Determination of Optimum Irrigation Scheduling for Onion at Kewot Woreda

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Abstract

Kewot woreda, which is located in Nort Shewa about 200 km away from Addis Ababa on the road to Dessie or Mekelle, has long experience in traditional irrigated agriculture. Farmers mainly grow onion in most of irrigation schemes. The irrigation schedule of farmers is not supported by any improved technology and is based on the availability of water and the farmer's turn regardless of the crop type, land size and water requirement. This causes the decline of productivity and quality t (er Th (r t

agriculture. However, most of irrigation practices in the region are run traditionally without considering the spatial and temporal supply of water that in turn affects growth, quantity and quality of crop production.

According to the diagnostic farming system survey of Kewot and Efratana Gedim woredas, there is immense water resources (streams and springs) with potentials for irrigation at both high lands and low lands. However, most of the irrigated farms are found in the low lands mainly Shewarobit, Jewha, Negesso, and Yellen. Extensive use of irrigation at Jewha – Negesso dates back to 1975, but not all potentially irrigable land is still cultivated because the amount of water currently diverted is not enough to irrigate the farmlands (Survey report of Efratana Gedem Woreda, 2001**).**

Onion, the main supplementary component of our daily diet and the high valued cash crop of the area, is the dominant vegetable crop growing by irrigation in these areas. According to A.M. Michael (1981) schedule irrigations of vegetables to maintain continues high soil moisture level in the soil is essential to get desirable yield.

The irrigation system of the study area is mainly traditional and has not been supported by improved technologies that could maximize productivity and water use efficiency. The ultimate economic and environmental consequence of poorly managed irrigation is the destruction of an area's productive base because application of too little water is an obvious waste as it fails to produce the desired benefit. Excessive flooding of the land is still more harmful as it tends to saturate the soil for too long, inhibit aeration, leach nutrients, induce greater evaporation and salinity, and ultimately raise the water table to a level that suppress normal root and microbial activity and that can only be drained and leached at great expense (Daniel, H., 1997)

The experimental area is about 200 km away from Addis Ababa on the road to Mekelle at latitude of 12° 1' 11" North of the equator and longitude of 39° 37' 48" East of the Prime Meridian. In the experimental irrigation scheme, when and how much to irrigate is determined by Water Users Committee of the Schemes based on the amount of available water with out considering land size, soil type, crop type, weather conditions. This causes farmers to apply excess water until water logging is created because they fill

that, unless it is extremely irrigated, it will face water stress until their turn reaches. This led to the decrement of yield quality and quantity in addition to its soil degradation impact such as salinity development and soil erosion.

In a three-year experiment conducted at Worer, onion was found to respond better at frequent rather than prolonged intervals of irrigation and maximum fresh bulb yield was recorded for an irrigation regime of one week frequency and 50 mm application (Michael, A. 2001). The over all three year results of Melkassa also reveal that 50 mm of water at 3-6 days intervals gave the highest yield with the optimum water use efficiency (Lemma, D. and E.Hearth.1992).

But there are not any researches done before in this area regarding irrigation scheduling for better yield and quality of onion while utilizing resources efficiently. Therefore this study was conducted for two years to determine the optimum irrigation amount and frequency of onion in order to utilize water resources in an environmentally friendly and economically feasible way while improving the yield

Materials and Methods

Treatments were set uniformly using Blanely Criddle Crop Water Requirement estimation method (to determine 30 mm per four days interval), previous recommendation from Worer Research center (50 mm water depth per week) and additional 70 mm water depth with various intervals. Blanely Criddle is used for initial estimation because of data limitation for other methods.

Onion seedlings were raised in the nursery and transplanted to the experimental fields at the stage of having three to four true leaves. Recommended onion spacing,40 cm bed including furrow, 20 cm between rows on bed 10 cm between plants used during transplanting. The

irrigation practice based on the availability of water, labor and time makes it difficult to include it as a treatment.

Prior to the application of treatments, common (equal amount) irrigation was applied daily for all experimental plots for one week to favor the establishment of seedlings. The amount of irrigation water for each plot was measured using partial flume in the first year and barrel fitted with plastic hose, which delivers water to the plot in the second year. Recommended Crop protection and agronomic activities were practiced during the experiment.

Data collected include total, marketable, and unmarketable (Decay, split, bolt and under weight) bulb weight, dry matter content, total soluble solids, storability, bulb color and vegetative data (leaf number, plant height, sheath length). Though data on pungency and trips count were planned, undertaking trips count was found to consume too much onion stands and there are no in land laboratories for pungency analysis.

Results and Discussion

Analysis of Variance was conducted by combining two years of irrigation seasons data using SAS statistical software. Analysis of variance shows as there is no significant difference between main plot treatments, depth of irrigation water, for most analyzed parameters except water use efficiency (WUE). Water use efficiency of irrigating 30 mm irrigation depth gave the highest efficiency. Sub plot treatment, irrigation interval, is found more important to affect total, marketable and unmarketable yield than depth of irrigation for this specific location. Though there is no significant difference of parameters for most main plot treatments, irrigating 30 mm depth gave better total and marketable yield, water use efficiency and low unmarketable yield.

Total yield, marketable yield, unmarketable yield (decay, split and bolt), average bulb weight, average leaf number, average sheath length and plant height were found significantly different for irrigation interval while only average sheath length and plant height shows significant difference for irrigation water depth.

A study was conducted for three years at Melkassa using adama red variety to identify the optimum irrigation regime that gives high yield under upper awash sandy loam soil condition. In the study, from three levels of irrigation regimes (3, 5, and 7 cm) and four frequencies (3, 6, 9 and 12 days) relatively higher yield was obtained in the first two frequencies with the highest being at 5cms of water (IAR, 1988a). However, in our case the interaction between main plots (irrigation depth) and sub plots (irrigation interval) is not found significantly different except for unmarketable yield. The rainfall condition of the area during the irrigation season (140.9 mm during first year and 179.1 mm second year) which is by far higher than average value of previous ten years, which was 57.9 mm from 1983 – 2000, and the heavy clay nature of the soil which holds water for long may have contributed for non significant interaction between irrigation depth and frequency. Moreover, the practice of unregulated continuous irrigation system may have raised the ground water level that may limit the downward movement of applied irrigation water. The color of onion bulb for all treatments was the same, Amaranth.

Effect of Irrigation interval on yield, quality and Water use efficiency

From table 1, total yield for four and seven days irrigation interval is relatively higher and significantly different from other intervals while there is no significant difference between the two intervals. However, irrigation per four days interval is not significantly different from 10 days interval, which is lower and significantly different from seven days interval. From all irrigation frequencies, 13 day irrigation interval gave the least and significantly different total yield. As interval increases from seven days to thirteen days, the average total yield decreased by 59.52 qt/ha. Therefore irrigating per seven days interval is better and safe to get relatively higher total yield.

Marketable yield for frequencies of four, seven and ten days interval is found relatively better and not significantly different each other. But marketable yield for four days interval is not significantly different from thirteen days interval which is the least and significantly different from seven and ten days interval. Therefore, seven and ten days interval are relatively better and safe to get better marketable yield. Marketable yield here refers to yield without any physiological and disease problem.

Table 1. Average Total and Marketable yield of onion for the whole experimental season

Main Plot	Year 1/1998		Year 2/1999		Combined	
	Total Yield (qt/ha)	Marketable yield (qt/ha)	Total Yield (qt/ha)	Marketable yield (qt/ha)	Total yield (qt/ha)	Marketable Yield (qt/ha)
1(30mm)	252.88a	154.955a	183.87a	163.88a	218.38a	159.419a
2(50mm)	246.15a	136.783b	164.48a	147.65a	205.32a	142.217a
3(70mm)	245.41a	131.162b	176.54a	158.48a	210.97a	144.821a
C.V (%)	5.0	6.3	9.9	9.2	7.8	9.4
LSD(0.05)	NS	16.312	NS	NS	NS	NS
Sub Plot						
1(4days)	243.45b	121.507b	191.51a	168.41a	217.48ab	144.96ab
2(7days)	288.46a	154.475a	188.35a	162.26a	238.40a	158.37a
3(10days)	242.45b	155.733a	180.47a	165.08a	211.46b	160.41a
4(13days)	218.23b	132.152b	139.53b	130.94b	178.88c	131.54b
C.V (%)	5.1	5.2	8.6	7.9	6.8	8.1
LSD(0.05)	26.212	18.835	36.465	30.247	23.599	19.92

As can be seen in table 2, dry Matter content does not show significant difference per irrigation intervals. This indicates as the interval and amount of irrigation in that specific location are not important to affect the dry matter content of onion. Average bulb weight for four and seven days irrigation frequency is found better than other frequencies. But irrigating per four days interval is not found significantly different from 10 days interval which is not significantly different from 13 days interval which is the least of all. Therefore irrigating per seven days interval is relatively better and safe to have high average bulb weight. Total soluble solids laboratory analysis for first year samples was done by taking composite samples from combined samples of the same treatment from all replications; therefore it was not possible to undertake statistical analysis. For this reason, here the

second year data is used for interpretation. Irrigating per seven days interval was found to give good and significantly different total soluble solids.

From water use efficiency (WUE) perspective, irrigating per ten and seven days interval gave the highest water use efficiency and irrigating per four days interval the lowest. From the analysis trend, WUE decreases as irrigation frequency decreases.

Table 2. Average dry matter content, bulb weight and total soluble solids of onion

Plots	Year 1/1998		Year 2/1999			Combined		
	Dry matter Content (%)	Average bulb weight (gm)	Dry matter content (%)	Average bulb weight (gm)	Total soluble solids (%)	Dry matter content (%)	Average bulb Weight (gm)	WUE (kg/lt)
Main plot								
1(30mm)	22.01a	101.94a	13.51a	59.25a	12.74a	17.76a	80.59a	0.41a
2(50mm)	22.07a	100.38a	13.26a	53.99a	12.77a	17.67a	77.19a	0.23b
3(70mm)	21.66a	104.73a	13.56a	55.36a	12.52b	17.61a	80.05a	0.16c
C.V (%)	3.9	4.3	2.4	9.1	0.57	3.5	7.4	8.25
LSD(0.05)	NS	NS	NS	NS	0.1316	NS	NS	0.0275
Sub Plot								
1(4days)	22.62a	98.47b	13.94a	61.97a	12.36c	18.28a	80.22ab	0.12c
2(7days)	21.42a	114.36a	13.39a	61.84a	13.07a	17.40a	88.09a	0.23b
3(10days)	22.29a	99.91b	13.29a	55.82ab	12.59b	17.79a	77.87bc	0.36a
4(13days)	21.34a	96.67b	13.15a	45.18b	12.69b	17.24a	70.92c	0.38a
C.V (%)	3.4	4.4	2.1	7.8	0.5	3.1	6.4	8.25
LSD(0.05)	NS	10.95	NS	10.73	0.152	NS	8.33	0.03

Unmarketable yield of ten and thirteen days irrigation interval gave least and significantly different yield from four and seven days interval. From unmarketable yield components, decay has shown the same trend as total unmarketable yield. Split is also high and significantly different for seven days interval. However, split is considered as unmarketable for export; in

Ethiopian case it is traditionally marketable. The amount of onion with bolter problem is found least for thirteen days irrigation interval, but other intervals did not show significant difference for this bolt problem. The other unmarketable component i.e. under sized/under weight (below 20 gm bulb weight) does not show significant difference for all frequencies (Table 3 and 4).

Table 3. Mean value of unmarketable yield and its components

Plots	Year 1/1998		Year 2/1999		Combined	
	Unmarketable Yield (qt/ha)	Decay (qt/ha)	Unmarketable Yield (qt/ha)	Decay (qt/ha)	Unmarketable yield (qt/ha)	Decay (qt/ha)
Main plot						
1(30mm)	97.929a	50.588a	19.991a	6.991a	58.960a	28.789a
2(50mm)	109.371a	56.624a	16.833a	5.094a	63.102a	30.859a
3(70mm)	114.244a	68.376a	18.055a	4.985a	66.149a	36.681a
C.V (%)	9.0	16.4	24.4	49.1	11.8	23.4
LSD(0.05)	NS	NS	NS	NS	NS	NS
Sub Plot						
1(4days)	121.940a	78.632a	23.100ab	6.743ab	72.52a	42.688a
2(7days)	133.987a	74.501a	26.086a	9.763a	80.04a	42.132a
3(10days)	86.718b	39.815b	15.391bc	3.981ab	51.05b	21.898b
4(13days)	86.082b	41.168b	8.595c	2.273b	47.34b	21.721b
C.V (%)	7.8	14.2	21.1	42.5	10.3	20.2
LSD(0.05)	20.381	20.217	9.4061	5.8934	10.615	10.722

NS = non significant

Table 4. Mean value of unmarketable yield components

Plots	Year 1/1998			Year 2/1999			Combined		
	Split (qt/ha)	Bolt (qt/ha)	Under Weight (qt/ha)	Split (qt/ha)	Bolt (qt/ha)	Under Weight (qt/ha)	Split (qt/ha)	Bolt (qt/ha)	Under Weight (qt/ha)
Main plot									
1(30mm)	33.547a	12.981a	0.8140a	4.194a	5.688a	3.1181a	18.871a	9.334a	1.966a
2(50mm)	37.714a	14.530a	0.5034a	3.264a	3.578a	4.8972a	20.489a	9.054a	2.700a
3(70mm)	32.585a	12.607a	0.6760a	4.519a	4.887a	3.6632a	18.552a	8.747a	2.170a
C.V (%)	14.6	18.1	34.8	66.5	37	28.3	20.9	24.7	36.1
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub Plot									
1(4days)	26.353b	15.954a	0.9999a	5.637ab	7.595a	3.125a	15.995b	11.775a	2.0624a
2(7days)	42.877a	15.954a	0.6536a	7.429a	5.708a	3.187a	25.153a	10.831a	1.9203a
3(10days)	33.903ab	12.607ab	0.3927a	1.903ab	5.171a	4.336a	17.903b	8.889a	2.3642a
4(13days)	35.328ab	8.974b	0.6117a	1.002b	0.396b	4.924a	18.165b	4.685b	2.7676a
C.V (%)	12.7	15.7	30.2	57.6	32	24.5	18.1	21.4	31.3
LSD(0.05)	10.693	5.11	NS	5.5991	3.6807	NS	5.773	3.1948	NS

From the above findings, we can understand that irrigating per four and seven days interval gives high unmarketable yield. This may be directly linked to high amount of applied irrigation water related to other treatments. Therefore, as the amount of applied irrigation water increases the amount of unmarketable yield components decay and bolt increases.

Regardless of high amount of unmarketable yield recorded for four and seven days irrigation interval, the amount of total and marketable yield for seven days intervals is higher. Taking in to consideration as split, here we considered as unmarketable, marketable in local markets, irrigating per seven days interval gives high marketable and low unmarketable yield.

Therefore irrigating per seven days interval is relatively advantageous for total, marketable and unmarketable yields and for better average bulb

weight. But in a situation when labor and water are serious problems in the irrigation area, irrigating per ten days interval can give higher marketable yield though not significantly different from four and seven days interval.

Effect of Irrigation interval on Vegetative development

From Table 5 it is possible to see that vegetative data (average leaf number, average sheath length and plant height) gave high value for four and seven days interval, but seven days interval is not significantly different from ten days interval for sheath length and plan height. As previously discussed, irrigating per four and seven days interval gave high and significantly different average bulb weight. Therefore, we can say that as the frequency of water application increases the vegetative condition of onion will be the better and this will increase the average bulb weight of onion. Hence, irrigating more frequently may be important when there is a need to produce better average bulb weight.

Table 5. Mean value of Vegetative data (leaf number, sheath Length and plant height)

Plots	Year 1/1998			Year 2/1999			Combined		
	Average Leaf no	Average Sheath Length (cm)	Plant Height (cm)	Average Leaf no	Average Sheath Length (cm)	Plant Height (cm)	Average Leaf No	Average Sheath Length (cm)	Plant Height (cm)
Main plot									
1(30mm)	12.118a	5.929a	59.288a	11.2289a	8.9965ab	46.073a	11.6736a	5.929a	52.681ab
2(50mm)	12.267a	5.463b	59.354a	11.2292a	9.3958a	46.823a	11.7479a	5.463a	53.089a
3(70mm)	12.650a	5.404b	59.275a	10.3056a	8.3085b	42.326b	11.4778a	5.404b	50.800b
C.V (%)	3.5	4.3	2.6	7.3	4.7	3.3	5.3	7.9	3.0
LSD (0.05)	NS	0.4255	NS	NS	0.7541	2.8469	NS	0.5447	1.9194
Sub Plot									
1(4days)	13.219a	6.139a	61.368a	11.9431a	10.2467a	48.629a	12.5810a	8.193a	54.998a
2(7days)	12.294b	5.683a	60.322a	11.6574ab	9.5417a	46.032ab	11.976a	7.613ab	53.177ab
3(10days)	12.106b	5.772a	59.672a	9.9782b	8.2619b	43.759bc	11.042b	7.017b	51.716b
4(13days)	11.761b	4.800b	55.861b	10.1061b	7.5509b	41.875c	10.934b	6.176c	48.868c
C.V (%)	3.0	3.7	2.3	6.3	4.1	2.9	4.6	5.3	2.6
LSD (0.05)	0.903	0.4913	3.2354	1.6422	0.8708	3.2874	0.8858	0.629	2.2164

Conclusions and Recommendations

Though there was clear visual observation at field condition, irrigation frequency and depth interaction failed to show significant difference for yield and other quality parameters except water use efficiency. Heavy clay soil which can hold water for long, higher rainfall condition during the research period and ground water level change because of continuous irrigation may have contributed for lack of interaction. Though it is irrigation frequency found more important in the study area, irrigating 30 mm depth gave better total and marketable yield, water use efficiency and low unmarketable yield.

From water use efficiency (WUE) perspective, irrigating per ten and seven days interval gave the highest water use efficiency and irrigating per four days interval the lowest. From the analysis trend, WUE decreases as irrigation frequency decreases.

From the study, irrigating per seven days interval at clay soils of Kewot irrigation areas, gave high total and marketable yield, water use efficiency, average bulb weight, total soluble solids and vegetative data. Irrigating per ten days interval also gave high marketable and low unmarketable yields and high water use efficiency. However, when we consider marketable in Ethiopian context by including split as marketable, irrigating per seven days interval outsmarts marketable yield in addition to its higher values of average bulb weight, total soluble solids and vegetative condition.

Therefore, 30 mm irrigation depth per seven days interval is relatively advantageous in clay soils of Kewot and other similar areas where the soil and agro climatic conditions are identical. But in a situation when labor and water are serious problems in the irrigation area, irrigating per ten days interval can give higher marketable yield with minimal water consumption though not significantly different from four and seven days interval.

Though the best possible interactions between irrigation depth and frequency were identified for the treatments of the study, investigating the exact reason for the insignificancy of irrigation depth and frequency interactions or searching significantly different and combinations will help a lot to determine appropriate and better irrigation scheduling for onion in the area.

References

Daniel Hillel, 1997, Small-scale irrigation for arid zones: Principles and options, FAO Development series 2, Rome

Diagnostic farming system survey of Efratana Gedem Wereda, 2001, Sheno Agricultural Research Center

Doorennbos. J.1992. Crop water requirement (FAO 24), FAO, Rome, Italy.

Lemma Dessalegn and Shimeles. 1988a. Research Experience in onion production. Institute of Agricultural Research, Addis Ababa , Ethiopia.

Lemma Dessalegn and E. hearth .1992. Agronomic studies on Allium. In: Horticulture Research and development in Ethiopia.1994. Proceedings of the second National Horticultural workshop of Ethiopia september-1992. Edward
Hearth and Lemma Dessalegn(Editors) .Addis Ababa ,Ethiopia.

Michael Abebe .2001. Irrigation Research technologies recommended for sustaining crop production in some irrigated areas of Ethiopia. Norwegian university of science and technology, Norway.

Michel, A.M 1981, Irrigation theory and practice, Vikaspublishing house Pvt.LTD,Ghaziabad, India.