# MICRO IRRIGATION IN RICE- A REVIEW


## ABSTRACT

Rice (*Oryza sativa*) is the most important staple food crop over half of the world's population and it provides 21 per cent of global human per capita energy.In India, rice is widely grown as the second food crop occupying about 43 million hectares of area.Water scarcity is a major constraint in the development of rice farming in some parts of the world. The water required to produce unit kg of rice is as high as 4000-5000 liters under conventional methods of water application (Transplanting under submerged conditions). During the crop growth period of rice, the amount of water usually applied to field is often much more than the actual field requirement because of adopting traditional flood irrigation methods. In order to meet the growing demand for water it is necessary to use water efficiently and reduce the loss of water. One such practice to conserve water is adoption of micro irrigation to a water loving crop like rice to reduce the wastage of water and to increase the water use efficiency. Micro irrigation is defined as the application of small quantities of water directly above and below the soil surface, usually as discrete drops, continuous drops or tiny streams through emitters placed along a water delivery line.



**Key words:**Rice, drip, sprinkler, water use efficiency, grain yield.


## Introduction

Rice is the staple food for more than half of the world's population and plays an important role in food security of many countries. It is the staple food for over 65 per cent population in India. (Kumar *et al.*,2018). Globally rice is cultivated in an area of 167.13 million hectares with a production of 782 million tonnes and with a productivity of 4,679 kg $ha^{-1}$(Anon., 2019). In India rice is grown in an area of 44.15 m ha with 116.4 million tonnes of production and 2,638 kg $ha^{-1}$ productivity (Anon., 2020). 90 per cent of the world rice comes from Asia of which 85 per cent of production is used for human consumption and it deserves a special status among cereals as world's most important wetland crop (Rajeshkumar*et al.,* 2019). Rice is primarily composed of carbohydrate, which makes up almost 80 per cent of its total dry weight. Raw, long grain white rice is a relativelygood source of energy, carbohydrates, calcium, iron, thiamin, pantothenic acid, folate and vitamin E, compared to maize, wheat and potatoes.

Rice is a semi aquatic plant which requires 2-3 times higher amount of water than any other cereal crop when grown under transplanted conditions (Prashant *et al.*, 2019). Among the major constraints affecting rice production across the globe, water scarcity appears to be a major challenge. More than 80 per cent of the fresh water resources in Asia are used for agriculture of which about half of the total irrigation water is used for rice production. Water is a very fundamental resource in agriculture and it is more or less the very essence of most if not all agricultural practices. However, this "liquid gold" is a resource that is gradually becoming scarce and expensive to access and as a result of the impending needs, combined water saving mitigation strategies in all sectors ought to be enforced as a means to minimize water wastage and maximize its output when used. (Nabanita *et al.*, 2018). The estimated water availability for agriculture which is 83.3 percent of total water used today will shrink to 71.6 percent in 2025 and to 64.6 percent in 2050 (Yadav, 2002). The shrinking water resources and competition from other sectors, the share of water allocated to irrigation is likely to decrease by 10 to 15 percent in the next two decades. Hence, the expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Highwaterconsumption is mainly attributed to the water lost by soil evaporation (E), by crop transpiration (T) and by deep percolation (D) below the rooting zone consequently to the hydrostatic load of a few saturated centimeters of shallow soil. The amount of water lost by transpiration is the only loss of water that is involved in crop production because transpiration is a driven process for growth and yield components formation. The reduction in E and D components is possible through the increase of the irrigation efficiency, which can be achieved through the micro irrigation which could allow to grow rice in areas with limited water availability and in soils which are not suitable for basin irrigation. It is an alternative method for rice to save water,to simplify crop management, to reduce environmental impact and to make possible the traditional crop rotation for rice. (Antonino *et al.*, 2009).Traditional method of irrigation not only consumes more water, but also causes severe wastage of water and nutrients thus leading to nutrient losses under anaerobic condition (Balaji *et al.*, 2015). In arid countries with large population growth and reduction of fresh water, there is considerable pressure on the agricultural sector to reduce water consumption and access to fresh water for industrial and urban sectors (Abdelraouf and Abuarab, 2012). The agricultural sector faces a serious challenge of producing more food with as little water as possible, which can be achieved by increasing crop water productivity (Abdelraouf *et al.*, 2013). Demand for rice is growing every year and it is estimated that in 2025 AD the requirement would be 140 million tonnes. Decreasing water availability for agriculture threatens the productivity of the irrigated rice ecosystem and ways must be sought to save water and increase the water productivity of rice (Guerra *et al.*, 1998). Because of the increasing demand for food with the increasing population growth and scarcity of water, rice producers face three major challenges*viz.*, i) To face water scarcity, ii) To increase productivity, iii) To produce more rice with less water. Hence, it is necessary to develop an alternative rice production system that requires less water and increases water productivity. Micro irrigation (Drip and sprinkler) is one such tool that can reduce water use and at the same time increase yield. It is the time to save water by adopting micro irrigation systems.

**Influence of micro irrigation on growth parameters**

In an experiment conducted in Bangalore, Karnataka, pooled data of 3 years showed thatsignificantly higher plant height, number of tillers per plant, leaf area per plant, leaf area index, total dry matter accumulation were recorded with drip irrigation scheduled at 2.0 $E_{Pan}$throughout the growth stages in aerobic rice as compared to surface irrigated puddled ricewhich could be attributed to continuous supply of water there by maintaining optimum water and nutrient availability throughout crop growth in drip irrigation(Anusha*et al.*, 2015). Drip irrigation at 1.4 IW:CPE ratio recorded significantly higher plant height, number of leaves per hill/plant, leaf area index and effective tillers per plant as compared to other drip irrigation levels (0.6, 0.8, 1.0 and 1.2 IW:CPE) and sprinkler and flood irrigation in an experiment conducted for 2 years at Chattisgarh(Anamika *et al.*, 2015).Sprinkler irrigation at 125 per cent pan evaporation recorded significantly higher plant height, number of tillers per hill in aerobic rice as compared to other sprinkler irrigation levels (75 % and 100 % pan evaporation) and lifesaving irrigation treatments (Shahanila*et al.*, 2016).Reduction in growth parameters with increase in severity of water stress might be due to anatomical changes in the plant like decrease in cell volume, cell division, cell elongation, intercellular space and thickening of cell wall as reported by Adriano *et al*. (2005). Significantly higher plant height, tiller number $m^{-2}$, leaf area index and dry matter production per plant was recorded with drip fertigation at 150 per cent $ET_C$ with 125 per cent RDF over surface irrigation with soil application of 100 per cent RDF in Coimbatore, Tamil Nadu (Ramdas and Ramanathan, 2017). Drip irrigation at 1.5 IW:CPE ratio recorded significantly higher plant height, number of tillers per plant, number of leaves per plant, leaf area, leaf area index and total dry matter production per plant over other levels (0.75, 1.0 and 1.25 IW:CPE ratio) in an experiment conducted in clay soil at Raichur, Karnataka which might be due to maintenance of adequate soil moisture by frequent irrigation which favoured faster cell division and cell elongation ultimately resulting in higher tiller production, more number of leaves and leaf area development and also higher dry matter production(Jagdish *et al.*, 2018).In a study conducted at Pantnagar, significantly higher plant height was recorded with Drip irrigation at 100 per cent CPE 2 days gap over the farmers practice (transplanted and flooded rice) by 14.7 per cent which could be due to even distribution of water with adequate availability and enhanced favorable rhizosphere for more nutrient uptake which in turn accelerate the growth, leading to the formation of higher growth attributes in the course contributing more photosynthates towards the sink(Bhardwaj *et al.,* 2018).A pooled data of 2 years study at Tamil Nadu in clay loam soil showed that significantly higher plant height was noticed with sprinkler Irrigation at 150% PE as compared to surface irrigation (Kumar *et al.,* 2018). Karthika and Ramanathan (2019) conducted an experiment in sandy loam soils of Tanjavur, Tamil Nadu and showed that significantly higher plant height, leaf area index, dry matter production, crop growth rate and relative growth rate were recorded with drip fertigation at 200% PE + 125% RDF as compared to surface irrigation and other levels of drip fertigation. In an experiment conducted at Raichur, Karnataka, direct seeded rice with drip irrigation at 4 hours daily recorded significantly higher plant height, leaf area index, number of tillers $m^{-2}$ and total dry matter per plant as compared to other treatments (Prashant *et al.,* 2019). Kumar (2009) revealed that aerobic rice with drip fertigation at 150 per cent $E_{pan}$recorded better plant height, number of tillers and leaf area as compared to drip fertigation at 100 per cent $E_{pan}$ and surface irrigation. This variation in growth parameters under surface and drip irrigation system was mainly due to the differences in wetting patterns, water distributions in soil and relative water use by crop (Sharma *et al*., 2013).

**Influence of micro irrigation on yield and yield parameters**

In an experiment conducted at Jalgaon, Maharashtra, significantly higher number of panicles $m^{-2}$, panicle weight, number of grains per panicle, 1000 grain weight and grain yield were recorded with Drip Irrigation at 100% CPE 2 days gap as compared to other treatments which might be due to even distribution of water with adequate availability and enhanced favorable rhizosphere for more nutrients uptake which in turn accelerate the growth, leading to the formation of higher yield attributes in the course contribute more photosynthates towards the sink (Bhardwaj *et al.,* 2018). Highest grain yield and straw yield was recorded with application of 100 % RDF through drip fertigation with water soluble fertilizers as compared to surface irrigation with soil application of RDF which can be mainly attributed to continuous availability of water and nutrients that resulted in higher uptake of nutrients in turn production of higher dry matter under drip fertigation(Rekha *et al.,* 2015).Karthika and Ramanathan (2019) reported that in Cauvery new delta zone of Tamil Nadu, highest grain yield and straw yield were recorded with drip fertigation at 200 % PE with 125 % RDF as compared to surface irrigation with application of 100 % RDF. Significantly highest number of panicles $m^{-2}$, spikelets per panicle, filled grains percentage, test weight and grain yield were recorded with lateral distance of 0.8 m, row spacing of 20 cm with dripper flow rate 1 lph + 30% more water on surface as compared to other treatments in Coimbatore, Tamil Nadu (Parthasarathi *et al.,* 2013). An experiment conducted in Sandy clay loam soils of Bangalore, Karnataka showed that significantly higher productive tillers per hill, panicle weight, filled grains per panicle, 1000 grain weight, grain yield and straw yield were recorded with Irrigation at 2.0 $E_{pan}$throughout growth stages which was found to be on par with irrigation at 1.5 $E_{pan}$upto tillering and 2.0 $E_{pan}$ from tillering to harvest as compared to other treatments (Anusha *et al.,* 2015). Higher grain yield recorded in these treatments might be due to its superiority in producing higher productive tillers $hill^{-1}$, panicle length, panicle weight, thousand seed weight and total number of grains $panicle^{-1}$ (Gururaj, 2013).The increase in yield attributes and yield under drip irrigation might be due to efficient water utilization, higher absorption and accumulation of nutrients by crop and maintenance of excellent soil-water-air relationship with higher oxygen concentration in the root zone (Sharma *et al.*, 2013). Significantly highest panicle length, sound grains per panicle, grain yield and straw yield were recorded with drip irrigation scheduled at 1.4 IW:CPE as compared to other drip irrigation treatments, sprinkler irrigation and flooding method in deep black clay soils of Raipur which might be due to sufficient availability of water whereas stress condition reduced grain yield (Anamika *et al.,* 2015). Balaji *et al.,* (2015) conducted an experiment in Sandy loam soils of Karnataka and revealed that significantly highest number of productive tillers per hill, number of panicles $m^{-2}$, panicle length, number of grains per panicle, grain yield and straw yield were recorded with drip irrigation at 150 % CPE + 125 % RDF as compared to conventional flooding method of irrigation. The increase in yield attributes under drip fertigation might be due to enhanced availability and uptake of nutrients leading to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts compared to conventional method of soil application of nutrients. Higher grain yield and straw yield might be due to better uptake of nutrients by the crop, because of higher root ramification *i.e.* both horizontal and vertical spread resulting in better contact with the soil particles might have helped in higher nutrient content and uptake and might have also been to the fact that higher soil moisture status. Significantly higher number of effective tillers $m^{-2}$, number of grains per panicle, panicle length, panicle weight, grain yield, straw yield and harvest index were recorded with SRI method with drip irrigation emitters spaced at 20cm which was found to be on par with SRI method with drip irrigation emitters spaced at 30cm over conventional paddy cultivation under continuous flooding in heavy clay soils at Bhopal (Rao *et al.*, 2017). In a field study conducted at Pantnagar in Silty clay loam soils grain yield increased to the extent of 35.31 per cent under direct seeded rice with drip irrigation at 20% CPE on 1 day gap over the conventional transplanted ricewhich might be due to initial higher plant growth in terms of number of shoots, higher shoot heights, LAI, total dry matter yield and higher yield attributing characters (Singh *et al.*, 2018). Jagdish *et al.*, (2018) revealed that significantly higher number of panicles $m^{-2}$, panicle weight, total filled grains per panicle, test weight, grain yield, straw yield and harvest index were recorded with drip irrigation scheduled at 1.5 IW:CPE which was found to be on par with drip irrigation scheduled at 1.25 IW:CPE. These improvements with 1.50 IW/CPE ratio might be due to the continuous and uninterrupted moisture supply throughout the crop growth period which resulted in increased moisturebesides higher cell division and elongation. The soil water distribution under drip irrigation is vertical in the beginning but later there will be a lateral distribution whereas, distribution remained primarily vertical under surface irrigation (Araujo *et al*., 1995). This resulted in low soil suction, better water and nutrient uptake by plants under higher IW/CPE of drip irrigation. Zheng *et al.* (2004) opined that the higher number of leaves, leaf area and leaf area index were positively contributed to higher dry matter production. Direct seeded rice with drip irrigation 4 hours daily recorded significantly higher productive tillers per hill, panicle length, panicle weight, 1000 grain weight and grains per panicle over the other treatments in medium deep black clayey soils of Karnataka (Prashant *et al.,* 2019). Paddy grain yield was highest by 53.4 per cent with application of irrigation water through drip scheduled at four hours per day over four hours once in every three days. Further, it was highest by 28 and 32.5 per cent over DSR farmer's practice and surface irrigation, respectively. Irrespective of the irrigation schedules drip irrigation treatments gave significantly higher grain yield over surface irrigation and farmers practice. The increase in grain yield was due to improved yield attributes. Yang *et al*. (2004) indicated that intermittent irrigation and maintaining moist, mostly aerobic soils not only enhances tillering but also the root system's development and functioning. Yield and yield attributes of rice were improved under drip irrigation than aerobic practice (Kato *et al*., 2009).Pinto *et al.* (2020) concluded that Soil water tension of 10 kPa was adequate to manage the sprinkler irrigation in rice, especially in the reproductive stage and when using cultivars developed for flooded environments at Brazil in lowland rice. Significantly highest grain yield was recorded with 0.8 Epan under drip irrigation @ 4 l/h at 3 days interval over the other treatments at West Bengal (Nabanita*et al.,* 2018).Results of a research in Pakistan showed that yield of rice increased by 18 per cent by adopting sprinkler irrigation (Gilani *et al.*, 2019).

**Influence of micro irrigation on water use efficiency**

Highest water productivity was noticed with drip fertigation (1.0+1.5 PE) with 75 % RDF through WSF as compared to surface irrigation with soil application of RDF and other drip fertigation treatments. Increase in water productivity was attributed to increased grain yield with decreased water consumption as compared to surfaceirrigation (Gururaj, 2013). A pooled data of two years showed that drip irrigation scheduled at 1.5 $E_{Pan}$recorded significantly highest water productivity as compared to continuous submergence (Transplanted) (Ramulu*et al.*, 2016). The water requirement was down by 50 per cent by reducing seepage, percolation and evaporation losses in view of ET based irrigation scheduling in aerobic rice (Medley and Wilson, 2008). Drip irrigation scheduled at 0.8 $E_{Pan}$@4 lph at 3 days intervalrecorded highest water use efficiency as compared to other treatments at West Bengal (Nabanita *et al.*, 2017). Lower amount of water consumption and higher water productivity was recorded with sprinkler irrigation over the other irrigation methods in a 2 year field study at Meerut, Uttar Pradesh in Loamy soils (Rajiv *et al.*, 2017). Highest water use efficiency and 30.7 per cent saving of water over flood irrigation was achieved with drip irrigation in an on farm trial conducted in Haryana. The drip irrigation methods used less water due to restriction of water loss through evaporation from large amount of ground, conveyance losses resulted in maximum water use by crops(Bansal *et al.*, 2018). In a field experiment conducted at Tamil Nadu, pooled data of 2 years showed that highest per cent water saving over surface irrigation was recorded with sprinkler Irrigation at 125% pan evaporation (Kumar *et al.*, 2018).

**Economics**

Highest gross returns, net returns and B:C ratio was recorded with drip irrigation as compared to other irrigation methods (Sprinkler and flood irrigation) in a field study conducted at Raipur (Hemlatha, 2015).

**Conclusion**

Micro irrigation practices can be adopted to reduce the wastage of water and supply required quantities of water to rice so as to decrease the water crisis because rice is the major consumer of huge quantities of water when cultivated under flooding method of irrigation. Water saving can be achieved, fertilizer requirement can be reduced as less quantities of fertilizer was required when applied through irrigation and energy can be saved. Water use efficiency and fertilizer use efficiency can be increased by adopting a suitable micro irrigation practice based on the soil type, slope of the land and availability of water.

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