2004). In Ethiopia, garlic, onion and shallot are important bulb crops produced for consumption and are income generating crops to most farmers in many parts of the country (Metasebia M. and Shimelis H 1998). The production systems of these crops are mainly in irrigation.

Garlic has shallow and sparse root system with roots limited to the top 60cm of the soil and maximum yield can be obtained when the soil moisture contents keep near to field capacity of the soil throughout the growing season. But it does not need over irrigation. The most critical stage for watering is during bulb development. Shortage of irrigation water or rainfall during this stage will result in smaller bulbs and earlier maturity. Over watering as the crop matures results bulb splitting and may cause storage problems (Drost, D.2010). In the watershed, flood/border irrigation is widely practiced for garlic and onion, which results in inefficient use of irrigation water due to losses in deep percolation, distribution and evaporation. Many studies have been carried out worldwide regarding the effects of deficit irrigation on yield of mainly horticultural crops. (F. J. Olalla et al.2004, C. Fabeiro Cortés et al .2003, Fereres E and Soriano MA. 2007). However, few studies on water use and water management of garlic exist. Therefore, this proposal is initiated to define deficit irrigation scheduling for garlic 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 garlic 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 Sand | Silt | Clay | Tex class |
| >100 | 1.54 | 1.63 | 7.05 | 0.10 | 31.38 | 30.56 | 11.68 | 57.76 | Clay |

### Treatments

There were seven irrigation treatments. Irrigation application depths were determined on the basis of soil water storage depletion. 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 irrigate much water beyond the soil field capacity level. This results runoff and deep drainage beyond the crops demand. On the other hand, farmers irrigate their plots in long interval; 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 reduced yield, poor quality and low water productivity.

**Table 2: Treatment setup of the experiment.**

| Trt code | Treatments | Description of the treatments |
|---|---|---|
| 1 | Farmers practice | Farmers use border irrigation system, no furrow, farmers irrigate this treatment on their required amount, but the researcher simply measure that amount |
| 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 based on the moisture content of the soil, |
| 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 based on the moisture content of the soil |
| 5 | Stress during late stage | From 90 days to maturity, the plots were applied with deficit based on the moisture content of the soil |
| 6 | Stress in all stages | Throughout the growing stages, the plots were received deficit irrigation based on the moisture content of the soil |
| 7 | optimum irrigation at all stages | Throughout the growing stages, the plots were received full irrigation based on the moisture content of the soil |

# 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.

### The response variables measured

Bulb diameter, No. cloves per bulb, yield, plant height and stand count, each variable were measured from the middle rows to avoid border effects.

**Statistical design:**

Randomized complete block design (RCBD) with three replications was used. The plot size was 3m by 3m. 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. Garlic (local variety) was tested; with spacing 30*10cm between rows and plants respectively

**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 (table 1), highest water productivity was obtained in all stages stress condition while it gave a lower yield. But DI has no significant difference on stand count and number cloves per bulb. Farmers practice gave a significant higher yield over the deficit treatments, but its water productivity is the least. There was no a significant yield difference between full/optimum irrigation and stress during late stages.

**Table 3: Effect of DI on stand count, number cloves per bulb and yield garlic**

| Treatment | SC/ha | No of cloves /bulb | Yld kg/ha | WP kg/m$^3$ |
|---|---|---|---|---|
| Farmers practice | 244213 | 11 | 7291.8$^a$ | 0.45$^c$ |
| Stress during IS | 238812 | 10 | 5389.0$^c$ | 0.89$^b$ |
| Stress during DS | 236728 | 10 | 4982.1$^c$ | 0.94$^{ab}$ |
| Stress during MS | 218981 | 10 | 5199.7$^c$ | 0.89$^b$ |
| Stress during LS | 260494 | 10 | 6226.9$^b$ | 1.07$^a$ |
| Stress in all stages | 216975 | 9 | 3632.9$^d$ | 0.98$^{ab}$ |
| OI in all stages | 264660 | 8 | 6298.5$^b$ | 0.96$^{ab}$ |
| CV(%) | 13.91 | 16.38 | 10.4 | 11.78 |
| LSD (0.05) | ns | ns | 729.36 | 0.13 |

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

# 6 Special issues raised

While the second year experiment was on trial, it was stolen before the necessary data got collected. Therefore, these preliminary data refer to one year only.

***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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