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Comparative evaluation of establishment and irrigation methods on summer rice productivity and quality

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Abstract
Field experiment was conducted during summer season of 2012 and 2013 for two consecutive years at the research cum Instructional farm IGKVV, Raipur Chhattisgarh to evaluate the effect of establishment and irrigation methods on productivity and quality of summer rice. 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). High-temperature stress in plants is a complex function of intensity (temperature in degrees), duration, and rate of increase in temperature (Wahid *et al*., 2007). Out of three methods of establishment, Direct seeded rice (DSR), Transplanted rice (TPR) and Wet seeded rice (WSR). TPR produced higher grain yield (4.0 and 4.8 t/ha) of summer rice which was statistically at par with direct seeded rice (DSR) (3.8 and 4.6 t/ha) during 2012 and 2013, respectively. Among four methods of irrigation *viz*. Conventional irrigation, Alternate wetting and drying, drip and Sprinkler, drip irrigation harvested the maximum grain yield over the rest of the irrigation methods followed by recommended practice perform better as compared to others with respect to grain yield and quality parameters followed by direct seeded rice during both the years. TPR recorded maximum grain length which was statistically at par with DSR and minimum grain length was measured in WSR during 2013. Among methods of irrigation, drip irrigated crop attained maximum grain length which was statistically at par with recommended practice and conventional irrigation during both the years. Significant variations were observed in white rice length due to irrigation methods during both the years and in white rice breadth due to irrigation methods during 2012. Drip irrigation were recorded maximum white rice length which was at par with recommended practice during both the years.

Keywords: Aerobic rice, temperature, quality, direct seeded rice, drip irrigation, and yield

Introduction

Rice is vital to more than half the world's populations. It is the most important food grain in the diets of hundreds of millions of Asians, Africans, and Latin Americans living in the tropics and subtropics. In these areas, population increases are high and will likely remain high at least for the next decade. Rice will continue to be their primary source of food. 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 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;) [6, 14, 15]. According to Matsui, rice yields in the existing cropping areas could be completely wiped out if most severe climate predications are correct. 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) [13].

Field to field irrigation is common practice in canal command where rice is grown. Improper irrigation methods and misconceptions are the stated reasons for the high wastage of a scare resource. A large amount of water is lost in seepage and percolation (S&P) and also overflows though streams in canal command. Loss from S&P is estimated at 50 per cent in heavy textured clay soils and about 85 per cent in light textured loamy sands and laterite soils. (Rathore *et al*., 2000) [8]. In Chhattisgarh, farmers grow summer rice both in canal and tube well commands.

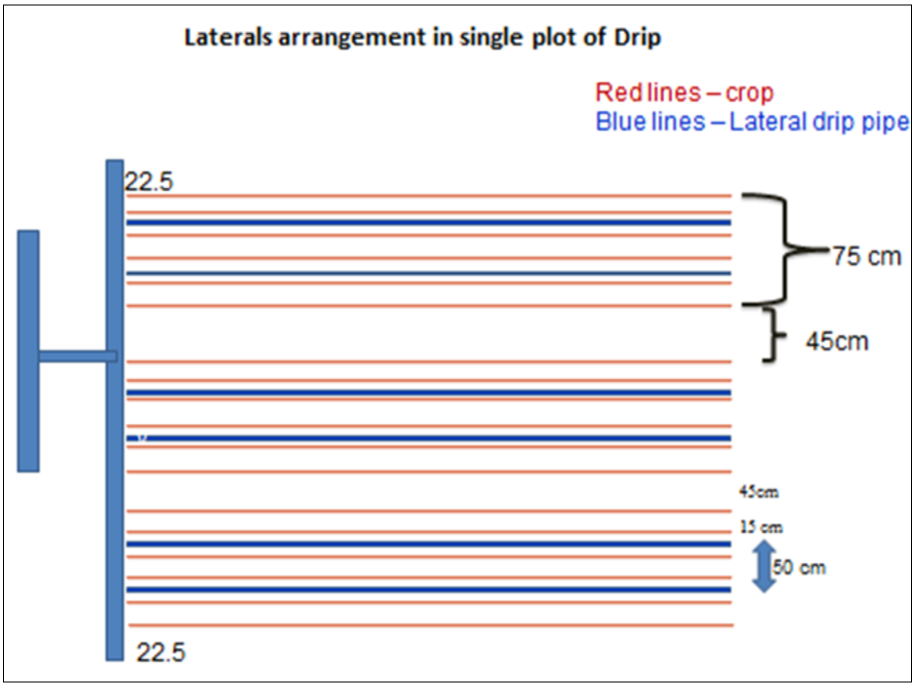
Tube well irrigation in summer rice is highly injudicious because of high use energy in lifting of groundwater which is scarce resource in the state. As farmers are well aware with cultivation of rice that force us to search alternate water management technologies for rice to economize water use and 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 color, texture, and surface abnormalities and milling characteristics are also important factors regulating the popularity and marketability. Owing to high temperatures (>30 °C) during the ripening period, abnormal morphology and coloration occur in rice, probably due to reduced enzymatic activity related to grain filling, respiratory consumption of assimilation products and decreased sink activity. In general, the temperature suitable for ripening is considered to be 24 °C at which temperature the maximum grain weight is observed. 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.

Decreases in grain quality under high night temperature condition are not due to the deficit of carbohydrates in the leaves and the culms because exposure of the vegetative parts to this temperature condition does not decrease grain quality (Morita *et al.* 2004) [5]. The quality characteristics of milled rice are classified both physically and chemically. Across the RH range of 25–85 per cent, high air temperature produces higher amounts of broken grains. At higher moisture content levels, milled rice sustains more extensive stress crack damage at low RH conditions and less stress crack damage at high RH conditions, relative to milled rice at lower moisture content levels (Siebenmorgen *et al*., 1998) [10].

Materials and Methods

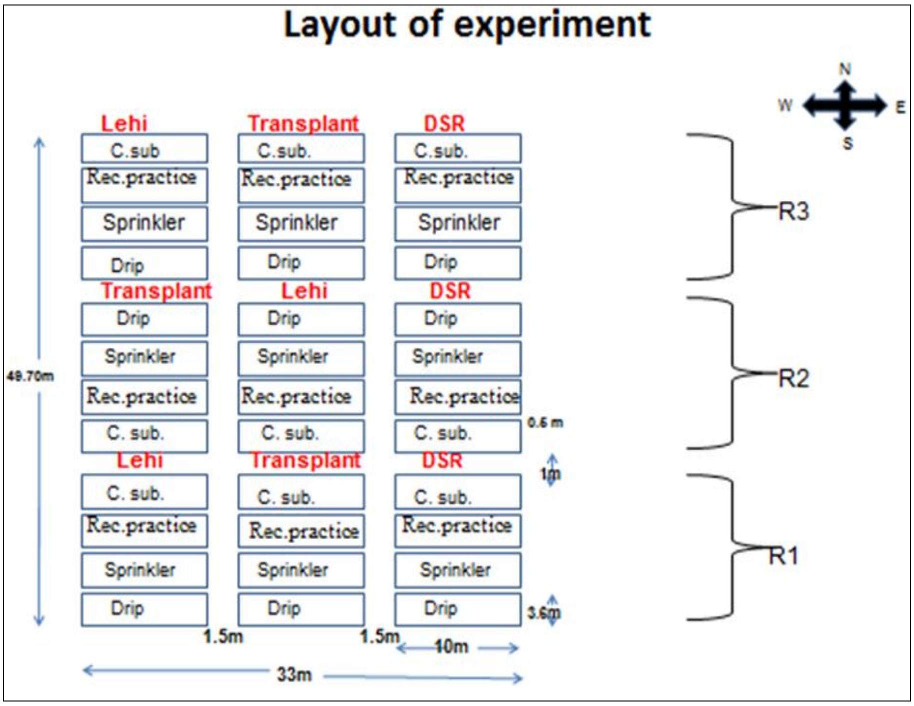
The experiments were conducted for two years during summer seasons of 2012 and 2013 at research cum instructional farm IGKVV, Raipur Chhattisgarh. The growing season of summer rice lasted from end of December to May. The soil was neutral in reaction (pH 7.3), medium in available nitrogen (318 kg/ha), and phosphorus (8.8 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 direct seeded rice (DSR), wet direct seeded rice (WSR) and transplanted rice (TPR) as main plots and four methods of irrigation Conventional irrigation, recommended practice, drip and sprinkler irrigation as sub plots. Rice varieties MTU-1010 taken and treatments were laid out in Strip plot design by replicating 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 as DAP and K as 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 WDSR during both the years. The field was prepared by ploughing with tractor drawn cultivar followed by cross harrowing to pulverize the soil. Then levelling of land was done through tractor drawn leveler. Puddling was done at sufficient water level for (TPR) and (WSR) treatments.



Results and Discussion

Phenology on crop establishment

Sowing of dry seeds was done on 1st January in all the methods of establishment but in DSR seed was drilled in field directly, while seeds were sown in nursery in TPR (Table 1). In DSR crop established within 8-10 days. In WSR, sprouted seeds were established in field at 12-15 days after incubation and in TPR, crop established at 36-39 days after seeding in nursery including transplanting period. Low temperature delayed germination and crop establishment (Fig.1). Emergence of rice seed took place in 8-10 days after sowing, indicates that low temperature inhibit germination therefore sowing should be delayed upto mid-January when temperature start rising. But it delays the crop maturity and may coincide with onset of monsoon in June. Therefore, farmers prefer to (WSR) broadcast sprouted seed in puddled soil or prepare nursery using sprouted seed and subsequently transplant in field. These two methods require huge quantity of irrigation water in puddling and also crop growth. Therefore, DSR seems a viable option for summer rice to save water but sprouted seed should be sown using drum-seeder for establishment of summer rice. On an average even after same time operations of sowing started but establishment of crop was occurred 9, 13 and 37 days after sowing of dry seed respectively in DSR, WSR and TPR. The maximum air temperature was 24-28 ^{0}C at the time of sowing whereas minimum temperature 9-11 ^{0}C during both the years (Fig.1).At low temperatures, germination proceeds very slowly and may take a month or longer. Rathore *et al*., (2009) [9] reported that seed germinate within 4-6 days after sowing at optimal temperature and soil moisture regimes. Yoshida (1981) [16] and Krishnan *et al*. (2011) [4] reported 16, 18 and 45 ^{0}C as low, optimum and high air temperature regimes for germination of rice seed.



Flowering and anthesis

The reproductive phase lasts approximately 45 days and booting stage lasts for about 15 - 20 days in almost all rice varieties. The internodes grow and quickly lengthen, causing the culm to shoot up from the base of the plant bearing the developing panicle. When temperatures are low, anthesis may start late in the morning and continue till the late afternoon. However, establishment of TPR was delayed by 24 days over WSR and 27 days to DSR but 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 establishment of crop roots and better uptake of nutrient 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 delayed by 13 days as compared to DSR and drip irrigation (Table 1). Limited water supply through drip irrigation also delayed flowering by 6-8 days and maturity by 13-14 days. When temperature drops from 24 to 21 °C, there is 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) [12]. In contrast, Iwashita (1961) and Azmi (1969) [1] reported that high temperature delayed flowering. An intermediate optimum temperature permits the most rapid development. Adverse temperatures above the optimum cause a lengthening of the time required for development.

Ripening and maturity

Maturity of the crop varied in different treatments. The DSR matured in 132 - 139 days. Drip irrigated matured in 129 - 132 days, whereas maturity in conventional irrigation was recorded in 137 - 139 days. 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 delayed by 5 and 8 days, respectively that counts owing to forthcoming monsoon season. 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.

Grain yield

Grain yield differed significantly due to different methods of establishment and irrigation (Table 2). TPR produced higher grain yield (4.4 and 4.7 t/ha during 2012 and 2013, respectively) which was statistically similar to DSR (3.8 and 4.6 t /ha during 2012 and 2013, respectively). Significantly lowest yield was harvested in WSR (3.567 and 3.961 t/ha during 2012 and 2013, respectively). Rice crop placed with different method of irrigation behaved differently. Among various irrigation methods drip irrigation harvested the maximum grain yield over the rest of the irrigation methods. Better yield may be due to sufficient availability of water whereas stress condition might has reduced the seed yield. Interaction between establishment and irrigation methods indicate that drip irrigated TPR gave statistically highest yield during 2013 whereas it was statistically similar to conventional irrigation, recommended practice of irrigation to transplanted rice during 2012. Similar trend was also reported by Sonit *et al.*, (2015) [12] revealed that the maximum seed yield was recorded in drip irrigation at 1.4 IW: CPE ratio which was 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.

Quality parameters on Length, breadth and L: B ratio of grain

Data pertaining to length, breadth and L: B ratio of grain is presented in Table 3. Results revealed that different methods of establishment and irrigation were unable to bring significant variation in length, breadth and L: B ratio of grain during both the years except grain length due to methods of establishment during 2013 and due to methods of irrigation during both the years. TPR recorded maximum gain length which was statistically at par with DSR and minimum grain length was measured in WSR during 2013. Among methods of irrigation, drip irrigated crop attained maximum grain length which was statistically at par with recommended practice and conventional irrigation during both the years. Minimum grain length was measured in sprinkler irrigation during both the years. In case of varieties, difference in length, breadth and L: B ratio of paddy, brown rice and kernel might be due to the fact that varieties bear different genetic characters. Similar results were also found by Kumar *et al.* (1996) [3], Pandey *et al.* (1999) [7], Singh *et al.* (2000) [11] and Dahiphale *et al.* (2004) [2].

Quality parameters on Length, breadth and L: B ratio of brown rice

The results revealed that different methods of establishment and irrigation were unable to produce significant variation in brown rice length and L: B ratio during both the years except in brown rice length due to methods of irrigation during 2013. Significantly higher brown rice length was measured in drip irrigated plant over other methods of irrigation and minimum was measured in sprinkler irrigated plants during 2013. Maximum brown rice breath was recorded in recommended practice which was at par with drip during 2012 and in drip irrigated plants during 2013. Minimum brown rice breadth was measured in sprinkler irrigated plants during both the years. DSR and TPR were statistically similar in brown rice breadth and minimum was measured in WSR during 2013. Dhahiphale *et al.* (2004) [2] revealed that quality parameters *viz.* kernel length (cm), kernel breadth (cm), kernel L: B ratio, kernel length after cooking, elongation ratio and amylose content (%) were not influenced significantly among Basmati genotypes.

Quality parameters on Length, breadth and L: B ratio of white rice

The results revealed that methods of the establishment and irrigation were unable to produce significant variation in length, breadth and L: B ratio of white rice during both the years. However, significant variations were observed in white rice length due to irrigation methods during both the years and in white rice breadth due to irrigation methods during 2012. Drip irrigation was recorded maximum white rice length and breadth which was at par with recommended practice during both the years and minimum was measured in sprinkler irrigation during both the years. Pandey *et al.* (1999) [7] reported that cv. Pusa Basmati-1 was better in kernel length, length: breadth ratio, kernel length after cooking and elongation ratio. Singh *et al.* (2000) [11] revealed that the Pusa Basmati-1 recorded maximum values of head rice recovery, kernel length after cooking and water uptake, while the other quality traits.

Quality parameters on Hulling, milling and head rice recovery

Hulling, milling and head rice recovery percentage did not show any significant variation due to different methods of establishment and irrigation during both the years. Transplanted rice with drip irrigation performed better with respect to grain yield and quality parameters followed by direct seeded rice during both the years. Similar results were also found by Kumar *et al.* (1996) [3] Pandey *et al.* (1999) [7], Singh *et al.* (2000) [11] and Dahiphale *et al.* (2004) [2]. Methods of irrigation treatments were unable to produce significant variation in length, breadth and L: B ratio of paddy, brown rice and kernel. Similar results have also been found by Singh *et al.* (2000) [11].

Table 1: Growth stages of rice in relation to establishment and irrigation methods of summer rice

Crop growth stages	Methods of establishment	2012				2013			
		Conv. Irrig.	Rec. Practice	Drip	Sprinkler	Conv. Irrig.	Rec. Practice	Drip	Sprinkler
		Days from January 1							
Sowing	DSR	1	1	1	1	1	1	1	1
	WDSR	1	1	1	1	1	1	1	1
	TPR	1	2	3	4	1	1	1	1
Establishment	DSR	8	8	9	9	9	9	10	10
	WDSR	12	12	12	15	13	13	13	13
	TPR	37	37	37	39	36	36	37	37
50% Flowering	DSR	104	103	98	100	107	104	99	102
	WDSR	108	105	101	104	113	111	108	110
	TPR	99	98	94	96	105	104	97	103
Maturity	DSR	137	135	129	134	139	136	132	134
	WDSR	138	134	132	134	145	141	137	140
	TPR	129	128	125	126	136	135	130	134

DSR- Direct seeded rice, WDSR-Wet seeded rice, TPR-Transplanted rice

Table 2: Interaction effect of methods of establishment and irrigation on seed yield of summer rice

Method of irrigation	Method of establishment							
	DSR	WDSR	TPR	Mean	DSR	WDSR	TPR	Mean
	2012				2013			
Conventional Irrigation	39.49	35.34	43.76		44.95	40.31	45.07	43.44
Recommended Practice	39.86	35.55	46.01		45.71	40.86	46.43	44.33
Drip	42.64	37.99	53.57		53.42	43.15	61.71	52.76
Sprinkler	30.5	33.79	32.75		39.43	34.13	38.58	37.38
	S.Em±		CD(P=0.05)		S.Em±		CD(P=0.05)	
	2.92		10.3		1.84		5.94	
	2.52		8.18		2.35		7.73	

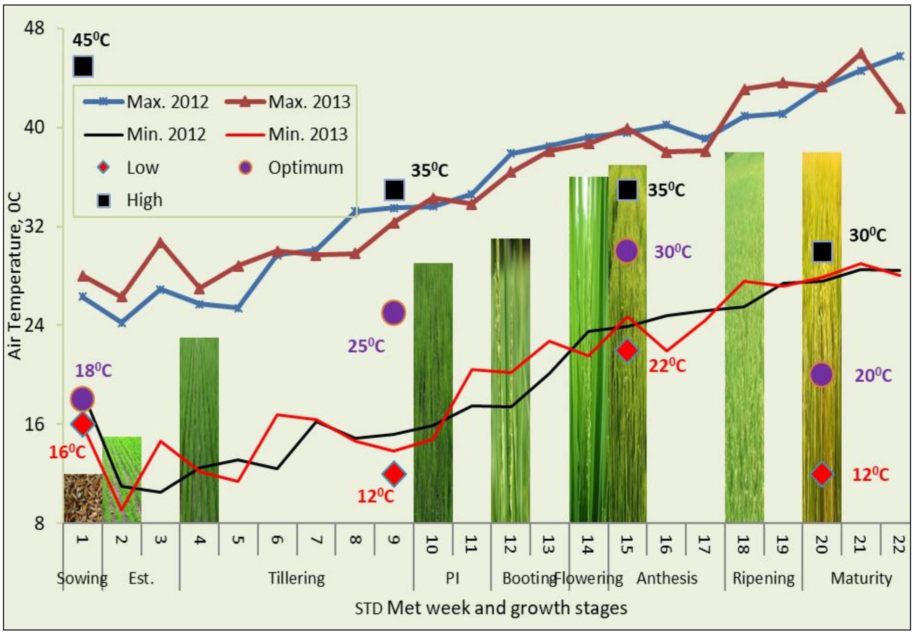


Fig 1: Weekly maximum and minimum air temperature and recommended limit of low, optimum and high air temperature at different growth stages of rice

Table 3: Effect of methods of establishment and irrigation on quality parameters of grain & brown rice of summer rice

Treatment	Grain length (mm)		Grain Breadth (mm)		Grain L/B ratio		Brown rice length (mm)		Brown rice Breadth (mm)		Brown rice L/B ratio	
	2012	2013	2012	2012	2013	2012	2012	2013	2012	2013	2012	2013
Method of establishment												
DSR	9.61	9.61	2.47	2.48	3.90	3.89	6.97	6.98	2.09	2.13	3.34	3.28
WDSR	9.56	9.55	2.42	2.40	3.96	3.99	6.77	6.94	2.03	2.03	3.34	3.42
TPR	9.63	9.63	2.55	2.50	3.78	3.86	6.98	6.87	2.05	2.10	3.41	3.27
S.Em±	0.03	0.02	0.03	0.04	0.04	0.06	0.06	0.03	0.01	0.01	0.04	0.04
CD (P=0.05)	NS	0.07	NS	NS	NS	NS	NS	NS	NS	0.06	NS	NS
Method of irrigation												
Conventional Irrigation	9.57	9.60	2.48	2.46	3.87	3.92	6.91	6.98	2.02	2.10	3.42	3.33
Recommended Practice	9.64	9.64	2.48	2.50	3.90	3.87	6.92	6.89	2.10	2.09	3.30	3.30
Drip	9.66	9.67	2.54	2.54	3.80	3.81	7.03	7.09	2.08	2.16	3.39	3.29
Sprinkler	9.53	9.48	2.41	2.33	3.96	4.08	6.76	6.77	2.02	2.01	3.34	3.37
S.Em±	0.02	0.03	0.03	0.06	0.05	0.10	0.08	0.03	0.02	0.01	0.03	0.02
CD (P=0.05)	0.08	0.10	NS	NS	NS	NS	NS	0.10	0.05	0.05	NS	NS

Table 4: Effect of methods of establishment and irrigation on white rice & head rice recovery of summer rice

Treatment	White rice length (mm)		White rice Breadth (mm)		White rice L/B ratio		Hulling (%)		Milling (%)		Head rice recovery (%)	
	2012	2013	2012	2012	2013	2012	2012	2013	2012	2013	2012	2013
Method of establishment												
DSR	6.26	6.22	1.97	2.00	3.19	3.12	74.33	75.35	64.98	65.88	51.66	51.56
WDSR	6.18	6.16	1.94	1.95	3.19	3.16	74.15	75.18	64.84	65.74	53.09	53.19
TPR	6.27	6.23	1.99	2.02	3.15	3.09	76.06	76.12	67.08	68.18	53.10	54.10
S.Em±	0.02	0.03	0.02	0.02	0.03	0.04	0.02	0.03	0.02	0.02	0.03	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Method of irrigation												
Conventional Irrigation	6.26	6.28	2.00	2.00	3.13	3.14	77.59	76.76	67.91	65.77	55.38	52.54
Recommended Practice	6.30	6.25	1.98	1.99	3.19	3.15	78.27	76.33	67.92	67.73	57.26	53.75
Drip	6.35	6.28	2.01	2.04	3.16	3.07	76.79	76.04	67.84	65.84	54.32	51.87
Sprinkler	6.02	6.00	1.88	1.92	3.21	3.13	75.84	75.93	63.98	65.82	50.05	51.85
S.Em±	0.05	0.04	0.02	0.03	0.06	0.05	0.05	0.04	0.02	0.03	0.06	0.05
CD (P=0.05)	0.18	0.12	0.09	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

After two years study I have concluded that the TPR method was found better in terms of method of establishment and along with irrigation. Drip irrigated TPR is the best to achieve higher yield and saving water over rest of the treatments. This indicates that however rice yield increased with drip irrigation to the extent of 108-119, 107-108 and 121-122% respectively in DSR, WSR and TPR but these differences were statistically similar. It emphasized to use drip fertigation for realizing the benefits of drip irrigation. Such variations among the drip and conventional flooding treatments are quite encouraging even after low yields for further work with fertigation in drip system. In drip fertigation work should be taken in separate fields in order to precisely maintenance of imposed treatments.

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