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Influence of Different Rice Cultivation Methods and Irrigation Regimes on Rice (*Oryza sativa* L.) Yield Attributes, Yield and Economics

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Abstract A field experiment was conducted at Hyderabad during *kharif* 2014 to study the water management for different methods of rice (*Oryza sativa* L.) cultivation in puddled soils. The treatments were direct seeding with drum seeder (DS), transplanting with machine (MTP) and conventional transplanting (CTP) as main treatments and four irrigation regimes (irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube, irrigation of 5 cm, when water level falls below 10 cm from soil surface in field water tube, irrigation of 5 cm at 3 days after disappearance of ponded water and recommended submergence of 2–5 cm water level as per crop stage). Significantly higher (20%) number of panicles were recorded by machine transplanting as compared to drum seeding and was on par with conventional transplanting. Different rice cultivation methods did not show significant influence on panicle length, filled and unfilled grains panicle^{-1} and test weight. MTP recorded significantly higher grain and straw (6088 and 6954 kg ha^{-1}, respectively) yields over DS method (5308 and 6295 kg ha^{-1}, respectively) and was on par with CTP method (5926 and 6886 kg h^{-1}, respectively). Among different irrigatiopn regimes recommended submergence of 2–5 cm water level (I_4) recorded significantly higher grain and straw yield (6148 and 7039 kg ha^{-1}, respectively). Machine transplanting recorded significantly higher gross returns (Rs 82,880 ha^{-1}), net refurns (Rs 50,035 ha^{-1}), and B : C (2.54) ratio over CTP and DS. However, CTP (Rs 44,088 ha^{-1}) was found on par with MTP in terms of recording net returns. Among different irrigation regimes significantly higher filled grains (306) panicle^{-1} and panicle weight were recorded with recommended submergence of 2–5 cm water level as per crop stage than irrigation of 5 cm submergence with 10 cm drop of water level in the field tube and was on par with irrigation of at 5 cm, when water level falls below 5 cm from soil surface in field water tube and irrigation of 5 cm at 3 DADPW. Higher gross returns (Rs 83706 ha^{-1}) were obtained with recommended submergence of 2–5 cm water level and net returns (Rs 47245 ha^{-1}) and B:C (2.48) ratio was significantly higher with irrigation of 5 cm at

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3 DADPW than recommended submergence and was on par with irrigation of 5 cm when water falls below 5 cm form soil surface in field water tube (Rs 44986 ha^{-1}).

Keywords Different methods of rice cultivation, Yield attributes, Yield, Economics.

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop for more than half of the world population, including regions of high population density and rapid growth. Transplanting is the most dominant and traditional method of establishment in irrigated low land rice. The area under transplanted rice in world is decreasing due to scarcity of water and labor. So, there is need to search for alternate crop establishment methods to increase the productivity of rice [1]. Under such circumstances the mechanical transplanting of rice has been considered most promising option, as it saves labor, ensures timely transplanting and attains optimum plant density that contributes to high productivity. The water use efficiency of rice is much lower than other crops. On an average, more than 5000 liters of water are used to produce on kilogram of rice. In irrigated wet seeded rice culture, water use efficiency on the farm can be increased by applying only the amount of water needed. Among the different methods of water-saving irrigation, the most widely adopted is alternate wetting and drying AWD irrigation method [2].

Materials and Methods

A field experiment was conducted during *kharif* 2014 at Rajendranaga, (17°32´ N 78°40´ E and 542.6 m above mean sea level) Hyderabad, Telangana. The experimental field was sandy loam in texture with a pH of 8.5 and EC of 0.56 dS m^{-1}, low in organic carbon (0.41%) and available nitrogen (166 kg ha^{-1}), high in available phosphorus (82 kg ha^{-1}) and potassium (361 kg ha^{-1}). The experiment was laid out in strip-plot design with three different rice cultivation methods as main plot treatments viz., Direct seeding with drum seeder (DS) (M_1), Transplanting with machine (MTP) (M_2) Conventional transplanting (CTP) (M_3) and four treatments as sub-plot treatments viz., Alternate wetting and drying (AWD) of 5 cm, when water level falls below 5 cm from soil surface in field water tube (I_1), AWD of 5 cm, when water level falls below 10 cm from soil surface in field water tube (I_2), irrigation of 5 cm at 3 days after disappearance of ponded water (DADPW) (I_3) and recommended submergence (RS) of 2–5 cm water level as per crop stage (I_4). Each individual plot was separated with providing buffer channels for proper maintenance of the treatments. The irrigation water measured with the help of water meter.

In different rice cultivation systems sprouted seeds were sown with manually operated rice drum seeder. It drops the seeds at 20 cm apart in continuous row. In conventional transplanting 25 days old rice seedlings were transplanted, with 2 seedlings per $hill^{-1}$ with spacing of 15 cm × 15 cm and machine transplanting 17 days oild rice seedlings raised separate in trays were transplanted, Kobota (NSP-4W) at 30 cm × 12 cm spacing. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}.

Results and Discussion

Yield attributes

Number of panicles (m^{-2})

Different rice cultivation methods and irrigation regimes had significant influence on number of panicles m^{-2} (Table 1). The data on panicles m^{-2} of various treatments indicated that among the cultivation systems machine transplanting recorded significantly higher (20%) number of panicles (290 m^{-2}) as compared to drum seeding (241 m^{-2}) and was on par with conventional line transplanting (278 m^{-2}). The increase in panicles m^{-2} with machine transplanting (MTP) and conventional transplanting was mainly due to optimum plant population and plant geometry that resulted in even distribution of light, moisture and nutrients among rice plants in unit area leading to manifestation of ideal growth and yield attributes. These results are in agreement with findings of Singh et al. [3]. Drum seeding method produced significantly less number of panicles (241 m^{-2}) over other methods of

Table 1. Yield attributes of rice as influenced by different systems of cultivation and irrigation regimes.

Treatments	Number of panicles m^{-2}	Panicle length (cm)	Fielld grains panicle^{-1}	Un filled grains panicle^{-1}	Panicle weight (g)	1000 grain weight (g)
Main plots - systems of cultivation (M)						
M_1- Direct seeding with drum seeder (DS)	241	23.4	276	29	2.8	11.7
M_2- Transplanting with machine (MTP)	290	23.5	287	29	2.8	11.8
M_3- Conventional transplanting (CTP)	278	23.8	300	27	2.8	11.5
SEm ±	5	0.2	9	1	0.1	0.2
CD (p=0.05)	21	NS	NS	NS	NS	NS
Sub plot - Irrigation regimes (I)						
I_1- Irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube (AWDI)	288	24.2	300	28	2.8	11.5
I_2- Irrigation of 5 cm, when water level falls below 10 cm from soil surface in field water tube (AWDI)	217	22.9	262	33	2.5	11.9
I_3- Irrigation of 5 cm at 3 days after disappearance of ponded water (DADPW)	270	23.6	284	29	2.9	11.8
I_4- Recommended submergence (RS) of 2–5 cm water level as per crop stage	304	23.6	306	23	3.1	11.5
SEm ±	6	0.3	6	1	0.1	0.2
CD (p=0.05)	22	NS	22	3	0.2	NS
Interaction of different systems of cultivation and irrigation regimes						
Irrigation regimes at same level of systems of cultivation						
SEm ±	13.6	0.4	18	2.0	0.2	0.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Different systems of cultivation at same level of irrigation regimes						
SEm ±	16	0.5	20	2.4	0.2	0.4
CD (p=0.05)	NS	NS	NS	NS	NS	NS

rice cultivation.

Recommended submergence of 2–5 cm water level as per crop stage (I_4) registered significantly more (40%) number of panicles (304) m^{-2} compared to AWDI of 5 cm when water falls below 10 cm from soil surface and on par with alternate wetting and drying irrigation (AWDI) of 5 cm, when water level falls below 5 cm from soil surface in field water tube (I_1) (288 panicle m^{-2}). There was no significant difference between AWDI of 5 cm when water level falls below 5 cm from soil surface in field water tube (I_1) and Irrigarion of 5 cm at 3DADPW (I_3) (270 panicles m^{-2}). Significantly lesser number of panicles was recorded under AWDI of 5 cm, when water level falls below 10 cm from soil surface in field water tube with 217 panicles m^{-2} than rest of the irrigation treatments. Reason for lower number of panicles m^{-2} was that plants had suffered from moisture stress; hence plants were unable to extract more nutrients from deeper layer of soil under moisture deficit conditions which ultimately led to poor growth and lesser number of tillers. Similar results were also observed earlier [4, 5].

Panicle length (cm)

Different rice cultivation systems did not show influence on panicle length (Table 1). However CTP recorded higher panicle length (23.8 cm) compared to MTP (23.5 cm) and DS (23.4 cm). Similar findings were reported by Gill et al. [6].

The panicle length of rice did not vary significantly either due to different irrigation regimes. However AWDI of 5 cm, when water level falls below 5 cm from soil surface in field water tube registered lengthier

Table 2. Yield, gross returns, net returns and B:C ratio of rice as influenced by different systems of cultivation and irrigation regimes.

Treatments	Yield (kg ha^{-1}) Grain	Straw	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Main plot - systems of cultivation (M)					
M_1- Direct seeding with drum seeder (DS)	5308	6295	72291	39799	2.25
M_2- Transplanting with machine (MTP)	6088	6954	82880	50035	2.54
M_3- Conventional transplanting (CTP)	5926	6886	80685	44088	2.21
SEm ±	139	81	1871	1695	0.06
CD (p=0.05)	546	317	7346	6653	0.22
Sub plot - Irrigation regimes (I)					
I_1- Irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube (AWDI)	5751	6872	78329	44986	2.36
I_2- Irrigation of 5 cm, when water level falls below 10 cm from soil surface in field water tube	5379	6204	73236	42993	2.43
I_3- Irrigation of 5 cm at 3 days after disappearance of ponded water (DADPW)	5817	6732	79205	47245	2.48
I_4- Recommended submergence (RS) of 2–5 cm water level as per crop stage	6148	7039	83706	43339	2.07
SEm ±	96	68	1304	939	0.04
CD (p=0.05)	334	236	4511	3249	0.14
Interaction of different systems of cultivation and irrigation regimes					
Irrigation regimes at same level of systems of cultivation					
SEm ±	239	182	3220	3054	0.10
CD (p=0.05)	NS	NS	NS	NS	NS
Different systems of cultivation at same level of irrigation regimes					
SEm ±	238	23	3202	3022	0.10
CD (p=0.05)	NS	NS	NS	NS	NS

panicle of 24.2 cm, followed by RS of 2–5 cm water level as per crop stage (I_4) 23.6 cm and irrigation of 5 cm at 3 DADPW (I_3) with 23.6 cm. Lower panicle length of 22.9 cm was registered under AWDI of 5 cm, when water level falls below 10 cm from soil surface in field water tube (I_2) might have caused moisture stress to rice plant, at panicle initiation stage resulting in reduced panicle length but not significant difference between irrigation regimes. Rezaei et al. [7] also reported similar observations of reduced panicle length under stress.

Number of filled grains panicle^{-1}

Different rice cultivation systems and interaction effect of systems of cultivation and irrigation regimes did not influenced significantly the number of filled grains panicle^{-1}. However significant differences of filled grains panicle^{-1} was recorded in among irrigation regimes (Table 1).

Number of filled grains (300) panicle^{-1} noted was higher with CTP method followed by machine transplanting (287) and drum seeding (276) among different systems of cultivation. Similar results were reported earlier [8, 9].

Among different irrigation regimes, significantly higher filled grains (300) panicle^{-1} were recorded with RS of 2–5 cm water level as per crop stage (I_4) which was on par with AWDI of 5 cm, when water level falls below 5 cm from soil surface in field water tube (I_1) and irrigation of 5 cm at 3 DADPW (I_3) but these treatments had significantly higher than AWDI of 5 cm submergence with 10 cm drop of water level in the filed tube. The difference between RS and with 5 cm drop of water level in the field tube and irrgiation of 5 cm at 3 DADPW was very less (only 6 and 22 grains panicle^{-1} respectively) but very high difference (44 grains panicle^{-1}) was observed with irrigation with 10 cm drop of water level in the field tube. Deficit irrigation during crop growth affected partitioning of dry matter at grain filling stage and resulted in significant reduction in number of filled grains panicle^{-1} due to moisture stress for certain days due to cyclic witting and drying. These results are in accordance with the earlier findings [4, 5].

Number of unfilled grains panicle^{-1}

Though there was statistically not different, more number of unfilled grains panicles^{-1} was observed in drum seeding (29) and MTP (29 grains panicle^{-1}) than CTP (27 grains panicle^{-1}). These results are corroborate with observations by Shantappa [9].

Among different irrigation water management treatments AWDI of 5 cm with 10 cm drop of water level in the field tube (I_2) recorded significantly higher number of unfilled grains panicle^{-1} (33) over rest of the treatments. Unfilled grains recorded with AWDI of 5 cm, when water level falls below 5 cm from soil surface in field water tube (I_1) (28 grains panicle^{-1}) and irrigation of 5 cm at 3 DADPW (I_3) (29 grains panicle^{-1}) was found on par with each other. Significantly lower unfilled grains (23) over rest of treatments were recorded with RS of 2–5 cm water level as per crop stage (I_4). These results were in close conformity with the earlier findings [4, 10].

Panicle weight (g)

Higher panicle weight was observed in CTP (2.85 g) followed by MTP (2.82 g) and DS (2.79 g). Although statistically not different among methods. These findings were supported by results earlier [8, 11].

Among different irrigation regimes, significantly lower panicle weight was recorded under AWDI with 10 cm drop of water level in the field tube (2.5 g panicle^{-1}) than rest of irrigation regimes. Significantly higher panicle weight was observed with RS of 2–5 cm water level as per crop stage (I_4) (3.1 g) and was on par with AWDI with 5 cm which water level in the field tube falls below 5 cm from soil surface (I_1) (2.8), irrigation of 5 cm at 3 DADPW (I_3) with (2.9 g). This might be due to that optimum soil water balance without any wide fluctuations and higher nutrient uptake due to better availability of nutrients which lead to higher dry matter in panicles in recommended submergence of 2–5 cm. Similar results were also observed earlier [5, 12].

Test (1000) grain weight (g)

The test weight of rice did not vary significantly either due to different rice cultivation systems or due to irrigation regimes or due to interaction effect. (Table 1) and average test (1000 grain) weight ranged from 11.5 to 11.9 g among different treatments, as the test weight of variety is genetically inherent character did not influenced by cultivation systems and irrigation regimes. Similar results were also observe earlier [7, 13].

Economic analysis

Gross returns (Rs ha^{-1})

MTP recorded significantly higher gross returns (Rs 82,880 ha^{-1}) over CTP (Rs 80,685 ha^{-1}) and DS (Rs (72,291ha^{-1}) and DS Rs 72,291 ha^{-1}) (Table 2). This was due to higher grain and straw yield under MTP than DS and CTP. These results are in accordance with the earlier findings [14].

In different irrigation regimes conventional practice of irrigation RS of 2–5 cm water level as per crop stage (I_4) recorded significantly higher gross returns (Rs 83,706 ha^{-1}) compared to AWDI with 5 cm drop of water level in the field tube (Rs 78,329 ha^{-1}) and AWDI 10 cm drop of water level in field water tube (Rs 73,236 ha^{-1}) and was on par with at 3 DADPW (Rs 79,205 ha^{-1}). This was due to higher grain and straw yield under recommended submergence of 2–5 cm water level as per crop stage than other irrigation treatments. These results are in accordance with the earlier findings [15]. Significantly lower gross returns were recorded with 5 cm submergence with 10 cm drop of water level in field water tube compared to rest of the treatments.

Net returns (Rs ha^{-1})

Among different cultivation methods, MTP was found economically best as it registered higher net returns (Rs 50,035 ha^{-1}) over other cultivation methods. However, transplanting in conventional method was found on par to MTP with net returns of Rs 44,088 ha^{-1}. Significantly lower net returns were obtained in DS (Rs 39,799 ha^{-1}) and was on par with CTP. Higher net retuurns in MTP mainly due to higher grain and straw yield which resulted in higher gross returns compared to other methods. In turn the cost of cultivation was lower with MTP compared to CTP. This could be due to labor saving of around 24 man days ha^{-1} in MTP over CTP. Zahide et al. [16] found that the advantage with mechanical transplanters was that one can transplant without searching for laborers which ultimately means that the cost of cultivation was reduced. Though there was lower cost of cultivation due to DS, the net returns were lower in due to low gross returns as a result of lower grain yield compared to CTP. These results are in accordance with the earlier findings [14, 17].

Among different irrigation regimes, irrigation of 5 cm at 3 DADPW recorded significantly higher net returns of Rs 47,245 ha^{-1} followed by irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube (Rs 44,986 ha^{-1}) than RS of 2–5 cm water level as per crop stage (43,339 Rs ha^{-1}) and AWDI of 5 cm, when water level falls below 10 cm from soil surface in field water tube (Rs 42,993 ha^{-1}). This was mainly due to higher grain and straw yield resulting in higher gross returns and lesser cost of cultivation in irrigation of 5 cm at 3 DADPW followed by AWDI of 5 cm when water level falls below 5 cm in field water tube compared to RS of 2–3 cm as per crop stage. Recommended submergence of 2–5 cm water level as per crop stage recorded higher cost of cultivation (Rs 40,367 ha^{-1}) compared to AWDI of 5 cm, when water level falls below 5 cm from soil surface in field water tube (Rs 33,343 ha^{-1}), irrigation of 5 cm at 3 DADPW (Rs 31,960 ha^{-1}) and irrigation of 5 cm, when water level falls below 10 cm from soil surface in filed water tube (Rs 30,243 ha^{-1}). This was because of higher number of irrigation given to recommended submergence of 2–5 cm water level as per crop stage treatment (31 irrigations) as compared to irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tuber (25 irrigations). These results are in accordance with findings of Dass et al. [15]. Significantly lower net returns were recorded with irrigation of 5 cm when water level falls below 10 cm from soil surface in field water tuber (Rs 42,993 ha^{-1}) die to lower gross returns as a consequence of lower grain and straw yield compared to other treatments.

Benefit: Cost ratio (B:C ratio)

B : C ratio is the basic agrionomic criteria to decide economic returns and was calculated based on gross returns divided by cost of cultivation of respective treatment combination. Machine transplanting among different systems, recorded higher B : C ratio (2.54) over drum seeding method (2.25) and conventional method transplanting (2.21). The higher benefit cost ratio in MTP was attributed to higher net returns with reduced cost of cultivation as these was labor saving of about 14 men days ha^{-1} over manual transplanting. The cost of machine transplanting was Rs 32,845 ha^{-1} with 35 labores. Were as manual transplanting cost was Rs 36,598 ha^{-1} with 49 labores. These findings are in conformity with [18].

Significantly higher B : C ratio (2.48) was obtained under irrigation of 5 cm at 3 DADPW over RS of 2–5 cm water level as per crop stage (2.07) and was on par with AWDI of 5 cm, when water level falls below 10 cm from soil surface in field water tube (2.43). The higher benefit cost ratio was attributed to higher net returns with reduced cost of cultivation compared to other irrigation regimes. These results are in accordance with findings of Dass et al. [15].

Conclusion

Machine transplanting produced higher yield, yield attributes, gross, net returns and B: C ratio compared to direct seeding with drum seeder and conventional transplanting systems of cultivations. Direct sowing with drum seeder produced significantly lower growth, yield and yield attributes, gross and net returns compared to other systems of cultivations. Recommended submergence of 2–5 cm water level recorded significantly higher number of panicle m^{-2}, filled grains, grain and straw yield was on par with irrigation of 5 cm when water falls below 5 cm from soil surface in field water tube. Gross and net returns and B : C ratio was significantly higher with irrigation of 5 cm at 3 DADPW and was on par with irrigation of 5 cm when water falls below 5 cm from soil surface in field water tube.

References

1. Farooq M, Kobayashi N, Wahid A, Shadhzad MA Basra (2009) Strategies for producing more rice with less water. Adv in Agron 101 : 351—388.
2. Li YH, Barker R (2004) Increasing water productivity for paddy irrigation in China. Paddy Water Environ 2 : 187—193.
3. Singh SP, Sreedevi B, Kumar RM, Subbaiah SV (2009) Grain yield and economics of wet direct sown rice under different establishment methods and nitrogen schedules. Oryza 45 : 245—246.
4. Sandhu SS, Mahalb SS, Vashist KK, Buttar GS, Brar AS, Maninder Singh (2012) Crop and water productivity of bed transplanted rice as influenced by various levels of nitrogen and irrigation in northwest India. Agric Water Manag 104 : 32—39.
5. Kumar S, Singh RS, Kumar K (2014) Yield and nutrient uptake of transplanted rice (*Oryza sativa*) with different moisture regimes and integrated nutrient supply. Curr Adv in Agric Sci 6 : 64—66.
6. Gill MS, Ashwani Kumar, Pradeep Kumar (2006) Growth and yield of rice (*Oriza sativa*) cultivars under various methods and times of sowing. Ind J of Agron 51 : 123—127.
7. Rezaei M, Shokri Vahed H, Amiri E, Karim Motamed M, Azarpour E (2009) The effects of irrigation and nitrogen management on yield and water productivity of rice. World Appl Sci J 7 : 203—210.
8. Chandrapala AG (2009) Productivity as influenced by rice crop establishment methods and nutrient management (S and Zn). PhD thesis. Acharya NG Ranga Agric Univ, Hyderabad.
9. Shantappa (2014) Studies on establishment techniques, irrigation water levels and weed management practices on productivity and emission of green house gasses (GHGS) in rice (*Oryza sativa* L.). PhD thesis. Raichur Univ Agric Sci, Raichur, India.
10. Pandey N, Verma AK, Tripathi RS (2010) Response of hybrid rice to scheduling of nitrogen and irrigation during dry season. Oryza 47 : 34—37.
11. Revathi P (2014) Influence of planting methods and integrated nutrient management on growth, yield and quality of rice. PhD thesis. Acharya N.G. Ranga Agric Univ, Hyderabad.
12. Azarpour E, Tarighi F, Moradi M, Bozorgi HR (2011) Evaluation effect of different nitrogen fertilizer rates under irrigation management in rice farming. World Appl Scien J 13 : 1248—1252.
13. Chowdhury MR, Kumar V, Sattar A, Brahmachari K (2014) Studies on the water use efficiency and nutrient uptake by rice under system of intensification. The Bioscan 9 : 85—88.
14. Manjappa K, Kataraki NG (2004) Use of drum seeder and transplanters for increasing rice (*Oryza Sativa*) Profitability. Ind J Agric Sci 74 : 19—20.
15. Dass A, Chandra S (2012) Effect of different components of SRI on yield, quality, nutrient accumulation and economics of rice (*Oryza sativa*) in tarai belt of Northern India. Ind J Agron 57 : 250—254.
16. Zahide Rashid, Soliha Rasool, Mudasir Rashid, Suhail Inamullah (2010) Mechanical transplantation of paddy. Intensive Agric, pp 18—20.
17. Hugar AY, Chandrappa H, Jayadeva HM, Sathish A, Mallikarjun GB (2009) Influence of different establishment methods on yield and economics of rice. Agric Sci Digest 29 : 202—205.
18. Manjunatha MV, Masthana Reddy BG, Shsshidhar SD, Joshi VR (2009) Studies on the performance of self-propelled rice transplant and its effect on crop yield. Karnataka J Agric Sci 22 : 385—387.