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:

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

Where: d_g = gross depth of water applied (cm), t = application time (min), l = furrow length in (m), w = furrow spacing in (m), and Q= 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 result of the study site

Soil property		Soil depth in (cm)				
		0-20	20-40	40-60	60-80	average
Particle size distribution	Clay %	46	50	52	54	50.5
	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

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.