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Thangjam Churachand Singh
M.Sc. (Agri.) Department of Agronomy, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Sajal Debbarma
Subject Matter Specialist (Horticulture), KVK, Panisagar, Tripura, India

AK Bhardwaj
Professor, Department of Agronomy, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
Thangjam Churachand Singh
M.Sc. (Agri.) Department of Agronomy, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Effect of drip irrigation on economics of direct seeded rice (*Oryza sativa* L.)

Thangjam Churachand Singh, Sajal Debbarma and AK Bhardwaj

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Abstract
The field experiment was conducted during *kharif* season of 2012-13 in H-Block of University Farm, G.B. Pant University of Agriculture and Technology, Pantnagar. During the field experiment 8 treatments were taken. Among those treatments five of the treatments were associated 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. The results from the experiment revealed that T_4- Drip irrigation at 20% CPE on 1 day gap have the highest net return of ₹ 91684.80 ha^{-1} which was followed by T_5 - Direct seeded rice with drip irrigation at 30% CPE on 2 day gap by obtaining ₹ 88161.96 ha^{-1}. The benefit in terms of B:C ratio was also highest due to T_4 - Direct seeded rice with drip irrigation at 20% CPE on 1 day gap (3.16) while comparing to all the other treatments allocated in the given experiment.

Keywords: Drip irrigation, rice, economics, B: C ratio

Introduction
Rice is the most important staple food in Asia, providing on average 32% of total calorie uptake (Maclean *et al*., 2002) [6]. India is the world's second largest rice producer accounting for more than 20 percent of global production produced from 43.38 mha. Future of rice production in India and Asia mainly depends on irrigated rice production system. Rice crops require substantial amount of freshwater because rice is mostly grown under flooded conditions (Tuong & Bouman, 2003) [8]. If the irrigated area is kept without expanding, rice production requirement in future could only be achieved by increasing the effectiveness, yield and the cropping intensity. This brings us the message that with increasing demand for food production under resource poor situations where agriculture becomes more and more intensive and competitive, cultivation must be geared to achieve higher productivity (yield per unit land and / or water resource) in order to meet the market demand of commodity. In this context, judicious management of all the inputs in agricultural production system is vital. Water is one of the basic requirements that plants require to obtain higher productivity. 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]. 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.

To safeguard food security and preserve precious water resources, ways must be explored to grow more rice with less water (Belder *et al.*, 2002) [2]. One of the best method to increase the efficiency and uniformity of irrigation is the use of the drip irrigation. When fertilizer is applied through drip, it is observed that 30 per cent of fertiliser could be saved (Sivanappan and Ranghaswami, 2005) [7]. 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 economics of direct seeded rice (*Oryza sativa* L.).

Materials 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 which is situated at 29ºN latitude, 790.29'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 30.1 °C, 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. The certified seeds of HKR-47 were used at the rate of 40 kg ha^{-1}. 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. 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. Fertigation with uniform dose of 150 kg N, 60 kg P_2O_5 and 40 kg K2O 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.

Economic analysis

Common cost of production per hectare was estimated by adding all the expenses, except cost of drip irrigation incurred in producing the crop. Adding the cost of different drip irrigation treatments to the common cost of production per ha was the cost of production per ha for different treatments.

Gross return hectare-1 for different treatments was calculated by multiplying the grain and straw yield to their respective prices (₹ 12.80 kg^{-1} grain & ₹ 2.00 kg^{-1} straw). Net returns ha^{-1} was obtained by deducting the total cost of production from gross returns ha^{-1} for different drip irrigation treatments. Net return in terms of rupees was obtained by dividing the net returns ha^{-1} with the cost of production ha^{-1} for different treatments which reflects the efficiency of capital used.

B:C ratio was calculated as follows:

$$\text{Benifit Cost Ratio (B: C Ratio)} = \frac{\text{Net Return}}{\text{Cost of Cultivation}}$$

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= 130m2. 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

Results and Discussions

Table 1: Cost of cultivation of direct seeded rice (2012)

Cultural operation	Charge (₹ $unit^{-1}$)	Price (₹ ha^{-1})
Seed (60 kg)	25 kg	1500
Main field preparation		
Ploughing (total 2.5 hrs.)	410/ hr	1025
Cross harrowing 2 times (total 4 hrs.)	450/ hr	1800
Bund preparation (6 labour)	150/ labour	900
Sowing		
Cost of labour (20 labour)	150/ labour	3000
Fertilizer application (Basal)		
N (150 kg)	12/ kg	1800
P (60 kg)	41/kg	2460
K (40 kg)	19/kg	760
Cost of basal application (2 labour)	150/labour	300
Plant protection		
Cartap hydrochloride (25 kg)	70/ kg	1750
Harvesting and threshing	2700	
Transportation	900	
Total of cost cultivation	18895	

Table 2: Cost of cultivation of drip irrigated direct seeded rice (2012)

Cultural operation	Charge (₹ unit-1)	Price (₹ ha^{-1})
Seed (60 kg)	25 /kg	1500
Main field preparation		
Ploughing (total 2.5 hrs.)	410/ hr	1025
Cross harrowing 2 times (total 4 hrs.)	450/ hr	1800
Bund preparation (6 labour)	150/ labour	900
Sowing		
Cost of labour (20 labour)	150/ labour	3000
Fertilizer application (Basal)		
N (150 kg)	12/ kg	1800
P (60 kg)	41/kg	2460
K (40 kg)	19/kg	760
Cost of basal application (2 labour)	150/labour	300
Plant protection		
Cartap hydrochloride (25 kg)	70/ kg	1750
Harvesting and threshing	2700	
Transportation	900	
Cost of drip installation at initial	104000/ha	Single drip installation plan = 10 years life span.
Cost of drip installation for 1 ha on 1 year basis	10400	
Total of cost cultivation	28895	

Table 3: Economic analysis on drip irrigated direct seeded rice.

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation in ₹/ ha	Gross return in ₹/ha	Net return in ₹/ ha	B:C ratio
T_1- Conventional transplanted rice (Control)	5224.50	6400.97	23649	79675.54	56026.54	2.37
T_2- Direct seeded rice with flood irrigation after 5days of disappearance of the surface water	4924.00	6222.90	18895	75473.00	56578.00	2.99
T_3- Direct seeded rice with flood irrigation after 7days of disappearance of the surface water	4301.25	5499.12	18895	66054.24	47159.24	2.50
T_4- Direct seeded rice with drip irrigation at 20% cumulative pan-evaporation on 1 day gap	8076.25	8651.90	28995	120679.80	91684.80	3.16
T_5- Direct seeded rice with drip irrigation at 30% cumulative pan-evaporation on 2 days gap	7787.75	8736.88	28995	117156.96	88161.96	3.04
T_6- Direct seeded rice with drip irrigation at 40% cumulative pan-evaporation on 3 days gap	7297.50	8354.90	28995	110117.80	81122.80	2.80
T_7- Direct seeded rice with drip irrigation at 50% cumulative pan-evaporation on 4 days gap	6199.50	7421.58	28995	94196.76	65201.76	2.25
T_8- Direct seeded rice with drip irrigation at 60% cumulative pan evaporation on 5 days gap	3844.25	5105.84	28995	59416.08	30421.08	1.05
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%). Higher grain yield was due to the cumulative effect of improvement in growth and yield attributes. Increase in yield might be due to more irrigations providing constant wetting of root zone which might have favoured greater release of nutrients from soil. Similar findings were also reported by (Kumar *et al*., 2013) [5].

Economics

Data pertaining to added cost due to different drip irrigation treatments to the cost of cultivation without are presented in Table 1, 2 and 3. Data indicated that total cost of cultivation of direct seeded was ₹ 23649/- in conventional irrigated condition and was increased to ₹ 28995/- in drip irrigated condition.

Above variable cost of cultivation differentiated the net return in rupees ha^{-1} and gross return in rupees per rupee investment also. T_8 treatment gave lowest net return of ₹ 30421.08ha^{-1} and gross return of ₹ 59416.08 ha^{-1} among all the treatments. The highest net return of ₹ 91684.80 ha^{-1} was due to T_4 - Direct seeded rice with drip irrigation at 20% CPE on 1 day gap followed by T_5 - Direct seeded rice with drip irrigation at 30% CPE on 2 day gap (₹ 88161.96 ha^{-1}) followed by T_6 - Direct seeded rice with drip irrigation at 40% CPE on 3 day gap (₹ 81122.80 ha^{-1}). The benefit in terms of B:C ratio was also highest due to T_4 - Direct seeded rice with drip irrigation at 20% CPE on 1 day gap (3.16) followed by T_5 - Direct seeded rice with drip irrigation at 30% CPE on 2 day gap (3.04) followed by T_2 - Direct seeded rice with flood irrigation after 5 days of disappearance of surface water obtaining a B:C ratio of 2.99. Both net return and B: C ratio had increased due to the high increase in grain yield which is the results of adequate water supply and nutrient availability to the root zone area of the crop under drip irrigation system (Ashoka *et al*., 2004) [1].

Conclusion

Based on the results obtained from the study conducted, it can be concluded that drip irrigation was found profitable for getting higher yield and economic returns over conventional method. T_4 - Direct seeded rice with drip irrigation at 20% CPE on 1 day gap is beneficial for obtaining higher net return and better B:C ratio over conventional irrigation method and it can be recommended to farmers for improving income in future with further research in this field.

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