

Irrigation Water Productivity of Basmati Rice; An On-Farm Comparison Between Rice Grown with Drip and Conventional Flood Methods of Irrigation

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ABSTRACT

In this on farm study, drip irrigation systems were installed in 21 farmers' fields in 1 acre area each, where rice is grown conventionally by flood irrigation. Pan E based irrigation schedule is followed in the drip treatments. A fertigation schedule is also implemented for fertilizer application in the drip irrigated fields. A comparison between conventional flood and drip method of irrigations were done on data of Irrigation water consumption, rice grain yield and irrigation water productivity (IWP). Overall hike in yield because of drip method of irrigation was 10-18 % of that in flood and mean IWP were 0.8 kg/m³ in drip and 0.3 kg/m³ in flood irrigated field.

India is the world's second largest producer of Rice. It is cultivated over an area of 44.2 million ha, which is about 50 % of the total irrigated agriculture area of the country (1). Short duration rice cultivation in rainy season (Kharif) is common in almost all States, however its cultivation is more concentrated in Northern States of Haryana and Punjab besides Eastern states and the Southern Peninsula.

Traditionally, low land rice or wet rice is cultivated in puddled soil as semi-aquatic crop. Under the low land system, water is consumed as much as 2295 mm/ha and 3000- 5000 liters utilized by the crop to produce one kg of grain [2]. The water productivity is as low as 0.15 kg/m³ in some cases [3]. The excessive use of irrigation water for rice production is a major socioeconomic, environmental and health concern for the region [4]. Several rice importers work in Haryana, for example, buying paddy from small holder farmers. The water footprint of these exports is extremely high and uncomfortable to afford.

Rice is also cultivated as dry land crop under rain-fed conditions in about 28 % area, by ploughing and harrowing the field dry and by direct sowing of the seeds. Such aerobic rice system, specially evolved rice varieties are cultivated as in Upland system with irrigation. The

seeds sown directly (DSR) and the soil moisture maintained to field capacity throughout the period of crop growth. Compared with traditional low land rice system, water inputs in aerobic rice system were less than 50% (470-650 mm), water productivity 64-88% higher, and labour use was 55% lower (4-5). These studies however did not separate the labour requirement for weeding *per se*.

Rice-Wheat Cropping System is predominant cropping system of India. Haryana has Rice-Wheat cropping system as irrigated and rain-fed crops. Farmers still use the conventional practices of irrigation and method of cultivation of rice so that the water table in Haryana is declining at a rate of 30-50 cm per year. The water table in 1970 was around 5 meter which has become 38-40 meter at present because of decline. The water productivity of rice is said to be 400 g/m³. Keeping this in mind the Water Productivity Project, WAPRO has been launched in Haryana, in 2018 by the active contribution and participation and co-funding of the Swiss Agency for Development and Cooperation (SDC), Helvetas, Mars, LT foods, Jain Irrigation Systems Ltd., and Partners in Prosperity. The data which form the basis of this paper is collected by Jain Irrigation scientists as part of the collaboration with WAPRO.

All the farmers have been irrigating the land through ground water extraction from bore wells. Rice based cropping system is the predominant cropping system in the four districts. The average productivity of Coarse Rice is about 4-5 t/ha and for Basmati is around 2.5-3 t/ha. The average rainfall in Haryana is low during the rainy season. Around more than 75% of irrigation water has been ground water. A pre-project survey indicated that in spite of declining water table farmers are pumping water for irrigation without any restriction.

The farmers are using huge volumes of water for getting a good yield. They are of the view that if the resource conservation technologies like drip irrigation technique are demonstrated in a field they are ready to use those technique.

At Jain Irrigation, we have come up with a solution. Irrigating rice crop with drip-fertigation technology reduces water consumption and methane emission besides increasing rice productivity. Soman (4) and Soman et al. (5) reported that aerobic rice hybrid ADT-45 and genotypes 27-P31,27-P63, PHB-71,ARIZE-6129,and ARIZE-6444 using drip irrigation with poly/paddy husk mulch, produced yields 4.5t-8.19 t/ha, harvested early by 8-10 days,17.7 to 25.2 % more yield than the conventional flooded cultivation system and in 27-P31, the maximum water productivity was 0.713 kg grain/m³ water. Anusha and Nagaraju (6) compared rice genotypes under drip irrigation with conventional puddled and transplanted system and observed that across genotypes drip irrigated rice recorded significantly higher yield 7934 kg/ha, 19% higher than that of conventional flood system(6659 kg/ha),resulted in 58% water saving. Water productivity was highest under drip (11.80 Kg/ha mm) as compared to puddled and transplanted rice 4.17 kg/ha mm.

We continued our interventions with drip-fertigation in the Basmati growers' belt in Southern Haryana. This paper describes on-farm results of the work done Haryana in the frame of WAPRO.

MATERIAL AND METHODS

This on- farm study is part of the project –“Water Productivity in Cotton and Rice” (WAPRO) phase II. Under this project SDC funded a part of the cost of drip systems supplied to the project farmers and Jain Irrigation, the technology provider, besides implementing the project and providing agronomy support to the farmers also provided part finance for the drip systems. The project farmers are all Basmati growers from Kaithal, Kurukshetra and Ambala districts of Haryana. Jain team has identified some 19 farmers in these districts who agreed to take up drip irrigated rice cultivation. The farms could be installed with drip during the planting season, *Kharif* 2019.

Data on yield, rain fall, irrigation water, fertilizer use, and yield of these fields were monitored. Detailed data on yield components (yield, tiller number per hill, gran per panicle and grain weight) were also recorded. In this paper, however we stress on yield and water productivity only.

We had already standardized package of practices (POP) for drip irrigated rice cultivation after 12 years of experimental and demonstration trials in many parts of India in farmers' fields. (Soman et al 2018). Generally, the package consists of the following steps.

- 1) Prepare well leveled and pulverized soil with adequate moisture. (Do a pre planting plough, irrigate and germinate weeds and plough again before land is ready for rice planting).
- 2) Prepare Bed and furrow if possible (optional). This option was not accepted by the farmers in this project in Haryana.
- 3) Hand sow / drill the seeds.
- 4) Row to distance (20 x 15 cm) (ROW –ROW x PLANT –PLANT)
- 5) Depth of seed 2 cm in dry seeded cultivation.
- 6) Fully drip Irrigate the field after sowing to provide the required moisture.
- 7) Drill the basal dose using a drill or apply on the bed before planting and incorporate.
- 8) Weed control: In the absence of standing water heavy weed infestation is envisaged. However, weeds could be easily controlled by a combination of hand weeding and rice husk mulching or by weedicide application. Application of Pendimethalin at 500ml/acre at 72 hours after sowing provided effective control.
- 9) Routine observation for insects (Stem borer, Leaf roller) and disease incidence were made during the crop.
- 10) Irrigation in drip plot was done by placing two drip lines on each bed or drip lines on the flat land Jain inline drip laterals 16 mm diameter with drippers of 4 lph placed at 50 cm spacing along the drip line.
- 11) Fertilizers were injected (fertigation) thru a ventury system following a schedule that was prepared for the location.

The irrigation schedule and fertigation program adopted in these farmer fields are given in Table 1 and 2 respectively.

Table 1. Irrigation schedule for Drip method for rice in Kurukshetra, Haryana \$

Period	Pan Evaporation mm/day	Water requirement of rice l/ac/day
June 15- June 30	5.3	1960
July 1- July 15	5.0	11890
July 16- July 31	4.3	12105
Aug 1 -Aug 15	4.7	17547
Aug 15 - Aug 31	4.5	16684
Sept 1 - Sept 15	4.7	14540
Sept 16 - Sept 30	4.4	13724
Oct 1- Oct 15	5.3	13118

Recommended fertilizer 60:24:16 kg/acre NPK. Basal dose of 50 kg/acre NPK (12:32:16) applied direct to soil at planting.

Table 2. Fertigation schedule for rice adopted in the farmers' fields

Growth Stage	Days after Sowing	Duration	Schedule
Vegetative	20-59 DAP	39 days	2.1 kg UREA per day or 14.7 kg /week
			1 kg MKP per week for 5 weeks 2.5 kg MgSO ₄ per week for 4 weeks 2 kg Zn EDTA per week for 5 weeks
Reproductive	60-89 DAP	29	5.1 kg UREA per week for 4 weeks
			1 kg MOP per week for 4 weeks 1 kg Zn EDTA per week for 3 weeks (Last dose only 0.5 kg)
Grain Maturity	90-115 DAP	25	3 kg MOP per week for 3 weeks. (last dose only 1 kg)

RESULTS AND DISCUSSION

Yield

Under conventional flood yield ranged from 2.75 to 7.5 t/ha across different rice varieties; and under drip irrigation it ranged from 2.5 to 8.1 t/ha, (fig 1). The varietal difference in yield is very dominant and is expressed both under flood and drip methods of irrigation. The overall shift in yield because of drip irrigation hovered around 10-18%. Overall, transplanted rice yielded more both in flood and drip (fig 2). The most used variety is PB 1509 by these farmers; its yield differences in flood and drip respectively in DSR and TPR planting systems clearly demonstrates the impact of drip method of irrigation in enhancing rice yield (fig 3). Drip out-yielded in both DSR and TPR.

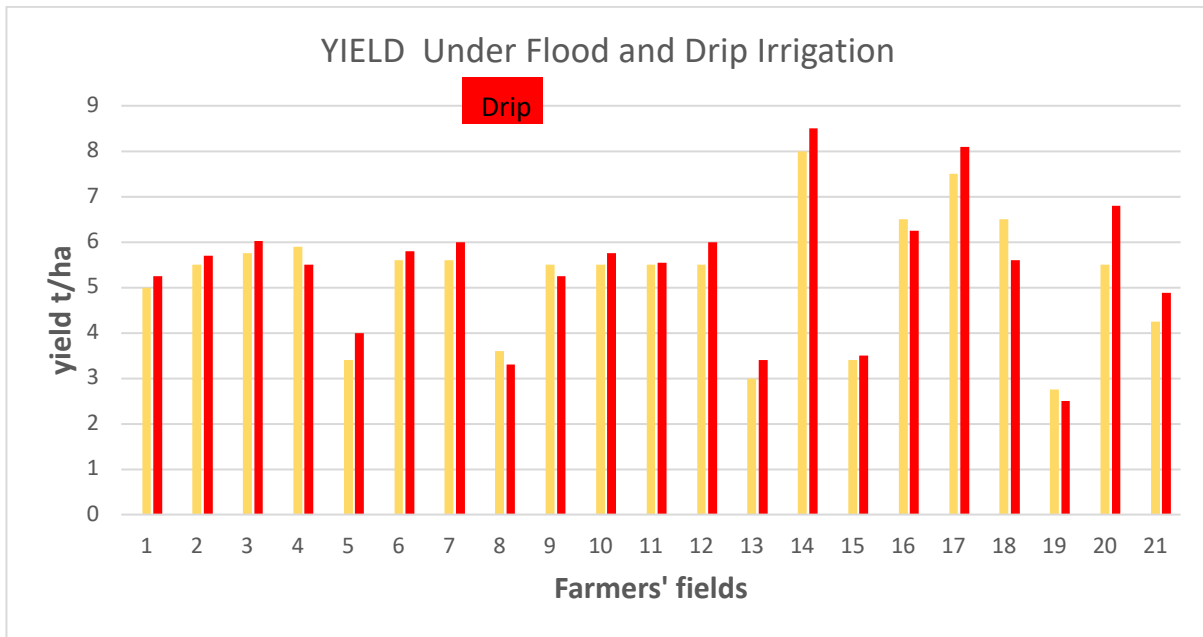


Fig 1. Yield under flood and drip methods of irrigation in the different farmers' fields

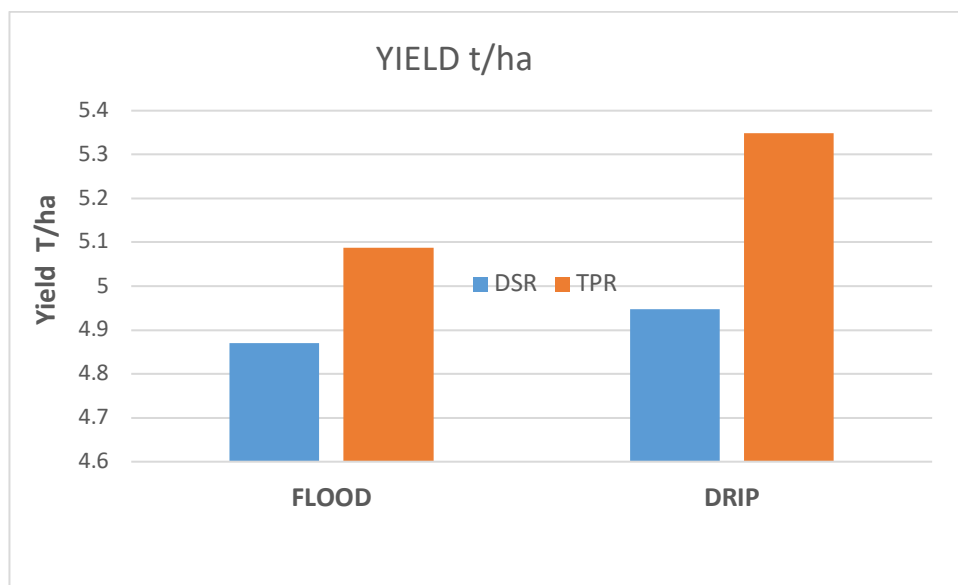


Fig 2 Mean yield under flood and drip in DSR and TPR methods of plantation

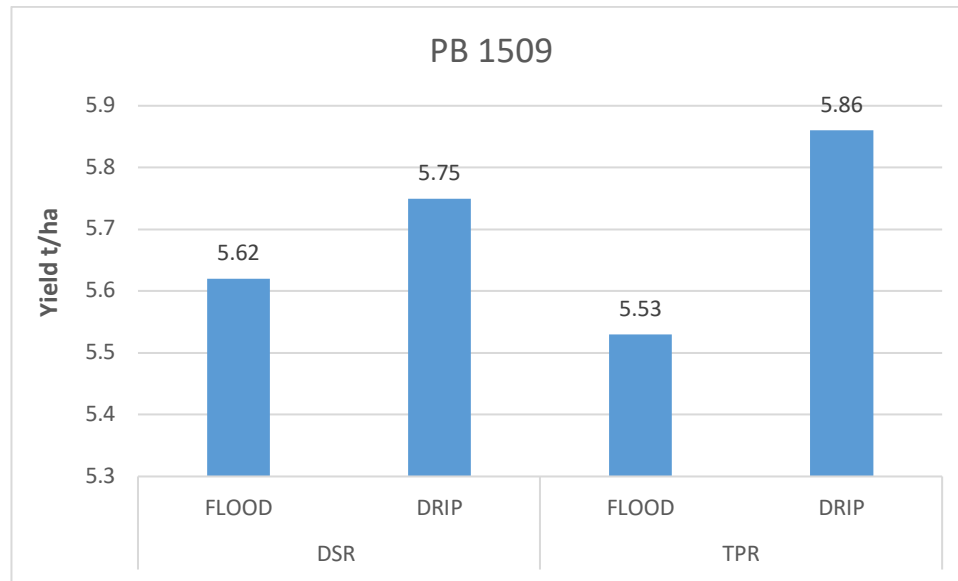


Fig 3. Yield differences for the most used variety (PB 1509) under flood and drip respectively in DSR and TPR

Irrigation water consumption for one season

Average irrigation water consumption in flooded fields is 6324.5 m³/ac/season and in drip fields 3084 m³/ac; Drip method releases an average 3240.5 m³ water/ac for other uses (fig 4). Average water consumption under TPR was more; TPR flood uses 6850 m³/season and TPR drip uses 3434 m³, and under DSR Flood the water consumption is 6384 m³ and DSR drip it is 2969 m³. The savings in water in drip irrigated rice fields and increased water productivity and grain yields under aerobic rice systems have been already reported by Soman et al (5 and 7) and Anusha and Nagaraj (6).

Irrigation Water productivity (IWP)

The water productivity (based on irrigation water only) was always superior in drip irrigated rice –trending around 0.8 kg paddy grain/m³ as against 0.3 kg/m³ in flood irrigated fields (fig 5).The Water productivity was then analysed separately for Direct seeded (DSR) and Transplanted rice (TPR) crops. TPR has marginally higher water productivity than DSR in both methods of irrigation (fig 6). This is an exception from the observations that DSR is superior to TPR in water productivity. This exception can be due to the high rainfall received during the season. Irrigation water productivity (IWP) even of a single variety of rice can't be a constant figure in different locations and under various crop management methods and crop seasons. IWP is also not just depended on water consumption alone, as other inputs affect the productivity. Even in our own work (5) the Irrigation water productivity obtained in flood and drip irrigated situations differed in absolute values from those obtained in this study. But a comparison of IWP in flood and drip methods of irrigation is relevant for similar crop management situations in the same season.

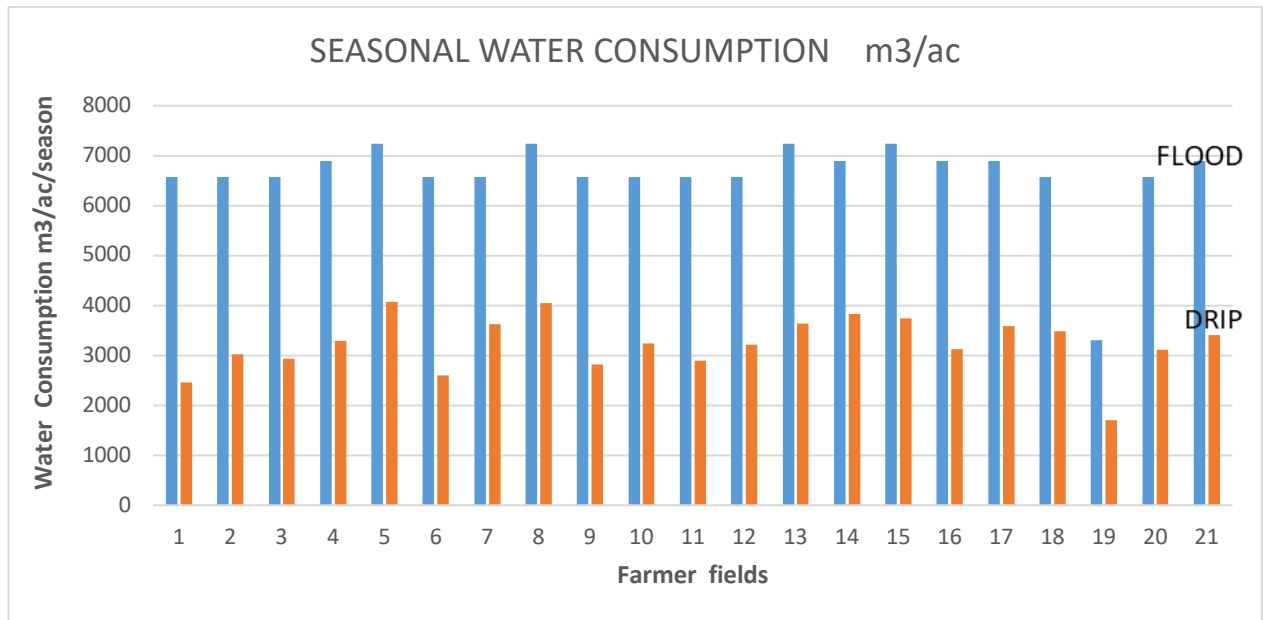


Fig 4. Irrigation water consumption in flood and drip methods of irrigation

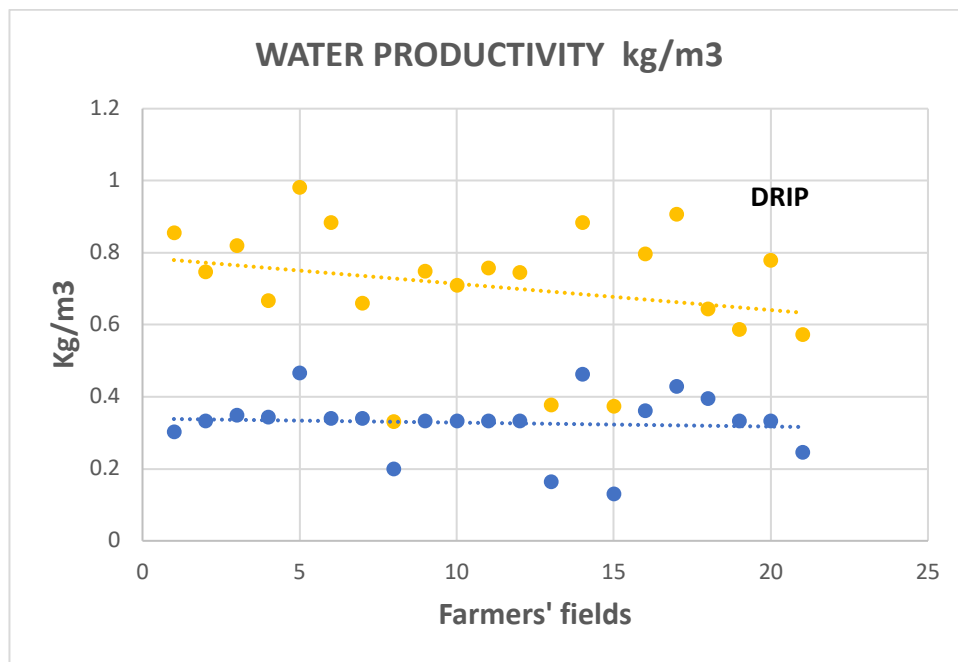


Fig 5. Irrigation water productivity of single season rice under flood and drip methods of irrigation

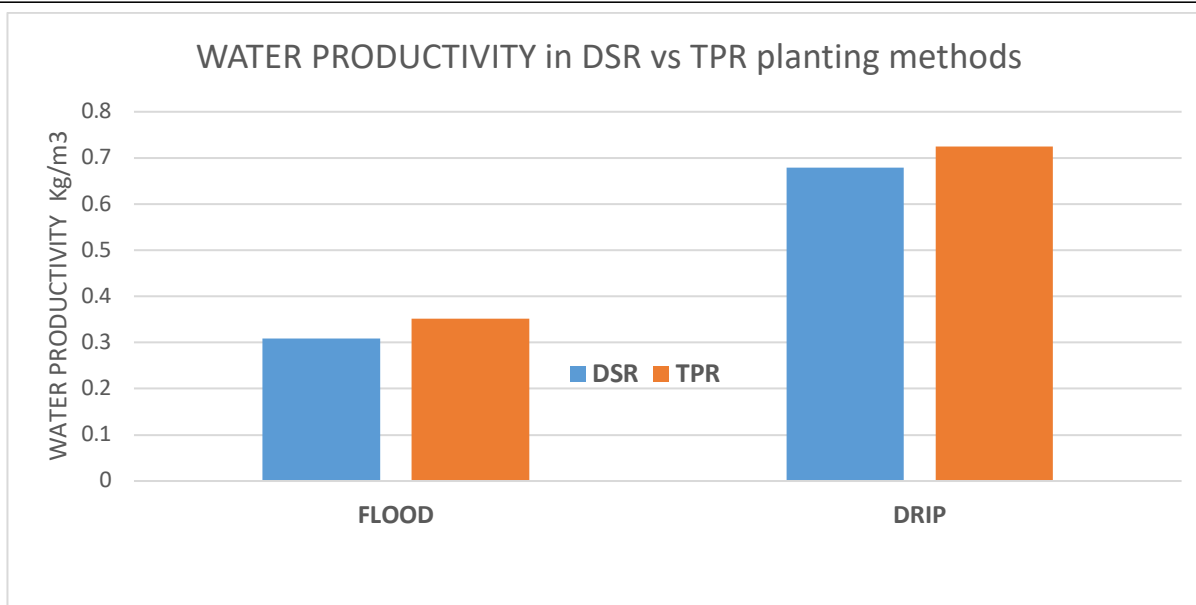


Fig 6. Water productivity in food and drip method of irrigation under DSR and TPR planting systems

SUMMARY

The summary of the benefits obtained from drip irrigating rice is given below (Table 3). Irrigation water consumption is reduced by 51% compared to flood irrigation. There is a slight (3%) difference in water consumption by DSR and TPR methods of planting. Because of heavy rains at the early season the water required for puddling operations were mostly satisfied by rainfall hence the difference between irrigation water consumption by DSR and TPR is very low. Irrigation water productivity improved by more than 100% when drip irrigated.

Table 3. Summary of the benefits from drip irrigating Basmati rice in Haryana in farmers' fields

Factor	Flood m ³ /ac	Drip m ³ /ac	Saving	%
Average irrigation water consumption (AVG)	6324.5	3084	3240.5	51%
Transplanted rice	6850	3434	3416	50%
Direct seeding	6384	2969	3415	53%
Water productivity (kg/m ³ water)	0.300	0.800	0.500	63%

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References

- [1]. Anon, (2016) Area and Production of Rice in India. Agricultural Statistics at a glance-Directorate of Economics and Statistics, Govt. of India, New Delhi.
- [2]. Dawe. D. (2005) Increasing water productivity in rice-based system in Asia-Past trends, current problems and future prospects. *Plant Production Sci.* 8-221-230.
- [3]. Ghosh. A, Singh. O. N, Rao, K. S. (2010). Improving irrigation management in dry season cultivation for optimum crop and water productivity in non-traditional rice ecologies. *Irrigation and Drainage* 60 (2) 174-178.
- [4]. Soman. P (2012): Drip Irrigation and Fertigation Technology for Rice cultivation: Asian Irrigation Forum, Asian development Bank, Manila, April 11-13, 2012. ADB. Manila. Philippines.
- [5]. Soman. P., Sundar Singh, Balasubrahmanyam, V.R. and Chaudhary Amol. (2018) Evaluation of the performance of aerobic rice using drip irrigation technology under tropical conditions. *International J. of Agri.Sci.* 10(10)6040-43
- [6]. Anusha. S and Nagaraju (2015) Performance of rice genotypes under drip irrigation in comparison with aerobic and puddled and transplanted condition. *Mysore J of Agril.Sci.* 49 (2)193-197.
- [7]. Soman, P. Sarwan Singh, A. K. Bharadwaj, T. Pandiaraj, and R. K. Bhradwaj (2018) On-farm drip irrigation in rice for higher productivity and profitability in Haryana, India. *International Journal of Current Microbiology and Applied Science.* 7 (2).