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Effect of Furrow Irrigation Methods and Drip Irrigation System on Yield and Yield Components of Different Crops

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Abstract
This paper was focused on reviewing of different documents and research findings from studies conducted on furrow irrigation methods and drip irrigation methods on different crop types. The reviewing coverage of the research findings conducted on comparison of furrow irrigation and drip irrigation was between 2012 and 2021. Approaches followed on reviewing the papers on different furrow irrigation system type and drip irrigation methods were through reviewing journals from websites and research output reports. On this paper review, achievements of comparison of furrow irrigation and drip irrigation under diverse agro-ecologies are highlighted based on the current knowledge from available sources. Based on different findings the use of drip irrigation method was best option for both crop yield increment and water use efficiency .So in current research findings in order to use drip irrigation for crop production purpose was best practice method due to year to year climate change and drought occurrences key solutions to avoid crop yield collapse and failure. But in order to use drip irrigation system the cost drip materials and awareness of farms are the key problem of different findings are indicated.
Keywords: drip, furrow irrigation, crop
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INTRODUCTION

Irrigation is one of the most important inputs to increase crop yields in arid and semi-arid regions. The main Objective of irrigation is to maintain an optimum soil moisture balance in the crop root zone, a through understanding of the relationships between soil, water, plant and atmosphere is crucial. Irrigation concerns the relationship between how a soil holds and stores water and how a plant uses water. Irrigation is widely carried out through surface and pressurized irrigation systems. Surface irrigation methods having relatively lower water use efficiency compared to the pressurized systems. From surface irrigation methods, furrow irrigation system is the most widely practice to irrigate many row crops including horticultural crops. Furrow irrigation, a method of applying irrigation water by small, parallel channels to irrigate entire crop field.

Furrow irrigation is widely used irrigation system in Ethiopia and practiced via many farmers and state farms. According to FAO (2001), 97.8% of the irrigated farm in Ethiopia practice surface methods of irrigation, especially small holder and commercial farmers using furrow system which is characterized as less efficient and high water loss during application.

The drip irrigation system is one of the most efficient forms of irrigation technology. With drip irrigation, it is possible to apply light and frequent irrigation water. The experience from their water use by 30% to 60% and crop yields often increase at the same time (Sijali, 2001). many countries shows that farmers who switch from furrow system to drip systems can cut Drip irrigation, currently used in Ethiopia, especially in central rift valley region for high-value vegetable crop production such as onions, potatoes, peppers, and lettuces, can result in a considerable saving in irrigation water, thus reducing the lost by deep percolation and risks of salinization if the correct management procedures are applied.

Drip irrigation is the most advanced irrigation method with the highest application efficiency. The drip irrigation method is rapidly gaining importance in areas where water is scarce or expensive and whenever high valued crops are grown. Because of high initial cost drip irrigation is not well adapted in developing countries like our country and hence the idea of low cost drip irrigation is introduced. Low cost drip irrigation system which operates under gravity is suitable and economical also give high yield for vegetable crops.

MATERIALS AND METHODS

This review material was collected from different research outputs on comparison of furrow irrigation methods and drip irrigation methods. This includes journals from online websites using www.goole.com and the research outputs on title of “comparison of furrow irrigation methods and drip irrigation methods”, MSc/PhD thesis research outputs. Generally the purpose is reviewing of different research outputs and collecting into one document and easily referring other users. All materials are different research output of different season.

RESULTS AND DISCUSSION

Green Beans

Furrow irrigation methods and Drip irrigation systems have a significant improvement on Green beans yield indifferent research findings. Mihiret Hailu (2019) reported that the analysis of irrigation system and deficit levels had significant effect on pod yield but not the interaction effect of irrigation system and deficit levels. Analysis of variance showed that pod yield significantly ($P < 0.05$) affected by irrigation system and a highly significant ($p<0.01$) difference in pod yield was observed due deficit levels. The largest yield was 17.16 observed from 100%ETc application level which was significantly different to all deficit irrigation levels. Among deficit irrigation, 80%ETc application gave the highest pod yield and significantly different to all deficit irrigation. Minimum yield of 12.34 ton/ha was obtained from the 40%ETc application and inferior to all irrigation level. The result indicates applying of water without deficit (100%ETc) increase pod yield. The higher pod yield in 100% ETc might be attributed to the optimum availability of soil moisture as well as plant nutrients in the soil. Deficit irrigation reduces pod yield of green bean. 80% ETc gave better yield compare to other deficit irrigation levels. The reduced yield under 40% ETc might be due to moisture stress caused by deficit irrigation.

The different irrigation systems also affect pod yield. The largest pod yield of 16.78 ton/ha was obtained from drip irrigation. The smallest yield of 13.75 ton/ha was obtained from alternate furrow irrigation application method. Drip irrigation give higher yield compare to furrow irrigation. The low yield under furrow irrigation might be cause of poor aeration and higher weed infestation problems (Kumari and Kaushal, 2014). In drip irrigation weed infestation is less and water is applied directly into the root zone. Drip irrigation is suitable for green bean production to get higher pod yield (Jha et al., 2017).

Additionally Mihiret Hailu (2019) also reported that Plant height, number of leaves per plant, number of branches per plant, and total fresh weight as well as total chlorophyll content generally increased when the supplied water was increased from 60 to 80% of ETc. Increasing water volume to 100% of evapotranspiration tended to decrease the fresh biomass accumulated during the growing period, compared to 80% of ET. Conversely, dry matter percent was increased by reducing water volume from 100 to 60% of ETc. With regard to the effect of green bean cultivars on plant vegetative growth parameters, there were no differences in their effects on the number of leaves per plant, number of branches per plant, total fresh weight, or dry matter percent.

Table 1. Mean values for interaction effect of irrigation system and deficit levels on growth, yield and yield components of green beans

	Treatments		DF	DM	Height	Biomass	PL	PD	Yield
Mihiret Hailu (2019) reported	DPI	100% ETc	42	61	66	16	14.33	8.3	18.83
		80%ETc	41	59.67	62	15.5	13.67	7.4	16.76
		60%ETc	39	58	58	15	12.67	7.3	15.1
		40%ETc	38	57	57	14	11.56	6.5	14
	CFI	100% ETc	44	63	64	16	13.67	7.4	17.33
		80%ETc	42	61	61	15	13.33	7	15
		60%ETc	40	59	56	15	13	6.8	14.2
		40%ETc	39	58	55.5	14.55	11	6.3	12
	AFI	100% ETc	40.6	60	61	15	13.33	6.16	15
		80%ETc	40.67	60	57	14.7	13	6.8	14.75
		60%ETc	39	59	55	14.6	11	6.2	14
		40%ETc	39	58	51	14	10.66	6	11
	LDS (5%)		NS	NS	NS	NS	NS	NS	NS
	CV (%)		3.68	2.7	5.48	4.39	9.85	2.1	5.17

Note: DPI is Drip irrigation, CFI Conventional furrow irrigation, AFI Alternative Furrow Irrigation DF is days to 50% flowering, DM is days to 50% maturity, PL is pod length, PD is pod maturity.

Onion

Onion growth parameters

The onion growth parameters are like number of leaves per plant, leaf height and plant height. Beniam Yaziz (2019) reported that the analysis shows a significant ($P<0.05$) difference between treatments due to irrigation method and irrigation levels on onion growth parameters. As the result shows that there was a significant effect observed on plant height due to Irrigation level and interaction, but the irrigation method had no significant effect on plant height. Among the irrigation levels, the maximum plant height was observed from 100%ETc application and significantly different to all deficit irrigation.

This result was also similar with Shimeles (2009) and Takele and Desalegn (2009) who reported that the plant height of pepper decreased with decreased irrigation levels and also increase with the irrigation level.

Wien (1997) indicated that plant height had a linear correlation with the availability of soil moisture. The

present result was also in agreement with the work of Al-Moshileh (2007) 45 who reported that with increasing soil water supply, plant growth parameters (plant height) were significantly increased.

Among the interaction effect of irrigation method and irrigation levels, conventional furrow irrigation with 100%ETc application gave significantly ($P<0.05$) higher plant height and significantly different to all other treatments. These result associated with treatment which received a larger amount of water that showed significantly taller plants compared with plots which received lower amounts at the same date of sampling. As the title of the thesis indicates comparison of furrow and drip irrigation but there is no drip irrigation analysis result on this thesis .When the analysis result of number of leaf per plant indicate that there was an increase in the number of leaf /plant using drip irrigation method and increase in depth of water application. The number of leaf/plant of onion was significantly affected ($P\geq0.05$) by irrigation method and irrigation level but not by their interaction effect.

Among irrigation level, a higher number of leaf/plant of 12.13 was observed at 100%ETc followed by 85%ETc, 70%ETc and 60% ETc irrigation level with the value of 10.6, 10.5 and 10.4 respectively. There was no significant difference between the last four treatments with irrigation level including 50% ETc level. The minimum leaf number was recorded at irrigation depth of 50%ETc irrigation level (10.1). The result was in agreement with the Wien (1997) who reported that leaf number had a linear correlation with the availability of soil moisture. Combined treatments also showed a statistically significant influence on a number of leaves. The multiple numbers of onion leaves were recorded treatment receiving full irrigation under drip irrigation method and which had no significant difference to treatments gave 85%, 70%, and 60% ETc under the same irrigation method and to conventional furrow irrigation method. Whereas, Treatment receiving 50% ETc using alternate furrow irrigation technique was gave the

In Addition to this parameter Biniam (2019) also reported that Onion Yield Parameters analysis results like bulb diameter, bulb height average bulb weight, marketable bulb yield and total bulb yield per hectare significantly affected by irrigation levels and irrigation method.

The bulb height (BH) of onion was recorded at the harvesting stage and the data revealed there was an effect of irrigation methods and irrigation levels on onion bulb height. Among the irrigation levels, the maximum height of bulb was recorded with irrigation level 100%ETc which had no significant diffidence from its immediate deficit level 85 %ETc whereas, the minimum height of the bulb was observed from the irrigation level of 50%ETc application. Neeraja et al. (1999), Sharda et al. (2006) and Metwally (2011) have also found a similar effect of irrigation levels on the height of the onion bulb. However, highs mean of onion bulb was observed in the application of irrigation water using drip irrigation method. The combined effect of irrigation method and different irrigation levels showed a significant influence on the height of the onion bulb and had no significant difference with drip irrigation.

The Analysis result of bulb diameter (cm) among the different levels, full irrigation application recorded higher bulb diameter (7.18 cm) and this was not significantly different to treatments receiving 85% and 70%ETc.The minimum bulb diameter was obtained treatment which receives 50% ETc irrigation level (5.5cm). This result fitting to Abdulaziz, 2003 and Biswas et al., 2003 they indicated that the bulb diameter of onions was increased at higher levels of irrigation. Similarly, Olalla et al. 2004 reported that treatment which received the greatest volumes of water yielded harvests with higher percentages of large-size bulbs whereas water shortages led to higher percentages of small-size bulbs. The maximum bulb size was achieved using drip irrigation method (6.7cm) and the minimum bulb size was recorded by using furrow irrigation method. This result associated with the application of the required depth irrigation water and makes to create favorable condition around the crop root zone in the way of efficiently utilized the available water and nutrient by the growing crop and this leads to encouraging vegetative growth as well.

The combined treatments also gave a significantly onion bulb size difference. Therefore, a combination of drip irrigation method and 100ETc depth application was given the largest onion bulb size and this was not significantly different to treatment receiving 85% and 70% under the same irrigation method. Moreover, 85% and 70% ETc application level under drip irrigation method not showing a significant difference to 100%ETc using CFI, 85% and 70% ETc under Alternative furrow irrigation method. Most of the time many researcher and students record different growth and yield parameters. Among those recorded parameters recording of bulb height of onion is no any importance. When rescored bulb height of onion what was the importance and how to determine but bulb diameter of onion is used for to determine marketable and unmarketable size of the onion bulb on user preference.

The marketable bulb yield of onion using drip irrigation method at full irrigation level was scored higher marketable bulb yield 49.13t/ha. This result had no significant yield difference to treatment receiving 15% below irrigation using the same irrigation method. Moreover, the result reveals that even if 15% less quantity of irrigation amount was supplied through drip method irrigation show a significant yield difference over conventional furrow irrigation method. Based on the result obtained using the drip irrigation method can increase by 18.18% of marketable bulb yield over using the conventional furrow irrigation method. The result is in

agreement with (Postel et al., 2001 and Howell, 2001) findings and reported that drip irrigation system can reduce irrigation requirements from 20 to 70% while increasing crop yields by 20–90% compared with surface irrigation.

Table 2.The mean value of Plant height, number of leaves and Leaf height

	Treatment	Plant height (cm)	No. of leaves per plant	Leaf height (cm)
Beniam Yaziz (2019) reported	Irrigation method (IRRI)			
	D	52.13b	11.3a	47.2b
	F	56.53a	10.2b	50.8a
	S.Em±	1.39	0.05	0.77
	LSD(0.05)	5.99	0.23	3.30
	CV (%)	7.01	1.36	4.28
	Level of irrigation (LI)			
	100%	62.43a	12.13a	57.1a
	85%	54.46b	10.6b	50b
	70%	52.4b	10.5b	47.1bc
	60%	52.16b	10.4b	46.8bc
	50%	50.2b	10.1b	44.1c
	S.Em±	1.88	0.42	1.41
	LSD(0.05)	5.75	1.29	4.31
	CV (%)	5.98	6.77	4.97
	Interaction (IRRIXLI)			
	D*(100%ETc)	54.5b	12.4a	50.7bc
	D* (85%ETc)	53.2b	11.5ab	48.9bc
	D* (70%ETc)	51b	11.4ab	48.7bc
	D* (60%ETc)	51.6b	11.1abc	45.7bc
	D* (50%ETc)	50.2b	9.7bc	45.5bc
	AFI* (85%ETc)	55.6b	10.1bc	51.1b
	AFI* (70%ETc)	53.3b	10.1bc	48.7bc
	AFI* (60%ETc)	53.1b	9.8bc	48bc
	AFI* (50%ETc)	50.2b	9.4c	42.7c
	CFI*(100%ETc)	70.3a	11.8ab	63.5a
	S.Em±	2.65	0.60	1.99
	LSD(0.05)	9.66	2.17	7.25
	CV (%)	5.98	6.77	4.97

Table 3 Mean of onion Yield attributes

	Treatment	Bulb diameter (cm)	Bulb height (cm)	Bulb weight (g)	Bulb dry matter (g)	MBY (t/ha)	TBY (t/ha)
Beniam Yaziz (2019) reported	Irrigation method (IRRI)						
	D	6.7a	5.88a	78.80a	42.66a	43.08a	46.30a
	F	6.3b	5.92a	67.38b	34.64b	27.95b	29.96b
	S.Em±	0.10	0.08	2.65	0.30	1.66	1.18
	LSD (0.05)	0.44	0.34	11.42	1.30	7.16	2.49
	CV (%)	4.46	3.71	9.58	2.14	2.48	2.22
	Level of irrigation(LI)						
	100%	7.18a	6.53a	83.73a	48.01a	44.67a	46.72a
	85%	7.03a	6.12ab	77.63ab	44.12a	39.95b	42.14b
	70%	6.90a	5.63c	73.98bc	43.85a	38.01b	40.25b
	60%	6.03b	5.58bc	70.60c	33.83b	29.46c	32.61c
	50%	5.56c	5.6d	59.50c	23.46c	25.51d	28.84d
	S.Em±	0.20	0.22	3.07	3.31	1.12	1.18
	LSD(0.05)	0.419	0.46	6.50	6.95	2.37	2.49
	CV (%)	5.23	6.38	10.90	14.69	6.11	6.14
	Interaction (IRRIXLI)						
	D*(100%ETc)	7.56a	6.46ab	88.26a	55.73a	49.13a	52.10a
	D*(85%ETc)	7.26ab	6.40abc	83.60ab	44.7b	46.56ab	49.53ab
	D*(70%ETc)	7.20ab	5.50d	80.06abc	44.63b	45.21b	47.93b

	Treatment	Bulb diameter (cm)	Bulb height (cm)	Bulb weight (g)	Bulb dry matter (g)	MBY (t/ha)	TBY (t/ha)
	D*(60%ETc)	6.13cd	5.46d	79.20bc	43.56b	39.43c	42.89c
	D*(50%ETc)	6.03de	5.60d	78.70de	24.7c	35.10d	39.06d
	AFI*(85%ETc)	6.80bc	5.83bcd	71.66bcd	43.53b	33.33de	34.75e
	AFI*(70%ETc)	6.7bc	5.73cd	67.90cd	43.06b	30.80e	32.59e
	AFI*(60%ETc)	6.13cd	5.86bcd	65.0de	24.10c	19.50f	22.34f
	AFI*(50%ETc)	5.4d	5.56d	60.93e	22.23c	15.92g	17.49f
	CFI*(100ETc)	6.80bc	6.60a	142.0abc	40.3b	40.20c	41.34cd
	S.Em ±	0.31	0.31	4.34	4.63	1.85	1.66
	LSD(0.05)	0.66	0.65	9.20	9.83	3.9	3.53
	CV (%)	5.23	6.38	7.01	14.69	6.11	6.14

Tagar A. *et'al* (2012) also reported that similarly total yield of tomato crop under drip irrigation system was more as compared to furrow irrigation system. Water saving also increase in yield and water use efficiency.

Drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method. Likewise higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water uses efficiency about 1.66 was obtained in furrow irrigation method. This may be because in drip irrigation method water is applied directly in the root zone of crop. Hence conveyance, evaporation and percolation losses reduced to larger extent.

Maize

Maize is critical for food security in Ethiopia. Over 9 million smallholder farmers grow maize on about two million hectares (14% of the total land area in Ethiopia) and around 88% of their production for food consumption (Tsedeke et al., 2015). In Ethiopia, maize grows from moisture stress areas to high rainfall areas and from lowlands to the highlands. It is largely produced in Western, Central, Southern, and Eastern parts of the country. In the 2015/2016 cropping season, 2,111,518.23 hectares of land was covered with maize and estimated production not less than 71,508,354.11quintals (MoA, 2016).Maize production both by furrow irrigation method and drip irrigation method are suitable. But in arid and semi-arid area drip irrigation method is more suitable and preferable due water saving purpose. As Borena FR, *et al.* (2021) reported that the result of water use efficiency of maize significantly ($p \leq 0.01$) influenced by furrow irrigation and drip irrigation. The highest water use efficiency was obtained from drip irrigation with 85% ETc (2.38 kg/m3) and minimum obtained from alternative furrow irrigation (0.81 kg/m3). Using drip irrigation system with 100% ETc shows that there is an increase the maize yield production by 57.53% and save 33.7% of irrigation water as compared to conventional furrow irrigation (farmers practice) but as compared to alternative irrigation with 100%Etc there is 71.5% of maize yield increment and 24.58% loss of irrigation water over alternative furrow irrigation. Similarly Tagar A. et'al (2012) also reported that Drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method. Likewise higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water uses efficiency about 1.66 was obtained in furrow irrigation method.

Deficit irrigation levels with drip irrigation has lower impacts on yields of maize grain production .The result of using alternative furrow irrigation with 100% ETc shows that 32.8% of yield reduction and 49.99% saves irrigation water as compared to the conventional furrow irrigation. The result of the study revealed that using drip irrigation system with 100% ETc can increase the maize grain yield production by 57.53% and save 33.7% of irrigation water as compared to conventional furrow irrigation (farmers practice) but as compared to alternative furrow irrigation with 100% ETc there is 71.5% of maize yield Increment and 24.58% loss of irrigation water over alternative furrow irrigation.

Table 4. Effect of irrigation system and irrigation levels on yield and water use efficiency

	Treatments	BM	Yid	TSW	WUE	HI
Borena FR, *et al.*(2021)	AFI(100%ETc)	13704^{b}	4753.1^{ef}	322.01^{ab}	0.81^{ef}	0.34^{efd}
	AFI(85%ETc)	14609^{b}	4711.9^{ef}	294.17^{b}	0.95^{ef}	0.32^{ef}
	AFI(70%ETc)	12963^{b}	4732.5^{ef}	301.05^{b}	1.18^{de}	0.37^{cdef}
	AFI(55%ETc)	13580^{b}	4043.7^{f}	258.02^{b}	1.26^{cde}	0.31^{f}
	Drip(100%ETc)	26132^{a}	16666.6^{a}	36.20^{a}	2.15^{ab}	0.64^{ab}
	Drip(85%ETc)	24962^{a}	12962.9^{b}	332.24^{ab}	2.38^{a}	0.52^{b}
	Drip(70%ETc)	23251^{a}	9465.0^{c}	330.20^{ab}	1.77^{bc}	0.42^{bcde}
	Drip(55%ETc)	13992^{b}	6378.6^{ed}	289.43^{b}	1.56^{cd}	0.46^{bc}
	LSD	3852.5	1680.4	53.01	0.56	11.10
	CV	1243	12.19	7.16	12.13	0.15

Conclusions

Based on Research findings on comparison of furrow irrigation methods and drip irrigation different crop type at different parts of the country recommendation should be used for different climate conditions. Research findings revealed that drip irrigation methods are significantly produced higher yield of diverse crops than furrow irrigation methods. Various crops under different agro-ecology and soil type were significantly different in water use efficiency response to drip irrigation type. So, application of drip irrigation methods and properly installed by skilled man power could be best for more yield production than furrow irrigation methods. Based on different findings most of research conducted on drip irrigation and furrow irrigation methods are not considered cost benefit and economic analysis of drip system materials and also accessories many research findings are simply mention more yield and water use efficiency on drip irrigation than furrow irrigation methods. It is obvious result yes more yield and water efficiency but cost benefit and economic analysis of drip system materials and also accessories are a must is easily materials are available and our farms are easily affordable and installed by farms are big questions answer by when a research is conducted.so train man is necessary for drip irrigation system installation purpose so not only more yield and water use efficiency but such worries are into considered when we conduct the researches. The findings clearly indicated the interactive effect of the drip irrigation method over furrow irrigation method has significant yield advantage over almost all the control treatment on different crop types. Generally this review aims to contribute towards the research conducted and to fill gaps in our country based on drip irrigation method and furrow irrigation method could be documented and easily accessed when somebody are need the materials under such title conducted findings. More or less filling of this gap as listed above by focusing on the use of drip irrigation method is a best water-saving practice.

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