Original Research Article

Review of the impact of drip irrigation mulching on soil characteristics and efficiency in water usage

Abstract

The method of irrigation and various types of mulch have an impact on the growth and yield of vegetables. The current study conducted a review of drip irrigation with varying volumes of irrigation (V, 0.8V, and 0.6V) that were implemented in drip treatments. Transparent mulch resulted in higher soil temperatures compared to black mulch. The application of black mulch resulted in a notable elevation of soil temperature within the root zone, with an increase ranging from 2.5 to 4°C when compared to crop plots that were not subjected to mulching. The moisture content in the non-mulched plots was found to be higher than that in the mulched ones. The utilization of plastic mulch resulted in water conservation ranging from 25% to 35% across various treatment conditions. The application of black mulch in all treatment groups resulted in a higher yield as compared to the control treatment. The implementation of drip irrigation and mulching techniques in vegetable growing has the potential to decrease cultivation expenses by optimizing water usage.

Keywords: Drip irrigation, water conservation, mulching

Introduction

Water is an indispensable and pivotal component for sustaining human life, particularly in developing nations such as India. The availability of water resources for agricultural purposes has been constrained in recent years as a result of the effects of global warming and the unpredictable patterns of rainfall in arid and semi-arid regions (Kader et al., 2019). Water, although considered a renewable resource, is currently facing significant challenges in terms of its availability in suitable quantities and quality. These challenges arise from the escalating global population and the expanding demand for water across all industries. The agricultural sector is the primary consumer of water, accounting for around 83% of total water usage, primarily for irrigation purposes. The efficient usage of available water resources is of utmost importance for India, a country that is home to 17% of the global population but possesses only 2.4% of land and 4% of water resources (Fanish, 2013).

Water scarcity is a significant concern to the global community in the 21st century.

The inadequate management of water and nutrients has played a significant role in the prevailing issues of water scarcity and pollution in various regions across the globe. Furthermore, this mismanagement posses a substantial obstacle to ensuring future food security and maintaining environmental sustainability. The efficiency of surface irrigation method is significantly lower when compared to contemporary irrigation systems such as drip, micro-jet, micro sprinkler, and overhead sprinkler.

Water is an essential resource for agricultural activities, and the shortage of water sources is rapidly escalating as a result of the intensification of farming practices.

In recent years, the escalation of water scarcity has been more pronounced due to the tremendous advancements in agriculture and industry. Water resources are inherently finite; nonetheless, there is a prevalent issue of inefficient water usage. The agricultural sector accounts for around 83% of the total water consumption. Approximately 50-70% of water is lost due to transpiration, evaporation, and field application and distribution losses in traditional irrigation techniques. The implementation of advanced irrigation methods, such as the drip irrigation method, along with effective water management practices and the use of mulching, has the potential to mitigate these losses. In the context of India, it is projected that by the year 2030, the demand for water will increase to approximately 1500 billion cubic meters. This increase in demand can be attributed to the need for producing more food grains in order to sustain the expanding population. The current water supply in India is approximately 740 billion cubic meters, highlighting the need for the adoption of prudent water management technology to improve crop water productivity (Jeelani et al., 2017; Kumari et al., 2018).

Drip irrigation refers to a highly efficient method of delivering water to plants by releasing it in small, localized quantities. This process involves the gradual release of water drop by drop, either at a specific place or in a grid-like pattern, directly onto or just below the soil surface in close proximity to the plant's root zone. The utilization of this approach is prevalent in various contexts due to its capacity to effectively administer and optimize the allocation of both water and fertilizer resources (Rajurkar et al., 2012). The implementation of efficient irrigation schedule is of utmost significance when making decisions aimed at optimizing crop yields and enhancing overall produce quality.

The effective implementation of irrigation scheduling necessitates a comprehensive understanding of crop attributes, including the specific water requirements of a certain crop at a particular stage of growth, as well as the appropriate methods for water application.

In addition to the aforementioned features, it is important to evaluate the efficiency with which water is supplied to the potential root zone of the crop for optimal plant growth, commonly referred to as water usage efficiency (WUE) (Jeelani et al., 2017). The Water Use Efficiency (WUE) can be enhanced through two approaches: increasing crop transpiration or improving yield per unit of water utilized. The maximization of WUE can be achieved by the use of many strategies, including deficit irrigation, the utilization of advanced irrigation technology, and the implementation of effective irrigation Scheduling. Additionally, enhancing agricultural water management techniques can contribute to the improvement of crop yields, hence, further enhancing WUE. The utilization of this technique in plant management has the potential to enhance both crop output and product quality. Hence, it is imperative to enhance water use efficiency (WUE) by reducing the amount of water used while maintainingthe agricultural output, particularly in locations with limited water resources. The determination of irrigation schedule, which involves the timing and quantity of irrigation water, is influenced by numerous intricate elements. However, among these factors, Microclimate assumes a paramount significance.

One of the water management strategies aimed at enhancing water use efficiency (WUE) is mulching. Various types of materials, including straw, plastic film, grass, hyacinth, gravel, and sand, have been utilized as mulches (Sweeny et al., 1987; Kader et al., 2019). The practice of mulching has been found to have a positive impact on crop production through its influence on soil productivity and weed control, among other factors. The specific benefits of mulching may vary depending on the type of mulch used (Asiegbu, 1991). Previous studies have indicated that the utilization of polyethylene mulch in vegetable cultivation has demonstrated efficacy in managing weed occurrence, minimizing nutrient depletion, and enhancing the hydrothermal conditions of soils (Asworth and Hurrison, 1983; Shrivastava et al., 1994).

The utilization of soil cover and mulching is widely recognized for its advantageous effects on soil moisture retention, Solarization, and weed management. Additionally, this phenomenon leads to the conservation of moisture, reduced soil compaction, and increased levels of carbon dioxide in the vicinity of plants (Arora et al., 2008). According to Kader et al. (2019), the use of plastic mulch results in the retention of elevated soil temperatures throughout nighttime, hence promoting favourable conditions for root activity. Additionally, it has been shown that this practice leads to a decrease in the population of undesirable plant species and enhances the microbiological processes occurring in the soil by creating a more favourable environment in the vicinity of the root zone. The consistent application of Mulches is beneficial for enhancing the organic matter composition of soil, thereby leading to an improvement in the soil's capacity to retain water. Therefore, the utilization of drip irrigation in conjunction with plastic mulch presents a robust scientific foundation for enhancing agricultural productivity (Sharma and Meshram, 2015). The utilization of mulching in conjunction with a drip irrigation system has been found to be a very efficient technique for modifying the growth environment of crops. This method has been shown to effectively enhance crop production and improve the overall quality of the produce through many mechanisms. These include the regulation of soil temperature, the preservation of soil moisture, the mitigation of soil erosion, the enhancement of soil structure, and the augmentation of organic matter content. The conservation of irrigation water is a crucial aspect of promoting sustainable agricultural development. To achieve this, many strategies aimed at conserving moisture have been implemented (Taylor et al., 1995).

Considering the advantages of mulching, specifically its ability to regulate soil temperature and preserve soil moisture in various agro-climatic regions, the implementation of mulching techniques in vegetable production has been recommended. This practice aims to reduce cultivation expenses and achieve high-quality yields, leading to greater financial gains. In the case of high-value crops, such as tomatoes and cucumbers, employing the practice of utilizing heavy paper or plastic sheets to cover the ground proves to be a financially viable strategy. This method serves the purpose of safeguarding the soil, conserving water, and inhibiting the growth of unwanted weeds. Figure 1 depicts the utilization of mulch in conjunction with micro irrigation.

Fig 1.Utilization of mulch in conjunction with micro irrigation.

Mulching at a field

The impact of various mulches and degrees of irrigation on plant growth and development

The moisture content of soil has a crucial role in determining the quality and quantity of crop output.

The presence of sufficient soil moisture during crucial periods of plant development not only enhances metabolic processes within plant cells, but also improves the efficiency of applied Mineral fertilizers on the crop. According to Saif et al. (2003), the growth and production of the crop might be negatively impacted by any level of water stress.

In their study, Anutin et al. (2007) examined the impact of various factors, including soil moisture, temperature, and Sugar Metabolism, on Japanese Radish (Raphanus sativus). Throughout the trial period, the researchers noted that the soil moisture contents in the mulched plots were consistently greater compared to the non-mulched plots. The moisture extraction pattern in summer groundnut was observed to be affected by various irrigation schedules. The Soil moisture contents were recorded to be highest at 40 mm irrigation, with values of 26.69% and 23.19% for the 0-15 cm and 15-30 cm soil depths, respectively. This was followed by values of 26.10% and 22.96% at 50 mm crop Evapotranspiration, and

25.27% and 22.76% at 60 mm, again for the respective soil depths (Patel et al., 2008). According to Deshmukh et al. (2013), the highest soil moisture content was seen under black plastic mulch, followed by paddy straw mulch, while the lowest soil moisture content was found in the treatment without any mulch. According to El-Zohiri et al. (2013), the presence of mulch in potato crops resulted in increased soil moisture levels compared to plots without mulch. The red polyethylene mulch exhibited the highest moisture level at 23.45%, while the black polythene mulch had a slightly lower moisture content of 22.75%. The blue polyethylene mulch had the lowest moisture content among the three, measuring at 20.88%.

The study conducted by El-Zohiri et al. (2013) reported that the bare soil exhibited the lowest moisture content, measuring at 16.52%..The study conducted by Taparauskiene and Miseckaite (2014) revealed considerable variations in soil moisture levels, highlighting the effectiveness of mulching the top soil layer in promoting the growth and enhancing the fruit output of strawberries. The study conducted by Taparauskiene and Miseckaite (2014) revealed that the straw mulched condition exhibited the highest soil moisture content at 18.0%. This was followed by the black polyethylene mulch condition, which recorded a soil moisture content of 16.5%. In contrast, the lowest soil moisture content of 16.2% was observed in the absence of mulching at a soil depth of 0-40 cm.

The study conducted by Zhang et al. (2017) examined the impact of two types of plastic mulches (transparent and black) and three levels of soil moisture content (35%, 55%, and 75%) on many aspects of potato growth, including root distribution, evapotranspiration, tuber production and quality, as well as water use efficiency. The treatment involving 75% wetted soil exhibited significantly higher evapotranspiration rates compared to the treatment involving 35% wetted soil, which had the lowest evapotranspiration rates. Therefore, it can be observed that there was a positive correlation between the wetted soil percentage and the evapotranspiration rate.

The summary of the comparison between the effects of various mulches and irrigation levels is presented in Table 1.

Table 1 presents the impact of various mulches and irrigation amounts on the moisture content.

S. No.	Study	Outcomes	References
1	Studied the effect on soil moisture, temperature and sugar metabolism in Japanese radish (*Raphanus sativus*)	Higher soil moisture contents in mulched plots than non-mulched plots throughout the experimental period.	Anutin *et al.* (2007)
2.	Studied the effect on soil moisture extraction pattern and different irrigation schedules in summer groundnut.	Soil moisture contents were found maximum (26.69 and 23.19%) at 40 mm followed by 26.10 and 22.96% at 50 mm crop evapotranspiration and 25.27 and 22.76% at 60 mm under 0–15 and 15–30 cm soil depths, respectively. The soil moisture content was found maximum (20.18%) with 50 mm crop evapotranspiration at 30–45 cm soil depth. For deeper layers, the maximum soil moisture contents were found 17.31 and 14.48% at 60 mm crop evapotranspiration at 45–60 and 60–75 cm soil depths, respectively.	Patel *et al.* (2008)
3.	Studied the effect on soil moisture using different mulching (black plastic mulch, paddy straw)	The results revealed that the soil moisture content was found maximum at 10 cm depth as compared to 30 cm depth under black plastic and paddy straw mulches, while it was found higher at 30 cm depth than at 10 cm depth in case of without mulch.	Deshmukh *et al.* (2013)
4	Studied the effect on soil moisture using different mulching in strawberry cultivation.	The highest soil moisture under black polyethylene mulch. Black as well as white polythene mulches conserved higher soil moisture contents by 1 to 3.5% as compared to no mulch.	Pandey *et al.* (2016)
5	Studied the effect on soil moisture using different mulching in gladiolus cultivation.	The higher soil moisture contents were ranged from 19 to 26%.The minimum soil moisture contents of 13 to 16% were registered under un-mulched treatments. The black polyethylene mulching with drip irrigation significantly helped to conserve soil moisture and to reduce the weed growth in gladiolus.	Salma *et al.* (2016)
6	Studied the influence of two plastic mulches (transparent and black) and three wetted soil%ages (35, 55 and 75%) on potato root distribution, evapotranspiration, tuber yield and quality, and water use efficiency.	Wetted soil treatment (35%) had more root development. 75% wetted soil treatment had significantly highest evapotranspiration and the lowest in 35% wetted soil treatment. Evapo-transpiration rate was increased with increase in wetted soil%age.	Zhang *et al.* (2017)
7.	Evaluated the effect of drip irrigation levels at 0.4CPE, 0.6CPE and 0.8 CPE and fertilizer application methods on growth, quality parameters, productivity and nutrient uptake of broccoli.	The results indicated that 0.8 CPE had higher soil water content in comparison to 0.4 CPE and 0.6 CPE. The treatment 0.8 CPE obtained better marketable curd yield due to favorable soil moisture regimes under the treatment.	Jeelani *et al.* (2017)

The impact of varying irrigation amounts on soil temperature

The thermal regime of soil, as indicated by soil temperature, is a crucial component in regulating microbiological activity and several processes involved in the establishment and development of plant life. Plastic film mulching is a mulching technique that has been seen to elevate soil surface temperature. This effect is attributed to its influence on the heat balance, resulting in an increase in soil temperature. Additionally, plastic film mulching has been found to have a good impact on crop emergence. The soil temperature beneath plastic film typically exhibits elevated levels and demonstrates variability, contingent upon the specific hue of the plastic mulches employed. According to a study conducted by Ramakrishna et al. (2006), various types of mulch materials were shown to have varying impacts on soil temperature. The use of polythene mulch, for instance, resulted in an increase of around 6.8°C and 4.8°C at depths of 5 cm and 10 cm, respectively. Singh et al. (2006) conducted an assessment to examine the impact of synthetic (black and white polyethylene) and organic mulches on soil hydrothermal regimes in brinjal.

The researchers recorded a range of Soil temperatures between 7.8 and 13.63°C when organic mulches were used, and a range of 3.86 to 8.97°C when synthetic mulches were used. The mulch materials exhibited a favourable moderation of soil temperature in comparison to the unmulched treatment. Singh and Kamal (2012) reported a temperature differential ranging from 2.2 to 3.4°C between soil that was mulched and soil that was left bare. Singh and Kamal (2012) observed that the minimum Soil temperature was highest at a depth of 10 cm when compared to a depth of 5 cm under black plastic mulch. Additionally, the lowest minimum soil temperature was recorded in the absence of Mulch. The study conducted by El-Zohiri et al. (2013) examined the impact of colored plastic mulches, specifically black, red, and blue, on soil temperature in potato cultivation. The soil temperature at a depth of 10 cm exhibited variations as a result of the presence of coloured mulches. The range of temperature differences observed between the mulched and control plots ranged from 4.37 to 8.92°C. According to Sharma and Meshram (2015), the black plastic mulch demonstrated the highest soil temperatures, followed by the red mulch, while the blue mulch exhibited the lowest temperatures.

According to Sharma and Meshram (2015), the soil temperature beneath black plastic mulch was found to be, on average, 1.29°C and 1.93°C higher compared to the temperatures observed under paddy straw mulch and in the absence of any mulch, respectively.

According to Sharma and Meshram (2015), the utilization of black plastic mulch resulted in a significant rise of 4.6°C in the average maximum soil temperature in capsicum crop. In comparison, the use of paddy straw mulch and the absence of mulch led to increases of 1.62°C and no increase, respectively. Singh and Ghosal (2015) reported that the polyethylene mulch treatment exhibited the greatest soil temperature, ranging from 21.9 to 22.9°C. In comparison, the control treatment showed somewhat lower soil temperatures. The grass mulch treatment, on the other hand, recorded the lowest soil temperature, ranging from 19.1

to 21.6°C. These temperature measurements were taken at a soil depth of 0-60 cm. In their study, Rana et al. (2015) reported that the surface and 15 cm depth beneath black plastic mulch had the greatest mean minimum soil temperatures of 20.6°C and 22.6°C, respectively. According to Pandey et al. (2016), the soil temperature was found to be highest when black plastic mulch was used, followed by plastic mulch, while the lowest soil temperature was seen when rice husk mulch was employed in strawberry cultivation. In a study conducted by Reddy et al. (2017), it was observed that the mean soil temperature at a depth of 15 cm exhibited a range of 13.5 to 27.5°C in the control plot. However, under the condition of black plastic mulch throughout the winter season, the temperature ranged from 15 to 31.5°C. During the summer months, the temperature at various depths exhibited a range of 15 to 35°C when black plastic mulch was employed, while the control plot in turmeric saw a temperature range of 14.5 to 32.5°C. In a study conducted by Job et al. (2018), it was observed that the soil temperature at a depth of 5 cm was measured at 22.3°C when mulch was applied. In contrast, the temperature dropped to a minimum of 20.6°C in the absence of mulch. Similarly, at a depth of 10 cm, the soil temperature was recorded as 21.8°C with mulch and 18.6°C without mulch.

The impact of drip fertigation and mulch on the availability of soil nutrients.

The utilization of drip irrigation in combination with plastic mulch enables the preservation of water and fertilizers. Drip irrigation is a method that involves the application of a reduced quantity of water, together with fertilizers, at regular intervals directly to the root zone, in accordance with the plants' specific water requirements. The utilization of this technology results in a decrease in the quantity of fertilizer applied in comparison to the broadcasted approach of fertilization (Yaseen et al., 2014). The utilization of drip irrigation, when combined with plastic mulch, offers supplementary advantages such as water and fertilizer conservation, in addition to increased crop output (Moreno and Moreno, 2008). According to a study conducted by Mulumba and Lal (2008), the impact of mulching on soil physical properties was examined. The researchers discovered that the application of mulch resulted in a considerable increase in accessible water capacity, ranging from 18% to 35%. Additionally, the retention of soil moisture at low suctions showed a notable improvement, with an increase ranging from 29% to 70%.

According to Tiwari et al. (2014), the results of the soil study revealed an augmentation in the levels of organic carbon, organic matter, available potassium, accessible phosphorus, total nitrogen content, and C:N ratio in the soil that was subjected to plastic mulch coverage. Yaseen et al. (2014) demonstrated that there is a negative correlation between mulch rate and soil bulk density. The researchers recorded a minimum value of 1.44 Mg m-3 at a depth of 0-10 cm. Pandey et al. (2016) conducted an assessment to determine the impact of several mulches (rice husk, black polythene, and white polythene) on different soil chemical characteristics. In their study, Pandey et al. (2016) observed that the highest recorded values for soil pH (7.49), available phosphorus (37.4 kg ha-1), and available potassium (473.3 kg ha-1) were lower in areas where black polythene mulch was used. Conversely, the largest soil organic carbon content (0.62%) and available nitrogen (424.5 kg ha-1) were discovered in areas where rice husk mulch was applied. In their study, Kumar et al. (2017) examined the impact of several mulching techniques on cauliflower cultivation in Nauni, Himachal Pradesh. The experimental findings indicated that the black plastic mulch treatment exhibited the highest levels of accessible nutrients, Specifically N (353.8 kg ha-1), P (48.9 kg ha-1), K (261.8 kg ha-1), Ca (702.3 kg ha-1), Mg (430.8 g ha-1), and $(SO4)_2$-S (67.7 kg ha-1), in comparison to the other treatments. Observations were made on the percentage increase in the availability of nitrogen (3.6-4.1%), phosphorus (27.6-35.1%), potassium (3.4-3.7%), and calcium (1.3%) from their original values. Nevertheless, it was shown that organic mulching, specifically grass and pine needle mulch, resulted in a greater concentration of soil organic carbon.

The impact on the absorption of Nutrients:

The adequate presence of Nutrients within the soil and plants is crucial for achieving optimal crop growth and output. Drip fertigation has been found to yield a fertilizer use efficiency of over 90%, surpassing the 40-60% efficiency typically recorded in surface irrigation with conventional fertilization. Furthermore, the practice of fertigation effectively sustains elevated nutrient concentrations in the uppermost layer of the soil, which is the prime zone for plant water absorption and nutrient uptake.Consequently, this method significantly enhances nutrient utilization efficiency. The utilization of Soil and plant analysis is a Sophisticated method for comprehending the development and physiological processes of plants at different stages of their growth (Sahana et al., 2018). In their study, Kumar and Dey (2011) conducted an assessment to determine the impact of different Mulches on the uptake of nutrients in strawberry plants. The study specifically examined the effects of mulches under both drip and surface irrigation systems.

The utilization of mulch resulted in an increased Nutrient absorption rate of 179.20% and 83.80% for drip irrigation and surface watering, respectively. The implementation of drip irrigation resulted in a 51% reduction in water usage for irrigation purposes, while also achieving a 19% increase in fruit output when compared to the surface irrigation treatment.

In a Study conducted by Kemal (2013), the impact of different irrigation levels (120%, 100%, and 50% of crop evapotranspiration) and nitrogen rates (0 kg ha-1, 59 kg ha-1, 105 kg ha-1, and 151 kg ha-1) on the nitrogen uptake and water use efficiency of shallot was investigated.

An irrigation system was implemented at a rate of 120% of the crop evapotranspiration. Two different amounts of fertilizer, 105 or 151 kg ha-1, were applied. This resulted in a significant total nitrogen uptake of 37.18 kg ha-1, indicating outstanding crop growth. The study conducted by Tiwari et al. (2014) revealed that the sapota leaf sample exhibited the highest concentration of nitrogen (1.40%), phosphorus (0.064%), and potassium (0.70%) under the treatment of 80% drip irrigation with mulch.

The study conducted by Tiwari et al. (2014) reported that the leaf sample exhibited the lowest N content at 1.26%, P concentration at 0.038%, and K concentration at 0.53% under the treatment of 100% drip irrigation with ring basin. In a study conducted by Fura (2014), it was demonstrated that the irrigation level of 120% crop evapotranspiration resulted in the highest nitrogen concentration in leaves (1.35%), bulbs (1.70%), and overall (3.12%). Additionally, this irrigation level led to a nitrogen uptake of 5.04 kg ha-1 by leaves, 35.6 kg ha-1 by bulbs, and a total nitrogen uptake of 40.63 kg ha-1. Alam et al. (2016) reported the lowest nitrogen concentration in the leaves to be 1.13%, while the bulbs exhibited a nitrogen concentration of 1.58%. The total nitrogen concentration was recorded at 2.71%. Additionally, the nitrogen uptake by the leaves was found to be 2.01 kg ha-1, whereas the nitrogen uptake by the bulbs was 12.03 kg ha-1. The total nitrogen uptake was measured to be 14.03 kg ha-1. These observations were made under the irrigation level of 50% crop evapotranspiration. In a study conducted by Jha et al. (2018), it was revealed that the cauliflower crop exhibited the maximum nitrogen uptake of 172 kg ha-1, phosphorus uptake of 17.13 kg ha-1, and potassium uptake of 117 kg ha-1. According to Sahana et al. (2018), their study demonstrated that pole bean plants cultivated in a poly house had the highest levels of leaf nutrients. Specifically, the nutrient concentrations were found to be as follows: nitrogen (0.86%), potassium (0.2%), iron (386 ppm), manganese (230 ppm), zinc (79.87 ppm), and copper (13.88 ppm).

In contrast, the maximum phosphorus content in the leaves (0.65%) was seen while applying 80% of the recommended dose of fertilizers (50.40:80:60 N,P_2O5, K_2O kg ha-1) in the form of a water-soluble fertilizer combination, together with mulching and a micronutrient spray (0.5%).

Growth of plants and the subsequent output of crops

The role of irrigation on agricultural output is significant, as it is linked to various aspects within the plant's environment that impact its growth and development. In situations where water availability is restricted, farmers have a tendency to extend the duration between irrigation events. This practice leads to water stress, which in turn negatively impacts crop yields and diminishes their quality. Drip irrigation has garnered attention due to its capacity to deliver small and frequent water applications in close proximity to the plant root zone. This method has been of interest due to its potential to reduce water requirements and potentially enhance production (Jain et al., 2000). In a study conducted by Jilani et al. (2010), it was demonstrated that the application of 200 kg ha-1 of nitrogen (N) resulted in the highest recorded values for several plant characteristics. These included the number of leaves (18.70), leaf length (33.33 cm), weight of leaves (160.67 g), root length (23.77 cm), root diameter (4.87 cm), root weight (139.28 g), and yield (99.88 t ha-1). In a study conducted by Inusah et al. (2013), the researchers examined the impact of several organic mulches, specifically grass and rice straw, on the production of onions in a tropical environment. The grass mulch treatment exhibited the greatest bulb diameter (5.71 cm), bulb weight (175.16 g), and bulb yield (10.58 tha-1). Following this, the rice straw mulch treatment yielded 6.63 t ha-1. The lowest yield of 3.20 t ha-1 was reported in the treatment without mulch. In their study, Begum and Saikia (2014) demonstrated that the application of irrigation during critical stages had a substantial impact on many plant characteristics. Specifically, the highest plant height (56.13 cm), number of leaves (60.60), and tuber yield (18.03 t ha-1) were observed when irrigation was applied at crucial stages. This was followed by irrigation applied at a rate of 25 mm crop evapotranspiration. At a crop evapotranspiration of 30 mm, the plant exhibited the smallest height (51.73 cm), the lowest number of leaves (55.80), and the lowest tuber production (15.43 t ha-1). In a study conducted by Vivek et al. (2015), the researchers examined the effects of utilizing an air injector in a Sub surface drip irrigation system on the growth performance and yield of radish crops. In their study, Kumar et al. (2016) examined the impact of varying levels of irrigation on brinjal plants. They discovered that the highest values for fruit length (13 cm), fruit diameter (6.7 cm), fruit weight (57 g), and fruit yield (10.74 kg ha-1) were observed when

the plants were subjected to 80% drip irrigation. Conversely, the lowest values for fruit length (9.5 cm), fruit diameter (6.0 cm), fruit weight (52 g), fruit yield (790.0 g plant-1), and fruit yield (6.25 kg ha-1) were recorded under 50% drip irrigation. According to the findings of Reddy et al. (2017), the treatment involving 0.8 volume with drip irrigation and mulch resulted in the highest measurements for various turmeric plant characteristics. These included a maximum plant height of 139.4 cm, stem girth of 10.81 cm, number of functional leaves at 11.41, corm weight of 863.5 g, corm length of 11.72 cm, and yield of 16.64 t ha-1. In comparison, the furrow fertigation method yielded the lowest results for these characteristics.

The study conducted by Islam and Zaman (2017) examined the effects of different irrigation intervals on Garlic production. The results indicated that the highest bulb yield of 10.48 t ha-1 was achieved when the irrigation interval was set at 10 days, with a total seasonal water usage of 372 mm. Following closely, the 15-day irrigation interval resulted in a bulb yield of 9.81 t ha-1, utilizing 275 mm of seasonal water. The bulb production of 8.0 t ha-1 was observed when the irrigation interval was set at 25 days, indicating that this period resulted in the lowest yield. The study conducted by Araujo et al. (2018) aimed to assess the growth of radish under different irrigation levels ranging from 50% to 150% of the reference evapotranspiration (ETo). Additionally, four forms of soil cover, including mulching, wood shavings, and rice hulls, were examined in the experiment. All of the variables examined exhibited a statistically significant change, with the exception of the dry mass of the front root when compared to the irrigation slides. Additionally, when the reference value of 150% ETo was used, the maximum productivity achieved was 700.07 q ha-1. According to Dash et al. (2018), the potato crop achieved a maximum yield of 22.63 t ha-1 when subjected to regular irrigation at a cumulative pan evaporation (CPE) of 35 mm. In contrast, the control group yielded the lowest production of 4.62 t ha-1. In their study, Rannu et al. (2018) examined the impact of irrigation and mulch on the mean fruit diameter of strawberries. The researchers observed that the largest fruit diameter (3.37 cm) was recorded when rice straw mulch was applied with irrigation at a five-day interval. This was followed by the application of black mulch with irrigation at the same interval. Conversely, the smallest fruit diameter

(3.01 cm) was observed when rice straw mulch was applied with irrigation at a fifteen-day interval.

Efficient use of water

The term "water use efficiency" (WUE) refers to a wide notion that has numerous definitions. Water use efficiency, according to farmers and farm managers, is the amount of crop produced

that can be harvested with the water supplied to the crop through rainfall, irrigation, and soil water storage (Singh et al., 2009). Efficiency in water consumption is frequently seen as a crucial factor in determining output under stress and even as a part of crop drought resistance. It has been used to imply that rainfed plants can produce more material for each unit of water consumed, yielding "more crop per drop." Radish evapotranspiration (ET) and water use efficiency (WUE) were shown to be impacted by the various soil water potential (SWP) treatments by Kang and Wan (2005).

According to Kashyap et al. (2009), 60% drip irrigation with mulch resulted in the highest water use efficiency (4.11 t ha-1) while furrow irrigation resulted in the lowest water use efficiency (0.59 t ha-1). According to Singh et al. (2009), 80% drip irrigation with mulch resulted in the maximum water use efficiency (1.34 t ha-1 cm-1) and 52.87 cm of water applied, whereas surface irrigation resulted in the lowest water use efficiency (0.42 t ha-1 cm-1) and 70 cm of applied water. According to research by Biswas et al. (2015), paddy straw mulching resulted in the highest water use efficiency (5.81 t ha-1 cm-1) and the lowest water use efficiency (592 kg ha-1 mm-1) at irrigation levels that were 50% higher than crop evapotranspiration. At irrigation levels of 50%, 75%, and 100%, the average seasonal water use for each drip treatment was 137 mm, 206 mm, and 274 mm, respectively. Under all degrees of irrigation, mulches with irrigation level observed higher water use efficiency.

According to Reddy et al. (2015), drip irrigation with mulch and trellising produced the highest water use efficiency (1.44 t ha-1 cm-1) with 43.1 cm depth water applied, followed by drip irrigation with mulch and 43.1 cm depth water applied, and furrow method produced the lowest water use efficiency (0.46 t ha-1 cm-1). With irrigation occurring every two days and fertigation occurring twice a month, brinjal had the highest water use efficiency (4.64 Mg m-3) while the control had the lowest (2.23 Mg m-3) (Saroch et al., 2016). In an experiment on Chrysanthemum, Jawaharlal et al. (2017) found that polythene mulch had the highest water use efficiency (113.5 kg ha-1 mm-1). The drip irrigation level at 60% was determined to have the highest water use efficiency (111.09 kg ha-1 mm-1). Without mulch, the lowest level (90.43 kg ha-1 mm-1) was found (Jawaharlal et al., 2017; Agrawal et al., 2018). According to Dash et al. (2018), the control treatment had the highest water use efficiency (48.8 kg ha-1 mm-1), followed by crop pan evaporation 50 (47.4 kg ha-1 mm-1), while crop pan evaporation 30 (39.9 kg ha-1 mm-1) had the lowest water use efficiency.

The maximum water use efficiency (47.01 kg m-3) was obtained at 130.9 mm water depth with entire leaves mulch and fertilizer present, according to Carvalho et al. (2018). This was followed by 130.9 mm water depth with whole leaves mulch and fertilizer absence. When papaya was grown in plastic mulch, silver plastic mulch produced the highest WUE (334.03 kg ha-1 mm-1), followed by black plastic mulch (298.24 kg ha-1 mm-1), and control treatment produced the lowest WUE (162.12 kg ha-1 mm-1) (Sakariya et al., 2018).

Price economics

The most significant constraint on crop diversification and production is water. Consequently, drip irrigation aims to accomplish the optimal water use efficiency of irrigation, which is crucial for the efficient use of limited water resources for crop production and economic benefits. The advantages of drip irrigation in terms of water and nutrient savings, increased cultivation intensity and yield, and a higher benefit-to-cost ratio, BCR; (Fanish, 2013) must be considered. Singh et al. (2009) reported that the greatest Gross return (101272 Rs ha-1), Net return (51386 Rs ha-1) and benefit cost ratio (2.03) were obtained with 80% drip irrigation with mulch, followed by 100% drip irrigation with mulch. The lowest Gross return (60410 Rs ha-1), Net return (15407 Rs ha-1) and benefit cost ratio (1.34) were observed at 60% trickle irrigation with mulch for tomatoes. Fanish (2013) conducted an experiment on maize and reported that the maximum cultivation cost (26013 Rs ha-1), Net return (46,985 Rs ha-1) and B:C ratio (2.83) were obtained under drip fertigation of various treatments. The economic returns of onion with mulching revealed a highest benefit-cost ratio of 2.31 for grass straw mulch, followed by rice straw mulch (1.09), while the lowest benefit-cost ratio of 0.03 were obtained under no mulch treatment (Inusah et al., 2013).

Conclusion

The use of mulch with trickle irrigation is not only beneficial for conserving water but also for increasing yield. This review provides two lessons for intensifying mulching practices in arid, semiarid, Sub-humid, and temperate regions, based on the comprehension of mulch use in vegetable productions. The selection of a particular mulch material, whether organic or inorganic, based on its durability, suitability/compatibility, intended above- and below-ground effects, and effectiveness in relation to the crop type and the surrounding environment. In addition to modifying the soil's hydrothermal regimes, the plastic mulching modifies the light environment surrounding the plant, which may influence plant growth and morphogenesis. In water-scarce regions, soil water evaporation losses can account for 50% or more of total precipitation. Consequently, the use of white polyethylene mulch (non-UV) during the crop growth period prevents extreme soil moisture loss and promotes crop establishment, particularly during seedling phases. The highest WUEs were obtained from foliage treatments that reduced crop water needs by as much as 50 percent. Although polythene mulch performed better in terms of yield and water use efficiency, straw mulch provided a greater economic return due to the fact that polythene mulch inhibits vegetation germination and retains more soil moisture than straw mulch, but is more expensive. For this reason, polyethylene mulch and trickle irrigation may be used to achieve production objectives in rain-fed environments where water availability is severely constrained or where land and water productivity are of paramount importance. If economically feasible, organic straw mulch is preferred. It is therefore, recommended that as far as practicable farmers should adopt the mulching option for crop production along with the drip fertigation. Organic mulches decompose over time and also add nutrients, resulting in greater economic returns. However, organic mulches harbor insects and vermin that can contaminate or degrade the quality of the produce; therefore, if there is a choice, the selection of mulch material should be based on a combination of factors. We believe that white plastic mulch would be preferable in terms of cost, durability, Soil moisture conservation, soil temperature increase, and frost protection, among others.

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