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Influence of Drip Fertigation on Growth and Yield of Rice Varieties (*Oryza sativa* L.)

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Field experiment was conducted at Central farm, Agricultural College and Research Institute, Madurai, during *rabi* 2009 - 2010 to study the Influence of drip fertigation on the growth and yield of rice varieties (*Oryza sativa* L.). Drip irrigation was scheduled once in three days and fertigation was given once in six days as per the treatment schedule. Observations on growth, yield attributes and yield of rice were recorded. Drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent (RDF)+ azophosmet + humic acid recorded 19 per cent increased yield as compared to drip irrigation at 125 per cent PE+100 per cent RDF through drip. The increase in rice grain yield with drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF + azophosmet + humic acid was mainly attributed by greater and consistent availability of soil moisture and nutrients which resulted in better crop growth, yield components and ultimately reflected on the grain yield.

Key words: Drip fertigation, Azophosmet, Humic acid, Rice

Rice is the dominant cereal crop in many developing countries and is the staple food for more than half of the world's population. More than 75 per cent of the annual rice supply comes from 79 million ha of irrigated paddy land. The present and future food security of Asia depends upon the irrigated rice production system. In Asia, more than 50 per cent of water available for irrigation is used for irrigated rice (Barker *et al.,* 1999). Water use in irrigated rice is high because the crop is grown under low land condition, the soil is puddled and the field is kept flooded with 3 to 5 cm depth of water after transplanting until 10 days before harvest. Because of continuous presence of ponded water, there is a huge loss of water by evaporation, seepage and percolation out of the root zone (Castaneda *et al.,* 2002). Thus, Indian farmers are using as much as 15,000 liters of water to produce one kg of rice when the maximum requirement is only 4,000 liters (Cyril Kanmony, 2001). Water requirement to produce one kg of rice is about two to three times more than the water required for producing one kg of other cereals such as maize or wheat. Until recently, this amount of water has been taken for granted. Now, however, the water crisis threatens the sustainability of irrigated rice ecosystems. The need to produce more rice with less water is crucial for food security for many Asian countries where water scarcity for agricultural use is increasing.

Worldwide, new rice cultivation practices are being evaluated due to the need for saving water in the face of increasing shortage. In the words of Dr. Bouman, rice irrigation scientist at IRRI, Philippines, "We may have to change the way rice is produced in the future" and a new theme "Grow more rice with less water" is gaining attention in all the rice growing regions. Rice production system will have to sustain itself with lesser water supply. To safeguard food security and preserve precious water resources, ways must be explored to grow rice using less water (Belder *et al.,* 2002). Fertigation is a relatively new but revolutionary concept in applying fertilizer through irrigation. It helps to achieve both fertilizer-use efficiency and water-use efficiency. When fertilizer is applied through drip, it is observed that 30 per cent of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005). Fertigation provides the essential nutrients directly to the active root zone, thus minimizing the loss of expensive nutrients which ultimately helps in improving the productivity and quality of farm produce. Hence, the present study was undertaken to study the influence of drip fertigation on the growth and yield of rice varieties (*Oryza sativa* L.) under drip fertigation system on the growth, yield parameters and yield of rice.

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Material and Methods

The present study on the Influence of drip fertigation on the growth and yield of rice varieties (*Oryza sativa* L.) was carried out during *rabi* 2009 – 2010 at Central farm, Agricultural College and Research Institute, Madurai, Tamil Nadu Agricultural University, Tamil Nadu, India, located in the southern agro climatic zone of Tamil Nadu, at 9°54' N latitude 78°54' E longitude and at an elevation of 147 m above mean sea level. The daily mean maximum and minimum temperatures during *rabi* season were 31.6 and 21.8 °C, respectively. The daily mean pan evaporation per day was 3.2 mm with relative humidity of 79.6 per cent during the season. During the cropping season, the crop received a total of 332.2 mm of rainfall. The soil of the study area was clayey with a pH of 7.4, available N, P, K status of 180, 10 and 312 N P K kg ha^{-1} respectively. The organic carbon content was 0.48% and EC 0.42 dSm^{-1}.

Preparation of field

The experimental field was made to good tilth condition by ploughing with tractor drawn disc plough followed by ploughing with cultivator thrice. The clods were broken with rotavator and the field was leveled.

Raised bed formation

Raised beds were formed manually with a top bed width of 70 cm and furrows were formed to a width of 30 cm and good tilth condition was made in the bed for easy sowing of seeds for early germination.

Method of sowing

Seeds were soaked in water for 12 hrs and shade dried for 12 hrs. The seeds were sown direct spot seeding and covered in line over the raised bed at the spacing of 20 x 15 cm.

Lay out of drip system

The water source is an open well. Water was pumped through 7.5 HP motor and it was conveyed to the main field using 90 mm of PVC pipes after filtering through sand and screen filter. From the mainline water was taken to the field through sub mains of 63 mm diameter PVC pipes. From the sub main, 12 mm laterals were fixed at a spacing of 100 cm at the rate of one lateral in the centre of every raised bed. The emitters in the inline laterals are fixed at 20 cm. A 16 mm tap was fixed at the head of each lateral in order to regulate the irrigation regimes and fertigation levels and laterals were closed with end plug. The drip irrigation system was well maintained by flushing and cleaning the filters. After installation, trial run was conducted to assess mean dripper discharge and uniformity coefficient of the system.

Drip irrigation schedule

First irrigation was given immediately after sowing and subsequent irrigations were scheduled once in three days based on the daily pan evaporation. The irrigation was given at 125 % PE and 150 % PE as per treatments. The quantity of water was calculated as follows.

$$\text{Volume (lit ha}^{-1}) = \text{PE} \times \text{Kp} \times \text{Area (m}^2)$$

PE = pan evaporation

K_p= Pan Factor (0.80)

Time of operation of drip system to deliver the required volume of water per plot was computed based on the formula

$$\text{Time of application} = \frac{\text{Volume of water required (l)}}{\text{Emitter discharge (lit ha}^{-1}) \times \text{No. of emitters / plot}}$$

Design and layout of the experiment

The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications with a plot size of 24 m × 4 m.

The treatmental structure comprised of two factors viz. two varieties and four drip fertigation treatments.

Varieties: V_1 - PMK (R) 3, V_2 - ARIZE 6444

T_1 - Drip irrigation at 125 % PE +100% RDF through drip

T_2 - Drip irrigation at 150 % PE +100% RDF through drip

T_3- Drip irrigation at 125 % PE +100 % RDF through drip + Azophosmet + Humic acid

T_4- Drip irrigation at 150 % PE +100 % RDF through drip + Azophosmet + Humic acid

Control- Surface irrigation + soil application of recommended dose of fertilizers (Maintained outside the experiment for comparison).

Fertigation - Once in 6 days as per crop demand from 15 DAS to 98 DAS.

Azophosmet seed treatment: 0.2 kg per 5 kg seeds, soil application: 2.0 kg ha^{-1} (basal).

Liquid biofertilizers: 500ml ha^{-1} at panicle initiation and flag leaf stages-two days after fertigation. Humic acid was applied through drip fertigation @ 500 ml ha^{-1} at panicle initiation and flag leaf stages-two days after azophosmet application.

Results and Discussion

Plant growth parameters

Generally, increased levels of irrigation regime through drip system with fertigation favoured plant height positively (Table 1). Drip irrigation at 150 per cent PE + drip fertigation of 100 per cent RDF + azophosmet + humic acid registered higher plant height as compared to drip irrigation at 125 per cent PE+ drip fertigation of 100 per cent RDF. The increased plant height to the tune of 5.5 per cent under this treatment might be due to the continuous availability of the required quantity of water along with the required nutrients. Drip irrigation of 150 per cent PE+ 100 per cent RDF as drip fertigation+ Azophosmet + Humic acid (T_4) recorded higher plant height at active tillering (56.5 cm), panicle initiation (82.6 cm) and maturity stages (103.6 cm). The lower plant height was recorded in drip irrigation of 125 per cent PE+ drip fertigation of 100 per cent RDF. Growth reduction under the irrigation regime at 125 per cent PE + drip fertigation of 100 per cent RDF was In proportion to the reduction in soil moisture status in tune with irrigation water input (Table1).

Table 1. Influence of drip fertigation on plant height (cm) of rice varieties cv. PMK(R) 3 and ARIZE 6444

Stages	Active tillering stage			Panicle initiation stage			Maturity stage		
Treatment	PMK(R)3	ARIZE6444	Mean	PMK (R)3	ARIZE6444	Mean	PMK(R)3	ARIZE6444	Mean
T_1	52.2	50.6	51.4	84.2	66.4	75.3	112	84.4	98.2
T_2	53.7	51.5	52.6	85.9	67.7	76.8	114	85.4	99.7
T_3	58.3	52.7	55.5	87.4	68.8	78.1	115.4	86.5	100.9
T_4	59.7	53.3	56.5	89.4	75.8	82.6	119	88.1	103.6
Mean	56	52		86.7	69.7		115.1	86.1	
	V	T	V x T	V	T	V x T	V	T	V x T
SEd	0.39	0.56	0.79	1.18	1.67	2.36	0.95	1.35	1.91
CD(0.05)	0.85	1.2	1.7	2.54	3.59	5.08	2.05	2.89	4.1

Bouman and Tuong (2001) stated that when rice is subjected to moisture stress lead to inhibition of leaf production, decline in leaf area, reduction in plant height, reduced tillering and enhanced leaf senescence.

Root length (cm)

Root length of rice was significantly influenced by varieties and available soil moisture under drip fertigation system(Table 2). Variety ARIZE 6444 (V_2) recorded significantly higher root length at all stages of crop growth, which produced 23.9 cm (active tillering), 29.8 cm (panicle initiation) and 32.8 cm (maturity stage). The variety ARIZE 6444 (V_2) with drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF + Azophosmet + Humic acid (V_2T_4) recorded the highest root length at all the stages of crop growth (27 cm, 33.7 cm and 37.1 cm at active tillering, panicle initiation and maturity stages respectively.

Table 2. Influence of drip fertigation on root length (cm) of rice varieties cv. PMK(R) 3 and ARIZE 6444

Stages	Active tillering stage			Panicle initiation stage			Maturity stage		
Treatment	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	19.2	21.4	20.3	24.1	26.7	25.4	26.5	29.4	28.0
T_2	20.1	22.7	21.4	25.1	28.4	26.7	27.6	31.2	29.4
T_3	20.9	24.4	22.6	26.1	30.5	28.3	28.7	33.5	31.1
T_4	22.0	27.0	24.5	27.5	33.7	30.6	30.3	37.1	33.7
Mean	20.6	23.9		25.7	29.8		28.3	32.8	
	V	**T**	**V x T**	**V**	**T**	**V x T**	**V**	**T**	**V x T**
SEd	15	0.22	0.31	0.25	0.35	0.50	0.27	0.39	0.55
CD(0.05)	0.33	0.47	0.67	0.54	0.76	1.08	0.60	0.84	1.19

Number of tillers per hill

The variety ARIZE 6444 (V_2) under drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF+ azophosmet + humic acid (V_2T_4) registered significantly highest number of tillers per hill at active tillering (28.5), panicle initiation (45.7) and maturity stages (32.0)(Table 3).This was followed by Variety ARIZE6444 (V_2) with drip irrigation at 125 per cent PE + drip fertigation of 100 per cent RDF + Azophosmet + Humic acid (V_2T_3) which produced 26.6 (active tillering), 42.6 (panicle initiation) and 29.8 (maturity stages) tillers per hill (Table 2). Similar results were expressed by (Bharambe *et al.*, 1997) and Vijayakumar (2009).

The variety ARIZE 6444 (V_2) recorded 43 per cent increased grain yield than PMK(R) 3 (V_1). This might be due to enhancement in growth and yield parameters as well as uptake of nutrients by this variety. Obviously, the cumulative effects of these parameters contributed to increased yield. The variety ARIZE 6444 (V_2) recorded higher grain yield (5426 kg ha^{-1}), when compared with the variety PMK(R) 3 (3795 kg ha^{-1}). Drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF + Azophosmet + Humic acid recorded 19 per cent increased yield compared to drip irrigation at 125 per cent PE+100 per cent RDF through drip. The increase in rice grain yield with drip irrigation at 150

Table 3. Influence of drip fertigation on number of tillers per hill of rice varieties cv. PMK(R) 3 and ARIZE 6444

Stages	Active tillering stage			Panicle initiation stage			Maturity stage		
Treatments	PMK (R) 3	ARIZE6444	Mean	PMK (R) 3	ARIZE6444	Mean	PMK (R) 3	ARIZE6444	Mean
T_1	20.4	24.2	22.3	30.5	38.7	34.6	24.4	27.1	25.8
T_2	21.4	25.4	23.4	32.1	40.6	36.3	25.7	28.4	27.0
T_3	23.1	26.6	24.9	34.7	42.6	38.6	27.8	29.8	28.8
T_4	24.4	28.5	26.5	36.1	45.7	40.9	29.3	32.0	30.4
Mean	23.0	26.8		34.0	42.8		27.3	30.0	
	V	T	V x T	V	T	V x T	V	T	V x T
SEd	0.21	0.30	0.42	0.22	0.31	0.44	0.19	0.28	0.39
CD(0.05)	0.45	0.64	0.91	0.47	0.66	0.94	0.42	0.60	0.85

Grain and Straw yield (kg ha^{-1})

per cent PE+ drip fertigation of 100 per cent RDF + azophosmet + humic acid was mainly attributed to greater and consistent availability of soil moisture and nutrients which resulted in better crop growth, yield components and ultimately reflected on the grain yield. Similar results were expressed by Vijayakumar (2009). Higher straw yield of 7038 kg ha^{-1} was recorded under the variety ARIZE 6444 (V_2). Drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF+ azophosmet+ humic acid (T_4) registered significantly higher straw yield (6552 kg ha^{-1}). Straw yield was found to be lesser under drip irrigation at 125 per cent PE+ drip fertigation of 100 per cent RDF (T_1).Variety ARIZE 6444 (V_2) with drip irrigation at 150 per cent PE+ drip fertigation of 100 per cent RDF+ Azophosmet+ Humic acid (V_2T_4) was found to be better as it recorded the straw yield of 7701 kg ha^{-1} (Table 4).

Table 4. Influence of drip fertigation on straw yield (kg ha^{-1}) and grain yield (kg ha^{-1}) of rice varieties cv. PMK(R) 3 and ARIZE 6444

Treatment	Straw yield (kg ha^{-1})			Grain yield (kg ha^{-1})		
	PMK (R) 3	ARIZE 6444	Mean	PMK(R)3	ARIZE 6444	Mean
T_1	4818	6287	5553	3588	4789	4188
T_2	4935	6839	5888	3793	5256	4525
T_3	5180	7326	6253	3803	5686	4745
T_4	5402	7701	6552	3997	5975	4986
Mean	5084	7038		3795	5426	
	V	T	V x T	V	T	V x T
SEd	92	131	185	96	136	192
CD(0.05)	198	280	397	206	292	412

Total water used (mm)

Drip irrigation is an efficient method to deliver water and nutrients to the plants because water is directly applied to the effective root zone of crop plants. The loss of water is minimum and that results in the lower water requirement in the drip irrigation system. In this experiment, the total water used by the crop at 150 per cent PE was 25.4 per cent higher than the drip irrigation at 125 per cent PE. Drip irrigation at 125 per cent PE has resulted in considerable saving in water compared to drip irrigation at 150 per cent PE (Table 5).

Table 5. Influence of drip fertigation on straw yield total water used (mm) of rice varieties cv. PMK(R) 3 and ARIZE 6444

Planting Systems	Irrigation water (mm)		Effective rainfall (mm)		Total water (mm)	
	PMK (R) 3	ARIZE 6444	PMK (R) 3	ARIZE 6444	PMK (R) 3	ARIZE 6444
DI at 125 % PE	426.3	478.4	108.9	108.9	535.2	587.3
DI at 150 % PE	504.8	569.3	114.8	114.8	619.6	684.1

Conclusion

From the above study, it can be concluded that variety ARIZE 6444 responded well to the water soluble fertilizer with liquid biofertilizer at 150 per cent PE and drip fertigation of 100 per cent RDF + Azophosmet + Humic acid (HA) (V_2T_4) and maximized the yield, in addition to better crop growth, higher yield attributes, yield and substantial quantity of water saving. Thus, it clearly indicated the feasibility of introducing drip fertigation in rice for higher water productivity; higher fertilizer use efficiency and sustainability in future rice production.

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