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Research article

# Role of Drip Irrigation System as Increasing Water Use Efficiency over Furrow Irrigation System

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**Water is man kind's most vital and versatile natural resource. It is also considered as an essential resource for irrigation. Agriculture uses 70% of the fresh water available for human use, making them largest user of water. With a rapidly growing world population, the pressure on limited fresh water resources increases. Irrigated agriculture is the largest water consuming sector and it faces competing demands from other sectors. Irrigation development is increasingly implemented in Ethiopia more than ever. Effective use of irrigation with the aim to increase the productivity at least to double the existing level is prerequisite. Under these circumstances, drip irrigation can be more useful than surface irrigation (furrow irrigation method) for cultivation of crops in the areas where fresh groundwater is available. This innovative irrigation technique is well known for high water application and water use efficiency along with appreciable water saving over traditional methods of irrigation. To sustain the rapidly growing world population, agricultural production needs to be increased yet the portion of fresh water currently available for agriculture (72%) is decreasing. Hence, sustainable methods to increase crop water productivity are gaining importance in arid and semiarid regions. Drip irrigation is one such hi-tech method receiving better acceptance and adoption, particularly in areas of water scarcity.**

**Keywords:** Drip irrigation, Furrow irrigation, Water use efficiency

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## INTRODUCTION

Water is man kind's most vital and versatile natural resource (Nata *et al*., 2008). It is also considered as an essential resource for irrigation. Irrigation can be defined as an artificial application of water to soil for the purpose of supplying the moisture essential in the plant root-zone to prevent stress that may cause reduced yield and/or poor quality of harvest of crops (Reddy, 2010). This is an intentional action made by human to apply water for growing crops, especially during dry seasons where there is a shortage of rainfall.

Food is produced in rural areas employing various factors of productions like land, water, labor, seed fertilizers, pesticides, machinery, though all the factor of production are extremely significant but water is no doubt the vital factor for the sustainable food production (Munir, et.al. 2010). Agriculture uses 70% of the fresh water available for human use, making them largest user of water (United Nations, 2006). This water resource not only maintains the crop production level but also helps in poverty alleviation of crop and non-crop producing farmers'.

With a rapidly growing world population, the pressure on limited fresh water resources increases. Irrigated agriculture is the largest water-consuming sector and it faces competing demands from other sectors, such as the industrial and the domestic sectors. With an increasing population and less water available for agricultural production, the food security for future generations is at stake. The agricultural sector faces the challenge to produce more food with less water by increasing CWP (crop water productivity). A higher CWP results in either the same production from less water resources, or a higher production from the same water resources, so this is of direct benefit for other water users (Kijne *et al*., 2003) as cited by (Zwart and Bastiaanssen, 2004).

In Ethiopia, small-scale traditional irrigation schemes constitute about 40% of the total irrigated land area. Despite this, the sector has largely been overlooked by authorities and not supported through improved water management technologies. Due to land and water resource shortages and the need for food self-sufficiency, it has become essential to improve the productivity of this sector (Geremew *et al.,* 2008). Currently government gives emphasis to develop the sub-sector to fully tap its potentials by assisting and supporting farmers to improve irrigation management practices and the promotion of modern irrigation systems (Awulachew *et al.,* 2006).

Irrigation in Ethiopia is considered as a basic strategy to alleviate poverty and hence food security. It is useful to transform the rain-fed agricultural system which depends on rainfall into the combined rain-fed and irrigation agricultural system. This is believed to be the most prominent way of sustainable development in the country (Gebremedhin and Asfaw, 2015).

Irrigation development is increasingly implemented in Ethiopia more than ever. Expansion of irrigated area combined with efficient management of water will enhance the attainment of food security and poverty alleviation goals of the country. Although the country is well known for its vast water resources potential its erratic distribution both in space and time coupled with limited capacity is the most challenging problem that limited the contribution of the resources to the socio-economic development of the country. Under such conditions water is sometimes not available where and when it is required (Mekonen, 2011).

Under conventional practices of irrigated agriculture, agriculture is considered as the major consumer of water compared to other sectors. The expansion of irrigated agriculture to feed the ever-increasing population on one hand and the increasing competition for water due to the development of other water use sectors on the other hand, as well as increasing concerns for environment, necessitated the improvement of water use efficiencies in irrigated agriculture to ensure sustained production and conservation of this limited resource (Mekonen, 2011).

Effective use of irrigation with the aim to increase the productivity at least to double the existing level is prerequisite. Under these circumstances, the micro irrigation systems, such as drip irrigation can be more useful than surface irrigation (furrow irrigation method) for cultivation of crops in the areas where fresh groundwater is available. In such areas, drip irrigation is good option (Yaseen *et al.,* 1992). This innovative irrigation technique is well known for high water application and water use efficiency along with appreciable water saving over traditional methods of irrigation (i.e. like flood irrigation).

To sustain the rapidly growing world population, agricultural production needs to be increased (Howell, 2001), yet the portion of fresh water currently available for agriculture (72%) is decreasing (Cai and Rosegrant, 2003). Hence, sustainable methods to increase crop water productivity are gaining importance in arid and semiarid regions (Debaeke and Aboudrare, 2004). Drip irrigation is one such hi-tech method receiving better acceptance and adoption, particularly in areas of water scarcity. Therefore, the efforts are now warranted to harness the available quantities of water and put them to efficient use to realize higher productivity per drop (Solaimalai *et al*., 2005).

Adoption of micro irrigation may help in saving significant amounts of water and increase the quality and quantity of produce. All these emphasize the need for water conservation and improvement in water use efficiency to achieve 'more crop per drop'. Micro irrigation is just one of the many irrigation and water management technology tools, but it is a tool that has several advantages. Irrigation events can be fine-tuned to spoon feed water and nutrients just in time to avoid plant stress. The major factors limiting its large scale adoption are high initial cost, lack of information on various aspects such as crop water requirement, scheduling of irrigation and fertigation (Fanish *et al.,* 2011).

Under common furrow irrigation, to refill the root zone over irrigation is inevitable, particularly in upper part of a field near the water source. Over irrigation leads to greater water losses and leaches the pesticides and chemicals into the ground water causing lower water application efficiency and pollution problems as well (Sharkawy *et al.,* 2006).

On-farm water use efficiency and hence water productivity can be improved by moving to a more efficient irrigation system. Sprinkler and drip irrigation can save non-effective water loss (Ali and Talukder, 2008). Modernization and optimization of irrigation systems can contribute to increase water productivity (Playán and Mateos, 2004). The technical aspects of modernization include water management, system operation and up gradation of structures and equipment.

With a growing population, water resource has become scarce resulting food insecurity. Due to scarce water resources and inefficient traditional surface irrigation practice, agriculture is faced with intensifying pressure to improve and manage the available water resources efficiently by increasing the efficiency of water for food production. As cropping land and water resources are becoming more limited, conservation is becoming an increasingly important topic.

A long-term perspective in shortage of fresh water resources, especially in arid and semi-arid area, highlights an urgent solution for innovative irrigation strategy and agricultural water management. Water is increasingly becoming scarce because of erratic distribution of monsoons and uncontrolled exploitation of water resources. Water resources should be used with a higher efficiency or productivity. To achieve this goal improvement in agricultural water management is a promising way. The scarce water resource necessitates its judicious use which will be possible by efficient water management practices like drip method for improved water application efficiency and precision placement.

## OBJECTIVE

- To review on water use efficiency of drip and furrow irrigation methods

## LITERATURE REVIEW

### World Water Resources

Reports show that from global water, 97 percent is sea water while only 3 percent is fresh water. Out of this fresh water, 87 percent is not accessible whereas only 13 percent is accessible. This makes the percentage of the accessible fresh water to be only 0.04 percent. According to the same report, more than 2 billion people are affected by water shortages in over 40 countries. Some 263 river basins are shared by two or more nations. Two million tons per day of human waste are deposited in water courses. On top of this, half of the populations of the developing world are exposed to polluted sources of water that increase disease incidence. Some 99 percent of natural disasters in the 1990s were water related, while the increase in numbers of people from 6 billion to 9 billion will be the main driver of Integrated Water Resources Management for the next 50 years (Cap-net, 2007).

Although water in sea and oceans is unlimited, fresh water resources are finite and limited. Water use in agriculture, industry and in municipalities annually amounts to 3240 $km^3$ (Kirda and Kanber, 1999). The increasing urban population adds additional demands for an increased share of fresh water allocation. Biswas (1992) stated that rapid world population increase and expansion of cities and modern industries contributed to the shortage of world water resources. Besides, the increase of competition among different sectors for fresh water will determine the more use of irrigation water for agriculture. Therefore, new technologies and innovations must be developed to increase efficient use of already scarce resource in many countries.

### Water Resources Potential of Ethiopia

Ethiopia is endowed with abundant water resources. A large number of rivers flowing on either side of the rift valley form a drainage network that covers most of the country. Most of the rivers that carry the water resources, however, end up in neighboring countries hence making them international or Trans-boundary Rivers. The total surface water resources of Ethiopia, coming from the country’s twelve river basins, are estimated to be in the order of 122 billion cubic meters per year. With regard to ground water resources, the true potential of the Country is not yet known, however it is widely reported that Ethiopia possesses a ground water potential of approximately 2.6 billion cubic meters of ground water (Awulachew *et al.,* 2006).

Ethiopia comprises 112 million hectares (Mha) of land. Cultivable land area estimates vary between 30 to 70 Mha. Currently, high estimates show that only 15 Mha of land is under cultivation. For the existing cultivated area, it is estimated that only about 4 to 5 percent is irrigated, with existing equipped irrigation schemes covering about 640,000 hectares. This means that a significant portion of cultivated land in Ethiopia is currently not irrigated. However, it is estimated that total irrigable land potential in Ethiopia is 5.3 Mha assuming use of existing technologies, including 1.6 Mha through RWH and ground water. This means that there are potential opportunities to vastly increase the amount of irrigated land (Awulachew *et al.,* 2010).

The main sources of water for irrigation, livestock consumption and domestic use in Ethiopia is mainly from rivers/streams, ground water, lakes and artificial ponds and surface water (seasonal). The distribution of these sources is uneven, in some areas abundant and in others scarce. This variability is mainly due to the diversified landscape and agro-climatic condition the country owns (Goshu, 2007).

“Green water” i.e., rainfall as reported by (Awulachew *et al.,* 2005), is the major source of agricultural water in Ethiopia. They also further stated that the major problem associated with the rainfall dependent agriculture in the country is the high degree of variability and unreliability. As a result, production capacity varies from region to region each year. Due to climate-induced rainfall variability, dry spells and drought, agricultural production often fails and is doing so more frequently over time.

### History of Irrigation Development

The earliest archeological evidence of irrigation in farming dates to about 6000 B.C. in the Middle East's Jordan Valley (Hillel, 1994). It is widely believed that irrigation was being practiced in Egypt at about the same time (Hoffman *et al*., 1990), and the earliest pictorial representation of irrigation is from Egypt around 3100 B.C. (Hillel, 1994). In the following millennia, irrigation spread throughout Persia, the Middle East and westward along the Mediterranean. In the same broad time frame, irrigation technology sprang up more or less independently across the Asian continent in India, Pakistan, China, and elsewhere (Reisner, 1986). Modern irrigation technology probably began with the Mormon settlement of the Utah Great Salt Lake Basin in 1847. Worldwide, many of the practical modern principles of irrigation system design and irrigated soil management can be traced to the lessons learned in the settling of the American West from 1847 to the close of World War II, when the total U.S. irrigated area had grown to 7.5 million ha (Hoffman *et al*., 1990).

Gebremedhin and Asfaw (2015) reviewed the Ethiopian irrigation development systems and found that irrigation was practiced during ancient times in Ethiopia even if its exact date of emergence is unknown. Ancient use of irrigation water was through use of surface irrigation methods and spate irrigation types. Modern irrigation was started at the Awash River basin with bilateral cooperation of Ethiopia and Dutch company. This was started during the 1950s for the productions of commercial crops such as sugar cane and cotton. Irrigation of these crops was applied by surface irrigation methods and less efficient pressurized irrigation systems.

Traditional small-scale irrigation schemes (SSIs) have existed for perhaps several hundred years, mostly developed by feudal landlords, notably in Hararge, Shewa and Gojam. These developments were usually no more than a few hectares in area and diverted water from streams, often only to provide supplementary irrigation. Over the past few decades many of these schemes have expanded as skills developed, irrigating areas of fifty or more hectares (Awulachew *et al.,* 2006).

Ethiopia's experience in large-scale irrigation development and management is in state enterprises, mainly growing industrial crops like cotton and sugar cane. The experience in modern small-scale irrigation (SSI) development and management started in the 1970s by the Ministry of Agriculture (MoA), in response to major droughts, which caused wide spread crop failures and consequent starvation. The sector could be used to reduce family risks that are associated with crop failures resulting from droughts (Awulachew *et al.,* 2006).

## Importance of Irrigation

Historically, it is the proven fact that the lands with easy access to water produce more than double as compared to rain fed farming systems (WDR, 2008). However out of total available crop lands (i.e. 13 billion hectares) only 18% is well irrigated (United Nations, 2006). There exists only 4 percent of irrigated agriculture in Sub-Sahara Africa as compared to 39 percent in South Asia and 29 percent in East Asia. Due to the significance of irrigated agriculture International institutions like World Bank played a pivotal role in development of irrigation infrastructure in the continents of the world.

Irrigation is one means by which agricultural production can be increased to meet the growing food demands in Ethiopia. Increasing food demand can be meet in one or a combination of three ways: increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity (number of crops per year). Expansion of the area under cultivation is a finite option, especially in view of the marginal and vulnerable characteristic of large parts of the country's land. Increasing yields in both rain fed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are the most viable options for achieving food security in Ethiopia. If the problem is failure of production as a result of natural causes, such as dry-spells and droughts, agricultural production can be stabilized and increased by providing irrigation and retaining more rainwater for insitu utilization by plants (Awulachew *et al.,* 2005).

Heavy reliance on rain-fed agriculture, during conditions of very variable rainfall and recurrent droughts, affects agriculture and, hence, has adverse effects on the economy of Ethiopia. Enhancing public and private investment in irrigation development has been identified as one of the core strategies to delink economic performance from rainfall and to enable sustainable growth and development (World Bank, 2006; MoWR, 2002; MoFED, 2006).

Irrigation contributes to the national economy in several ways. At the micro level, irrigation leads to an increase in yield per hectare and subsequent increases in income, consumption and food security (Lipton *et al.,* 2003; Hussain and Hanjra, 2004). Irrigation enables smallholders to diversify cropping patterns, and to switch from low-value subsistence production to high-value market-oriented production (Namara *et al.,* 2008). Irrigation can benefit the poor specifically through higher production, higher yields, lower risks of crop failure, and higher and all year round farm and non-farm employment (Hussain and Hanjra, 2004).

The impact of drought on the overall macro- economy of Ethiopia is very significant. There is very strong correlation between hydrology and Ethiopia's GDP performance. It is widely accepted that the Ethiopian economy is taken hostage to hydrology due to the so far insignificant infrastructural development in the water sector. Oftentimes, Ethiopia is ravaged by droughts, leading to dramatic slowdowns in economic growth. The development of water storage facilities which could be used, among other things, to develop irrigation is seen as a way of reducing Ethiopia's dependence on the annual availability of rainfall (World Bank, 2006).

Van den Berg and Ruben (2006) conducted a study in rural Ethiopia and observed that irrigation is highly beneficial for the farmers directly involved in crop production. They also concluded that farmers having irrigated lands are less poor as compared to the farmers with non-irrigated lands.

## Furrow Irrigation

Furrows are small channels, which carry water down the land slope between the crop rows. Water infiltrates into the soil as it moves along the slope. The crop is usually grown on ridges between the furrows. This method is suitable for all row crops and for crops that cannot stand water for long periods, like 12 to 24 hours, as is generally encountered in the border or basin methods of irrigation. Water is applied to the furrows by letting in water from the supply channel, either by pipe siphons or by making temporary breaches in the supply channel embankment. The length of time the water is to flow in the furrows depends on the amount of water required to replenish the root zone and the infiltration rate of the soil and the rate of lateral spread of water in the soil (Reddy, 2010).

Furrows can be used on most soil types. However, as with all surface irrigation methods, very coarse sands are not recommended, as percolation losses can be high. Soils that crust easily are especially suited to furrow irrigation because the water does not flow over the ridge, and so the soil in which the plants grow remains friable. In sandy soils, water moves faster vertically than sideways (lateral). Narrow, deep V-shaped furrows are desirable to reduce the soil area through which water percolates. However, sandy soils are less stable, and tend to collapse, which may reduce the irrigation efficiency (Awulachew *et al.,* 2009). As compared to the other methods of surface irrigation, the furrow method is advantageous as: Water in the furrows contacts only one half to one-fifth of the land surface, thus reducing clustering excessive evaporation of water. Furrows may be straight laid along the land slope if the slope of the land is small (about 5 percent), for lands with larger slopes, the furrows can be laid along the contours (Reddy, 2010).

Furrow irrigation is suitable for many crops, especially row crops (Namara *et al.,* 2005). Crops those can be damaged, if water covers their stem or crown, should be irrigated by furrows. Furrow irrigation is also suited to the growing of tree crops. In the early stages of tree planting, one furrow alongside the tree row may be sufficient but as the trees develop then two or more furrows can be constructed to provide sufficient water.

The shape, length and spacing are determined by natural circumstances, i.e. slope, soil type and available stream size. However, other factors may influence the design of a furrow system, such as the irrigation depth, farming practice and the field length. Uniform flat or gentle slopes are preferred for furrow irrigation. These should not exceed 0.5%. Usually a gentle furrow slope is provided up to 0.05% to assist drainage following irrigation or excessive rainfall with high intensity. On undulating land furrows should follow the land contours (Awulachew *et al.,* 2009).

## Drip Irrigation

Drip irrigation system is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 liters per hour) from a system of small diameter plastic pipes filled with outlets called emitters or drippers. Water is applied close to the plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent than with other methods and this provides a very favorable high moisture level in the soil in which plants can flourish (Reddy, 2010).

The drip irrigation system is particularly suited to areas where water quality is marginal, land is steeply sloping or undulating and of poor quality, where water or labor are expensive, or where high value crops require frequent water applications. It is more economical for orchard crops than for other crops and vegetables since in the orchards plants as well as rows are widely spaced. Drip irrigation limits the water supplied for consumptive use of plants. By maintaining a minimum soil moisture in the root zone, thereby maximizing the water saving. A unique feature of drip irrigation is its excellent adaptability to saline water. Since the frequency of irrigation is quite high, the plant base always remains wet which keeps the salt concentration in the plant zone below the critical (Reddy, 2010).

Drip irrigation is one of the latest innovations for applying water to row planted, widely spaced crops, especially in the water scarce areas. There can be considerable saving of water by adopting this method since water can be applied almost precisely and directly in the root zone without wetting the entire area. This technology not only uses each drop of water most efficiently but also results in good crop growth and yield advantage due to stable moisture content maintained always in the root zone of the crop by way of frequent irrigation at shorter intervals (Fanish *et al.,* 2011). They reviewed and concluded that drip irrigation requires less irrigation water with increased irrigation efficiency and ensure uniform distribution of water and fertilizers as compared to conventional methods.

Drip irrigation can achieve 90-95% efficiency by reducing evaporation and deep percolation (Bresler, 1990). In addition to this desirable feature of drip irrigation, uniform distribution of water is possible and it is one of the most important parameters in design, management and adoption of this system. Ideally, well designed system applies nearly equal amount of water to each plant, meets its water requirement and is economically feasible (Mizyed and Kruse, 2008). This method is profitability used in arid and semiarid areas where water is scarce and often poor in quality in respect of salt concentration and labor is expensive (Hillel, 2001).

In drip irrigation system, only a fraction of the soil surface generally between 15 to 60 per cent is wetted. Earlier, drip irrigation was considered as an emerging technology with its application limited to some special crops. The benefits of drip irrigation may include better crop survival, minimal yield variability and improved crop quality. Several experiments have shown positive responses in most of the crops to high frequency drip irrigation (Segal *et al*., 2000).

Drip irrigation is often preferred over other irrigation methods because of its high water application efficiency on account of reduced losses, surface evaporation and deep percolation. Because of high frequency water application, concentrations of salts remain manageable in the rooting zone (Fanish *et al.,* 2011).

A well designed drip irrigation system benefits the environment by conserving water and fertilizer. A properly installed drip system can save as much as 80 percent of the water normally used in other types of irrigation systems. Another advantage to drip irrigation is that there is less evaporation from the soil, especially when drip irrigation is used with plastic mulch. Water is applied more evenly throughout the field, thus eliminating the need to run the irrigation longer to wet the whole field (Anne and John, 2000).

In a study Yildirim and Korukcu, (2000) reported that drip irrigation generally achieves better crop yield and balanced soil moisture in the active root zone with minimum water losses. On the average, drip irrigation saves about 70 to 80% water as compared to conventional flood irrigation methods (Camp *et al*., 2001).

Highly efficient water use can be obtained with careful management of drip irrigation. This careful management requires providing the necessary water to meet evapotranspiration needs of the crop, but avoiding increased irrigation above this point. More frequent irrigation above the required increase the non-beneficial components of the water balance and has both economic costs such as pumping cost, and social costs such as waste of the water resource and excessive drainage of possibly chemical laden water (Lamm *et al*., 1993). Water savings can be obtained by minimizing the non-beneficial components of the water balance while still maintaining the high level of transpiration necessary to attain high yields. With careful management, the non-beneficial components (runoff, evaporation and long term drainage) can be minimized by drip irrigation resulting in increased water use efficiency without scarifying crop yield.

## Principles of Drip Irrigation Method

Drip irrigation involves dripping water onto the soil at a very low flow rates from a system of small diameter plastic pipes fitted with outlets (drip emitters). The basic concept underlying the drip irrigation method is to supply the amount of water needed by the plant within a limited volume of soil and as often as needed. Water is applied close to the plant so that only the part of the soil immediately surrounding the plant is wetted. The volume of soil irrigated by each drip emitter and the water flow along the soil profile are the function of the characteristics of the soil (texture and hydraulic conductivity) and the discharge rate of the drip emitter. Applications are usually frequent (every 1-3 days) to provide a favorable moisture level for the plant to flourish (Isaya, 2001).

The basic components of any drip irrigation system include water source to provide the amount of water required at the necessary pressure to distribute and push water out of the drip emitters, control valve to open and shut off the water, flow meter to measure the amount of water moving through the system, filter to remove particles from the irrigation water that may clog the drip emitters, pressure regulator to regulate water pressure, main and sub-main lines to carry and distribute water to the drip laterals, drip laterals to carry the water and distribute it to the drip emitters, emitters to control the flow of water from the laterals into the soil and flushing manifold to washes sediments from the lateral lines. The coverage area determines the pressure required to overcome friction losses associated with water delivery and filtration (Isaya, 2001).

According to IDE (2002), the arguments for drip irrigation is water saving, higher yields, energy saving, easier to harvest, less salinization and foliage remains dry (no leaf burning), fertilizers and pesticides can be delivered accurately to the cultivated plants, adaptability to different land forms, suitability for different soil types, better vegetable hygiene in a drier soil, no need for drainage. Whereas, the problem in drip irrigation is clogging of emitters, mechanical, damages, initial cost and not suitable for all the crops (e.g. rice, wheat).

## Water Application and Saving, Increase in Yield and Water Use Efficiency

Mentioned that unwise use of irrigation water through furrow irrigation methods has farther constrained the cropping intensities and crop yields. The main reason for this injudicious use of water is to employ furrow water application practices like monitoring the crop canopy or using plant indicators, which only allows farmer to decide when to irrigate and amount of water is applied just near to the top edges of the bund of the field, which results the application efficiency (WAE) is the ratio between water stored in root zone and water applied from source during irrigation (Allen, 1998).

Irrigation water use efficiency has been defined in agronomic terms as yield or economic yield per unit of irrigation water applied (El-Hendawy *et al.,* 2008; Ozbahce and Tari, 2010). Optimizing irrigation management and decreasing overall volume of water applied through the use of drip irrigation can lead to other potential benefits such as reduced nutrient requirements and leaching (Eldredge *et al.,* 2003; Reyes-Cabrera *et al.,* 2014; Shock *et al.,* 2007). Chawla and Narda (2001) compared drip irrigation to conventional furrow irrigation in potato and found potential water and nutrient savings of 30% and 70%, respectively.

Compared to the sprinkler and furrow irrigation methods (with efficiency of 60-70% in high management systems), drip irrigation can achieve 90-95% efficiency (Isaya, 2001). With drip irrigation system, irrigation takes place on a frequent basis, enabling water manager to maintain the soil moisture at optimum level. A well designed, well maintained drip irrigation system can also apply water more evenly than other irrigation methods. These features lead to more uniform and higher crop yields per land unit (IDE, 2002).

Singh *et al.* (2005) found from their experiments that the potato yield was 588.0 quintals/ha with drip irrigation method compared to 507.8 quintals/ha with furrow irrigation. Moreover, Ibragimov *et al.* (2007) found that yield was higher by 18-42% and water use efficiency by 35 to 103% in drip mode.

Erdem *et al.* (2006) conducted an experiment to study water-yield relationships of potato under different irrigation methods and regimens and the result revealed that drip irrigation method yielded higher values of IWUE and WUE, since drip irrigation consumed less water than furrow irrigation. Water use efficiency values increased from 4.70 to 6.63 kg $m^{-3}$ for furrow-irrigated treatments, and from 5.19 to 9.47 kg $m^{-3}$ for drip-irrigated treatments.

Water conveyance and application losses for flood are substantially higher, compared with other irrigation systems, such as sprinkler or drip irrigation. The findings of many research reports (Ferreira and Carr, 2002; Yuan *et al.*, 2003) usually conclude that the less water used, the higher the irrigation water use efficiency. Drip irrigation has been shown to allow for reduced water application without negatively affecting yield and quality (Chawla and Narda, 2001; Starr *et al.,* 2008; Yuan *et al.,* 2003).

When compared to furrow irrigation in India, drip irrigated treatments yielded comparably with 30% less water applied (Chawla and Narda, 2001). Deficit irrigation, or irrigating below crop ET may also be possible through the use of drip irrigation. Yuan *et al.* (2003) based application rates with drip on crop ET demand, and found that it was possible to decrease water application up to 75% of ET replacement without affecting yield. The ability to irrigate below crop ET demand and reduce overall application rates can improve irrigation water use efficiency of crop production.

Drip irrigation has major advantages as compared to other methods include; higher crop yields, saving in water, increased fertilizer use efficiency, reduced energy consumption, tolerance to windy atmospheric conditions, reduces the labor cost, improved diseased and pest control, feasible for undulating sloppy lands, suitability on problems soils and improved tolerance to salinity (Michael, 2008). Yildirim, and Korukcu, (2000) reported that trickle irrigation generally achieves better crop yield and balanced soil moisture in the active root zone with minimum water losses. On the average, trickle irrigation saves about 70 to 80% water as compared to conventional flood irrigation methods (Ishfaq, 2002).

The drip irrigation system has major advantages that were watering high efficiency, use less water pressure, high yield, saving water. It provides higher crop yields when compared to the furrow irrigation system to the same of planting areas and quantity of water. The drip irrigation system could provide better performance than the furrow irrigation system. Trickle irrigation method saved 88.32% water and gave 5.97% more yield as compared to that furrow irrigation method. Higher water use efficiency about 0.038% was obtained in trickle irrigation method; whereas lower water use efficiency about 0.004% was obtained in furrow irrigation method (Bazai *et al.,* 2015).

Drip irrigation has proved its superiority over other conventional method of irrigation, especially in the cultivation of fruits and vegetables due to precise and direct application of water in root zone. A considerably saving in water, increased growth, development and yield of vegetables under drip irrigation has been reported (Imtiyaz *et al.,* 2000).

Qureshi *et al.* (2015) conducted an experiment to study effect of drip and furrow irrigation systems on sunflower yield and water use efficiency in dry area of Pakistan and the results revealed that drip irrigation has the potential to save 56% water and increase sunflower yield by 26% over furrow irrigation. Drip irrigation system is efficient method having 3 times more water use efficiency than furrow irrigation system.

Abd El-Hafez *et al.* (2001) reported that drip irrigation method increased field and crop water use efficiency by 35 and 9.52 percent respectively as compared to furrow irrigation in maize. Furrow (conventional) and drip irrigated corn yield were compared in Central Asian Uzbekistan. Under drip irrigation 371 to 428 mm of water was used and 547 to 629 mm of water used under furrow irrigation system.

Tagar *et al.* (2012) conducted an experiment on the comparative study of drip and furrow irrigation methods at the farmer's field in Umar Kot and the results revealed that the drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method. Higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water used efficiency about 1.66 was obtained in furrow irrigation method. Total volume of water applied to the crop under drip irrigation system was 2344.75 $m^3$/hec. Similarly total volume of water applied to the crop under furrow irrigation system was 5380.0 $m^3$/hec. These results reveal that total volume of water used under drip irrigation system was less as compared to furrow irrigation system. Total yield of crop (Tomato) under drip irrigation system was 11440 kg/hec. Similarly total yield of crop under furrow irrigation system was 8945 kg/hec. These results suggest that total yield of crop under drip irrigation system was more as compared to furrow irrigation system.

## SUMMARY AND CONCLUSION

Water is essential substance for sustaining life on the earth. Its consumption by the agriculture sector continues to dominant the overall requirements of water. Moreover the increasing population, urbanization and unsustainable consumption of water have further imposed the greater demands on water in arid and semi regions of the country. Thus it becomes indispensable to properly manage water at all levels in order to fulfill food and fiber requirements. Management of water resources at macro level is quite costly and time taking, even though unavoidable. On the contrary the management of water at field level is relatively inexpensive, more feasible, and easily workable and can be implemented in short span of time.

A long-term perspective in shortage of fresh water resources, especially in arid and semi-arid area, highlights an urgent solution for innovative irrigation strategy and agricultural water management. Water resources should be used with a higher efficiency or productivity. To achieve this goal improvement in agricultural water management is a promising way. The scarce water resource necessitates its judicious use which will be possible by efficient water management practices like drip method for improved WAE and WUE. Drip irrigation is often preferred over other irrigation methods because of its high WAE on account of reduced losses, surface evaporation and deep percolation.

In this review it is concluded that drip irrigation method can give overall better performance with respect to water saving, increase in yield and water use efficiency than old traditional flooding methods. A properly installed drip system can save as much as 80 percent of the water normally used in other types of irrigation systems. Many study revealed that drip irrigation method yielded higher values of IWUE and WUE, since drip irrigation consumed less water than furrow irrigation. Drip irrigation has been shown to allow for reduced water application without negatively affecting yield and quality. Deficit irrigation is possible through the use of drip irrigation without affecting yield.

Water is an important input for growing crops. So water saving irrigation methods should be followed in order to save water and maximize yield. Due to severe competition for water from human beings, intensive agriculture, flora and fauna, etc. value of water will go up. So proper irrigation scheduling is required for maximizing yield and water use. Study is needed to find out the best irrigation management technique (in terms of irrigation methods and schedule).

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