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Review on Innovative Irrigation Water-Saving Strategies to Improve Water and Yield Productivity of Onions

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Abstract

The global human population has exploded, and our natural resource base is declining. To feed these people, increased global food production, particularly in poorer countries, will undoubtedly be required. The main source of income for rural people in smallholder agriculture. Rainfall unpredictability and inconsistency are major challenges in rainfed agriculture, and smallholder farmers are particularly vulnerable to crop production. Irrigation is critical for agricultural output because it reduces rainfall variability and inconsistency. However, irrigation water is becoming a more precious resource around the world, and low water usage efficiency, combined with rising competition for water resources, is prompting growers to adopt novel irrigation and production strategies that conserve water. As a result, mulch and deficit irrigation are two extensively utilized water-saving solutions for improving the water productivity of crops grown in water-scarce areas. As a result, new ideas are needed to improve the efficiency with which limited water is used. Deficit irrigation and mulching methods could be used to make better and more efficient use of limited water supply. The efficient and cost-effective use of natural resources through low-cost solutions such as mulch and deficit irrigation are sensible and adaptive for maximizing crop yields while lowering production costs. In arid climates, combining mulch with appropriate deficit irrigation to raise crop yield and water productivity is an effective strategy to establish a good trade-off between water use and production, as well as improve water productivity. Deficit irrigation and mulching will become more important in locations where available water supplies limit agricultural production, to maximize the productivity of their limited water resources. Farmers, on the other hand, must carefully select irrigation systems and water-saving technology to maximize yield and water productivity, as well as play a key part in farm-level water management strategies, resulting in increased output per unit of water used in agriculture. Combination of deficit irrigation strategies with other practices like mulching, help to improve water productivity and minimize losses in yield or quality in vegetable crops.

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Deficit irrigation, mulch, water productivity, water scarcity, agriculture.

Introduction

The world's population has exploded, and our natural resource base is dwindling (Page *et al.*, 2020). To feed these people, increased global food production, particularly in poorer countries, will undoubtedly be required (United Nations, 2019). Agriculture is the primary source of food for the world's population (Abu-Zeid, 2003). Agriculture is a vital economic sector in developing nations, which are grappling with low water resource usage efficiency and dwindling water supplies (Li *et al.,* 2020). The main source of income for rural people is smallholder agriculture (Belay *et al.,* 2020) Rainfall unpredictability and inconsistency are major challenges in rainfed agriculture, and smallholder farmers are particularly vulnerable to crop production (Yimam *et al.,* 2020). Irrigation is critical for agricultural output because it reduces rainfall variability and inconsistency (Al-ghobari & Dewidar, 2017). As a result, irrigation will continue to be crucial in meeting people's demands via increasing output (Belay *et al.,* 2019). Irrigation development is one strategy for addressing this issue, and it has received substantial attention in the country's economic development projects (Ayele, 2011). Water, on the other hand, is becoming increasingly scarce around the world, and irrigated agriculture remains one of the greatest and wasteful uses of this resource. Growers are being forced to adopt new irrigation and crop practices that utilize water more wisely due to low water use efficiency (WUE) and rising competition for water resources with other sectors (Costa, 2007). As a result, one method that is frequently employed in water-saving technology is to improve the IWP of crops cultivated in water-scarce locations (Jia *et al.,* 2017). Conservation agriculture has a critical impact as a water-saving approach in irrigated crop production to alleviate water stress in agriculture. This is crucial for retaining soil moisture, controlling soil temperature, and minimizing soil evaporation, all of which affect crop output and water productivity (Kader *et al.,* 2019).

Adapting CA methods in vegetables is a viable strategy for increasing water efficiency and crop output, which directly contributes to the sustainability of smallholder farmers' livelihoods in the region (Assefa *et al.,* 2019). Soil and water conservation are critical in agriculture for improving the livelihoods of rural farm households (Abebe *et al.,* 2020). The CA techniques considerably lowered irrigation water usage by 13 percent to 29 percent, and the yield return produced under CA was 10% to 30% higher, with chances to improve water use by reducing irrigation water requirements (Belay *et al.,* 2020). When compared to conventional farming, conservation agriculture increases crop output by 37.4 percent on average (Assefa *et al.,* 2020). Conservation agriculture approaches result in a 20% increase in yields and a 21% reduction in irrigation water usage (Belay *et al.,* 2020). Conservation agriculture saves around 18% to 28% of irrigation water (Yimam *et al.,* 2020). Mulch and deficit irrigations are the most essential conservation agriculture and water-saving practices for improving water and crop yield (Iglesias & Garrote, 2015).

Irrigation systems have long played a significant role in boosting agricultural production by increasing the efficiency of irrigation water use, which is becoming increasingly scarce as a result of increasing water scarcity. To reduce evapotranspiration and improve water use efficiency and output under deficit irrigation and mulching, it is critical to evaluate various water-saving techniques (Khan *et al.,* 2015). Agriculture uses more than two-thirds of the world's freshwater supply. This issue creates significant friction in the allocation of freshwater among irrigation users as well as between agriculture and other economic sectors. As a result, regulated deficit irrigation and mulch are important technologies since they aid in water conservation (Chai *et al.,* 2016). Irrigated agriculture is the world's largest consumer of available freshwater, accounting for around 70% of the total freshwater supply (Dirirsa *et al.,* 2017). Irrigation is the most important agricultural use of water, and its availability is decreasing. Water scarcity and increasing competition for water would diminish irrigated farming's availability. Simultaneously, the requirement to fulfill rising food demand will necessitate increasing agricultural productivity with less water. Water efficiency will be a major concern soon, and it will necessitate the development of systems and practices that offer a more precise supply of water to crops. In this situation, deficit irrigation has the potential to significantly improve water usage efficiency (WUE) (Smith *et al.,* 2002). Water scarcity, as well as increased competition for water supplies among irrigation users, is forcing. Farmers should take water conservation techniques more seriously, especially in places where intensive vegetable production and limited water resources exist. Deficit irrigation solutions can be used to improve WUE while also conserving water (Costa, 2007). The available water supply in some locations is insufficient to provide the maximum yield on irrigable soils, necessitating deficit irrigation (Kadayifci *et al.,* 2005). DI is an irrigation practice in which a crop is irrigated with a quantity of water that is less than the entire necessary for optimal plant growth. This is to lower the amount of water used to irrigate crops, improve plants' positive responses to a certain degree of water deficiency, and boost the crop's WUE (Chai *et al.,* 2016). DI is an optimized approach in which net returns are maximized by minimizing irrigation water usage and allowing crops to endure some degree of water deficit and yield loss without incurring a yield penalty (Capra & Consoli, 2015). As farmers strive to boost the productivity of their limited water resources in locations where available water supplies limit agricultural production, DI will become more important over time.

To enhance crop output, farmers must carefully select water conservation and irrigation systems (Geerts & Raes, 2009). Regulated DI is a way to reduce water use while limiting negative effects on production (Smith *et al.,* 2002).

As a result, new ideas are needed to improve the efficiency with which limited water is used. Deficit irrigation and mulching methods could be used to make better and more efficient use of a limited water supply (Mubarak & Hamdan, 2018). Different methods of mulching have been used to improve water and crop output (Govindappa *et al.,* 2015). The efficient and cost-effective use of natural resources using low-cost solutions such as mulch and deficit irrigation is sensible and flexible for optimum water and agricultural yield enhancement while also lowering production costs (Barche *et al.,* 2020). In arid climates, combining mulch with appropriate deficit irrigation to raise crop yield and WUE is an efficient strategy to establish a good trade-off between water use and output, as well as improve WUE (Wen *et al.,* 2017). Deficit irrigation and mulching will become more important in locations where available water supplies limit agricultural production, to maximize the productivity of their limited water resources. Farmers, on the other hand, must carefully select irrigation systems and water-saving technology to maximize yield and water productivity, as well as play a key part in farm-level water management strategies, resulting in increased output per unit of water used in agriculture (Geerts & Raes, 2009). The combination of deficit irrigation strategies with other practices like mulching helps to improve WUE and minimize losses in yield or quality in vegetable crops (Mubarak & Hamdan, 2018).

Deficit irrigation

In dry places, deficit irrigation has been intensively studied as a profitable and long-term production method. This method tries to maximize water productivity and stabilize rather than maximize yields by minimizing water applications to drought-sensitive crops. It is effective in enhancing water productivity for a variety of crops without incurring significant production losses (Geerts & Raes, 2009). Irrigated agriculture is currently, and will continue to be in the future, a water-scarce environment. Irrigation management will move from focusing production per unit area to maximizing production per unit of water consumed, or water productivity, as a result of insufficient water availability. Deficit irrigation, defined as the delivery of water below full crop-water requirements (evapotranspiration), is an important method for lowering irrigation water use in times of scarcity (Kifle & Gebretsadikan, 2016). Water conservation strategies are predicted to be crucial in increasing water efficiency. By purposely straining plants to a profitable level, significant water savings can be realized. The term "deficient irrigation" refers to this method of management (Leskovar & Agehara, 2012). Deficit irrigation is an optimization approach in which net returns are maximized by minimizing irrigation water usage; crops are intentionally allowed to experience some water deficits and yield decline (Capra & Consoli, 2015) Deficit irrigation and furrow irrigation application systems are major problems for improving water production in water-scarce places (Seid, 2015). Deficit irrigation with a 60 percent MAD estimated threshold and a goal water extraction area of 0–50 cm could be considered a strategic approach to save water while achieving maximum WUE (Reza *et al.,* 2014). Crop cultivation requires a lot of water, and any scarcity has an impact on ultimate yields. As a result, farmers have a proclivity to over-irrigate, which is incompatible with resource conservation. Deficit irrigation and furrow irrigation application systems are major problems for improving water production in water-scarce places (Seid, 2015). Deficit irrigation with a 60 percent MAD estimated threshold and a goal water extraction area of 0–50 cm could be considered a strategic approach to save water while achieving maximum WUE (Reza *et al.,* 2014). Crop cultivation requires a lot of water, and any scarcity has an impact on ultimate yields. As a result, farmers have a proclivity to over-irrigate, which is incompatible with resource conservation. Due to the global development of irrigated regions and the scarcity of irrigation water, it is now necessary to optimize WUE to maximize agricultural yields in often recurring shortfall irrigation conditions. The yield response to a water deficiency during a certain crop development period varies depending on crop sensitivity at that growth stage (Mubarak & Hamdan, 2018). In water-scarce areas, deficit irrigation practices could be a viable crop production approach (Ararssa, 2019). Deficit irrigation will be a key component of farm-level water management measures, resulting in increased output per unit of water utilized in agriculture (Geerts & Raes, 2009).

Irrigation water shortages can result in lower economic yields, while excessive irrigation might result in non-beneficial water use. As a result, the farm level, which refers to when and how much to irrigate, plays a crucial role. Farmers may be forced to use deficit irrigation to cope with restricted water availability during drought years, making this practice critical for irrigated agriculture. Deficit irrigation is the practice of applying irrigation depths that are less than those required to meet crop water requirements (CWR) at specific times during the crop season. Increasing water productivity (WP) could be the most efficient way to use water (Rodrigues, 2009). With a large drop in irrigation water, deficit irrigation systems allow crops to survive some degree of water deficit and, in certain cases, yield reduction. Water is delivered at levels below full evapotranspiration (ETC) throughout the season in the traditional deficit irrigation method (DI) (Miguel Costa, 2007).

Deficit irrigation practices

The world's population is fast increasing, and as a result, the country may experience increased food insecurity. As a result, increasing agricultural productivity is vital to feed the population. Drought and inadequate irrigation systems place a significant strain on water resources. As a result, optimal irrigation planning and management should be taken into account (Tewabe *et al.*, 2020). However, because of a temporal and spatial imbalance in rainfall distribution, producing a sustainable and consistent food supply is becoming nearly impossible. This frequently resulted in a lack of water at a key time, resulting in crop failure. To combat these natural occurrences, irrigated agriculture methods must be improved. When there is a scarcity of water and drought, deficit irrigation can help you make more money by maximizing your water use efficiency (Dirisa *et al.*, 2017). As a result, water will not be available at the required time. Crop failure is frequently caused by a lack of water during critical growth stages. Deficit irrigation, a strategy in which water supply is cut below maximum level and mild stress is tolerated with minimum effect on yield, is gaining popularity as a way to combat such situations and improve water productivity (Yenesew & Tilahun, 2009). Deficit irrigation in Ethiopia has improved water use efficiency without significantly reducing grain yield. Water use efficiencies were improved, and 50 percent to 75 percent of water was saved without significantly reducing yield. As a result, the water saved could be used to cultivate additional land in areas where water is scarce, and it could increase cultivated land, particularly in regions where natural resources are scarce (Seid, 2015). In Ethiopia, the maximum yield was obtained from 100% ETc, while the smallest yield was obtained from 50% ETc. However, when compared to 100% ETc and 85 percent ETc, 50% of ETc exhibited a considerable yield loss. The maximum and minimum water productivity were obtained with 50% ETc and 100% ETc, respectively (M, 2019). Water shortage is a major element in plant production in Ethiopia's dry and semi-arid regions, hence getting high WUE values is preferable to achieving maximum yield (Ahmadi-Mirabad *et al.*, 2014).

Effect of deficit irrigation on crop yield and water productivity

Crop cultivation requires a lot of water, and any scarcity has an impact on ultimate yields. As a result, an approach that is incompatible with resource conservation. Due to the global development of irrigated regions and the scarcity of irrigation water, it is now necessary to optimize WUE to maximize agricultural yields in often recurring shortfall irrigation conditions. As a result, deficit irrigation is a method of scheduling irrigation when there is a restricted supply of water (Yang *et al.*, 2015). The amount of water available for irrigation should determine the shortfall strategy. In the ranges of irrigation regimes investigated, the relationship between yield and irrigation amount may be defined as linear, and the ranges of irrigation water use efficiency (IWUE) values found were narrow. When water is scarce, a 50 percent uniform deficit irrigation system with 46 percent water savings can provide the maximum water use efficiency. Irrigation deficits of 25% are dispersed across the growing seasons (Ambachew *et al.*, 2014). When compared to full irrigation throughout the growing season, deficit irrigation lowered biomass, yield, and a few other features. As the amount of irrigation water increased, so did the ET values. WUE and IWUE readings, on the other hand, declined as irrigation volume increased (Sincik *et al.*, 2008). Deficit irrigation can help in instances when irrigation water availability is limited by reducing irrigation water use. When complete irrigation is not possible in field crops, a well-designed DI regime can optimize WP over a large region. RDI has been found to boost not only WP but also farmers' net income in a variety of horticultural crops. The basis for the positive reactions to water deficits reported in circumstances when RDI is advantageous should be investigated. While the DI can be used as a tactical approach to minimize irrigation water use when supplies are constrained due to droughts or other circumstances, its long-term effectiveness is unknown (Zhuo & Hoekstra, 2017). Under semiarid circumstances and in similar places, deficit irrigation with the traditional furrow application technique is the optimal water-saving practice for the irrigated agriculture system to generate optimum crop yields (Hailu *et al.*, 2018). The maximum yield can be reached if all of the crop's water requirements are met. Deficit irrigation, on the other hand, could increase the irrigated area or the frequency of cultivation. While DI can be used as a tactical approach to minimize irrigation water use when supplies are constrained due to droughts or other circumstances, its long-term effectiveness is unknown (Zhuo & Hoekstra, 2017). Under semiarid circumstances and in similar places, deficit irrigation with the traditional furrow application technique is the optimal water-saving practice for the irrigated agriculture system to generate optimum crop yields (Hailu *et al.,* 2018). The maximum yield can be reached if all of the crop's water requirements are met. Deficit irrigation, on the other hand, could increase the irrigated area or the frequency of cultivation. High yields and water usage efficiency values might have been achieved for many crops if the proper period of water application had been chosen (Bekele & Tilahun, 2007). With limited irrigation water, combining mulch with deficit irrigation increases crop output and water use efficiency, especially in arid locations. When compared to no mulching, it increased maximum grain yield without water stress by 0.4–0.6 t ha1 and WUE by 0.2–0.3 kg m3 for various irrigation rates (Wen *et al.,* 2017).

Effect of deficit irrigation on yield and water productivity of onions

Irrigation is required during the entire growing season to maximize onion output. If water is in short supply, deficit irrigation should be employed during the ripening or vegetative stages (Kadayifci *et al.,* 2005). Given the delicate stage of the crop, deficit irrigation can boost water production without significantly affecting bulb yield. When compared to stressing the crop throughout the growing season, stressing the onion by one-half or one-quarter of ETc at the bulb formation stage resulted in poorer yield. This means that watering is particularly important during the bulb development stage. As a result, it is preferable to avoid straining the crop during the bulb development stage when arranging irrigation with insufficient water for onion bulb production (Dirisa *et al.,* 2017).

Effects of Mulching

Due to global warming and unpredictable rainfall and irrigation in arid and semi-arid regions, agricultural water resources have been depleted over time. Mulching has a critical impact as a water-saving practice in irrigated crop production to alleviate water stress in agriculture. This is crucial for retaining soil moisture, controlling soil temperature, and minimizing soil evaporation, all of which can have an impact on crop output and water productivity (Kader *et al.,* 2019). Mulching is a technique for conserving moisture, reducing weed growth, regulating soil temperature, and providing plants with a microclimate. This technology benefits horticulture crops in several ways, including increased growth, development, and production, as well as soil and water conservation (Barche *et al.,* 2020). Mulching improved vegetable crop development and fruit yield by modifying the crop growing environment by minimizing weed infestation, depleting soil moisture, and changing soil temperatures. This helps to reduce herbicide and diesel usage, prevent pollution and ensure organic food production (Barche *et al.,* 2020). Mulching with various irrigation practices is one of the techniques for increasing soil productivity and reducing water usage. The region's growing water demand underscores the need to implement low-input and water-saving technology for agricultural sustainability and crop production, particularly in semi-arid areas (Mebrahtu & Mehamed, 2019). Agricultural management practices are frequently inefficient and can result in significant losses of soil organic carbon and fertility, yet the information in many African locations is poor (Dossou-Yovo *et al.,* 2016). Under mulch, onion bulb diameter, total yield, dry matter, and water productivity all increased significantly, regardless of irrigation level. Seasonal crop water requirements were also significantly reduced (about 33 percent). Regulated deficit irrigation improved water productivity, onion crop quality, and quantity greatly when mulch was employed, and this strategy could be a potential management practice to address water shortage implications in the water constrained region (Mubarak & Hamdan, 2018). To maintain high crop production while minimizing negative environmental impact, management approaches that simultaneously increase soil characteristics and yield are critical (Dossou-yovo *et al.,* 2016). Mulching can have a significant impact on the hydrothermal microenvironment of plants (Li *et al.,* 2018). During the whole growing season and the yield creation stage, onion plants were extremely susceptible to a lack of soil water, but in the vegetative and ripening periods, they were somewhat insensitive. Evapotranspiration rates and yields of onions grown in deficit irrigation are lower. So, to have the best yield, irrigation is required throughout the entire growing season. Water is scarce, thus irrigation with mulch should be employed to make up for the shortfall (Kadayifci *et al.,* 2005). Mulching has been a popular strategy in modern field agriculture because of the benefits it provides, including increased soil warmth, reduced weed pressure, moisture conservation, reduction of certain insect pests, improved crop yields, and more efficient use of soil nutrients. Mulching has become a common method in modern field agriculture because of the benefits it provides, including increased soil warmth, reduced weed pressure, moisture conservation, reduction of certain insect pests, improved crop yields, and more efficient use of soil nutrients (Ray & Biswasi, 2016).

Types of mulching

Organic mulches

The most frequent mulching materials used for fruit and vegetable production are rice and wheat straw. After decomposition, straw improves the fertility of the soil. In comparison to other organic mulching materials (grasses, leaves, and leaf litter), straw has a long life (Goel *et al.,* 2019). Organic mulches such as leaves, straws, crop residues, and by-products, farmyard manure, and by-products of the timber industry are used to prevent moisture evaporation, root freezing, and weed growth, conserve soil moisture, maintain soil temperature, and change the soil structure, which usually increases root growth. Due to the decomposition of organic matter, aeration is improved in clay soils, and water holding capacity is increased in sandy soils. Increase soil organic matter content, improve long-term soil fertility, and enhance soil biological activity by increasing PH and making the soil reaction more alkaline (Barche *et al.,* 2020). Organic mulching has several advantages, including reflecting the sun, preventing evaporation, and improving the soil's condition. These mulches slowly disintegrate, providing organic matter that helps maintain the soil loose, organic matter, and other soil microorganisms in the soil and creating an extremely permeable soil. This promotes root growth, enhances water infiltration, and increases the soil's water holding capacity. However, there are also drawbacks to organic mulching, such as stored moisture fostering the development of illnesses and pests, and straw containing seeds that could become weeds (Goel *et al.,* 2019).

Inorganic Plastic mulch

Mulching has become a common practice in modern agriculture. Plastics are the most widely utilized mulching materials, and they are employed practically everywhere due to their low cost and proven production results (Haapala *et al.,* 2014). Plastic mulching resulted in a much higher maize yield and yield components than when no mulching was used, and it also had a bigger role in reducing evapotranspiration (Mebrahtu & Mehamed, 2019). Plastic mulches are impermeable to water when compared to other mulches, preventing direct evaporation of moisture from the soil and thus limiting water losses. Plastic mulches are a key component of plastic culture and have been employed in commercial vegetable cultivation. Increased yields, earlier maturing crops, higher-quality crops, improved insect management, weed control, achieving maximum water use efficiency by reducing evaporation, impact the microclimate around the plant by modifying the surface radiation budget, and decreasing soil water loss are just a few of the benefits for the user. It does not, however, increase soil fertility (Barche *et al.,* 2020). Plastic mulch is the most widely utilized mulching material, and white polyethylene, in particular, is employed practically everywhere due to its low cost and proven production results (Ray & Biswasi, 2016). Plastic mulch aids in moisture conservation, weed control, and radiation reduction. It aids in moisture conservation, soil temperature stabilization, soil solarization, and weed control (Goel *et al.,* 2019). In terms of lowering moisture evaporation from the soil surface and enhancing soil moisture status while also improving soil nutrient status, plastic mulch is thought to be more effective than straw mulch. Plastic mulch is less effective than straw mulch (Guan *et al.,* 2016).

Effect of plastic mulch on crop yield and water productivity

The various mulching materials used in agriculture can save water resources, resulting in higher crop yields in both irrigation and rain-fed farming. In agriculture, the use of plastic mulch is often advised for lucrative raw crops (Kader *et al.,* 2019). Plastic mulches had a significant impact on chilly growth and yield, with plastic outperforming the other plastic mulches. Plastic mulch inhibited weed development, increasing fruit output. In tropical circumstances, mulching looks to be a viable strategy for increasing chili output and water productivity (Halim *et al.,* 2011). In semiarid locations, plastic mulching is an excellent way to boost water and agricultural yield. When compared to no mulching throughout the growing season, the average soil temperature improved by 5.5 percent–9.3 percent, decreased soil evaporation, and conserved water in topsoil layers (Yang *et al.,* 2018). In agricultural productivity, plastic mulch is commonly employed. It has the potential to boost water efficiency by 9.5 percent on average (Deng *et al.,* 2019). Plastic culture, which uses plastic mulch in new ways to conserve water, is becoming increasingly essential in delivering both water conservation and agricultural productivity. New products and methods are being developed to conserve water, which could have a significant impact on the future status and availability of water resources (Ingman *et al.*, 2015).

Effect of plastic mulching on yield and water productivity of onions

Plastic mulching was supposed to save water by reducing evaporation. When compared to a non-mulch condition, using plastic material as a mulch increased onion output by 12–15 percent (Igbadun *et al.*, 2012). For onion cultivation, plastic mulch created a warmer environment. Plastic mulching, on the other hand, increased the levels of nitrogen, phosphate, potassium, and sulfur in the soils (Sarkar *et al.*, 2019). The application of plastic mulch enhances the yield of onion bulbs by 29%. (Shirzadi *et al.*, 2020). In temperate climates, plastic mulches offer many advantageous impacts on onion crop performance, including increased soil temperature, moisture conservation, texture, and weed, insect, and disease management (Hanada, 1991). Onion growth and bulb output increased with the use of plastic mulch (Anisuzzaman *et al.*, 2009). When compared to other mulches, black plastic mulch outperformed the others in terms of onion growth and yield contributing features, resulting in the highest onion bulb yield. Plastic mulch is commonly used in vegetable production to prevent water evaporation. When compared to bare soil output, plastic mulch increases onion bulb marketable production (Ramalan *et al.*, 2010).

Effect of straw mulch on crop yield and water productivity

Water productivity enhancement for long-term crop production and water conservation is a fundamental challenge for agricultural water management. In an arid and water-scarce region, managed deficit irrigation with straw mulch can successfully handle water scarcity and its repercussions while also sustaining crop productivity (Mubarak & Hamdan, 2018).

In dryland wheat production, straw mulching enables optimal water storage. This improved soil water storage, aboveground biomass, grain yield, and WUE while lowering evapotranspiration (Yan *et al.*, 2018). Straw mulching is a common practice for conserving soil moisture and increasing crop yields. To boost soil water conservation and improve agricultural sustainability in drylands, straw mulching should be spread during the fallow period or at a low rate throughout the year in dry years (Wang *et al.*, 2018). Straw mulching reduced crop evapotranspiration, enhanced above-ground microclimate, increased yield, and WUE significantly, but decreased soil evaporation (Li *et al.*, 2015). Straw mulching boosted potato production and WUE substantially. In general, the effects of plastic mulching on potato yield and WUE were greater than those of straw mulching. Only under DI, where WUE was raised by 4–6%, were the complementary effects of straw mulch detected. Mulch effects were primarily caused by a decrease in soil surface temperature, which delayed crop growth and development and, as a result, reduced light interception (Adil *et al.*, 2019). Tillage had a larger impact on soil water content, water usage, and WUE than straw mulching. These findings imply that straw mulching has a lot of promise for increasing yield and WUE in areas where water scarcity has a big impact on grain production stability (Tao *et al.*, 2015). With increasing mulching rates, the physical and chemical parameters of the soil improved significantly, as did the organic matter content. Bulk density, porosity, and aggregate stability were also improved (Jordán *et al.*, 2010). During the entire growing season, straw mulches considerably raised the soil water content (SWC), increased the net photosynthetic rate (Pn) leaves, and reduced and maintained the soil temperature (Liao *et al.*, 2021).

Effect of straw mulch on yield and water productivity of onion

Straw mulching aided the onion plants' growth. Under straw mulch, bulb diameter, total yield, dry matter, and water productivity all improved dramatically, regardless of irrigation level. Seasonal crop water requirements were also significantly reduced (about 33 percent). When full irrigation was used instead of deficit irrigation, onion yield and water productivity were higher.

However, when mulch was utilized, regulated deficit irrigation dramatically increased water productivity as well as onion crop quality and quantity, suggesting that this strategy could be a useful management practice for dealing with the impacts of water scarcity in the arid region (Mubarak & Hamdan, 2018). The benefits of mulching on potato output vary depending on climatic circumstances and field management, and 28.7% plastic mulching and 5.6 percent straw mulching also enhanced the WUE of potatoes (Li *et al.*, 2018).

Effect of rice straw mulch on crop yield and water productivity

Rice straw management and its impact on nitrogen cycling and soil fertility are critical challenges for crop production systems' long-term viability. The use of rice straw mulch enhanced crop output considerably (Dossou-yovo *et al.,* 2016). In comparison to standard agricultural practice, rice straw mulches could boost wheat production and improve the quantitative and qualitative properties of soil aggregates and soil organic carbon (SOC) within a short period (Naresh *et al.*, 2016). The use of rice straw mulch enhanced yield considerably, and under rice straw mulch, soil moisture and microbial carbon were higher, which helped to increase soil quality and yield (Dossou-yovo *et al.,* 2016).Rice straw mulching produced the best results in terms of vegetative growth, such as leaf features, flowering, and yield. Rice straw mulching reduces the tendency of olive trees to alternate bearing, and mulching the soil with rice straw in arid and semiarid areas where water is scarce helps to reduce the amount of water applied, increase the volume of moisture stored in the soil, and reduce evaporation (Gammal, 2015).

Effect of rice straw mulch on yield and water productivity of onion

Mulching using rice straw increased the onion crop's water productivity substantially. The onion crop should be mulched with rice to increase irrigation water usage under a limited water supply and improve agricultural water output (Igbadun *et al.*, 2012). Paddy Straw is an inexpensive and easy-to-find source of organic mulch that is also environmentally favorable. It also conserves soil moisture by minimizing evaporation loss from the soil, resulting in a more stable soil moisture regime (Ram *et al.*, 2019). Under tropical conditions, rice straw could considerably improve onion productivity and yields (Inusah *et al.*, 2002). Rice straw mulch reduced the overall weed population on onion by 51%, and it could be employed in onion to increase marketable yields (Abouziena & Radwan, 2015). During the growing season, high soil evaporation and temperature reduce onion productivity. Rice straw mulching can be used to modify them. Mulching with leftover rice straw is anticipated to offer a favorable hydrothermal regime, with weed infestations reduced by 92%, improved total N uptake and reduced soil water evaporation, enhanced onion bulb yields of 17%, and irrigation water productivity (Singh, 2018). All prior growth, total bulb yield, and its components were boosted by the rice straws mulch (Barakat *et al.,* 2019b).

Water Use Efficiency

Water control has a lot of potential for increasing water production in irrigated agriculture. However, in most circumstances, it will result in a lower net return per unit of land. As a result, they would be motivated to pursue water conservation measures only if there is sufficient land that can be used for irrigated agriculture with the water conserved (Kumar *et al.,* 2003). Water management in irrigated agriculture is critical to ensuring food security (Adeboye *et al.,* 2015). Improving water use efficiency is one significant technique for dealing with future water shortages, which will be exacerbated by the growing human population. Increasing agricultural water productivity is a vital solution because agriculture is the world's largest consumer of freshwater (Dirisa *et al.,* 2017). Water productivity analysis combines physical water accounting with yield or economic output to determine how much value may be derived from water use. Physical (kg/m3) water productivity was calculated for the project area using the formula WP=Output/Q, where WP is water productivity (kg/m3 or $/m3), Output is irrigated agriculture output, crop yields (t/ha) or its value converted into monetary units, and Q is water resources supplied or consumed, m3 (Abdullaev & Molden, 2004). Many factors, such as irrigation technology and field water management, influence water productivity. The influence of improvements in technology and management, as well as investment, on water productivity, and to look for opportunities to increase food security by increasing water productivity. The rise in water productivity is due to both increased crop yield and improved water efficiency (Cai & Rosegrant, 2009). Because the goal of employing RDI in crop production is to determine how much irrigation can be saved or how much crop yield can be produced per unit of water supply, water usage efficiency (WUE) is a significant variable in assessing plant responses to RDI-induced water stress (Chai *et al.*, 2016). Water use efficiency can be measured in terms of the number of grapes produced per unit of applied water or the total amount of water consumed. ETC refers to the total amount of water consumed, which includes soil water, effective in-season rainfall, and irrigation. Full potential wine water usage is the least efficient, regardless of which metric of water use efficiency is utilized. Using deficit irrigation, you can boost your efficiency (Verdegaal *et al.,* 2004).

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