

Increasing Net Return in *Boro* Rice Cultivation through Water Management in Shallow Tube Well Command

PRADIP KUMAR BORA

*School of Natural Resource Management, College of
 Post Graduate Studies Central Agricultural University
 Umiam, Meghalaya 793103, India*

Abstract

An experiment was conducted to find out the most economical irrigation schedule for *boro* rice (summer rice) cultivation under shallow tube wells (STW) command areas so that the profit from this irrigated rice can be enhanced by minimizing the cost of irrigation. The experiment was conducted with five treatments : T1-Irrigation to a uniform depth of 5 cm 1 day after depletion of ponded water (DADPW), T2-At 3 DADPW, T3-At 4 DADPW, T4-At 5 DADPW and T5-Irrigating at an interval of 10 days (refilling to a depth of 5 cm). Considering the life of the machine as 10 years (200 h per annum) and 13% per annum interest on investment, the cost of irrigation was found to be Rs 1.69/m³. It was found that T₃ i.e. irrigation at 4 days after depletion of ponded water (DADPW) gave the highest return followed by T₅ under prevailing agro-climatic conditions.

Key words : *Boro* rice, Water management, Net return.

Water management in rice should be looked into from two perspectives. Firstly, on farm water management to reduce the loss at individual farmer's field, thereby reduce the over all cost of production. Secondly, reduction of water demands in rice cultivation to ensure the food security for the present and the future, which is threatened by the scarcity of water. In Asia, irrigated agriculture accounts about 90% of diverted fresh water and more than 50% of this is used for irrigating rice fields. On the other hand, Asia produces about 92% of world rice. More than 75% of these rice comes from about 79 million ha of irrigated land (1). The food security of Asia, where about 60% of world population lives, is now challenged due to increased food demand and declining water availability (2). In agriculture, the situation is aggravated by increasing the costs of irrigation development. Because of these situations rice producers are facing three challenges : To save water, to increase water productivity and produce more rice with less water (2). Use of water in rice field can be grouped into two phases- the amount of water required to prepare the land and the amount of water to meet the evapo-transpiration (ET) and other outflows (3). The other outflows include the seepage and percolation losses from the rice field. For transplanted rice the amount of wa-

ter required to prepare the land may vary from soil to soil that have little room to maneuver. However, water input can be reduced by decreasing ponded water depths to soil saturation or by alternate wetting and drying. Total water requirement for transplanted rice depends on the sizes of the outflows and the duration of land preparation and crop growth. For a 100 day crop growth duration of a modern short duration variety, total ET flows are about 400—500 mm in the wet season and 600—700 mm in the dry season and total seepage and percolation accounts about 100—500 mm in heavy clay soils and 2500—3000mm in sandy loam soils (1). Typical ET values of rice in tropics are 4—5 mm per day in the wet season and 6—7 mm per day in the dry season (De Dutta, 1981). The rice yield per unit ET can be as high as 1.6 kg/m³ which is comparable to any cereal crop (3). The low water productivity of rice is not due to ET components but other components of water use in the cultivation process.

The typical seepage and percolation for irrigated rice vary from 1—5 mm per day in heavy clay soils to 25—30 mm per day in sandy and sandy loam soils (2). They can nevertheless be reduced through water management techniques. Percolation increases when the depth of water standing in the field is increased.

Table 1. Depth of water applied under different schedules. DADPW : Days after depletion of ponded water.

Treatments	Depth of water applied, mm	
	Year	Year
	2003-04	2004-05
T ₁ 1 DADPW	325.0	287.5
T ₂ 3 DADPW	237.5	225.0
T ₃ 4 DADPW	212.5	212.5
T ₄ 5 DADPW	200.0	225.0
T ₅ At the interval of 10 days	212.5	207.5

Farmers maintain deep water to enhance advancement of water in plot to plot irrigation which is practiced in most large irrigation systems. This is aggravated by farmers' preference to maintain in rice fields a relatively high water depth to control weeds, reduce the frequency of irrigation and as an insurance against possible future shortage due to unreliability of delivery system (3). It has also been estimated that seepage and percolation accounts for 50–80% of the total water input in the field (4) and most of the field level management strategies involved minimizing the seepage and percolation losses which can be done by reducing the depth of ponded water, keeping the soil just saturated and alternate wetting and drying.

Water saving irrigation however runs the risk of yield reduction because of the possible water stress. Tabbal et al. (1) reported that keeping the soil around saturation can loss yield up to 7% as compared to standing water control, but the water saving may be increased to 31–58%. Similarly, intermittent irrigation at 8–10 days reduced the yield by 25% and increased water saving by 60%. The water saving techniques are more effective in lighter soils where seepage and percolation are more responsive to changes in ponded water depth (5). On the other hand, saturated soil treatments reduced water inputs by 31–58% in transplanted and 32–49% in direct wet seeded rice. The large reduction in water input combined with the slight reductions in grain yield led to large increase of 29–118% in water productivities in the saturated soil treatments over the standing water control (1). If the total duration from land soaking to crop establishment could be reduced by 30 days, the total amount of water supplied to the rice field would be reduced by about 17% water productivity would in-

Table 2. Yield of paddy under different treatments. DADPW: Days after depletion of ponded water.

Treatments	Paddy yield, t/ha	
	Year	Year
	2003-04	2004-05
T ₁ 1 DADPW	5.24	3.51
T ₂ 3 DADPW	4.84	3.24
T ₃ 4 DADPW	5.37	3.44
T ₄ 5 DADPW	5.07	3.13
T ₅ At the interval of 10 days	5.14	3.21

crease from 0.45 kg/m³ to 0.55 kg/m³. After crop establishment evaporation seepage and percolation flows can be reduced further by adopting alternate wetting and drying method of irrigation (6, 7). Water saved in the farm level does not necessarily mean water saved in the system level. Nevertheless, the reduction of outflow in the farm level by reducing seepage and percolation increase over all saving of irrigation water due to scale effect. Reduction of percolation from the irrigation command may lead to reduction in the groundwater recharge, which can be re-used at the downstream through sub-surface exploitation, but in the high rainfall areas with alluvium soils where recharge is relatively very high during rainy season such reduction at the field level is not going to affect significantly.

Summer rice is cultivated in Assam in about 3.27 lakh ha area with an average productivity of 1.9 t/ha. This is considered to be the third important crop in Assam in relation to area coverage after winter rice (17.49 lakh ha) and autumn rice (4.64 lakh ha) (8). Productivity of *boro* rice is also the highest among all the rice cultivated in Assam (1.55 and 0.97 t/ha for winter and autumn rice, respectively), *Boro* rice was traditionally cultivated in the low lying areas where water was available during December and January. At present, it has been shifted to midland areas after wide spread installation of shallow tube wells (STW). The STW are operated with 5 hp diesel engine run pump and the consumption of diesel is nearly 1.2 liter/h. The traditional knowledge of water management in rice cultivation requires continuous inundation of rice field which makes the farmers irrigate rice cultivation requires continuous inundation of rice field which makes the farmers irrigate the field at frequent interval.

Further, the *boro* rice cultivated mid-land areas

Table 3. Treatment wise net income from paddy cultivation (Rs). DADPW : Days after depletion of ponded water.

Treatments	Year 2003-04				Year 2004-05			
	Cost of Irrigation	Yield	Gross income	Net income	Cost of Irrigation	Yield	Gross income	Net income
T ₁ 1 DADPW	5492.50	5.24	28820.00	23327.50	4858.75	3.51	19305.00	14446.25
T ₂ 3 DADPW	4013.75	4.84	26620.00	22606.25	3803.50	3.24	17820.00	14017.50
T ₃ 4 DADPW	3591.25	5.37	29535.00	25943.75	3591.25	3.44	18892.50	15301.25
T ₄ 5 DADPW	3380.00	5.07	27857.50	24477.50	3802.50	3.13	17215.00	13412.50
T ₅ At the interval of 10 days	3591.25	5.14	28311.25	24720.00	3506.75	3.22	17696.25	14189.50

consist of sandy loam soils, where percolation and seepage loss is too high. During December and January, the ground water table in Brahmaputra Valley also goes down due to low recharge after the post monsoon season. This increases the percolation loss from the irrigated rice field. Seepage loss from mid land region is always high due to presence of natural gradient to the down stream areas. The losses may remain in the hydrologic system and finally add to groundwater. This may be considered for reuse from the resource point of view but the losses from irrigated field definitely increase the cost of irrigation. Therefore, introduction of the concept of farm level water management in irrigated rice culture is of paramount importance to enhance the net benefit from rice cultivation. While suggesting such technique it must be taken into consideration that by saving water one should not loss production to such an extent that the whole approach becomes counter productive. The present study was undertaken with the objective to minimize the cost of irrigation through some user friendly irrigation schedules adopting water saving concept at farm level. The highest net benefit from the irrigated rice cultivation is the guiding factor in the present study.

(The author acknowledges the help and facilities given by the Chief Scientist, Regional Agricultural Research Station, Shillongani, Nagaon under Assam Agricultural University, Jorhat to carry out the experiment).

Methods

The experiment was conducted in Regional Agricultural Research Station, Nagaon, Assam which is located in the Central Brahmaputra Valley Zone (located between 25°–45' to 26°–45' north latitude and

92°–33'–6'' east longitude). The soils of the experimental site was sandy clay loam and moderately suitable for irrigation. The experiment was carried out for two consecutive *boro* rice seasons in the years 2003-04 and 2004-05 with popular *boro* cultivar Joymati. Five different farmers' friendly irrigation schedules were used for this study. These were : T₁-Irrigation to a uniform depth of 5 cm 1 day after depletion of ponded water (DADPW), T₂-at 3 DADPW, T₃-at 4 DADPW, T₄-at 5 DADPW and T₅-irrigating at an interval of 10 days (refilling to a depth of 5 cm). Experiment was conducted with complete randomized block design with four replications. The rainfall received during the crop seasons were adjusted to the irrigation requirement. 5 hp diesel engine operated centrifugal pump attached to a shallow tube well was used for irrigation which was already installed at the corner of the experimental fields.

Different cost components of irrigation such as the fixed cost distributed over 10 years (200 h) of effective life of the machine and with the interest at of 13% per annum on the investment and operation and maintenance cost including the fuel and the operator's expenditure were found out. It was attributed to per

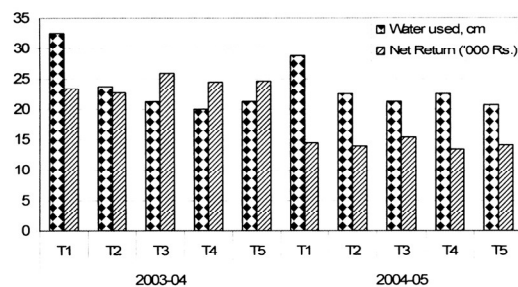
**Figure 1.** Water used and net return under different treatments.

Table 4. Treatment wise average yield and average net income. DADPW : Days after depletion of ponded water.

Treatments	Cost of irrigation	Yield	Gross income	Net income
T ₁ 1 DADPW	5175.63	4.38	24063	18887
T ₂ 3 DADPW	3908.13	4.04	22220	18312
T ₃ 4 DADPW	3591.25	4.41	24214	20623
T ₄ 5 DADPW	3591.25	4.10	22536	18945
T ₅ At the interval of 10 days	3549.00	4.18	23004	19455

unit water applied to the rice field. The yield data of rice was taken and based on the prevailing market rate the net profit from the irrigated rice cultivation was determined.

Results and Discussion

Considering the cost of installation at Rs 22,500/- of a shallow tube well with 200 h effective life of operation per annum and the interest at 13% per annum on the investment, the cost of pumping was found to be Rs 72.97 per hour of pumping. With an average discharge of 12 l/s, the cost of pumping was found to be Rs 1.69/m³ of water.

In the year 2003-04, the seeds were sown in the seedbed on the 22 December and transplanted in the main field on the 7 February. Crop was harvested on the 7 June. The total duration of crop was 167 days. Rainfall received during the crop season was 403 mm. In the year 2004-05, the seeds were sown on the 14 December. It was transplanted in the main field on the 8 February and harvested on the 2 June. The total duration of crop was 170 days. Rainfall received during the season was 387 mm.

The treatment wise application of water was recorded in terms of depth in mm and is given in Table 1 for 2003-04 and 2004-05.

The paddy yield as recorded for both the crop seasons and given in is Table 2.

The pooled data over 2 years were statistically highly significant for the treatment T₁, but the rest of the treatments were found to be at par. Hence, water saving could be possible under all the treatments baring T₁, which practically keeps standing water through out the crop season.

The cost of production of paddy excluding the cost of water application was assumed to be uniform

hence not deducted from the net income. With the prevailing market rate of raw paddy during the years of experiment, at Rs 5,500/- per tonne, the net income in each treatment was found out and given in the Table 3.

The average of 2 years gave the net return Rs 20,623.00 for T₃: Irrigation at 4 days after depletion of ponded water closely followed by T₅: Irrigating at 10 days interval (Rs 19,455.00) (Table 4). However, the pooled data analyses over 2 years did not exhibit statistically any significant difference among the treatments. In the first year of experiment, the yield under T₃ was the highest and did not found any yield reduction over T₁ where practically no depletion of ponded water allowed. In the second year, a yield reduction of about 2% was found in T₃ from T₁. The cost of irrigation was found to be significantly higher in T₁. On the other hand the cost of irrigation in T₅ was the lowest but at par with T₃ and T₄. In all the treatments, the grain yield was not found to be significantly different.

Conclusion

In the experiment, the net return in the treatment T₃, i.e. 4 days after depletion of ponded water was found to be the highest followed by T₅, i.e. irrigating at the interval of 10 days. The cost of irrigation was found to be the least when irrigated at the interval of 10 days. However, the experiment could not establish the superiority of any of the treatments when the net return was taken into account. On the other hand, the water saving was significant in the treatments T₂ through T₅ over T₁. Considering the net return and water saving, the water application schedule of 4 DADPW and irrigation at the interval of 10 days on sandy clay loam soil may be recommended for *boro* rice.

References

1. Tabbal D. F., B. A. M. Bouman, S. I. Bhuiyan, E. B. Sibayan and M. A. Sattar. 2002. On-farm strategies for reducing water input in irrigated rice ; case studies in Philippines. *Agric. Water Manag.* 56 : 93—112.
2. Bouman B. A. M. and T. P. Tuong. 2001. Field water management to save water and increase its productivity in irrigated lowland rice. *Agric. Water Manag.* 49 : 11—30.
3. Tuong T. P. and S. I. Bhuiyan. 1999. Increasing water

- use efficiency in rice production : farm level perspectives. *Agric. Water manag.* 40 : 117—122.
4. Sharma P. K. 1989. Effect of periodic moisture stress on water use efficiency in wetland rice. *Oryza* 26 : 252—257.
 5. Tuong T. P., M. C. S. Wopereis, J. A. Marquez and M. J. Kropff. 1994. Mechanisms and control of percolation losses in irrigated puddled rice fields. *Soil Sci. Soc. Am. J.* 58 : 1794—1803.
 6. Belder P., B. A. M. Bouman, J. H. J. Spiertz, R. Caban-gon, Lu Guoan, E. J. P. Quilang, Li. Yuanhua and T. P. Tuong. 2004. Effect of water saving irrigation on rice yield and water use in typical low land conditions of Asia. *Agric. Water Manage.* 65 : 193—210.
 7. Bouman B. A. M., L. Feng, T. P. Tuong, Lu. G. Wang and Y. H. Feng. 2007. Exploring options to grow rice under water short conditions in northern China using a modeling approach II. Quantifying yield, water balance components and water productivity. *Agric. Water Manag.* 88 : 23—33.
 8. Anonymous. 2006. Agricultural statistics (www.dacnet.nic.in).