

Feasibility of drip irrigation in rice cultivation

Subramanian E¹, Vijayakumar S², Sathishkumar A³ and Aathithyan C⁴

Tamil Nadu Agricultural University, AC&RI, Madurai, Tamil Nadu 625 104

Rice is cultivated in all type of ecosystems and its productivity is being a challenge in the upcoming decades due to growing water scarcity, frequent monsoon failure, increasing soil moisture stress, labour scarcity and invasive pests and diseases. So we need to find out a suitable water management techniques for rice that can ensure “more rice per drop” with less labour, energy, input and capital investment. Drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of the root zone. Because of its low water use with a reasonable yield, drip irrigated rice has greater scope in areas where water availability is limited especially in well irrigated area. However, the yield of drip irrigated rice is still lower than the transplanted rice. The productivity could be enhanced by fine tuning the crop management and developing special high-yielding rice varieties for drip irrigated rice for sustainable and viable aerobic rice systems.

Keywords: Cultivars, Drip irrigation, Rice, Water

INDIA has the largest rice growing area in the world and it stands second in production next to China. In India, rice is cultivated an area of 43.49 million ha with the production of 165.3 million tonnes. Rice culture is classified according to the source of water supply as rainfed, irrigated, deep water and flood-prone. Based on land availability rice lands are further classified as lowland (bunded, with chances for stagnation of water) and upland (unbunded, no provision for holding standing water; instead, freely allowed to move down according to the topography). According to water management practices, lands are classified as drylands (wherein stagnation of water is not permitted, irrigation is provided to recharge the micro-pores only) and as wetlands (wherein both macro and micro pores are allowed to be filled with). In the latter situation, anaerobic soil is the condition. Rice is the only crop which is cultivated in all type of land.

Need for micro irrigation

Water is becoming increasingly scarce in the traditional river valley command area because of many reasons like erratic monsoon behaviour, deteriorating hydrological balance and increasing demand for non-agricultural purpose. In Asia, irrigated agriculture accounts for 90% of total diverted freshwater and more than 50% of this is used to irrigate rice. Since several sectors vying for the same finite quantity of water, future rice production will therefore depend heavily on developing and adopting strategies and practices that will produce more quantum of rice with less and less water to feed the ever increasing population. As there is a demand to bring more area under assured irrigation, the availability of water for irrigation is expected to diminish in the coming years due to the competing demand from other users. As compared to surface water, a greater proportion of irrigation water

comes from groundwater and this source is increasingly being exploited in an unscientific manner. The growing water scarcity impulse, very efficient utilization of irrigation water through water saving irrigation technologies, to maximize the production per unit of water in rice production.

In crop management practices, one of the components is the initial establishment technique, which plays an important role in deciding the performance of crop in the latter stage. Unless proper establishment technique is practiced, the growth and development and finally the yield will be in jeopardy. In general, the transplanting of rice is the traditional system of rice crop establishment. But this method accounts for 21% of total operational cost and takes the energy of 30%/ha/day. This method can be substituted by direct seeding which could reduce labour needs by more than 20% in terms of working hours. The water saving will also be

nearly 20%. Moreover, when there is little shortage of water or immediate receipt of rainfall direct seeding comes in handy.

The term “Aerobic rice” was coined recently by International Rice Research Institute (IRRI), Philippines for high yielding rice grown in well drained, non-puddled and non-saturated soil. Aerobic cultivation entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation and fertilizers and aiming at high yields. It has characteristics of both upland and lowland varieties. Growing rice aerobically saves water by

- eliminating continuous seepage and percolation
- reducing evaporation and
- eliminating water required for land preparation like puddling, plastering and levelling

Controlled irrigation or alternate wetting and drying entails an irrigation schedule where water is applied to the field after the disappearance of ponded water. This technology is a departure from continuously flooding the fields and introduces a period of dry (aerobic) soil conditions. Similarly, there are evidences that the cultivation of rice through system of rice intensification (SRI) can increase rice yields by two to three fold compared to current yield levels besides saving water considerably. However, still, we need to focus on “more rice per drop” under water scarce situation with finding suitable water management techniques for rice. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of the root zone.

Drip irrigation is one such tool that can reduce water use and at the same time increase yield. Water saving through drip irrigation system varied from 12 to 84% for different crops besides increasing the

productivity of crops. Thus, the importance of scientific water management and the need to adopt advanced techniques like drip irrigation is to be exploited for the system as a whole besides achieving twin objectives of higher productivity and better water use efficiency

Many research findings indicated that drip technology can reduce water use and maintain the productivity of many crops. A study was established at the University of Missouri Marsh Farm in 2005 and 2006 to evaluate low-pressure, subsurface drip-irrigation for rice. Results indicated that subsurface drip-irrigation reduced irrigation inputs by 80% compared with conventional flood-irrigation. Rice maturity was delayed 2 weeks with drip-irrigation compared with conventional flood-irrigated plots; however, no yield differences were observed between the main effects of irrigation technique, with only minor milling quality reductions with drip-irrigation. Now, it is the right time to determine the feasibility of drip irrigation in rice. If so, it could be a promising technology to address dwindling water availability and increasing demands on irrigation water.

Varieties for drip irrigation

The majority of the present day rice varieties were specifically bred for transplanted conditions. But, for direct seeding/ aerobic rice cultivation, rice varieties must be improved for early seedling vigour, weed competitiveness, submergence tolerance to survive untimely rainfall during stand establishment and drought tolerance to survive dry conditions during germination and

later growth stages. Rice varieties meant for direct-seeded flooded rice must possess early seedling vigour and enhanced foliar growth to combat weeds at vegetative stage, moderate tillering (10-12 tillers), less foliar growth and enhanced assimilate export from leaves to stem during late vegetative and reproductive phases, sustained high foliar N concentration at productive stage, strong stems to withstand lodging at maturity and to store assimilates and improved reproductive sink capacity with a prolonged ripening period.

Still, research on aerobic rice has high hopes because some strains of rice known as upland varieties are already successfully grown in dry soil. Among the variety/hybrids studied in South India (Tamil Nadu), ADT 45 recorded the maximum grain yield of 3950 kg/ha. This was closely followed by KRH 2 hybrid (3,890 kg/ha) and CORH 3 (3860 kg/ha). Hence, the rice varieties ADT 45, KRH 2 hybrid, KRH 2 hybrid, PMK 3 and ASD 16 are promising rice variety/hybrid for aerobic irrigation. However, the yield of rice irrespective of the varieties are low when compare to the potential yields of the variety under drip irrigation. Because of its low water use with a reasonable higher yield, aerobic rice has greater scope in areas where water availability is limited. However, special high-yielding aerobic rice varieties need to be bred and a lot of research is still needed to develop sustainable and viable aerobic rice systems.

Table 1. Consumptive use of water (mm) under different systems of rice establishment

Particulars	Aerobic rice	Wet seeded rice	Trans-planted rice
Land preparation	0	175	250
Water used for crop growth including rainfall	560	1,025	1,050
Total water used	560	1,200	1,300
Evapotranspiration	515	504	528

Table 2. Panicles m⁻², grain yield and water productivity of rice varieties under aerobic irrigation

Variety/ Hybrid	Panicles m ⁻²	Grain yield (kg ha ⁻¹)	Total water used (mm)	Water use efficiency (kg rice ha mm ⁻¹)
ADT 43	294	1,248	522	2.39
ADT 46	262	1,321	584	2.26
CO 43	306	2,805	654	4.29
PMK 3	346	3,684	522	7.06
MDU 3	309	2,943	542	5.43
ASD 16	315	3,138	542	5.79
ADT 45	322	3,950	597	6.62
CORH 3	308	3,860	621	6.22
KRH 2	316	3,890	634	6.13

Ideal irrigation regimes for drip irrigation

Irrigation scheduled at IW/CPE ratio of 1.2 was recorded the higher growth parameters like plant height, crop growth rate, root volume and productive tillers followed by irrigation scheduled at IW/CPE ratio 1.0, 0.8 and micro sprinkler irrigation. Generally, the higher CGR under irrigation at IW/CPE ratio 1.2 might be due to the beneficial effect of water in impelling the normal cell turgidity, cell elongation and functioning of biopolymer apart from improving the nutrient uptake. Irrigation scheduling of IW/CPE ratio 1.5 up to PI thereafter 2.0 recorded more number of panicles m^{-2} (349) at harvest stage compared to other treatments.

Six irrigation regimes ((50%, 75%, 100% and 125% Pan Evaporation during entire cropping period and changes in irrigation regime according to the crop stage (Tillering-50%, Flowering-75% & Maturity-50% PE and Tillering-75%, Flowering-100% & Maturity-75% PE)) were tested. The different irrigation regimes positively influenced the grain yield of rice under drip irrigation. The maximum grain yield of 3893 kg/ha was obtained with 125% of Pan Evaporation (PE) irrigation regime (Fig. 1). This is mainly due to the availability of higher moisture to the root zone at regular interval as it favoured better crop growth and yield attributes. This was followed by irrigation at 100% PE which yielded 3695 kg/ha. Irrigation regime at 75% during tillering, 100% during flowering and 75% during maturity phase registered more grain yield of 3550 kg/ha as compared to 75% PE throughout the crop period (3234 kg/a). The lowest grain yield of 2771 kg/ha was recorded with irrigation at 50% PE which might be due to scarcity of soil moisture at the root zone as it affected the growth



Fig. 1. Growth of rice under drip irrigation at 125% PE

parameters like plant height, tiller numbers and leaf area as well as yield attributes like productive tillers, filled grains and test weight.

Weed management

Transforming crop establishment technique from transplanted to direct seeding has resulted in dramatic changes in the type and degree of weed infestation (Fig. 2). Weed management is one of the most critical factors for the successful production of direct seeded rice as the soil conditions favour simultaneous germination of weed seeds along with paddy seeds. Crops, as well as weeds, have the equivalent requirement for growth and development and competition starts when crop and weeds grow close to each other and the supply of a single necessary factor falls below the demand of both. Once it occurs, the other factors which are essential for plant growth cannot be utilized

effectively though it may be present in abundance.

Though the conventional method of manual weeding is widely practised, it is difficult to differentiate and remove the grassy weeds especially *Echinochloa colonum* and *E. crus-galli* due to phenotypical similarities between weeds and rice seedlings in the early stages. The only effective method to control weeds in the early stage is pre-emergence application

of herbicides followed by mechanical or hand weeding twice at 25 and 50 days after sowing.

Pendimethalin is a selective herbicide and it effectively controls majority of the annual grasses and to some extent, it controls certain broadleaved weeds in rice. Bensulfuron methyl + Pretilachlor is a pre-emergence herbicide mixture, which is used for controlling weeds in rice. In this combination, bensulfuron methyl is the active ingredient with pretilachlor as granules. This herbicide effectively manages the wide spectrum of grasses, sedges and broadleaved weeds. Due to its granular formulation, it eases the way of application by mixing it with sand. It plays a major role in inhibition of essential branched chain amino acids. Bispyribac sodium belongs to the group of Pyrimidinyl oxybenzoic which effectively manage the grasses, sedges and broadleaved weeds. It is a

Table 3. Influence of Irrigation levels, variety/hybrid on grain yield of rice under drip fertigation.

Treatments Irrigation levels	Variety/Hybrid (kg ha ⁻¹)				
	ADT 43	ADT 45	CORH 3	KRH 2	Mean
50 % PE	2,442	2,980	2,830	2,830	2,771
75 % PE	2,640	3,564	3,370	3,360	3,234
100 % PE	3,080	3,950	3,860	3,890	3,695
125 % PE	3,260	4,140	3,970	4,200	3,893
Tillering-50%, Flowering-75% and Maturity-50% PE	2,710	3,470	3,230	3,216	3,156
Tillering-75%, Flowering-100%, and Maturity-75% PE	3,050	3,820	3,539	3,790	3,550
Mean	2,864	3,654	3,466	3,548	



Fig. 2. Drip irrigated rice in seedling and grain filling stage

selective systemic herbicide used for both early post emergence and post emergence application. This herbicide controls the weeds by inhibition of acetolactate synthase enzyme.

Nutrient management

With any rice establishment method, N fertilization is one of the important factors that affect rice production and it accounts for about 67% of the total amount of fertilizers applied to rice. The use of efficiency of fertilizer N rarely exceeded 40%. Though modern rice varieties respond well to N fertilization, the recovery of applied N is very low. Of the three primary nutrients, nitrogen is the most deficient in Indian soils and its retention in soils is very low due to various losses such as surface runoff, volatilization, leaching and denitrification. This leads to low recovery of applied N, which normally varied, between 25 and 40%. Nitrogenous fertilizer is one of the costliest and perhaps the most crucial primary nutrients which can limit the rice yield. Therefore, the application of an appropriate quantity of fertilizer N at the right time is one of the important agronomic techniques to increase yield and N uptake of the direct seeded rice.

Application of N in three to four splits at 10 to 15 days after sowing, active tillering, and panicle initiation and flowering stage to semi-dwarf varieties proved beneficial in terms of higher yield coupled with minimum N loss. Fertigation in rice relatively new but revolutionary concept in applying fertilizer through irrigation. Hartz has stated that crop yields under fertigation have greater yield potential than previously imagined. It helps to achieve both fertilizer-use efficiency and water-use efficiency. By definition, fertigation is the precise application of soluble fertilizers through the sprinkler and drip irrigation. The benefits of fertigation have been examined in several studies. Much of the studies relate to fertigation in commercial crops. Irrespective of the variety and irrigation levels, the variation in growth, yield parameters and grain yield of rice was noticed between rows closes and rows furthest to the drip line. In our study, the lowest yield variation of 10% was recorded in ADT 45 rice variety with 125% PE levels. Increasing irrigation levels showed a lesser difference in grain yield between rows closes and rows furthest to the drip line. Whereas, the lower levels recorded higher

variations between rows closes and row furthest to the drip line.

SUMMARY

Compared with aerobic rice, water consumption in drip rice was similar and even higher in 125 % PE and yield reduction up to 15 % was noticed in drip irrigated rice. Because of its low water use with a reasonable yield, drip irrigated rice has greater scope in areas where water availability is limited especially in well irrigated area. However, the yield levels are still lower than the aerobic rice. The productivity of exiting varieties under the aerobic rice ecosystem could be enhanced by fine tuning the crop management. However, developing high yielding cultivars for every rice eco systems is the first priority. Hence, more focus is needed to increase the yield level in drip-irrigated rice in the cropping system approach for its sustainability.

¹Assistant Professor, TNAU, AC&RI, Madurai, Tamil Nadu-625 104, ²Scientist, ICAR-National Rice Research Institute, Cuttack, Odisha 753 006, ³Teaching Assistant, TNAU, AC&RI, Madurai, Tamil Nadu 625 104, ⁴Senior Research Fellow, TNAU, AC&RI, Madurai, Tamil Nadu 625 104.

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