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INVESTIGATING THE FEASIBILITY OF DRIP IRRIGATION FOR WATER CONSERVATION IN SUGARCANE CULTIVATION

Dr. Kulvinder Kaur

Assistant Proessor, Department of Geography, Institute of Integrated & honors Studies(IT&HS), Kurukshetra University, Kurukshetra

ABSTRACT

As a major contributor to the nation's gross domestic product, the sugar sector is one of the agro-based industries in the nation. Over time, the sugar sector has garnered more attention than any other food-related sector, resulting in extremely attentive and frequently too cautious attention to detail. However, the sugarcane crop requires a lot of water and has historically been grown mostly using surface irrigation, which has relatively low water use efficiency (35–40%) due to significant distribution and evaporation losses. As the rainfall is unrealizable and concentrated and the variable factor further reduce its effectiveness. Hence, it has become a topic of discussion or debate in several forms over the fast decrease in accessible potential for irrigation and the paucity of water for irrigation. For this, drip irrigation is one of the techniques that have recently been implemented to improve the water utilization rate in Indian agriculture, taking into account the paucity of water. In contrast to the surface technique of irrigation, the drip irrigation method uses an intricate system of pipes to deliver water right into the crop's root zone, saving a significant quantity of water by minimizing distribution losses and evaporation. In this article, the same method has been investigated for its feasibility of water conservation when implemented for sugarcane cultivation through different case studies that have been previously reported.

Keywords: Drip irrigation, water conservation, sugarcane cultivation, case studies.

1. INTRODUCTION

Irrigation plays a significant role in the agricultural development of a region; without an assured supply of water, neither the high-yielding varieties (HYV) nor economical fertilization or pesticides, which are the basis of modern agricultural growth, can be effectively used. Hence, for efficient utilization of the existing land capabilities and to enhance the state of innovation adoption, there is an acute need for suitable irrigation methods.

A significant issue in light of climate change and an increasing world population is the usage of water in agricultural production. The largest user of the limited water resources on our world is agriculture, which is a resource that is becoming more and scarcer. 70% of the clean water resource on Earth is used for agriculture, and in certain developing countries, 95% of all water withdrawals are made for this purpose [1].

“[1]An ensured and regulated supply of agriculture water from ground and surface resources is the basic and essential aspect upon which the future planning of irrigation depends”.

One particular kind of micro irrigation technology is drip irrigation. The most effective method of delivering nutrients and water to crops is drip irrigation. It provides precisely what every crop requires, whenever it needs it, to grow to its full potential by delivering nutrients and water straight to the roots zone of the plant at the appropriate times and amounts. Farmers can increase yields while using less water, fertilizer, energy, as well as crop protection goods by implementing drip irrigation systems. In contrast to conventional irrigation techniques like flood irrigation or center pivot irrigation, a drip or micro-irrigation system can lower energy expenditures by 50% and boost a farmer's water utilization by up to 70% [1].

The drip irrigation technique was developed to increase water efficiency and has been used since the early hours of the morning in several regions of India. With its ability to conserve water, drip irrigation shortens pumpset

[1] Jasbir singh An agricultural geography of Haryana, Kurukshetra, 1976, P-108

operating hours while simultaneously lowering electricity usage and boosting crop productivity. Although the main goal of drip irrigation technology is to improve agricultural water efficiency, it also has several additional positive social and economic effects on society. For various crops, the decrease in water consumption resulting from the use of the drip irrigation technique as opposed to the surface approach ranges of higher percentage.

Drip irrigation is very much important for the crops that need high percentage of water throughout its growth. Sugarcane is one of them. Sugarcane crop requires a lot of water and has historically been grown mostly using surface irrigation, which has relatively low water use efficiency (35–40%) due to significant distribution and evaporation losses.

In India, sugarcane has been grown since the Vedic era. In the agricultural sector, sugarcane accounted for 2.6% of India's gross cultivated area in 2006–07 and contributed almost 7% of the entire value of output from agriculture. After textiles, sugarcane is the primary raw material used in the second-biggest agro-based sector. In 2010–11, there were roughly 527 operational sugar factories in the nation, with a combined installed annual capacity for production of about 242 lakh metric tonnes [2]. The main product of sugar cane is sugar. The amount of sugar consumed domestically fluctuates between 22 and 23 million metric tonnes per year, while the amount produced in India during the previous five years has fluctuated between 24.3 and 26.3 million metric tonnes. Maharashtra is the biggest sugar producer, accounting for around 34% of all sugar produced in the country. Other than this, Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh are the ones where sugarcane is grown most frequently. Although the combined area of sugarcane in these five states was approximately 81.63 per cent in 2000-01, the combined area of sugarcane in Uttar Pradesh and Maharashtra was nearly 60 per cent in the same period. The area planted with sugarcane increased at a pace of more than 1.81 percent every year despite being a crop that requires a lot of water.

One of the major crops that are excellent for irrigation by drip is sugarcane. Although farmers have grown sugarcane under drip irrigation in a number of states and locations, the crop's current coverage is extremely restricted, primarily because of a lack of knowledge regarding the drip irrigation method's significance. Farmer reluctance to invest in drip irrigation technology stems from its relatively higher fixed capital requirements. Furthermore, farmers frequently inquire about the payback period of their drip investment due to the lack of reliable field level research highlighting the benefits of this technique.

2. DRIP IRRIGATION: AGRICULTURAL PROSPECTIVE

2.1 What is Drip Irrigation?

Using surface irrigation approaches, water is applied to the whole field. While it hydrates the plants, overhead irrigation creates runoff. Drip irrigation, on the other hand, is a far more regulated irrigation technique. It functions by putting the roots in direct contact with water. The use of drip emitters, which discharge water gradually, makes this system easier to utilize. Drip emitters are tiny, often sized like a quarter, and they are placed on ground-level in rows. A feeder hose is used to connect drip emitting devices to a water source. A pipe with drip emitters integrated into it is used in another variation of drip irrigation. Trickle tape is a variation on the drip irrigation method [3].

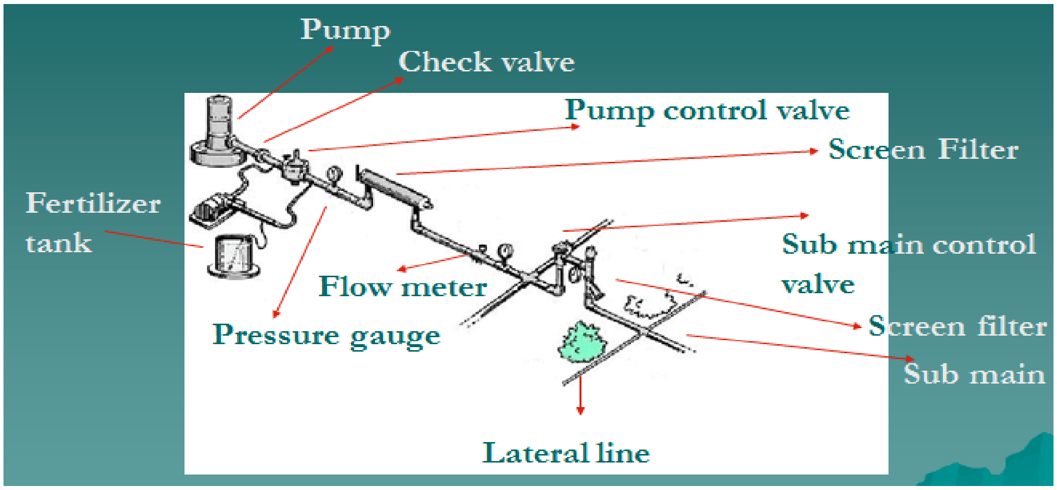

Figure 1: Drip irrigation components details [4]

The mainline, valve, sub-main, overflow preventer, level regulator, filter, tube adapters and fixtures, emitters, drip tubing, as well as the end caps are the essential parts of a drip irrigation system. The pipe that goes from the water's source, usually a outdoor tap, to the valve is known as the mainline, and the conduit that runs beyond the valve to the location where the drip piping joins it is known as the sub-main. The sub-mains are often only utilized in situations where several drip tubing lines and zones are supplied by the same mainline water supply. The mainline and sub-main's aggregate length shouldn't be more than 400 feet [5].

The valve, which has an automatic or manual control setting, regulates the flow of water entering the system. In order to avoid irrigation water from reentering the pipes and contaminating the primary water source, backflow preventatives are required. If the water pressure is more than forty pounds per square inch, regulators for the pressure are required. In the event that required unsure of your water pressure, installing one is a smart choice.

Like sprinkler systems, drip irrigation can be operated by hand or programmed to run automatically. Using a manual operation lets you benefit from rains before using extra water. Drip irrigation is meant to operate every day—that is, unless it rains—because tiny amounts of water are given gradually. The amount of water that plants need each day and the flow rate of the emitters will determine how long the drip irrigation system should run. One or two applications of water are made each day. Watering in the early morning is ideal because evaporation will also be lower.

2.2 Benefits of Drip Irrigation

The control that drip irrigation techniques offer is by far their greatest advantage. These irrigation methods are also very accurate and cost-effective. Conventional lawn sprinkler systems, for instance, can emit one to five gallons (four to twenty litres) of water every minute. The quantity of water which a typical sprinkler requires is expressed in gallons per minute. On the other hand, a drip emitter's water consumption is expressed in gallons per hour. Water moving so slowly almost certainly finds its way into the ground, which is where it will be utilized more effectively and won't evaporate. Water wastefully running off is virtually eliminated with a properly constructed and maintained drip irrigation system [5].

2.3 Why is Drip Irrigation Preferred By Farmers?

In addition to offering a higher return on investment than other irrigation techniques, drip farming allows farmers to run their operations more profitably and sustainably by optimizing water use and increasing crop yields [6].

1. Increased yields of consistently high grade Significant water savings because zero waste, runoff, or evaporation 100% of the land is used
2. Drip irrigation evenly irrigates every kind of soil and topography.

3. Energy-saving
4. Minimal pressure drip systems for irrigation effective crop protection and fertilizers use that doesn't involve leaching more consistency.
5. Less reliance on the weather, and reduced dangers.

2.4 Why Irrigation by Drip is Preferred by Plants?

Similar to human, plants prefer to receive both water and nutrients in a balanced manner. A month's worth of food is too much for anyone to take in one sitting, and the same is true with plants []. For this reason, drip irrigation ensures ideal growing conditions that aid in producing the maximum yields possible by applying water and nutrients often and in small dosages. This is the reason why drip irrigation systems increase plant productivity.

1. High water and nutrient supply.
2. Freshwater and nutrient dosages based on the necessities of the plant's development.
3. Excellent soil aeration and lack of saturation.
4. Prevents excessive salinity brought on by fertilizer application.
5. Avoid moistening the foliage since this may lead to fungal illnesses.

2.5 Why do We Need DIS in the World?

Ten billion individuals will inhabit the earth by 2050, and there will be 20% fewer acres of agriculture available per person to provide enough food. It is obvious why there is need to find a means of raising agricultural output and resource efficiency when we take into account the growing scarcity of water []. This is where DIS comes into play, enabling farmers to produce more energy per hectare and cubic metre of water, so altering the financial picture of global agriculture.

1. Lessen the effect of climate change and droughts on food production.
2. Prevent the pollution of rivers and groundwater due to fertilizer leaching.
3. Encourage rural communities, lessen poverty, and discourage emigration to urban areas.

3. Analysis of Reported Studies

Here in this section, various studies related to adoption, constraint and feasibility of drip irrigation for water conservation in sugarcane cultivation has been analyzed. The detailed information and analysis of the studies has been mentioned below.

3.1 Study 1 (Mahesh et al, 2016)

Location

The research study was conducted in a farmer's property (Iyyar Thottam), Puttuvikki, which is located in the west agroclimatic region of Tamil Nadu, closer to the Tamil Nadu Agricultural University, Coimbatore.

Site Selection

The experimental location is located 418 metres (1,371 feet) above mean level of the ocean at a latitude of 10°97' North and a longitude of 76°92' East. An aggregate of 530.50 mm of rain fell in 38 rainy days throughout the growing season of the sugarcane crop, which is 14.15% less than average rainfall. During January to December, the monthly mean highest temperature varied between 29.20 ^{o}C and 35.89 ^{o}C, while the monthly average lowest temperature varied between 19.00 ^{o}C and 24.53 ^{o}C. The early morning humidity level on an annual mean basis varied between 78.84 and 88.73%.

The relative humidity of the monthly average evening varied between 34.74 and 60.81%. The average number of sunshine hours per month varied from 2.85 to 8.32 hours. In July, the monthly average highest wind velocity of 12.84 km/h was recorded.

RESULTS

In the current investigation, the total amount of water used for subsurface drip irrigation (SSDI) was just 1279 mm, resulting in a 30.73% reduction in water usage as compared to surface irrigation (1846 mm). In this study, surface drip irrigation (SDI) resulted in a 22.70% reduction in water consumption, with a water demand of 1427 mm, substantially less than that of surface irrigation (1846 mm).The low rate of application at regular intervals that matched actual crop water needs at different stages was the reason for the water savings under both the SSDI (and SDI. The current study also showed that SSDI outperformed SDI in terms of incremental water savings, with the latter achieving savings that were 8–9% lower.

IMPLICATION

1. Here a filed study was carried out to evaluate the effectiveness of a different subsurface drip irrigation technique (SSDI system) and contrast it with a surface drip irrigation technique (SDI system).
2. It was found through experimentation that the SSDI system consistently produced cane and sugar yields which were much higher than those of the SDI method.
3. Additionally, tests have shown that, when compared to an SDI system, the SSDI system has enhanced the irrigation water use efficiency.
4. With the same amount of irrigation water and fertigation, the SSDI method produced yield increases that were meaningful. In this experimental study, the new irrigation technique (SSDI) has resulted in water savings of up to 30.73%.
5. The SSDI system's demonstrated increases in yield and water savings may be the result of the the omission of water losses through soil evaporation and improved water redistribution in the wet bulb may be the root cause of the experimentally reported improvement in yield and water conservation in the SSDI system.

3.2 Study 2 (Sheini-Dashtgol et al.2020)

Location

In 2016–2017 and 2017–2018, both of the cropping seasons, the tests was carried out in Iran. Split-plots with a simple design of full random blocks with two components and a total of three replications were used for the purpose of this study.

Site selection

The test field was situated 7.6 metres from sea level in a warm, arid weather zone at longitude 48°33 E, latitude 30°59 N. Cuttings from the area's popular cultivar, CP69-1062, have been planted in two rows with a 40 cm gap between each row and sent directly to the stack. Two rows were arranged with the tubes in the middle. Soil samples were taken at depths of 0–30, 30–60, and 60–90 cm prior to field cultivation. Analysis of the soil was done to find the EC, pH, cations, and anions.

Results

According to their findings, the majority of the time the volume of wetness was oval, and the water radius under drops would rise in proportion to the amount of moisture present in the soil profile. The largest moisture range was seen at a level of 30 to 60 cm and at a distance of 30 cm from the discharge pipe. This result showed a maximum moisture dispersion at installation depths of 20 cm and 0 to 60 cm. The plant responds to the rooting both horizontally and vertically in SDI, where water is given to it periodically and partially.

Implications

The area with the greatest sugarcane production was 20 cm deep and 50 cm away from the drippers. The 50-centimeter emitter spacing and 20-centimeter depth had the greatest stalk density. In addition to the high water output of the produced sugar and sugarcane, sugarcane quality increased when the use of water decreased. As a result, on average, two yields of experiments conducted in 50 cm of dripper space and 20 cm of dripper depth generated higher WP of sugarcane and sugar as 6.6 and 0.73 kg.m-3, respectively.

3.3 Study 3 (Shanthy et al.2021)

Location

The certified cane growers of Kallakurichi Cooperative Sugar Mills in Tamil Nadu who installed drip irrigation systems were the subjects of the study.

Site Selection

In contrast to the state's average output of 98 tonnes per hectare for the 2018–19 season, the average cane yield level observed in the mill's designated area was 80.00 t / ha. This region was specifically chosen since it typically produced a moderate amount of sugarcane. Other factors included the fact that sugarcane drip irrigation systems (DIS) have been installed since 2015 and that, in order to maximize sugarcane yield, it is critical to evaluate farmer input, adjust the system, and spread its use among other certified cane growers.

Result

Although drip irrigation for sugarcane was suggested in Tamil Nadu as early as 2002, the method was only adopted in the sugar mill area in 2015. The findings show that since all of the respondents experienced drip-laid farmers, they all employed drip irrigation systems. To save water, half of those surveyed (50%) and over fifty percent (58.33%) used trash mulching and alternate furrow irrigation, respectively. Even if adding more potash (60 kg) to help lessen the drought was highly popular among the respondents, only 13.33% of them really did so in order to survive the drought. Hence, drip irrigation was found to be more effective in conserving water than additional fertilizer application. The reported benefits of using drip irrigation are

Table 1: Factor analysis

Factor	Percentage
Saving in labour cost	100
Huge water saving	100
Higher cane yield than normal irrigation	98.33
Reduced impact of drought	98.33
Efficient use of fertilizer	96.67
Availability of water for raising another crop	95.00
Less evaporation loss of water	95.00
Avoidance/ Minimize weeds	91.67
Possibility of multiratooning	43.33

Implication

1. Average yield gained by the farmers through conventional irrigation = 92.20 t/ hectare
2. The respondents' average output from drip irrigation was 119.63 t/ha.
3. Yield increase = 27.43 t /ha
4. The percentage of increased production resulting from the implementation of drip irrigation is 29.75%.

3.4 Study 4 (Singh et al.2021)

Location

A total of three years of field experiments were carried out at Punjab Agricultural University's study farm, Faridkot, Punjab, India The study year was 2014–2015, 2015–2016 (plant crop), and 2016–2017 (ra toon crop).

Site Selection

Situated 211 metres from average sea level, the study farm intersects at 30 400 N latitude and 74 440 E longitude. Geographically, this area is a part of India's Trans-Gangetic plain agro-climatic zone, which is part of the Indo-Gangetic alluvial plains. These plains are made up entirely of Pleisocene and more recent alluvial deposits from the Indo-Gangetic the system's rivers, that have entirely covered the ancient land surface. The monotony of these sediments varies.

Results

The experiment was designed using a split-plot design with three irrigation schemes: drip irrigation across the sugarcane bed and furrow paired row planting at 30–30: 120 cm spacing between rows in main plots and all three fertigation levels of 60, 80, and 100% suggested N (RDN, 150 kg N/ha for plant crop and 225 kg N/ha for ratoon crop) in subplots. A total of three irrigation schemes were used in the test. 100% RDN by line top and flood irrigation served as an extra control.

In a pair of row cultivation system, drip irrigation was used every three days, and fertigation was done in ten identical splits according to treatment. Drip irrigation at 100% CPE produced the highest cane output in 2014–2015 and 2015–2016, outperforming drip irrigation at 60% and 80% CPE by a wide margin.

Throughout the ratoon 2016–2017, cane yield statistically comparable to that of 80% RDN and 100% RDN, but the maximum cane production was observed during the fermentation with 100% RDN, which was much superior than 80 and 60% RDN throughout 2014–2015 and 2015–2016. In comparison to the typical practices of surface flood irrigation and soil fertiliser application, drip irrigation at 100% CPE with 100% RDN produced notably greater cane yields in 2014–2015, 2015–2016 (plant), and 2016–2017 (ratoon), correspondingly. In 2014–2015, the largest net returns were reported at 100% CPE and 100% RDN levels, totaling Rs. 150,900, 175808, and 201666 per hectare.

3.5 Study 5 (Kumari et al.2022)

Area

The two main citrus-growing areas in the state of Haryana, Sirsa and Fatehabad, were the sites of the study. Thirty participants were chosen at random from various communities within each district.

Results

It was determined that the vast majority of cultivators in western Haryana had a high (61.67%) level of understanding of drip irrigation, followed by a moderate (31.67%) level of expertise. The data also showed that 40.00% of respondents had a high degree of drip irrigation adoption, compared to low (35.00%) and moderate (25.00%) levels of adoption. Numerous socioeconomic characteristics, including income, land ownership, exposure to mass media, education, and socioeconomic position, have been found to be substantially correlated with the degree of awareness and uptake of drip irrigation. To increase farmers' usage of drip irrigation, these indicators must be improved in rural regions.

From the different case studies, it has been observed that the use of drip irrigation in sugarcane is totally feasible. Additionally, the Indian government offers farmers subsidies to increase the use of drip irrigation. Minimal irrigation water supplied by a drip system allowed for maximum water production, and vice versa, as fertilizer levels rose, so did water productivity. With its ability to conserve water, drip irrigation shortens plumpest operating hours while simultaneously lowering electricity usage and boosting crop productivity. Since water is becoming more and scarcer, drip irrigation is thought to be the cornerstone of sustainable sugarcane farming. However, an awareness among famers is found to be minimum which need to be boost to introduce such beneficial technique at ground level of sugarcane farming.

CONCLUSION

Irrigation is one of the most important basic ingredients in the process of agriculture development. The irrigation facilities' in any region can transform the subsistence agriculture landscape gradually into a commercial one, making the abrasion economy market-oriented. The rice-wheat farming system is the most common in north India, particularly in Punjab, Haryana, and the western portion of Uttar Pradesh. However, due to diminishing resources and monoculture constraints, some areas must be diversified away from this cropping system. Sugarcane can boost farmer profitability and provide a strong opportunity for the state's agricultural system to become more diverse. In addition to this, advanced irrigation methods, such as drip irrigation, have been introduced to improve cultivation. Drip irrigation is a more cost-effective technique and is feasible for sugarcane cultivation. In this paper, different studies have been investigated to check the feasibility of drip irrigation for sugarcane cultivation, and it has been found that water is getting harder to come by; hence, drip irrigation is considered the key to sustainable sugarcane growing. But it turns out that there isn't much awareness among farmers, which needs to change in order to promote such a useful technology at the base of sugarcane growing.

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