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Impact of Drip Fertigation on Water Use Efficiency and Economics of Aerobic Rice

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Abstract

Field experiment was conducted on red sandy loam soils, during Kharif 2013 at Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore to find out the effect of drip fertigation with combination of water soluble fertilizers and normal fertilizers or alone on water productivity and economics of aerobic rice during kharif 2013. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising of 3 replications and 10 treatments. Results show that water use efficiency and economics differed significantly among the treatments. Consistently use of high water potency (91.01 kg/ha.cm^{-1}) was noted when the crop was drip fertigated with 100% recommended dose of fertilizers. High net income (Rs.58104 ha^{-1}) was, however, observed for fertigation with 100% RDF in which 50% applied as basal dose and 50% top dress through water soluble fertilizers.

Keywords: Aerobic rice; Fertigation; Water use efficiency; Yield; Net income

Introduction

Rice (*Oryza sativa L.*) is the most important staple food crop in Asia and human consumption accounts for 85% of total production of rice and it deserves a special status among cereals as world's most important crop. The traditional method of rice cultivation consumes around 5000 liters of water to produce one kg of grain, which is three times higher than other cereals. Traditional rice production system not only leads to wastage of water but also causes environmental problems and reduces fertilizer use efficiency. Attempts to increase water productivity either by reducing water consumption or by increasing the yields will automatically facilitate higher growth in agricultural production. Keeping these in points International Rice Research Institute developed the-aerobic rice technology to address the water crisis in tropical agriculture. In aerobic rice system, wherein the crop is established in non-puddled, non-flooded fields and rice is grown like an upland crop (unsaturated condition) with adequate inputs and supplementary irrigation when rainfall is insufficient. The water productivity of rice under aerobic conditions was 32-88% higher than under flooded conditions [1].

Drip irrigation through the trickle supply of water drops holds promise in this respect [2]. Trickle fertigation permits application of nutrients directly at the site of high on centration of active roots. Since nutrients are applied to a limited soil volume, the fertilizer use efficiency is also high. On the other hand, conventional fertilization especially on light soils may cause huge nutrient losses through leaching, percolation and volatilization. Drip fertigation also enables accurate adjustment of water and nutrient supplies to meet the crop requirements. Taking these points into account an investigation was carried out to evaluate the effects of drip fertigation on yield, water use efficiency and economics of aerobic rice.

Material and Methods

The field experiment was conducted from July 2013 to December 2014 Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. The experimental site is situated at between 12° 51' N latitude and 77° 35' E longitude at an altitude of 930 m above mean sea level (MSL). Soil type of the experimental field is red sandy clay loam. MAS 946-1 variety of aerobic rice maturing in about 145 days was planted at a spacing of 25 cm × 25 cm in rows accommodating 1.60.000 plants per hectare.

The experiment was laid out in randomized complete block design with ten treatments with three replications. The treatments consisted of combinations of different dose and type of fertilizers viz., T_1: Surface irrigation with soil application of RDF, T_2: 50% RDF (50% basal with NF + 50% top dress through DF with NF), T_3: 75% RDF (50% basal with NF + 50% top dress through DF with NF), T_4: 100% RDF (50% basal with NF + 50% top dress through DF with NF), T_5: 50% RDF (50% basal with NF + 50% top dress through DF with WSF), T_6: 75% RDF (50% basal with NF + 50% top dress through DF with WSF), T_7: 100% RDF (50% basal with NF + 50% top dress through DF with WSF), T_8: 50% RDF through drip fertigation with WSF, T_9: 75% RDF through drip fertigation with WSF and T_{10}: 100% RDF through drip fertigation with WSF.

The sowing was taken up on July 28th, 2013 by maintaining the intra and inter row spacing of 25 cm with seed rate of 5 kg.ha^{-1}. Immediately after sowing the seeds are covered with soil with the help of plank. The normal fertilizers used were Urea, Di ammonium phosphate (DAP) and muriate of potash (MOP) as N, P and K sources, respectively and the water soluble fertilizers are 19:19:19 and calcium ammonium nitrate. The experimental data recorded were subjected to analysis by using Fisher's method of Analysis of Variance (ANOVA). The levels of significance used in F and t test was a p=0.05.

Results and Discussion

Water use efficiency

Higher water use efficiency in drip fertigation is probable as the volume of water applied through drip system roughly corresponds to

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the consumptive use of plants. Consistent with this, Total water used was highest in surface irrigation method (1073 mm) when compared to different levels and source of fertilizer with drip fertigation (714.5 mm). In case of water use efficiency aerobic rice fertigated 100% RDF through drip fertigation with water soluble fertilizer recorded significantly higher water use efficiency (91.01 kg/ha.cm^{-1}), followed by 100 and 75% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through water soluble fertilizer (85.99 and 78.38 kg/ha.cm^{-1}) and 75% RDF through drip fertigation with water soluble fertilizer (79.27 kg/ha.cm^{-1}). The lowest WUE was observed when the crop with surface irrigation with soil application of RDF (31.45 kg/ha.cm^{-1}). Increase in water use efficiency in drip fertigation system over furrow irrigation was mainly due to the controlled water release near the crop root zone [3]. It is also due to higher yield levels due to higher uptake of nutrients by crop as a result of timely and frequent supplementation of water and nutrient to root zone leading to the decrease in leaching and volatilization losses of nitrogen. The favourable effect of water and nutrients on crop growth and pod yield in drip irrigation probably resulted in higher water use efficiency (Table 1). These results are in accordance with findings of Kumar and Sundarapandian [4,5].

Economics

The economics of different treatments in aerobic rice cultivation under both drip fertigation and conventional method of irrigation were worked out and are presented in Table 2. The drip fertigation system has been found more profitable than surface irrigation due to higher yield. Among the different drip fertigated treatments the gross returns were higher when the crop was fertigated with 100% RDF through water soluble fertilizers (Rs. 121222 ha^{-1}) these were closely followed by the treatment with 100 and 75% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer (114364 and 105093 ha^{-1}, respectively). This is mainly due to increase in grain and straw yield as compared to rest of the treatments.

Meanwhile, higher net returns (Rs.58104 ha^{-1}) were recorded with 100% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer which was comparable with 75% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer (Rs.54148 ha^{-1}). Higher B: C ratio was recorded in 75% RDF in which 50% was applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer (2.06). This is due to high cost of water soluble fertilizer compared to normal fertilizer. Surface irrigation with soil application of RDF recorded lower net returns (Rs.26606 ha^{-1}), whereas application of 50% RDF through drip fertigation recorded least B:C ratio (1.66) because of lower grain and straw yield. These results were in accordance with the findings of Veeraputhiran et al. [6], Abdelraouf et al. [7] and Richakhanna [8].

Yield

Data presented in Table 3 illustrated that reducing fertigation

Treatments	Irrigation water used (mm)	Total water used I_R+E_R (mm)	Water productivity (kg ha-cm^{-1})
T_1:Surface irrigation with soil application of RDF	846.00	1073.0	31.45
T_2:50% RDF (50% basal with NF+50%top dress through DF with NF)	487.15	714.5	47.47
T_3:75% RDF (50% basal with NF+50%top dress through DF with NF)	487.15	714.5	54.51
T_4:100% RDF (50% basal with NF +50%top dress through DF with NF)	487.15	714.5	60.18
T_5:50% RDF (50% basal with NF+50%top dress through DF with WSF)	487.15	714.5	57.48
T_6:75% RDF (50% basal with NF+50%top dress through DF with WSF)	487.15	714.5	78.38
T_7:100% RDF(50% basal with NF+50%top dress through DF with WSF)	487.15	714.5	85.99
T_8:50 % RDF through drip fertigation with WSF	487.15	714.5	68.02
T_9:75 % RDF through drip fertigation with WSF	487.15	714.5	79.27
T_{10}:100% RDF through drip fertigation with WSF	487.15	714.5	91.01
S.Em ±	-	-	4.39
CD @ 5%	-	-	13.05
CV (%)	-	-	11.63

NF: Normal fertilizer; **DF:** Drip fertigation; **RDF:** Recommended dose of fertilizer (100:50:50 kg NPK ha^{-1}) **WSF:** Water soluble fertilizer

Table 1: Total water used (mm) and water use efficiency (kg ha-cm^{-1}) of aerobic rice under drip fertigation.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
T1:Surface irrigation with soil application of RDF	38520	65126	26606	1.69
T_2:50% RDF (50% basal with NF+50%top dress through DF with NF)	38720	65905	27185	1.70
T_3:75% RDF (50% basal with NF+50%top dress through DF with NF)	39695	75190	35496	1.89
T_4:100% RDF (50% basal with NF +50%top dress through DF with NF)	41260	82891	41632	2.01
T_5:50% RDF (50% basal with NF+50%top dress through DF with WSF)	45632	78394	32762	1.72
T_6:75% RDF (50% basal with NF+50%top dress through DF with WSF)	50945	105093	54148	2.06
T_7:100% RDF(50% basal with NF+50%top dress through DF with WSF)	56261	114365	58104	2.03
T_8:50 % RDF through drip fertigation with WSF	55213	91766	36553	1.66
T_9:75 % RDF through drip fertigation with WSF	63716	106452	42736	1.67
T_{10}:100% RDF through drip fertigation with WSF	72223	121222	48999	1.68

NF: Normal fertilizer; **WSF:** Water soluble fertilizer; **DF:** Drip fertigation; **RDF:** Recommended dose of fertilizer (100:50:50 kg NPK ha^{-1})

Table 2: Economics of aerobic rice as influenced by drip fertigation.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1:Surface irrigation with soil application of RDF	3375	6296	0.35
T_2:50% RDF (50% basal with NF+50%top dress through DF with NF)	3392	6628	0.34
T_3:75% RDF (50% basal with NF+50%top dress through DF with NF)	3895	7285	0.35
T_4:100% RDF (50% basal with NF +50%top dress through DF with NF)	4300	7961	0.35
T_5:50% RDF (50% basal with NF+50%top dress through DF with WSF)	4107	7090	0.37
T_6:75% RDF (50% basal with NF+50%top dress through DF with WSF)	5600	8462	0.40
T_7:100% RDF(50% basal with NF+50%top dress through DF with WSF)	6144	8659	0.42
T_8:50 % RDF through drip fertigation with WSF	4860	7717	0.39
T_9:75 % RDF through drip fertigation with WSF	5664	8664	0.40
T_{10}:100% RDF through drip fertigation with WSF	6503	9285	0.41
S.Em±	318.75	409.23	0.03
CD @ 5%	947.04	1215.87	NS
CV (%)	11.54	9.08	15.03

NF: Normal fertilizer; **WSF:** Water soluble fertilizer; **DF:** Drip fertigation; **RDF:** Recommended dose of fertilizer (100:50:50 kg NPK ha^{-1})

Table 3: Grain and straw yield of aerobic rice as influenced by drip fertigation.

levels from 100% to 50% NPK of recommended fertilizer significantly decreased among the different fertigated treatment the higher grain yield was recorded with 100% RDF through drip fertigation with water soluble fertilizer (6503 kg.ha^{-1}) which was on par with 100 and 75% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer (6144 and 5600 kg.ha^{-1}) and 75% RDF through drip fertigation with water soluble fertilizer (5664 kg.ha^{-1}). Higher grain yield may be due to its superiority in producing higher productive tillers hill^{-1}, panicle length, thousand seed weight and total number of filled grains panicle^{-1} with lower% chaffyness than the other treatment. This was mainly attributed that higher number of productive tillers were due to continuous availability of water and nutrients that resulted in higher uptake of nutrients in turn production of higher dry matter under drip fertigation. These findings are in conformity with the findings of [4,9,10].

There was no significance difference in harvest index among the treatments. Whereas 100% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through drip fertigation with water soluble fertilizer recorded the highest harvest index (0.42).

The present study summarised that application of RDF through drip fertigation with water soluble fertilizers recorded higher grain and straw yield as compare to soil application of 100 RDF with normal fertilizers and which was given on par results with 100 and 75% DF (50% basal with NF + 50% top dress through DF with WSF) which may be recommended as alternate for former one. Though 100% RDF through drip fertigation with water soluble fertilizer recorded higher yield and higher gross and net returns, B:C ratio was less mainly due to higher cost of WSF.

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