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Participatory Evaluation and Demonstration of Alternative, Fixed and Conventional Furrow Irrigation on Onion Yield and Water Use Efficiency at Mirab Badawacho Woreda

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Abstract

Water saving irrigation technologies are key for crop production in arid and semi-arid lands considering the scarcity of water in these regions. Deficit irrigation is thought to be one of the promising strategies to increase water use efficiency (WUE) under scarce water resources. The experiment was conducted at Mirab Badawacho Woreda, Hawora Kebele, Goche Irrigation Scheme of SNNPR of Ethiopia. A study was carried out to investigate and demonstrate the effect of Alternate furrow irrigation (AFI), Fixed furrow irrigation (FFI) and Conventional irrigation (CFI) on yield of onion and water use efficiency. To achieve this three treatments(AFI, FFI and CFI) were laid in randomized complete block design(RCBD) with five replications. Yield and yield component data were collected and analyzed using SAS software in probability of 5% confidence level. The results showed that there is no significant difference between the treatments on plant height, bulb diameter, bulb weight, and yield of onion, but alternative and fixed furrow irrigation save 50% of irrigation water as compared to conventional furrow irrigation. The minimum water use efficiency is obtained under conventional furrow irrigation and a significant difference over alternative and fixed furrow irrigation. Therefore, For Onion, irrigation with Alternative and Fixed furrow irrigation were recommended as it gives yield very near to that under full irrigation, provides good saving water application time, energy, irrigation water and improves crop water productivity.

Key Words: Alternative, Conventional, Fixed ,Onion , Water productivity

Introduction

Onion (Allium cepa L.) is an important bulb crop, belonging to the family Alliaceae (Hanelt,1190). It is one of the most important and popular bulb crops cultivated commercially in nearly most parts of the world. Onion is considered as one of the most important vegetable crops produced on large scale in Ethiopia and also occupies economically important place among vegetables in the country(Lemma and Shimeles, 2003). It is important in the daily diets of human's in worldwide and Ethiopians as well (MoARD, 2009). Onion is a recently introduced

bulb crop in the agriculture commodity of Ethiopia and it is rapidly becoming a popular vegetable among producers and consumers (Lemma and Shimeles, 2003; Dawit *et al.*, 2004). Onion is one of the most important vegetable crops in Ethiopia which is used almost daily as a spice and vegetable in the local dish regardless of religion, ethnicity, and culture (CSSE, 2006).

Furrow irrigation, reported to be one of the least efficient methods compared with other irrigation methods (Burt, *et al*, 1997) is still one of the most widely used forms of surface irrigation. The studies of (Du, *et al.*, 2010) have been suggested efficiency of conventional furrow irrigation (CFI) or every furrow irrigation, can be improved by converting it to alternate furrow irrigation (AFI).

Deficit irrigation has been used as a water saving method in agricultural production to increase benefit and water use efficiency (Mitchel, *et al*,1991). Deficit irrigation, under furrow irrigation, can be induced via different irrigation techniques such as fixed-furrow. Fixed furrow irrigation (FFI) is a way to save water and showed a small improvement over the alternate furrow irrigation (Slatni, *et al*, 2011).

For economic and environmental benefit of using every-other furrow irrigation method is higher than any other irrigation methods, because less water is applied and a greater economic return can be obtained (Nelson, *et al*, 2011).

Other investigations had shown that alternative furrow irrigation which affects the stomata may directly respond to the availability of water in the soil by reducing their opening (Kang et al., 1998). Evaluations of alternative furrow irrigation (AFI) have been made for Onion (Deribew,), for Potato (Woldesenbet, 2005) and for Maize (Mitslal, 2008).

Different techniques of saving agricultural water use have been investigated globally. Various researchers (Stone and Nofziger, 1993) have used wide spaced furrow irrigation or skipped crop rows as a means of improving WUE. They selected some furrows for irrigation while other adjacent furrows were not irrigated for the whole season i.e. fixed furrow irrigation (FFI) which means that irrigation is fixed to one of the two neighboring furrows. Irrigation water scarcity is a major problem in arid and semi arid area of Ethiopia. Therefore, this study investigates the best water saving furrow irrigation systems without significant yield reduction.

Materials and Methods

Description of the study area

The study was conducted at Hawora Kebele, Mirab Badawacho Woreda, Hadeya zone of southern nation nationality and peoples of Ethiopia. Mirab Badawacho, is one of Woredas (districts) in Hadiya Zone which found in SNNPR. It is bordered with Kambata Tambaro Zone north and north-east and east by Misrak Badawa

cho and with south by Wolaita Zone and with north west Kachabira Woreda. And it is located about 357 km south west of Adis Abeba and 127 km from the regional Capital, Hawassa. The major vegetable crops grown are Tomato, Onion, Head cabbage, Hot-pepper. The experimental site was located at an altitude range of 1700 -1800 m.a.s.l m.a.s.l, latitude range of $07^{0}7'$ - $07^{0}10'N$ and longitude range $37^{0}44'$ - $37^{0}47'E$.



Experimental Design and Treatment

The experiment was laid out in randomized complete bock design with three treatments and five replications (farmers were used as replication). The treatments were alternate furrow irrigation (AFI), fixed furrow irrigation (FFI) and conventional furrow irrigation(CFI). The size of each plot was 10m by 10m and Space between plots been 1m and between replication 1.5m. Space between plant, plant rows and rows 10cm, 20cm and 40cm respectively was used.

Climate data

The average climatic data (Maximum and minimum temperature, relative humidity, wind speed, and sun shine hours) of the study area were obtained from meteorological station. The potential evapotranspiration(ETo) was estimated using CROPWAT software version 8.

Month	Min	Max	Humidity(%)	Wind	Sun(hrs)	Rad	ЕТо
	Temp (°C)	Temp (°C)		(km/day)		(MJ/m?/day)	(mm/day)
January	13.3	29.1	77	95	8.1	19.9	3.91
February	14	29.7	75	104	7.6	20.3	4.18
March	13.8	28.8	81	173	7.5	21	4.35
April	13.5	28.1	92	130	7.1	20.4	3.95
May	13.1	26.3	93	104	6.1	18.3	3.47
June	12.8	24.2	94	104	5.9	17.6	3.19
July	12.3	22	92	95	3.7	14.5	2.65
August	12.1	22.5	90	104	4.2	15.6	2.82
September	12.8	25.5	97	86	5.6	17.9	3.23
October	12.8	27.2	87	95	7.2	19.8	3.71
November	13	29.2	87	69	8.8	21.1	3.96
December	12.8	29	72	69	8.3	19.7	3.78
Average	13	26.8	86	102	6.7	18.8	3.6

Average climatic data of the experimental area

Crop Data

Maximum effective root zone depth (RZD) of onion ranges between 0.3 - 0.6 m, total growing period ranges from 135 - 175 days, seasonal crop water requirement 350 - 550mm and has allowable soil water depletion fraction (P) of 0.25(Andreas *et al.*, 2002). Onion average Kc would be taken after adjustments have been made for initial, mid and late season stage to be 0.7, 1.05 and 0.95, respectively.

Soil Data

Soil physical and chemical properties like textural class, bulk density, field capacity, permanent wilting point and infiltration rate, acidity, electric conductivity of the soil was measured in the field and laboratory.

The soil was analyzed in laboratory, gravimetric method, pH meter method, soil and water ratio method were used to determine soil moisture content, pH value and electrical conductivity respectively.

Crop Water Determination

Crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration (Allen *et al.*, 1998). For the determination of crop water requirement, the effect of climate on crop water requirement, which is the reference crop evapotranspiration (ET_0) and the effect of crop characteristics (Kc) are important (Doorenbos and pruitt, 1977). The long term and daily climate data like maximum and minimum air temperature, relative humidity, wind speed, sunshine hours, and rainfall data of the study area were collected to determine reference evapotranspiration. Crop data like crop coefficient, growing season and development stage, effective root depth, critical depletion factor of onion and maximum infiltration rate and total available water of the soil was determined to calculate crop water requirement using CropWat model.

ETc = ETo x Kc

Where, ETc= crop evapotranspiration, Kc = crop coefficient, ETo = reference evapotranspiration.

Irrigation Water Management

The total available water (TAW), stored in a unit volume of soil will be determined by the expression.

$$TAW = \frac{(FC - PWP) * Bd * Dz}{100}$$

For maximum crop production, the irrigation schedule should be fixed based on readily available soil water (RAW). The RAW could be computed from the expression:

$$RAW = (TAW * p)$$

Where, RAW in mm, p is in fraction for allowable/permissible soil moisture depletion for no stress and TAW is total available water in mm.

The depth of irrigation supplied at any time can be obtained from the equation

$$Inet(mm) = (ETc_{mm} - Peff_{mm})$$

The gross irrigation requirement was obtained from the expression:

 $GI = \frac{NI}{Ea}$

Ea=application efficiency of the furrows (60%)

The time required to deliver the desired depth of water into each furrow will be calculated using the equation:

$$t = \frac{1 * w * dg}{6Q}$$

Where: $d_g = \text{gross depth of water applied (cm), t} = \text{application time (min), l} = \text{furrow length in (m), w} = \text{furrow spacing in (m), and Q} = \text{flow rate (discharge) (l/s)}$

Data Collection

Climate data like maximum and minimum air temperature, relative humidity, wind speed, sunshine hours and rainfall data was collected to calculate crop water requirement. To determine physical and chemical properties of soil, samples were collected gravimetrically. Amount of applied water per each irrigation event was measured using calibrated parshall flume. During harvesting plant height, bulb weight, and bulb diameter were measured from the net harvested area of each plot.

Statistical Analysis

Data were analyzed using SAS 9.0 statistical software at probability of 5% confidence level. The factor of the experiment was considered as single factorial Randomized Complete Block Design (RCBD) during the analysis.

RESULT AND DISCUSSION

Physical and Chemical Properties of Soil

The average result of soil textural analysis showed that, the composition of sand, silt and clay percentage were 32, 17.5 and 50.5 respectively. Thus, according to the USDA soil textural classification, the experimental site soil were clay soil. The top soil surface had slightly lower bulk density (1.04g/cm3) than the subsurface(1.34g/cm3). Bulk density typically increase increases with soil depth since subsurface layers are more compacted and have less organic matter, less aggregation, and less root penetration as compared to surface layer, therefore contain less pore space. The bulk density shows slight increase with depth. This is because of slight decrease of organic matter with depth and compaction due to the weight of the overlying soil layer (Brady and Weil, 2002). In general, the average soil bulk density of study site(1.18 g/cm3) is below the critical threshold level (1.4 g/cm3) and was suitable for crop root growth. The acidity(pH) of the study site soil is 4.7, thus the United States Department of Agricultural National Resources Conservation Service groups soil pH values 4.5 - 5.0 range is very strongly

acid(Burt, 2018). strongly acidic soil have influence on growth and yield of onion production. Soil pH for onion is suitable with a range of 6.2 to 6.8.(Karim and Ibrahim, 2013). The electric conductivity critical value for agricultural use according to Hillel, (1980) is < 2.0 ds/m. Thus, the experimental site soil was less than this value (1.55 ds/m), so it is suitable for onion growth.

Soil property	Soil depth in (cm)						
	0-20	20-40	40-60	60-80	average		
Particle size	Clay %	46	50	52	54	50.5	
distribution	Sand %	36	30	34	28	32	
	Silt %	18	20	14	18	17.5	
Textural class	clay	Clay	clay	clay	clay		
pH		4.88	4.67	4.6	4.66	4.7	
EC (ds/m)	1.45	1.59	1.60	1.56	1.55		
BD (g/cm3)		1.04	1.03	1.32	1.34	1.18	

Soil	result	of	the	study	site
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Onion response to furrow irrigation

The table shows that there is no significant difference between the treatments on plant height, bulb diameter, bulb weight, and yield of onion, But alternative and fixed furrow irrigation save 50% of irrigation water as compared to conventional furrow irrigation. The minimum water use efficiency is obtained under conventional furrow irrigation and a significant difference over alternative and fixed furrow irrigation. Conventional furrow irrigation reduce the water use efficiency significantly as compared to fixed and alternative furrow irrigation systems. The highest water use efficiency(11.4kg/m3) water use efficiency(5.72kg/m3) was obtained under conventional furrow irrigation.

Treatment	PH(cm)	BD(CM)	BW(gm)	TY(t/ha)	WUE(kg/m3)
Alternative furrow irrigation	38.56	3.7	144	25.12	11.4a
Fixed furrow irrigation	42.37	3.62	139	24.9	11.06a
Conventional furrow irrigation	43.07	3.97	178	25.78	5.72b
CV(%)	8.08	13.23	37.13	4.83	4.82
LSD (5%)	NS	NS	NS	NS	0.654

Conclusion And Recommendation

In this study, Alternative and Fixed furrow irrigation has the potential to save 50 % of irrigation water relative to conventional furrow irrigation, greatly improving water use efficiency, without causing a detrimental effect on the bulb yield under the studied semi-arid climate of Ethiopia. Yields of the onion in double row on ridge system under an alternative and fixed furrow irrigation system were similar to those under the conventional furrow irrigation. Alternative and Fixed furrow irrigation were also saved time and labour by 50% because irrigate only half

number of furrows within a plot. Therefore, in water scarce area alternative and fixed furrow irrigation were recommended to save water, time and labour without significant yield reduction.

REFERENCES

- Burt, C. M., Clemmens, A. J., Strelkoff, T. S., Solomon, K. H., Bliesner, R. D., Hardy, L. A., Howell, T. A., Eisenhauer, D. E., (1997). Irrigation performance measures: efficiency and uniformity. J. Irrig. Drain. Eng. 123, 423–442.
- Burt,R., (2014). Soil Survey Staff. Soil survey laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. 5th ed. U.S. Department of Agriculture, Natural Resources Conservation Service. pp. 276-279
- CSSE (Crop Science Society of Ethiopia)(2006). Farmers' participatory onion seed production in the Central Rift Valley of Ethiopia: achievement, constraints and its implication for the national seed system. Conference summary, The Conference of the Crop Science Society of Ethiopia, Addis Abeba, Ethiopia.
- DawitAlemu, AberaDeressa, Lemma Desalegn and Chemdo Anchala(2004). Domestic vegetable seed production and marketing. Research report. No 57. EARO, Addis Ababa, Ethiopia.
- Deribew Shanko, (2006). Performance evaluation of alternate, fixed and conventional furrow irrigation systems for onion production. MSc Thesis Presented to the School of Graduate Studies of Haramaya University, Harer, 103p.
- Du, T. S., Kang, S. Z., Sun, J. S., Zhang, X. Y., Zhang, J. H., (2010). An improved water use efficiency of cereals under temporal and spatial deficit irrigation in north China. *Agric. Water Manag.* 97 (1), 66–74.
- HaneltP(1990) Taxonomy, Evolution and History in onions and Allied crops, edited by Harim D.
- Kang S., Liang, Z., Hu, W., and Zhang, J., (1998). Water use efficiency of controlled root division alternate irrigation on maize plants. Jornal of Agricultural Water Management, 38, 69-76.
- Karim Smr and Ibrahim Nr,(2013). Effect of Planting Time, Day Length, Soil pH and Soil Moisture on Onion. International Journal of Biology, Pharmacy and Applied Science. 2(4): 807-814.
- Lemma D, Shimeles A (2003). Research experiences in onions production. Research report No. 55, EARO, Addis Ababa Ethiopia, p: 52.
- Mitchell, J. P., Shennan, C., Grattan, S. R. & May, D. M.(1991), Tomato fruit yields and quality under water deficit and salinity. *J Amer Soc Hort Sci*, 116, pp. 215-221.
- Mitslal Gebreslassie, (2008). Performance of alternate and conventional furrow irrigation methods on maize (Zea mays L.) production. MSc Thesis Presented to the School of Graduate Studies of Alemaya University, Harer, 86p.

- MoARD(2009). Rural Capacity Building project. Course for Training of trainers on improved . *Horticultural crop technologies*. 5-19.
- Nelson, D. J. & Al-Kaisi, M. M.,(2011). Agronomic and economic evaluation of various furrow irrigation strategies for corn production under limited water supply. *Journal of Soil and Water Conservation*, 66(2), pp. 114-120.
- Slatni, A., Zayanib, K., Zairia, A., Yacoubia, S., Salvadorc, R. & Playánc, E.,(2011). Assessing alternate furrow strategies for potato at the Cherfech irrigation district of Tunisia. *Biosystems Engineering*, 108(2), pp. 154-163.
- Stone, J.F, and D.L, Nofzger. (1993). Water use and yields of cotton grown under wide spaced furrow irrigation. Agricultural Water Management 24: 27-38.
- Woldesenbet Gebre. (2005). Evaluating Alternate furrow irrigation for potato production in subhumid area of east gojam. Degree of master of science in soil and water engineering. Ale maya University, Alemaya, 92p.

