Indian Journal of Agronomy **63** (2): 168–173 (June 2018)

Research Paper

Effect of crop establishment and irrigation methods on summer rice (*Oryza sativa*)

HEMLATA[1], JITENDRA JOSHI[2], S.L. MEENA[3], A.L. RATHORE[4], AMBIKA TANDON[5] AND ANAMIKA SONIT[6]

Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh 492 012

Received: July 2017; Revised accepted: May 2018

ABSTRACT

Field experiment was conducted during summer (*Kharif*) seasons of 2012 and 2013 at the research cum instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh to evaluate the effect of crop establishment and irrigation methods on productivity and quality of summer rice (*Oryza sativa* L.). Out of the 3 methods of crop establishment, viz. direct-seeded rice (DSR), transplanted rice (TPR) and wet-seeded rice (WSR); TPR produced significantly higher grain yield (4.8 t/ha) which was statistically at par with direct-seeded rice (4.6 t/ha). Among the 4 methods of irrigation, viz. conventional irrigation, alternate wetting and drying, drip and sprinkler irrigation methods; drip irrigation recorded the maximum grain yield over the rest of the irrigation methods followed by recommended practice with respect to grain yield and quality parameters. TPR recorded maximum grain length which was statistically at par with DSR and minimum grain length was measured in WSR. Among methods of irrigation, drip irrigated crop attained maximum grain length which was statistically at par with recommended practice and conventional irrigation. Significant variations were observed in rice length due to crop establishment and irrigation methods. TPR and drip irrigation methods recorded the maximum rice grain length. TPR resulted in the highest net returns (₹37.05 × 10^3/ha) and benefit : cost ratio (1.34) among crop establishment methods; whereas among irrigation methods, drip irrigation recorded significantly higher net returns (₹44.14 × 10^3/ha) and benefit: cost ratio (1.77).

***Key words* :** Direct seeded rice, Drip irrigation, Quality parameters, Transplanted rice, Wet seeded rice

Rice is an important global food crop and provides food security for many countries. In the future climatic conditions, the yields of rice would be reduced depending on the growing-season and environmental conditions as present-day high temperatures have been implicated to cause reductions in rice yield in many rice-growing areas (Nagarajan *et al*., 2010; Wassmann *et al*., 2009a, b). In the rice-growing regions including those in tropical and subtropical regions, rice has already been cultivated as a summer crop despite relatively high temperatures that occur during its growth cycle (Sung *et al*., 2003).

Rice is commonly grown by transplanting seedlings into puddled soil (wet tillage). This production system is labour, water and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce (Kumar and Ladha, 2011). These factors demand a major shift from transplanting to direct seeding of rice in irrigated ecosystem. Cultivation of rice during dry season offers a great potential for boosting and stabilizing the rice yield where *kharif* rice is having low productivity due to erratic rainfall distribution. Summer rice recorded higher productivity in shallow lowland areas, whereas productivity had traditionally been very poor during the wet season which is mainly because of the fact that summer rice is more manageable than the wet season rice (Singh, 2002; Singh *et al.,* 2015). In these areas, farmers are shifting to summer rice cultivation by utilizing the harvested rain water stored in small ditches, village ponds and by tapping the ground water using shallow tube wells. Sowing pre-germinated seeds in wet (saturated), puddled soils offer a good alternative method of crop establishment under such situation (Saha *et al.,* 2012; Satapathy *et al.,* 2016). Flood irrigation is common practice in canal command area where rice is grown. Improper irrigation methods and misconceptions are chief reasons for the high wastage of a scare resource. A large amount of water is lost in seepage

[1]**Corresponding author's mail:** hemlatanirala@gmail.com
[1]Subject Matter Specialist, Krishi Vigyan Kendra, Anjora; [2]Ph.D. Scholar, Raipur; [3]Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi; [4]Director of Extension Service; [5]Assistant Professor, Agronomy; [6]Farm Manager, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh

and percolation and also overflows through streams in canal command areas. Loss from seepage and percolation is estimated about 50% in heavy textured clay soils and 85% in light textured loamy sands and laterite soils (Rathore *et al.,* 2000). In Chhattisgarh, farmers are growing summer rice both in canal and tube well commanded area. Tube well irrigation in summer rice is highly injudicious because of high energy use in lifting of groundwater which is scarce resource in the state. Alternate water management technologies for rice are needed to economize water use and improve rice productivity over existing level.

Grain yield is not the only consideration in the cultivation of rice, and grain dimensions, the appearance in terms of colour, texture, and surface abnormalities and milling characteristics are also important factors regulating the popularity and marketability. There may be differences among cultivars in the ratio of imperfect rice incidence, suggesting that the cultivar difference in the pattern and severity of the incidence and the ripening capability at high temperature are genetically controlled. The quality characteristics of milled rice are classified both physically and chemically. Across the relative humidity range of 25–85%, high air temperature produces higher amounts of broken grains. At higher moisture content levels, milled rice sustains more extensive stress crack damage at low relative humidity conditions and less stress crack damage at high relative humidity conditions, relative to milled rice at lower moisture content levels (Siebenmorgen *et al*., 1998). Thus, crop establishment and irrigation management are the important issues with regard to changing climatic as well as genotypic characteristics, which might be required distinct management practices in the field. The objective of this study was to assess the effect of crop establishment and irrigation methods on the productivity quality and profitability of summer rice.

MATERIALS AND METHODS

An experiment was conducted for 2 years during summer (*kharif*) seasons of 2012 and 2013 at research cum instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The growing season of summer rice was from end of December to May in the respective years. The soil was neutral in reaction (*p*H 7.3), medium in available nitrogen (318 kg/ha) and phosphorus (14.8 kg/ha) and rich in potassium (428 kg/ha). Experiment was divided into vertical and horizontal strip with strip plot design. The vertical strip was further divided into three methods of establishment i.e. direct seeded rice (DSR), wet direct seeded rice (WSR) and transplanted rice (TPR) as main plots and 4 methods of irrigation i.e. conventional irrigation, recommended practice, drip and sprinkler irrigation as sub-plots. Rice variety 'MTU 1010' was taken as test crop and treatments were laid out in strip plot design replicated thrice. Recommended fertilizer dose of 80–60–40 kg NPK/ha was applied in all the treatments. One-fourth of nitrogen, full dose of P through DAP and K through muriate of potash was applied as basal at the time of transplanting/sowing in all the treatments. Remaining nitrogen was applied in three equal splits at early vegetative, active tillering and panicle initiation stages in both the years. The crop was established by using a seed rate of 40 kg/ha for TPR and 80 kg/ha for DSR and WSR during both the years. The field was prepared by ploughing with tractor drawn cultivar followed by cross harrowing to pulverize the soil and levelling of land was done through tractor drawn leveler. Puddling was done at sufficient water level for TPR and WSR treatments. Data were recorded at the time of harvesting and statistically analysed. Economics were calculated for crop establishment and irrigation methods based on prevailing minimum support price of rice and labour wages/man-day.

RESULTS AND DISCUSSION

Crop phenology stages

Sowing of seeds was done on 1st January in all the methods of crop-establishment. In the DSR, seeds were drilled directly in field, while seeds were sown in nursery for TPR on the same day. Emergence of rice seed took place 8–10 days after sowing, which indicates that low temperature inhibit germination and therefore sowing should be delayed up to mid-January when temperature starts rising. But it can delay the crop maturity and may coincide with onset of monsoon in June. Therefore, farmers prefer to WSR i.e. broadcast sprouted seed in puddled soil or prepare nursery using sprouted seed and subsequently transplant in the field. Although the sowing was done on the same day in all the 3 methods but establishment of crop occurred 9, 13 and 37 days after sowing of dry seeds respectively in DSR, WSR and TPR.

The reproductive phase appeared within 45 days after sowing and booting stage occurred about 15–20 days later. However, TPR was delayed by 24 days over WSR and 27 days to DSR although flowering advanced by 2–5 days than DSR and 7–11 days over WSR. On an average, 50% flowering was recorded in TPR in 100 days whereas DSR and WSR took 102 and 108 days, respectively. In TPR, better roots growth and better nutrient uptake may be the reasons for advancement of crop stage in this study. Flooding and micro sprinkler irrigation delayed flowering by 7–10 days, whereas maturity was delayed by 13 days as compared to DSR and drip irrigation. Limited water supply through drip irrigation also delayed flowering by 6–8 days and maturity by 13–14 days. When temperature dropped from 24 to 21°C, there was a sharp increase in days to heading. Drip irrigation at 1.4 IW : CPE ratio advanced flowering by 7–10 days and maturity by 15 days over flooding and sprinkler irrigation (Sonit *et al*., 2015). An intermediate optimum temperature permits the most rapid development. Adverse temperature above the optimum cause a lengthening of the time required for development.

Maturity of the crop varied in different treatments. In DSR, crop matured in 132–139 days whereas maturity in drip irrigated and conventional irrigation was recorded in 129-132 and 137–139 days, respectively. Delayed maturity in WSR was recorded by 138–145 days as compared to 132–137 days in drip irrigation. Drip irrigated plot in TPR matured in 125–130 days, whereas 129–136 days was taken for maturity by crop in conventional irrigation. On an average, the crop matured in 130, 135 and 138 days respectively in TPR, DSR and WSR. Normally transplanted crop matured in 130 days, whereas DSR and WSR were delayed by 5 and 8 days, respectively. Drip irrigation advanced crop maturity by a week over conventional flooding method. Thus, drip irrigation and transplanted rice matured about a week earlier than conventional irrigation and wet seeded rice.

Growth and yield attributes

Significantly taller plants were recorded under TPR compared to WSR; however, it remained at par with DSR (Table 1). Among the different irrigation methods, drip irrigation recorded significantly higher plant height compared to sprinkler irrigation, although it remained at par with conventional irrigation and recommended practice. Number of tillers/m^2 were significantly influenced due to crop establishment and irrigation methods. Among the crop establishment methods, significantly highest number of tillers/m^2 were recorded with DSR compared to TPR and remained statistically at par with WSR. Among the irrigation methods, drip irrigation recorded highest number of tillers/m^2 compared to sprinkler irrigation and remained at par with other irrigation methods. Highest panicle length was recorded with TPR compared to WSR and remained statistically at par with DSR. Similar trend was also observed for panicle weight. Among the different irrigation methods, the highest panicle length and weight were recorded with drip irrigation compared to sprinkler irrigation; however, it remained at par with conventional irrigation and recommended practice.

Yield

Grain yield differed significantly due to different crop establishment and irrigation methods (Table 1). TPR produced higher grain yield (4.8 t/ha) which was statistically similar to DSR (4.6 t/ha). Significantly lowest yield was recorded in WSR (3.5 t/ha). Rice crop irrigated with different method of irrigation behaved differently. Among various irrigation methods, drip irrigation produced significanly higher grain yield (5.3 t/ha) over the rest of the irrigation methods. Better yield in drip irrigated crop might be due to sufficient availability of water whereas, stress condition might have reduced the seed yield. Interaction between establishment and irrigation methods indicated that drip irrigated TPR gave statistically highest yield whereas it was statistically similar to conventional irrigation, recommended practice of irrigation to transplanted rice (Table 2). Similar trend was also reported by Sonit *et al*. (2015) who revealed that the maximum seed yield was accured in drip irrigation at 1.4 IW : CPE ratio

Table 1. Effect of crop establishment and irrigation methods on growth, yield attributes and yield of summer rice (mean data of 2 years)

Treatment	Plant height (cm)	Tillers/m^2 (Nos.)	Panicle length (cm)	Panicle weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Crop establishment method							
DSR	69.0	706.6	21.0	2.1	4.6	5.5	45.4
WSR	61.5	678.4	19.8	1.7	3.5	4.8	45.3
TPR	71.7	534.3	21.7	2.1	4.8	5.1	48.1
SEm±	1.90	28.95	0.35	0.1	0.08	0.13	0.46
CD (P=0.05)	7.45	113.75	1.00	0.3	0.30	0.50	1.81
Irrigation method							
Conventional irrigation	67.3	722.2	20.5	2.0	4.3	5.3	45.1
Recommended practice	69.5	731.5	21.1	2.0	4.4	5.4	45.0
Drip irrigation	70.8	809.7	21.6	2.1	5.3	5.5	48.8
Sprinkler irrigation	62.1	571.3	19.3	1.7	3.7	4.4	46.1
SEm±	1.89	37	0.35	0.1	0.17	0.09	0.89
CD (P=0.05)	7.02	128.1	1.10	0.3	0.60	0.30	NS

DSR, Direct-seeded rice; WSR, wet-seeded rice; TPR, transplanted puddle rice and remained statistically at par with traditional flooding. The above reasons might be responsible for low yield across the treatments and statistically similar seed yield in drip and conventional flooding treatments. The maximum straw yield was obtained under DSR which was significantly higher compared to WSR and remained at par with TPR. The significantly higher harvest index was registered with TPR compared to other crop establishment methods. The significantly higher straw yield (5.5 t/ha) was recorded with drip irrigation compared to sprinkler irrigation; however, it remained statistically at par with conventional irrigation and recommended practice.

Table 2. Interaction of establishment and irrigation methods on seed yield (t/ha) of summer rice

Treatment	Establishment method		
Irrigation method	DSR	WSR	TPR
Conventional irrigation	4.2	3.8	4.5
Recommended practice	4.3	3.8	4.6
Drip irrigation	4.8	4.1	5.8
Sprinkler irrigation	3.5	3.4	3.6
SEm±	0.24	0.24	0.26
CD (P=0.05)	0.81	NS	0.84

Quality parameters

Data pertaining to length, breadth and L : B ratio of grain is presented in Table 3. Results revealed that different methods of crop-establishment and irrigation were unable to bring significant variation in length, breadth and L: B ratio of grain except grain length and breadth due to irrigation methods. TPR recorded maximum grain length and minimum grain length was recorded with WSR. Among methods of irrigation, drip irrigated crop attained maximum grain length which was statistically at par with recommended practice and conventional irrigation and significantly superior than sprinkler irrigation. Minimum grain length was measured in sprinkler irrigation. Similar results were also found by Kumar *et al.* (1996), Pandey *et al.* (1999), and Dahiphale *et al.* (2004).

Hulling, milling and head rice recovery varied significantly due to different methods of establishment and irrigation (Table 3). Among the crop-establishment methods, transplanted puddled rice recorded significantly higher hulling, milling and head rice recorded compared to DSR and WSR. Among the irrigation methods, recommended practice recorded significantly higher hulling, milling and head rice recovery compared to rest of the irrigation methods. Similar results were also found by Kumar *et al.* (1996), Pandey *et al.* (1999) and Dahiphale *et al.* (2004).

Economics

Productivity of rice in irrigated areas has approached to plateau. Therefore, reduction in cost of cultivation is the need of hour for further increase in the output. There were significant differences in cost of cultivation, gross returns, net returns and benefit cost ratio (B:C ratio) due to different methods of crop-establishment and irrigation except due to methods of establishment in B : C ratio (Table 4). It is evident from the data that among the crop-establishment mehtods, highest input cost of cultivation was recorded in TPR (₹27.85 × 10^3/ha) and the lowest cost of cultivation was recorded under WSR (₹24.72 × 10^3/ha). Among the different methods of irrigation, conventional irrigation registered highest total cost of cultivation

Table 3. Effect of crop establishment and irrigation methods on quality parameters of summer rice (mean data of 2 years)

Treatment	Grain length (mm)	Grain breadth (mm)	Grain L : B ratio	Hulling (%)	Milling (%)	Head rice recovery (%)
Crop establishment method						
DSR	9.61	2.48	3.90	74.8	65.4	51.6
WSR	9.56	2.41	3.98	74.7	65.3	53.1
TPR	9.63	2.53	3.82	76.1	67.6	53.6
SEm±	0.03	0.04	0.05	0.03	0.02	0.04
CD (P=0.05)	NS	NS	NS	0.09	0.07	0.14
Irrigation method						
Conventional irrigation	9.59	2.47	3.90	77.2	66.8	54.0
Recommended practice	9.64	2.49	3.89	77.3	67.8	55.5
Drip irrigation	9.67	2.54	3.81	76.4	66.8	53.1
Sprinkler irrigation	9.51	2.37	4.02	75.9	64.9	51.0
SEm±	0.03	0.05	0.08	0.05	0.03	0.06
CD (P=0.05)	0.09	0.15	NS	0.16	0.11	0.23

DSR, Direct-seeded rice; WSR, wet-seeded rice; TPR, transplanted puddled rice

Table 4. Effect of crop establishment and irrigation methods on economics of summer rice

Treatment	Cost of cultivation (× 10^3 ₹/ha)*	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Crop establishment method				
DSR	26.91	59.94	33.03	1.24
WSR	24.72	53.51	28.80	1.18
TPR	27.85	64.90	37.05	1.34
SEm±	0.63	1.91	1.76	0.05
CD (P=0.05)	1.90	6.33	5.38	NS
Irrigation method				
Conventional irrigation	29.46	58.67	29.31	0.99
Recommended Practice	26.92	60.45	33.53	1.24
Drip irrigation	24.75	68.90	44.14	1.77
Sprinkler irrigation	24.84	49.79	24.95	1.01
SEm±	0.69	2.17	1.85	0.06
CD (P=0.05)	2.01	6.51	5.54	114

*Irrigation charges with cost of drip system (Basic cost 1.20 lakh/ha, life 10 year for 3 seasons each year were included); DSR, direct-seeded rice; WSR, wet-seeded rice; TPR, transplanted puddled rice

(₹29.46 × 10^3/ha). The minimum cost of cultivation was recorded under drip irrigation (₹24.75× 10^3/ha). Among the crop-establishment methods, the maximum gross return was registered in TPR (₹64.90× 10^3/ha). However, it was nearer to DSR in respect to gross returns (₹59.94× 10^3/ha). The lowest gross returns was recorded under WSR (₹53.51 × 10^3/ha). Among the irrigation methods, the maximum gross returns was registered in drip irrigation (₹68.89 × 10^3/ha) and the lowest gross return was recorded under sprinkler irrigation (₹49.79× 10^3/ha).

Among methods of establishment, the maximum net returns was registered with TPR (₹37.05 × 10^3/ha) which was nearer to DSR (₹33.03 × 10^3/ha). The minimum net returns was recorded under WSR (₹28.80 × 10^3/ha). With regards to methods of irrigation, maximum net return (₹44.14 × 10^3/ha) was registered in drip irrigation which was significantly superior over the other treatments. The lowest net returns (₹24.95 × 10^3/ha) was obtained under sprinkler irrigation.

Different methods of establishment did not affect benefit : cost ratio significantly; however, the maximum value of benefit: cost ratio was registered with TPR (1.34) and it was similar to DSR (1.24). Among the methods of irrigation, drip irrigation recorded significantly higher benefit : cost ratio (1.77) compared to other irrigation methods and the minimum benefit : cost ratio was obtained under conventional irrigation (0.99).

Based on the 2 years study, it can be concluded that the TPR method of rice cultivation was better option amongst the crop establishment methods and among the irrigation methods, drip irrigation resulted in significantly higher productivity, net returns and benefit : cost ratio. Therefore, it is suggested that for increased productivity and profitability of the farmers rice can be grown through TPR method in conjunction with drip irrigation under summer rice conditions in Chhattisgarh.

REFERENCES

Dahiphale, A.V., Giri, D.G., Thakre, G.V. and Kubde, K.J. 2004. Yield and yield parameters of scented rice as influenced by integrated nutrient management. *Annals of Plant Physiology* **18**(1): 207–208.

Kumar, M., Haque, M., Singh, S.B. and Pathak, S.K. 1996. Effect of graded levels of nitrogen on yield and quality of scented rice varieties in Southern alluvial soil. *Indian Journal of Agricultural Sciences* **48**(2): 279–282.

Kumar, V. and Ladha, J.K. 2011. Direct-seeded rice: recent developments and future research needs. *Advances in Agronomy* **111**: 297–413.

Nagarajan, S., Jagadish, S.V.K., Hari Prasad, A.S., Thomar, A.K., Anand, A., Pal, M. and Agarwal, P.K. 2010. Local climate affects growth, yield and grain quality of aromatic and non-aromatic rice in northwestern India. *Agriculture Ecosystems and Environment* **138**: 274–281.

Pandey, N., Sarawgi, A.K., Rastogi, N.K. and Tripathi, R.S. 1999. Effect of farmyard manure and chemical N fertilizer on grain yield and quality of scented rice (*Oryza sativa* L.) varieties. *Indian Journal of Agricultural Sciences* **69**(9): 621–623.

Rathore, A.L., Sahu, K.K., Pal, A.R., Tomar, H.S., Verma, S.K. and Markale, P.C. 2000. Dry seeded rice technology: An effective measure for drought alleviations. A technical Bulletin published by Directorate of Research Services, Indira Gandhi Agriculture University, Raipur, Chhattisgarh. 27 P.

Saha, S., Rao, K.S. and Jena, S.R. 2012. Agro-techniques for wet direct sown rice. (In) *Extended Summaries. Vol. 3. 3rd International Agronomy Congress,* Nov, 26-30, New Delhi, pp. 718–720.

Satapathy, B.S., Pun, K.B., Singh, T. and Rautaray, S.K. 2016. Influence of dates of sowing and varieties on growth and yield of direct wet sown early ahu rice (*Oryza sativa* L.) under flood prone lowland ecosystem of Assam. *Annals of Agricul-*

tural Research New series **37**(1): 1–5.

Siebenmorgen, T.J., Nehus, Z.T., and Archer, T.R. 1998. Milled rice breakage due to environmental conditions. *Cereal Chemistry* **75**: 149–152.

Singh, T., Pun, K.B., Satapathy, B.S., Saikia, K. and Lenka, S. 2015. Incremental yield and returns from rice variety Naveen in front line demonstrations- an analysis. *Oryza* **52**(1): 59-64.

Singh, U.P. 2002. Boro Rice in Eastern India. Rice-Wheat Consortium Regional Technical Coordination Committee Meeting. 10-14 February 2002. Rice- Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India. Pp 2.

Sonit, A., Rathore, A.L., Hemlata, Jha, D., Rathore, K., Suneel and Nandeha, K.L. 2015. Effect of pressurized irrigation system on productivity, water and energy use efficiency of summer rice. *The Ecoscan* **9**(1 and 2): 249–254.

Sung, D.Y., Kaplan, F., Lee, K.J. and Guy, C.L. 2003. Acquired tolerance to temperature extremes. *Trends in Plant Science* **8:** 179–187.

Wassmann, R., Jagadish, S.V.K., Heuer, S., Ismail, A., Redona, E., Serraj, R., Singh, R.K., Howell, G., Pathak, H. and Sumfleth, K. 2009a. Climate change affecting rice production: The physiological and agronomic basis for possible adaptation strategies. *Advances in Agronomy* **101:** 59–122.

Wassmann, R., Jagadish, S.V.K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redon, A.E., Singh, R.K. and Heuer, S. 2009b. Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. *Advances in Agronomy* **102:** 91–133.