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Determination of Optimal Nitrogen Fertilizer Rate and Soil Moisture Level for Onion (*Allium Cepa L.)* in Central Rift Valley of Ethiopia

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Abstract

Irrigation is a vital practice in the Central Rift Valley of Ethiopia. However, water scarcity is the major limiting factor to agricultural production and productivity in the area. A field experiment was conducted on clay loam soil at the experimental field of Melkassa Agricultural Research Centre with the objectives of determining optimal Nitrogen fertilizer rate and soil moisture level for the onion yield and water productivity. The experiment was arranged in split-plot design with three replications. The treatments include three soil moisture levels (100% ETc, 75% ETc and 50% ETc) as main plot and four nitrogen fertilizer rates of 23, 46, 69, 92 and no nitrogen as a sub-plot. The highest average bulb yield of 28.6 t/ha was obtained at the full application of irrigation(100% ETc) and the lowest average bulb yield of 22.8 t/ha was recorded at 50% level of irrigation deficit. Onion bulb yield increased significantly with an increase in nitrogen fertilization from 23 to 92 N rate kg/ha. The highest average bulb yield of 30.1 t/ha was obtained at the 92 Kg/ha N rate and the lowest average bulb yield of 20.1 t/ha was recorded from no application of nitrogen rate. The highest bulb yield of 33.1 t/ha was recorded from the fully irrigated that combined with high nitrogen levels. Moisture stress at different deficit levels with the nitrogen levels had a significant ($p<0.05$) influence on water productivity. Water productivity was higher for 92 N-rate kg/ha treatment and minimum water productivity was obtained at zero nitrogen rate treatment. Therefore, under a limited water area, it can be concluded that more water-saving and an associated increase in water productivity with high nitrogen fertilizer resulting in a yield increment of the onion by 32.5% can solve the problem of water shortage.

Keywords: Deficit irrigation • Evapotranspiration • Nitrogen rate • Onion • Water productivity

Introduction

Background and justification

Irrigated agriculture is the main user of the available water resources. About 70% of the total water withdrawals and 60-80% of total consumptive water use are consumed in irrigation [1]. The irrigated area should be increased by more than 20% and the irrigated crop yield should be increased by 40% in 2025 to secure the food for 8 billion people [2]. Therefore, water resources should be used with higher efficiency or productivity. To achieve this goal, improvement in agricultural water productivity is highly imperative. Many investigations have been conducted to gain experiences in irrigation of crops to maximize performance, efficiency, and profitability, and investigations in water-saving irrigation still are continued [2]. Therefore, this project component will be developed with the aim of improving crop water productivity through different water-saving mechanisms. The sustainable use of water in agriculture has become a major concern. The adoption of strategies for saving irrigation water and maintaining acceptable yields may contribute to the preservation of this ever more restricted resource [3]. In areas of water shortage and long summer droughts, maximizing water productivity may be more beneficial to the farmer than maximizing crop yield.

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Globally, fertilizer demand is projected to continue rising. It is forecast to reach about 200 Mt towards 2020 [4]. Future growth will be influenced by nutrient use efficiency gains, which have been observed for three decades in developed. In contrast, there are still large areas where farmers use little fertilizer and mine their soil nutrient reserves. This is particularly the case in sub-Saharan Africa, where farmers are estimated to have used 11 kg nutrients/ha in 2013, i.e. only 10% of the global average, but the region has witnessed the strongest growth rate since 2008. Plant nutrients and water are complementary inputs, the incremental return to fertilizer inputs is larger when water is not limiting and vise verse. Smallholder farmers must also consider risk and uncertainty when determining whether or not to apply fertilizer. If rainfall is inadequate or late in arriving, the investment in fertilizer might generate no return. Performance of agricultural inputs fertilizer and water use efficiency should be analyzed together, reflecting the overall effectiveness of the farming system, including crop yield and soil nutrient levels. Therefore, this study is conducted to determine the optimum rate of nitrogen and required irrigation level, and to identify the interactive effect of nitrogen and moisture levels on yield and yield quality of onion.

Materials and Methods

Description of the study area

Field experiment was conducted at Melkassa Agricultural Research Center (MARC). The center is located in the Central Rift Valley, Ethiopia at 8°24′ - 8°25′ N latitude, 39°18′ - 39°19′ E longitude, and altitude of 1,550 m above sea level. The mean maximum temperature varies from 26.4 to 30.9 °C while the mean minimum temperature varies from 11.1 °C to 16.5 °C, with an average value of 20.12 °C. The average annual rainfall in the area is 824.9 mm. The climate of the area is characterized as semi-arid with a uni-modal low and erratic rainfall pattern. Loam and clay loam soil textures are the dominant soils of the area

Experimental design: A field experiment was conducted to determine optimal Nitrogen fertilizer rate and soil moisture levels for onion *(Allium Cepa L.)* yield and water productivity at Melkassa Agricultural Research Center in the

Central Rift Valley of Ethiopia for three years. The experiment was designed as a split-plot design in RCBD and replicated three times. Three irrigation water application levels: 100% ETc, 75% ETc and 50% ETc, and four Nitrogen levels and 100% ETc with zero level N as a control treatment were applied. The treatments were randomized both at the main and sub-plot levels. The deficit irrigation levels in the main plots while Nitrogen fertilizer rate in subplots. Onion seedlings were prepared at the nursery. The experimental plots inter and intra row spacing were done based on the recommended agronomic value for onion. Onion is known by two row crop so transplanting was done on 40 cm, 20 cm and 10 cm spacing of row plant (i.e, plant row spacing across furrow was 40 cm, across the ridge was 20 cm and along the ridge 10 cm between plants). The experimental field was divided into 45 plots and each plot size was 3.6 m × 5.5 m dimension (19.8 m^2 plot area) to accommodate six furrows with a spacing of 60 cm and having 5.5 m in length. Each plot consisted of five ridges and six furrows. The blocks have a buffer zone of 1.2 m from water supplying canal and plots were separated by 2 m from each other to eliminate influence of lateral flow of water. A field channel was constructed for each block to irrigate the field. For each plot box shaped structures were constructed to dissipate the energy of water diverted to the plots. The amount of irrigation water applied calculated using CROPWAT 8.0 software by using necessary input data (crop, soil and climatic data). Irrigation water applied up to field capacity by monitoring soil moisture content using gravimetric method and/or using soil moisture measuring devices at different soil depth interval from the surface to the depth of maximum root zone depth depending on the crop type. Applied water to the field measured by parshall flume (Table 1).

Soil analysis: Representative soil samples were taken from the experimental site for chemical analysis (PH, EC, CEC, total available N, OC, and OM) and for physical property (BD, Texture, FC, and PWP). Soil moisture was measured before and after irrigation using gravimetric method.

Materials: Soil auger, flow measuring device (parshall flume), soil moisture measurement devices (oven dry) and stopwatch.

Collected Data: The crop data was collected from the middle rows in order to avoid border effects. The plants were picked randomly carefully from middle three rows by avoiding one plant from starting and ending of three middle rows. Data related to yield and yield components were recorded.

Water productivity: Water productivity (WP) was estimated as a ratio of grain yield to the total ETc through the growing season and calculated using the following equation [5].

WP =(Y/ET)

Where, WP is water productivity (kg/m^3), Y crop yield (kg/ha) and ET is the seasonal crop water consumption by evapotranspiration (m^3/ha).

Data Analysis: Yield and yield components data and water productivity data were subjected to statistical analysis using the SAS package.

Results and Discussion

To evaluate the yield response to deficit irrigation in combination with the Nitrogen levels, a number of direct and indirect measurements had been made. These included computations of crop water requirement using climate data, determination of nitrogen levels, determination of water use efficiency and yield performance assessment. Yield response of onion to deficit irrigation and nitrogen levels: The highest average bulb yield of 28.6 t/ha was obtained at the full irrigation level and the lowest average bulb yield of 22.8 t/ha was recorded at 50% deficit irrigation as presented in (Table 2). The bulb yield differences were significant at 5% level of probability. The yield reductions with increased deficit irrigation levels from 0 to 25 and 50% were 6.3, and 20.3%, respectively. Nitrogen fertilization treatments had also shown a marked effect on onion bulb yield. Onion bulb yield increased significantly with an increase in nitrogen fertilization from 23 to 92 N rate kg/ha. The highest average bulb yield of 30.1 t/ha was obtained at the 92 Kg/ha N rate and the lowest average bulb yield of 20.1 t/ha was recorded at none application of N rate as presented in Table 2. However, an increase in yield with 46 kg/ha from 92 kg/ha was insignificant. The bulb yield differences were significant at a 5% level of probability. The bulb yield increased with increased nitrogen rate from 0 to 23, 46, 69 and 92 kg/ha was 19.4, 34.3, 44.8 and 49.8%, respectively.

Deficit irrigation in combination with nitrogen levels had significantly influenced the bulb yield of onion ($P<0.05$). The highest bulb yield of 33.1 t/ha was recorded from the fully irrigated that combined with high nitrogen levels. It has no significant difference from 100% ETc with 69 and 46 kg/ha N rate and 75% ETc that combined at 92, 69 and 46 kg/ha N rate. The lowest bulb yield of 16.7 t/ha was recorded from the 50% ETc at no nitrogen level. The result indicated that the use of deficit irrigation combined with a high nitrogen fertilizer rate had no significant effect on onion bulb yield as compared to full irrigation combined with a high nitrogen fertilizer rate. The result also indicated that the use of deficit irrigation combined with a high nitrogen fertilizer rate had significantly increased onion bulb yield as compared to the control treatment resulting in a yield increment of onion by 32.5%. Generally, the result shows that using deficit irrigation significantly increases onion production combining with high nitrogen fertilizer rate. Thus 75% ETc is more efficient than 50% for equal amount of nitrogen fertilizer rate application. The water scarcity scenario for irrigation in the short and long term and the probably scenario of water allocation for different uses following criteria of efficiency and productivity, Thus, the strategies for irrigation management would adjust the irrigation depth to fulfill a proportion of crop water requirements. Likewise [6,7] carried out deficit irrigation strategies by estimating economic water productivity indices and water use efficiency indicators that were based on a proper understanding of crop water requirements. Among the various methods and tools to determine crop water requirements, the soil water balance calculation is commonly used (Figure 1).

Table 1. Treatments and treatment combinations.

Treatment	N rate (kg/ha)				
Irrigation Intervals	0	23	46	69	92
100% ETc	T1	T2	T3	T4	T5
75% ETc	T6	T7	T8	T9	T10
50% ETc	T11	T12	T13	T14	T15

Remark: The source material for N was UREA

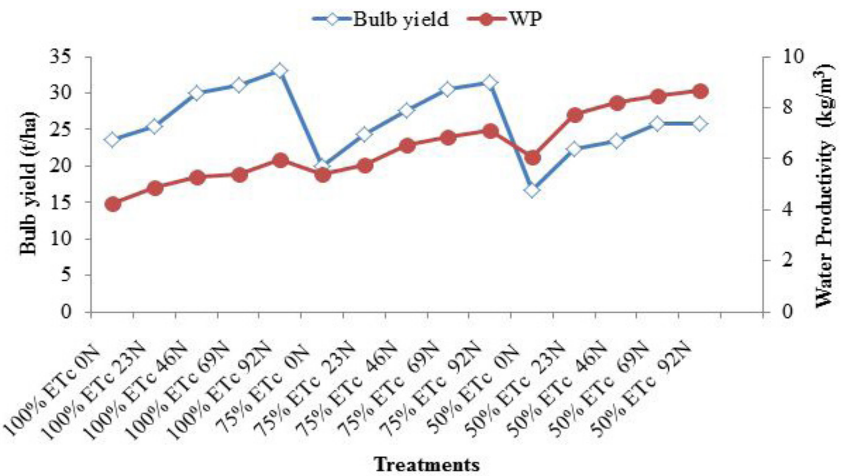

Figure 1. Effect of soil moisture levels and nitrogen rates on onion yield and water productivity.

Table 2. Effect of nitrogen fertilizer rate and soil moisture level on onion yield and WP.

Irrigation Levels (M-plots)	Bulb Yield (t/ha)	WP (kg/m³)
100 % ETc	28.6a	5.2c
75 % ETc	26.8b	6.3b
50 % ETc	22.8c	7.8a
$LSD_{(0.05)}$	1.51	0.56
CV (%)	9.87	12.19
N-rate (Kg/ha) S-plot	**Yield (t/ha)**	**WP (kg/m³)**
92	30.1a	7.3a
69	29.1a	6.9ab
46	27.0ab	6.7b
23	24.0bc	6.1c
0	20.1c	5.3d
$LSD_{(0.05)}$	3.99	0.52
CV (%)	28.37	12.22

Table 3. Interaction effect of irrigation levels and nitrogen rate on onion bulb yield and WP.

Irrigation levels	Bulb yield (ton/ha)					Water productivity (Kg/m³)				
	Nitrogen rate									
	0N	23N	46N	69N	92N	0N	23N	46N	69N	92N
100% ETc	23.7^{def}	25.4^{bcdef}	29.9^{abcd}	31.1^{ab}	**33.1^{a}**	**4.3h**	4.9gh	5.3fg	5.4fg	6.0def
75% ETc	19.9^{fg}	24.4^{cdef}	27.7^{abcde}	30.5^{abc}	31.4^{ab}	5.4fg	5.8efg	6.5cde	6.9bcd	7.1bc
50% ETc	**16.7^{g}**	22.3^{efg}	23.5^{efg}	25.9^{bcdef}	25.7^{bcdef}	6.1def	7.8ab	8.2a	8.5a	**8.7a**
LSD(0.05)			6.909					0.907		

Water productivity: Moisture stress at different deficit levels had a significant ($p<0.05$) influence on water productivity. Water productivity was higher for moisture stressed treatment. The minimum water productivity was obtained at no stressed treatment due to high water usage. Moisture stress at different deficit levels with the nitrogen levels had a significant ($p<0.05$) influence on water productivity. Water productivity was higher for 92 N-rate kg/ha treatment and minimum water productivity was obtained at zero nitrogen rate treatment due to low product. The study revealed that producing onion with 92 N-rate kg/ha resulted in higher product and water productivity as shown in Table 2. The interactive effect of deficit irrigation and nitrogen fertilizer rate had a significant ($p<0.05$) influence on water productivity (Table 3). The highest water productivity was recorded from the 50% ETc combined with a high nitrogen fertilizer rate. The lowest water productivity was recorded from the full irrigation that was no nitrogen fertilizer (control treatment). The result also indicated that the use of deficit irrigation combined with high nitrogen fertilizer rate resulted in a yield increment of onion by 32.5% and increase water productivity by 65% against the control treatment [8,9].

Conclusion

The aim of this experiment was to determining optimal Nitrogen fertilizer rate and soil moisture level for onion yield and water productivity. The experiments have been laid out in a split-plot design with three replications having 15 experimental treatments. The result indicated that the use of deficit irrigation combined with a high nitrogen fertilizer rate had no significant effect on onion bulb yield as compared to full irrigation combined with a high nitrogen fertilizer rate. Water productivity was higher for moisture stressed treatment. Moisture stress at different deficit levels with the nitrogen levels had a significant influence on water productivity. The highest water productivity was recorded from 50% ETc combined with a high nitrogen fertilizer rate. The lowest water productivity was recorded from the full irrigation that was no nitrogen fertilizer (control treatment). The result also indicated that the use of deficit irrigation combined with high nitrogen fertilizer rate resulted in a yield increment of onion by 32.5% and increase water productivity by 65% against the control treatment. Generally, the result shows that using deficit irrigation significantly increases onion production combining with high nitrogen fertilizer rate. Thus 75% ETc is more efficient than 50% for equal amount of nitrogen fertilizer rate application.

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References

1. Huffaker, Ray, Joel Hamilton, Steven R. Evett and Robert J. Lascano, et al. "Irrigation of agricultural crops." 30 (2007).
2. Sleper, D. A., S. L. Fales and M. E. Collins. Foreword in Irrigation of agricultural crops agronomy monograph ASA-CSSA-SSSA publishing (2007): 664
3. Topcu, Gulacti, Abdulselam Ertas, Ufuk Kolak and Mehmet Ozturk, et al. "Antioxidant activity tests on novel triterpenoids from Salvia macrochlamys." *Arkivoc* 7 (2007): 195-208.
4. Heffer, Patrick and Michel Prud'homme. "Fertilizer outlook 2014-2018." Paris, France: International Fertilizer Industry Association (*IFA*) (2014).
5. Zwart, Sander J and Wim GM Bastiaanssen. "Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize." *Agric Water Manag* 69 (2004): 115-133.
6. Pereira, Rogério Gomes, Alexandre Bryan Heinemann, Beata Emoke Madari and Marcia Thais de Melo Carvalho, et al. "Transpiration response of upland rice to water deficit changed by different levels of eucalyptus biochar." Pesquisa Agropecuária Brasileira 47 (2012): 716-721.
7. Allen, Richard G., Luis S. Pereira, Dirk Raes and Martin Smith. "Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56." Fao, Rome 300 (1998): D05109.
8. Kang, Shaozhong, Zongsuo Liang, Yinhua Pan and Peize Shi, et al. "Alternate furrow irrigation for maize production in an arid area." *Agric Water Manag* 45 (2000): 267-274.
9. Sun, Hong-Yong, Chang-Ming Liu, Xi-Ying Zhang and Yan-Jun Shen, et al. "Effects of irrigation on water balance, yield and WUE of winter wheat in the North China Plain." *Agric Water Manag* 85 2 (2006): 211-218.

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