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Effect of drip irrigation on growth and yield of direct seeded rice (*Oryza sativa* L.)

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Abstract
The experiment was conducted during *Kharif* season of 2012-13 in H-Block of University Farm, G.B. Pant University of Agriculture and Technology, Pantnagar. Eight treatments were taken where five of the treatments were with drip irrigation treatment in direct seeded rice which was given in accordance to different per cent of cumulative pan evaporation (CPE) with different days of interval and control treatment was taken as conventional transplanted rice. Results revealed that T_4- Drip irrigation at 20% CPE on 1 day gap have performed better regarding the growth parameter as well as in terms of grain and straw yield by obtaining higher grain yield (8076.25 kg ha^{-1}) and straw yield(8651.90 kg ha^{-1}) which is statistically superior then conventional transplanted rice and any other treatments.

Keywords: Drip irrigation, Rice, Yield and CPE

Introduction
Rice is one of the most dominant cereal crop in the world and the staple food for more than half of the world's population. India is the world's second largest rice producer accounting for more than 20 percent of global production produced from 43.38 mha. The present and future food security of Asia and India depends upon the irrigated rice production system. Irrigated rice crop uses high amount of water because the crop is grown under low land condition, the soil is puddle and the field is kept flooded with 3 to 5 cm depth of water after transplanting until 10 days before harvest. In this system there is continuous presence of ponded water which leads to heavy loss of water by evaporation, seepage and percolation out of the root zone (Castaneda *et al.*,2002) [3]. Mostly Indian farmers are using as much as 15,000 litres of water to produce 1kg of rice when the maximum requirement is only 4,000 litres (Cyril Kanmony, 2001) [4]. Water requirement of produce 1kg of rice is about two to three times more than the water required for producing1kg of other cereals such as maize or wheat. As the water crisis threatens the sustainability of irrigated rice ecosystem, there arises the need to produce more rice with less water to ensure the food security of India where water scarcity for agricultural use is increasing.

New rice cultivation practices are needed and being evaluated due to the need for saving water in the face of increasing shortage. Rice production system will have to sustain itself with lesser water supply. To safeguard food security and preserve precious water resources, ways must be explored to grow more rice with less water (Belder *et al.*, 2002) [1]. One of the best method to increase the efficiency and uniformity of irrigation is the use of the drip irrigation. Drip irrigation can supply water to the plant with correct quantity at correct time without creating any hazardous effect to the soil plant environment and also create an opportunity to do fertigation through it. When fertilizer is applied through drip, it is observed that 30 per cent of fertiliser could be saved (Sivanappan and Ranghaswami, 2005) [6]. So drip fertigation provides the essential nutrients directly to the active root zone, thus minimizing the loss of nutrients which ultimately helps in improving the productivity and quality of farm produce. Hence, the present study was undertaken to study the effect of drip irrigation on growth and yield of direct seeded rice (*Oryza sativa* L.)

Material and Methods
The present study on the effect of drip irrigation on growth and yield of direct seeded rice (*Oryza sativa* L.) was carried out during *Kharif* 2012-13 at H block of University Farm, G.B. Pant University of Agriculture and Technology, Pantnagar. It is situated at 29ºN latitude, 79^0.29'E longitude and at an altitude of 243.83 meters above mean sea level.

It falls under *Tarai* belt of Shivalik range of Himalayan foot hills. The total rainfall during the crop season was 906.80 mm out of which the maximum was received in the month of August The relative humidity ranged from 55 to 97% in morning and 20 to 97% in the afternoon. The maximum and minimum temperature ranged from 23.7 to 39.7 and 10.4 to 30.1ºC, respectively during the crop growing period. Soil of the experimental area was silty clay loam in texture moderately dark coloured, derieved from calcareous silty alluvium from the mountains and classified as "mollisol". Initially, the soil of the experimental plot was rich in organic carbon(0.79%), available nitrogen (238.08 kg ha^{-1})available phosphorus(172 kg ha^{-1}) and medium in potassium content(219 kg ha^{-1}), having neutral reaction.

Preparation of field

The field was prepared by tractor drawn implements. It consisted of one ploughing followed by three harrowing and leveling. The individual plots were demarcated manually with the help of rope, bamboo pegs and lime.

Method of sowing

The certified seeds of HKR-47 were used at the rate of 40 kg ha^{-1}. The seed was soaked in water on 16th June, 2012. These soaked seeds were taken out on the next day and incubated in moist gunny bags for 48 hours for sprouting seeds. Sowing was done by broadcasting the sprouted seeds in well puddled plots on 20th June, 2012 for direct seeded puddled rice. In case for drip irrigated direct seeded rice the soil was not puddled and line sowing was done in moist friable prepared seed bed.

Lay out of drip system

The water source is bore well. Water was pumped through 7.5 HP motor and it was conveyed to the main field using 90mm of PVC pipes after filtering through sand and screen filter. From the main line water was taken to the field by through sub mains of 63 mm diameter PVC pipes. The emitters in the inline laterals are fixed at 20cm. The drip irrigation system was well maintained by flushing and cleaning the filters.

Irrigation Scheduling

Under conventional irrigation treatment, irrigation was maintained at 5cm depth throughout the crop growth. First irrigation was given immediately after sowing.

In the case of drip irrigation plots, initial soaking irrigation was given immediately after sowing. Subsequent irrigation was scheduled accordingly to the treatment through the drip system based on OPE values and subsequent irrigation given based on the pan evaporation values from USWB Open Pan Evaporimeter (OPE) installed at Crop Research Centre of Govind Bhallabh Pant University of Agriculture and Technology in Pantnagar. The calculated quantity of water was applied to each plot through 63 mm PVC turbo pipes.

V (mm) = (Ep x % of Ep according to treatment x Kc)

Where,
V- Volume of water required (mm)
Ep- Pan evaporation (mm/day)
Kc- Crop co-efficient (1.0 for all the crop growth stages)

The operation time of drip system to deliver the required volume of water per plot for different treatments was computed based on the formula:

$$\text{Time of operation (sec.)} = \frac{\text{Volume of water required}}{\text{Emitter discharge (2.4 lph) x No. of emitters}}$$

Design and layout of the experiment

The experiment was laid out in Randomized Block Design (RBD) with four replications and eight treatments with a plot size of 6.5m x 20m= 130m^2. The treatment details are as follows:

T_1: Conventional transplanted rice (Control)
T_2: Direct seeded rice with flood irrigation after 5 days of disappearance of surface water
T_3: Direct seeded rice with flood irrigation after 7 days of disappearance of surface water
T_4: Direct seeded rice with drip irrigation at 20 % cumulative pan-evaporation on 1 days gap
T_5: Direct seeded rice with drip irrigation at 30 % cumulative pan-evaporation on 2 days gap
T_6: Direct seeded rice with drip irrigation at 40 % cumulative pan-evaporation on 3 days gap
T_7: Direct seeded rice with drip irrigation at 50 % cumulative pan-evaporation on 4 days gap
T_8: Direct seeded rice with drip irrigation at 60 % cumulative pan-evaporation on 5 days gap

Fertigation with uniform dose of 150 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied through urea (46% N), phosphoric acid (60% P_2O_5) and white potash (60 % K_2O) for direct seeded rice with drip irrigation. Fertigation for N fertilizer was applied as urea (4.7 kg/0.013 ha) for once a week up to 17 weeks of cropping season, P once a week as phosphoric acid (1.3 kg/0.013 ha) up to 4 weeks of cropping season and K once a week as white potash (0.87 kg/0.013 ha) up to 7 weeks of cropping season for all drip irrigation treatment.

Results and Discussions

Crop Growth: Shoot height and root length

Table1: Shoot height and root length of rice at different stages of crop growth as influenced by different drip irrigation treatments

Treatment	Shoot height (cm)				Root length (cm)			
	Days after sowing				Days after sowing			
	30	60	90	Harvest	30	60	90	Harvest
T_1- Conventional transplanted rice(Control)	33.90	53.30	85.77	92.90	11.65	33.58	31.55	30.02
T_2- Direct seeded rice with flood irrigation after 5days of disappearance of the surface water	33.78	52.95	84.78	92.28	12.63	33.85	31.85	30.30
T_3- Direct seeded rice with flood irrigation after 7days of disappearance of the surface water	33.20	52.72	83.30	90.80	12.95	34.10	32.05	30.60
T_4- Direct seeded rice with drip irrigation at 20% CPE on 1day gap	37.55	59.52	91.48	98.98	14.65	36.08	34.02	32.55
T_5- Direct seeded rice with drip irrigation at 30% CPE on 2days gap	36.75	57.12	89.10	96.60	15. 00	36.75	34.75	33.20
T_6- Direct seeded rice with drip irrigation at 40% CPE on 3days gap	35.98	54.90	87.48	94.98	15.28	37.08	35.07	33.47
T_7- Direct seeded rice with drip irrigation at 50% CPE on 4days gap	34.00	54.27	86.88	94.38	16.30	38.60	36.50	35.10
T_8- Direct seeded rice with drip irrigation at 60% CPE on 5days gap	33.27	53.20	86.10	93.60	17.50	41.00	39.00	37.45
S.Em.±	0.66	0.46	0.44	0.40	0.13	0.27	0.29	0.27
CD at 5%	1.94	1.34	1.28	1.16	0.39	0.81	0.85	0.80

Generally, irrigation through drip system with fertigation favoured plant height positively which is shown in table 1. Among different irrigation treatment, T_4 treatment (DSR+DI at 20% CPE on 1 day gap) show significantly taller shoot height (37.55, 59.52, 91.48 and 98.98 cm respectively) at 30, 60, 90 days after sowing and harvest but which was statistically at par with T_5 and T_6. The increased plant height may be due to the continuous availability of the required quantity of water along with the required nutrients. The minimum shoot height was recorded in T_3 treatment (DSR+FI after 7 days of disappearance of the surface water) which was statistically at par with all the treatments except T_4, T_5 and T_6.
Root length increased with the advancement in crop growth up to 60 DAS and gradually decreases up to harvest stage. The difference in root length due to various treatments were highly significant at 30, 60, 90 days after sowing and harvest stage. Among different irrigation treatment, T_8 treatment (DSR+DI at 60% CPE on 5 days gap) obtained significantly longer root length (17.50, 41.00, 39.00 and 37.45 cm at 30, 60, 90 days after sowing and harvest stage respectively) at all crop growth stages. T_1 treatment (conventionally transplanted rice) resulted insignificantly shorter root length (11.65, 33.58, 31.55 and 30.02 cm at 30, 60, 90 days after sowing and harvest stages respectively) compared to all other treatments but it was at par with T_2 and T_3 at all the crop growth stages except at 30 DAS. The enhancement of growth parameters might be due to the restricted wetting area and root zone application of nutrients through drip system coupled with constant and continuous availability of optimum soil moisture which permitted the plants to absorb more nutrients. These results are in agreement with the findings of (Reddy & Aruna 2012) [5].

Table 2: Total number of shoots (No. m^{-2}) of rice at different stages of crop growth as influenced by different drip irrigation treatments

Treatment	Total number of shoots (No. m^{-2})			
	Days after sowing			
	30	60	90	Harvest
T_1- Conventional transplanted rice (Control)	559.75	572.75	562.75	559.00
T_2-Direct seeded rice with flood irrigation after 5days of disappearance of the surface water	537.75	550.75	541.75	537.50
T_3- Direct seeded rice with flood irrigation after 7days of disappearance of the surface water	523.25	535.50	526.25	523.00
T_4- Direct seeded rice with drip irrigation at 20% CPE on 1day gap	648.25	665.25	656.50	652.50
T_5- Direct seeded rice with drip irrigation at 30% CPE on 2days gap	625.50	641.50	632.00	628.25
T_6- Direct seeded rice with drip irrigation at 40% CPE on 3days gap	602.50	616.00	606.50	602.25
T_7- Direct seeded rice with drip irrigation at 50% CPE on 4days gap	581.50	586.50	576.50	574.00
T_8- Direct seeded rice with drip irrigation at 60% CPE on 5days gap	511.50	527.75	518.50	516.75
S.Em.±	2.48	3.34	3.38	3.26
CD at 5%	7.30	9.83	9.95	9.58

Number of shoots m^{-2}

The shoot m^{-2}due to drip irrigation treatment at 30 days after sowing were statistically higher than non drip irrigated treatments except T_8 treatment (DSR+DI at 60% CPE on 5 days gap) which observed lowest number of shoots m^2. At 60 days stage, drip irrigation treatment significantly enhanced the number of shoot m^{-2} over all the non drip irrigation treatments except T_8 (DSR+DI at 60% CPE on 5 days gap) which was statistically at par with T_3 treatment (DSR+FI after 7 days of disappearance of the surface water). At 90 days after sowing and at harvest stage also drip irrigation treatments produced significantly more number of shoot m^{-2} over all the non drip irrigation treatments except T_8 treatment (DSR+DI at 60% CPE on 5 days gap) which was statistically at par with T_3 treatment (DSR+FI after 7 days of disappearance of the surface water). The reasons for higher number of shoots m^{-2} may be due to the continuous supply of required quantity of water and nutrients below the rootzone of the crop. This result is in conformity with (Bharambe *et al.*,1997) [2] and (Vanitha & Mohandass, 2014) [8].

Table 3: Grain yield and straw yield of rice as influenced by different drip irrigation treatments

Treatment	Grain yield	Grain yield increased	Straw yield	Straw yield increased
	(kg/ha)	%	(kg/ha)	%
T_1- Conventional transplanted rice(Control)	5224.50	-	6400.97	-
T_2- Direct seeded rice with flood irrigation after 5days of disappearance of the surface water	4924.00	-6.10	6222.90	2.86
T_3- Direct seeded rice with flood irrigation after 7days of disappearance of the surface water	4301.25	-21.46	5499.12	-16.40
T_4- Direct seeded rice with drip irrigation at 20% CPE on 1day gap	8076.25	35.31	8651.90	26.02
T_5- Direct seeded rice with drip irrigation at 30% CPE on 2days gap	7787.75	32.91	8736.88	26.74
T_6- Direct seeded rice with drip irrigation at 40% CPE on 3days gap	7297.50	28.41	8354.90	23.39
T_7- Direct seeded rice with drip irrigation at 50% CPE on 4days gap	6199.50	15.73	7421.58	13.75
T_8- Direct seeded rice with drip irrigation at 60% CPE on 5days gap	3844.25	-35.90	5105.84	-25.37
S.Em.±	78.13	-	98.77	-
CD at 5%	229.78	-	290.48	-

Grain yield and straw yield of rice

T_4 (DSR+DI at 20% CPE on 1 day gap) recorded highest grain yield (8076.25 kg ha^{-1}) which was statistically higher than all the treatments. The lowest grain yield was recorded under treatment T_8 (3844.25 kg ha^{-1}). The percent increased in grain yield for drip irrigation treatments over control are (T_4-35.31%, T_5-32.91%, T_6-28.41 %and T_7-15.73%). The higher grain yield in drip irrigated plots maximum with T_4-Drip irrigation at 20% CPE on 1 day gap 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. T_4 (DSR+DI at 20% CPE on 1 day gap) obtained highest straw yield (8651.90 kg ha^{-1}) which was statistically higher than all the treatments but at par with T_5 (8736.88 kg ha^{-1}). The lowest straw yield was obtained under treatment T_8 (5105.84 kg ha^{-1}). The percent increased in straw yield for drip irrigation treatments over control treatment (conventional transplanted rice) are (T_4-26.02 %, T_5-26.74%, T_6-23.39%and T_7-13.75%).

Conclusion

From the above study it can be concluded that Drip irrigation at 20% CPE on 1 day gap recorded maximum grain yield (8076.25 kg ha^{-1}) and straw yield (8651.90 kg ha^{-1}) of rice which was significantly higher over the conventional transplanted rice and obtained a percent increased of 33.31% grain yield and 26.02 % straw yield over transplanted rice. Thus, it clearly indicated that the feasibility of introducing drip irrigation and fertigation in rice for sustainability in future rice production.

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