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Evaluation of Water Use Efficiency of Rice Genotypes under Different Rice Establishment Methods and Different Growing Environment

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A B S T R A C T

The present investigation was carried out during kharif season 2015 at research farm of College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, it was laid out in a Split-Split plot design replicated thrice with three establishment methods (M1-Direct Seeding, M2-Unpuddled transplanting, and M3-Puddled transplanting) as main plot treatment, two dates of sowing (D1-27th June and D2-11th July) as sub plots and two varieties (V1-Naveen and V2-Pooja) as Sub-Sub plot treatments. The minimum water use efficiency was noticed in rice cultivar 'under early puddle transplanted situation as compared to the other treatment combinations. Whereas, the lowest water use efficiency was observed in cv. 'Naveen' under late sown direct seeded condition. The transplanted rice registered maximum grain yield (3483kg/ha) as compared to unpuddled transplanted rice and direct seeded rice.

Introduction

Rice is the staple food of over half the world's population, and a vital nutritional source for rural poor of most of the countries in the world providing 20% of their dietary energy. The demand of rice as staple food for about 3 billion people is expected to increase further with increase in population. Globally rice is grown in 162.3 mha, and India accounts for 27.47% with a cultivated area of 44.6 mha, the corresponding production being 738.1 and 104.20mt. The average production under Indian condition is 2.44 t ha^{-1} compared to the world's average of 4.5 t ha^{-1} (CACP2015). Odisha occupies an area of 4.41 m ha producing 6.94mt with an average productivity of 1.57 t ha^{-1}, 35.56% less than the national average (Govt. of Odisha, 2012-13).

With its ability to adopt itself to a wide range of geo-hydrological situations, rice enjoys a unique place among the field crops. Based on two major environmental determinates of source like water and degree of flooding, rice can be grouped under different ecosystem such as rainfed upland, rainfed low-land, medium land, deep water and tidal wetlands. In spite of its wider adaptability and

cultivation, are we in a position to balance rice production under these ecosystems. Besides maintaining a healthy soil environment is a major point of concern of all the stakeholders,

Transplanting in puddle soil is the most dominant and traditional method of establishment in irrigated low land rice. Puddling, the typical pre planting management practice, is done to reduce water infiltration and to maintain the standing water in the field, which helps in weed management and facilitates easier transplanting (Sharma and De data, 1986) The depth of the water influences the type and density of weed flora (Kent and Jonson, 2001, Kumar and Ladha, 2011).

Besides water management, tillage can also influence weed emergence due to changes in the mechanical characteristics(bulk density, penetration resistance, aggregate mean weight diameter and surface roughness) of the seedbed (Carman, 1996) as well as the vertical distribution of seeds in soil (Chauhan and Johnson, 2009). Puddled flooded Soil has many other benefits such as neutralising soil pH, improving the availability of plant nutrients (P, K, Ca, Mg, Mn and Fe) and allowing for the accumulation of organic matter (Poonamperuma, 1972; Sahrawat, 2005).

Mainly the indirect increase in the availability of nutrient by puddling is through the reduction of cation leaching (Aggarwal *et al.*, 1995). In spite of all such advantages, puddling in rice associated with many problem of the soil structure, creation of hard Pan, increased methane emission, increased bulk density and soil compaction (Kirchhof *et al.*, 2000). Moreover puddling and transplanting also requires large amount of scarce water resources as well as labour (Kumar and Ladha, 2011). The puddling rice transplanting operations consumes about 25%of the total water required for rice during the growing season. The destruction of soil structure and formation of hard pan during puddling may have adverse effects on the growth and yield of subsequent non rice crop in the relation and these crops also require more energy for field preparation (Kumar and Ladha, 2011).

Materials and Methods

Water use efficiency

Effective Rainfall (ER)

Effective rainfall is the proportional of rainfall useful in crop production (DASTANE, 1972). The storage capacity of the soil and rooting depth of the crop are the important factors in deciding the magnitude of effective rainfall. Any rain received after the soil has attained field capacity (FC) down to the rooting zone becomes ineffective.

Water use Efficiency (WUE)

The field Water use efficiency was calculated by using the following formula.

FWUE=Economic yield (kg ha^{-1})/ Consumptive use of water (cm)

Water Requirement (WR)

It was estimated by the following formula

$WR=ER+IR+\Delta SW+\Delta GW$

Where:

ER= effective rainfall (cm)
IR= Gross irrigation requirement
ΔSW= Soil water contribution (cm)
ΔGW= Ground water contribution (cm)]

It has been presumed that the soil profile and ground water table contribution are very negligible during kharif season.

Statistical analysis

The data collected for different characters were subjected to statistical Analysis and subsequent F test appropriate to the experimental design (cochram and cox. 1950). The standard error of mean (SEm ± and difference (CD) at 5 percent and significance level was worked out for the different parameters.

Results and Discussion

Grain yield

The grain yield of rice is a function of total number of panicles, number of grains per panicle and the grain weight, which was significantly influenced by the planting methods, dates of sowing and the rice cultivars (Table 1). The transplanted puddled rice registered maximum grain yield of 3438kg/ha which was almost 17.5%more than unpuddled transplanted rice and 42.7% more than direct seeded rice 2440kg/ha. The early sown crop (27th June) produced maximum grain yield (3117kg/ha) with yield advantage of almost 19% than that crop sown on 11 July (2808 kg/ha). The highest grain yield was obtained with *cv.* Pooja (3070kg/ha) which was almost 7.5% higher than that observed with *cv.* Naveen (2856kg/ha). Interaction between varieties and dates of sowing was found non-significant.

Straw yield kg/ha.

Unlike grain yield the straw yield was also significantly influenced by the different rice establishment methods, planting dates and genotype. Table 1**.** The maximum straw yield (3445kg/ha) was recorded from paddy crop transplanted after puddling which was almost 19% and 40 % higher than that observed in unpuddled transplanted and direct seeded rice, respectively. Similarly the crop planted on (27th June) registered more straw yield (2997 kg/ha) as compared to the crop planted on 11th July. The rice *cv.* Pooja produce almost 11% higher straw yield than *cv.* Naveen (2783kg/ha). The interaction effects were non-significant.

Table.1 Grain yield, straw yield, and harvest index as affected by different establishment methods, growing environments and varieties

Management	Grain yield kg/ha	Straw yield kg/ha	Harvest Index (%)
M1	2440	2458	49.81
M2	2964	2896	50.06
M3	3483	3445	50.27
SEm+	62.6	24.4	0.25
CD (0.05)	197.4	77.0	NS
Growing Environments			
D1	3117	2997	50.89
D2	2808	2868	49.47
SEm+	51.1	19.9	0.21
CD (0.05)	161.1	62.9	0.66
Variety			
V1	2856	2783	50.64
V2	3069	3081	49.90
SEm+	59.1	78.9	0.17
CD (0.05)	182.2	243.2	0.53

Table.2 Water use efficiency of two cultivars of rice as influenced by different establishment methods and dates of sowing

Treatment	Grain (kg/ha)	Rainfall (mm)	Irrigation (mm)	Total water (mm)	WUE (kg/ha.mm)
M1D1V1	2412.3	748.3	180	928.3	25.99
M1D1V2	2664.6	751.3	180	931.3	28.61
M1D2V1	2193.0	731.8	180	911.8	24.05
M1D2V2	2493.4	733.6	180	913.6	27.29
M2D1V1	3070.2	748.3	240	988.3	31.07
M2D1V2	3004.4	751.3	240	991.3	30.31
M2D2V1	2815.8	731.8	240	971.8	28.97
M2D2V2	2969.3	733.6	240	973.6	30.50
M3D1V1	3530.9	748.3	300	1048.3	33.68
M3D1V2	4019.7	757.3	300	1057.3	38.02
M3D2V1	3114.0	731.8	300	1031.8	30.18
M3D2V2	3267.5	733.6	300	1033.6	31.61

Harvest index (%)

The estimated value of harvest index influenced significantly by the dates of sowing and rice genotypes but was non-significant with different planting methods, thus the harvest index values of the crops harvested under different planting methods were at par. The maximum harvest index value (50.89%) observed in early sown crop followed by the crop sown 11th July (49.47%) but among the tested rice genotype *cv*. Naveen registered higher harvest index value (50.64%) as compared to *cv*. Pooja (49.90%).

Water use efficiency (WUE)

The rainfall received and irrigation applied to both the rice genotypes under different rice establishment methods and dates of sowing are depicted in Table 2. The water use efficiency of both the cultivars under different treatment combinations estimated and presented in Table 2. The data clearly revealed that the minimum water use efficiency was noticed in rice cultivar Pooja under early puddled transplanted situation (M_3-D_1V_2-38.02 Kg/ha.mm) as compared to other treatment combinations. Whereas, the lowest water use efficiency was observed in cv. Naveen under late sown direct seeded condition (M_1-D_2V_2-24.05 kg/ha.mm).

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