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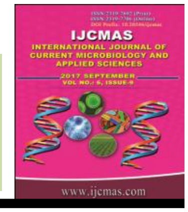

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Effect of Different Crop Establishment Methods and Irrigation Regimes on Rice (*Oryza sativa* L.) Yield and Water Use Efficiency

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A B S T R A C T

A field experiment was conducted at Agricultural Research Institute Rajendranagar, Hyderabad during *kharif* 2014 to study the "Water management for different systems of rice (*Oryza sativa* L.) cultivation in puddled soils". The treatments comprises of three systems of cultivations (direct seeding with drum seeder, transplanting with machine and conventional transplanting) 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). Machine transplanting recorded significantly higher grain and straw (6088 and 6954 kg ha^{-1}, respectively) yields over drum seeding method (5308 and 6295 kg ha^{-1}, respectively) and was on par with conventional transplanting method (5926 and 6886 kg ha^{-1}, respectively). Significantly higher water use efficiency (4.7 kg mm^{-1}) was recorded with machine transplanting compared to drum seeding (4.0 kg mm^{-1}) and was on par with conventional transplanting (4.5 kg mm^{-1}). Among different irrigation 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) and was on par with irrigation of 5 cm when water falls below 5 cm from soil surface in field water tube (I_2) (5751 and 6872 kg ha^{-1}, respectively). There was saving of water to the extent of 28.5 (1271.7 mm), 40.4 per cent (1085.0 mm) and 36.5 (1154.7mm), by I_1, I_2 and I_3 respectively compared to recommended practice of irrigation (1819.7mm), though there was reduction of grain yield by 5.4, 12.5 and 6.5 per cent, under I_1, I_2 and I_3 respectively.

Keywords

Different systems of rice cultivation, Yield, Water productivity.

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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 labour. So, there is need to search for alternate crop establishment methods to increase the productivity of rice (Farooq *et al.*, 2009). Under such circumstances the mechanical transplanting of rice has been considered most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that that contributes to high productivity. Another major concern in rice production systems is the dwindling trend of availability of water resources. 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 one 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 (Li and Barker, 2004).

Materials and Methods

A field experiment was conducted during *kharif*, 2014 at Agricultural Research Institute (17°32' N 78°40' E and 542.6 m above mean sea level) Rajendranagar, Hyderabad, Telangana.

The experimental field was sandy loam in texture with a pH of 8.5 and EC of 0.56 dSm^{-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 systems as main plot treatments *viz.,* Direct seeding with drum seeder (M1), Transplanting with machine (M2) Conventional transplanting (M3) and four treatments as sub-plot treatments *viz.,* irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube (I_1), irrigation 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 (I_3) and recommended submergence 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 x 15 cm and machine transplanting 17 days old rice seedlings were transplanted, with 30 cm x 12 cm. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}.

Results and Discussion

Yield

Machine transplanting recorded (14.7%) and (10.5%) higher grain and straw yield (6088 and 6954 kg ha^{-1} respectively) which was significantly superior to drum seeding method (5308 and 6295 kg ha^{-1} respectively). However conventional transplanting method (5926 and 6886 kg ha^{-1}) was found on par to machine transplanting method with 2.7 and 1.0 per cent variation respectively (Table 1).

The lowest yield on other side was recorded with drum seeding of sowing (5308 and 6295 kg ha^{-1} respectively) as required crop stand was not maintained in field because of damage by there was rain fall immediately after drum seeding of sprouted seeds and gaps filled afterwards did not compensate the yield loss. These findings are in agreement with the results reported earlier by Anoop Dixit *et al.,* (2007), Manjunatha *et al.,* (2009) and Venkateswarlu *et al.,* (2011).

Recommended submergence of 2-5 cm water level as per crop stage recorded significantly higher grain yield of 6148 kg ha^{-1} and was on par with irrigation of 5 cm at 3 DADPW.

There were 5.7, 6.9 and 14.3 per cent higher in yield under recommended submergence over irrigation at 3 DADPW and AWDI of 5 cm at 5 cm and 10 cm water level fall in field water tube from surface respectively. Straw yield of 7039 kg ha^{-1} was significantly higher under recommended submergence of 2-5 cm water level as per crop stage and was on par with AWDI of 5 cm, when water level falls below 5 cm from soil surface in field water field tube (6204 kg ha^{-1}). Similar results were found by Das *et al.*, (2000), Uppal *et al.*, (1991), Kumar *et al.*, (2006). However there was no significant effect of interaction between systems of rice cultivation and irrigation regimes.

Total water applied

Drum seeding system recorded higher total applied water (1359.4 mm) among different cultivation systems as compared to CTP (1325.5 mm) and MTP (1313.5 mm) (Table 1).

The Field water use depends mostly on irrigation frequency and the quantity of water used by the crop. Water input (irrigation plus effective rainfall) in different treatments varied between 1085 mm to 1819.7 mm. The recommended submergence of 2-5 cm water level as per crop stage consumed more water (1819.7 mm) among different irrigation regimes.

This was followed by irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube (1271.7 mm) and irrigation of 5 cm at 3 DADPW (1154.7 mm). Increased consumptive use of water registered under recommended submergence of 2-5 cm water level as per crop and irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube was mainly due to more frequent irrigations and increased daily evapotranspiration. It was due to recommended submergence of 2-5 cm water level as per crop stage, where the number of irrigations was 35 compared with 28 in irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube and 26 in Irrigation of 5 cm at 3 DADPW. Practicing irrigation of 5 cm, when water level falls below 10 cm from soil surface in field water tube treatments were recorded least water consumption (1085 mm) among different irrigation regimes.

Increased dry cycles with reduced evapotranspiration got by this treatment and had negative effect on yields. Similar observations were reported by Ramakrishna (2007).

Water use efficiency (WUE)

Significantly higher water use efficiency (4.7 kg mm^{-1}) was recorded in case of machine transplanting as compared to drum seeding (4.0 kg mm^{-1}) and was on par with conventional transplanting (4.6 kg mm^{-1}). This was due to higher grain yield and comparatively lower irrigation water used in MTP (Table 1).

The different irrigation practices significantly influenced the WUE of the rice crop. The WUE was higher in the treatment with irrigation of 5cm when water level falls below 10 cm from soil surface in field water tube (I_2), which registered 4.9 kg mm^{-1} and was on par with irrigation of 5 cm at 3 DADPW (4.8 kg mm^{-1}) and irrigation of 5cm when water level falls below 5 cm from soil surface in field water tube with (4.5 kg mm^{-1}). The lowest WUE was accounted with recommended submergence of 2-5 cm water level as per crop stage (I_4), which recorded 3.5 kg mm^{-1}. The higher water use efficiency (WUE) can be increased either by increasing yield or by maintaining the same yield level with reduced quantity of water input.

Table.1 Yield (kg ha^{-1}), Applied Water (mm), Total water (mm) and Water Productivity (kg mm^{-1}) of rice as influenced by different Systems of cultivation and irrigation regimes

Treatment	**Yield (kg ha^{-1})**		**Applied Water (mm)**	**Total water (mm)**	**Water Productivity (kg mm^{-1})**
Main plot - systems of cultivation					
M_1- Direct seeding with drum seeder	5308	6295	1141	1359	4.0
M_2- Transplanting with machine	6088	6954	1100	1313	4.7
M_3- Conventional transplanting	5926	6886	1087	1325	4.5
SEm ±	139	81			0.1
C.D (P=0.05%)	546	317			0.3
Sub plot - Irrigation regimes					
I_1- Irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube	5751	6872	1063	1271	4.5
I_2- Irrigation of 5 cm, when water level falls below 10 cm from soil surface in field water tube	5379	6204	813	1085	4.9
I_3- Irrigation of 5 cm at 3 days after disappearance of ponded water	5817	6732	945	1154	4.8
I_4- Recommended submergence of 2-5 cm water level as per crop stage	6148	7039	1619	1819	3.5
SEm ±	96	68			0.2
C.D (P=0.05)	334	236			0.6
Interaction between different systems of cultivation and irrigation regimes					
Irrigation regimes at same level of systems of cultivation					
SEm±	239	182			0.3
C.D (P=0.05)	NS	NS			NS
Different systems of cultivation at same level of irrigation regimes					
SEm ±	238	203			0.3
C.D (P=0.05)	NS	NS			NS

In the present study also, reduction in consumptive water use under irrigation of 5 cm when water level falls below 5 and 10 cm from soil surface in field water tube and irrigation of 5 cm at 3 DADPW coupled with the maintenance of yield at an optimum level increased the WUE. WUE under AWDI of 5 cm submergence depth with 10 cm drop of water level in the field tube treatment was 40 per cent compared to the recommended submergence of 2-5 cm water level as per crop stage. Irrigation of 5 cm, when water level falls below 5 cm from soil surface in field water tube and irrigation of 5 cm at 3 DADPW treatments compared to the conventional method of irrigation practice recorded higher WUE of 28.5 and 36.1 per cent over recommended practice due to reduction in consumptive use.

Machine transplanting recorded (14.7%) and (10.5%) higher grain and straw yield respectively which was significantly superior to drum seeding method. However conventional transplanting method was found on par to machine transplanting method with 2.7 and 1.0 per cent variation respectively. Significantly higher water use efficiency (4.7 kg mm^{-1}) was recorded in case of machine transplanting as compared to drum seeding (4.0 kg mm^{-1}) and was on par with conventional transplanting (4.6 kg mm^{-1}). There was saving of water by 36.5, 28.5 and 40.4 per cent respectively compared to recommended practice of irrigation, though there was reduction of grain yield by 5.4, 6.5 and 12.3 per cent due to irrigation of 5 cm at 3 DADPW, irrigation of 5 cm when water falls below 5 cm from soil surface in field water tube and irrigation of 5 cm when water falls below 10 cm from soil surface in field water tube respectively.

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