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# Evaluation of Drip Fertigation System for Aerobic Rice in Western Zone of Tamil Nadu

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author VKD designed the study and carried out experiment. Author SKN performed the statistical analysis. Author GT wrote the first draft of the manuscript. Author MM managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

The productivity of rice is in decreasing trend due to non-availability of irrigation water. Hence, rice cultivation with minimum water which paves way for the research on aerobic rice (*i.e.,* growing in the non-flooded and non-puddled situation). Field experiments were conducted at Agricultural Research Station, Bhavanisagar during 2013-14 and 2014-15 to evaluate the drip fertigation system and to work out the economics in aerobic rice at different irrigation and nitrogen levels. The treatments included four irrigation levels (irrigation at 100%, 125%, 150% PE daily and conventional irrigation at IW/CPE = 1.25) with a combination of three fertigation levels (100,150 and 200 kg N $ha^{-1}$) of nitrogen. The experiment was laid in split plot design replicated thrice. The test variety is PMK 3, with a duration of 130-135 days. Entire quantity of phosphorus and 50 per cent of potassium was applied basally. Different doses of nitrogen and remaining 50 per cent of potassium was applied as fertigation in weekly intervals from 21 days after sowing. Irrigation was given daily

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basis with daily Pan Evaporation rate. Concerning different irrigation levels, 150 per cent PE on daily basis recorded significantly higher grain yield (5069 kg $ha^{-1}$), WUE (7.37 kg/ha mm) and net income of Rs. 33607 $ha^{-1}$ and B:C ratio of 1.88. For nitrogen levels, 150 kg N per ha recorded significantly higher grain yield (4146 kg $ha^{-1}$), WUE (6.69 kg/ha mm) and net income of Rs. 20464 $ha^{-1}$ and B:C ratio of 1.53. For aerobic rice, the irrigation at 150 per cent PE on daily basis combined with 150 kg N per ha recorded significantly higher grain (5483 kg $ha^{-1}$), WUE (8.18 kg/ha mm) and higher net income of Rs. 39448 $ha^{-1}$ and B:C ratio of 2.03.

*Keywords: Aerobic rice; drip irrigation; fertigation; water productivity; water use efficiency.*

## 1. INTRODUCTION

In India, rice is the principal food crop grown in an area of 44.1 m.ha with a production of 105.5 mt and productivity of 2.39 t $ha^{-1}$. In Tamil Nadu, it is grown in an area of 17.95 lakh ha with a production of 57.28 lakh tonnes and productivity of 3191 kg $ha^{-1}$ [1]. Lowland rice requires around 1000 to 5000 liters of water for producing one kg grain which is about twice or even more than wheat or maize water requirement [2]. However, the increasing scarcity of freshwater for agriculture and the equal demand from the non-agricultural sector threaten the sustainability of the irrigated rice ecosystem [3,4,5,6]. One of the recent developments is to grow rice as an upland crop *viz.* wheat or maize and named as ‘aerobic’ cultivation [7]. Aerobic rice cultivation saves water input and increases water productivity by reducing water use during land preparation and limiting seepage, percolation and evaporation [8]. To make aerobic rice successful, new varieties and management practices need to be developed. Optimum irrigation scheduling and nitrogen are critical for profitable yield realization of aerobic rice [7]. Drip irrigation and fertigation methods have been proved to be the water and nutrient efficient methods, respectively in most of the crops apart from increasing the productivity. Information is not available on the response of aerobic rice to drip irrigation and fertigation [7]. Hence, the present investigation was carried out to find out the influence of irrigation levels and nitrogen doses on aerobic rice under drip irrigation in sandy loam soils.

## 2. EXPERIMENTAL DETAILS

### 2.1 Description of the Study Area

Field experiments were conducted during 2013-14 and 2014-15 at Agricultural Research Station, Bhavanisagar, Tamil Nadu. The soil of the experimental site was sandy loam in texture, medium in organic carbon (0.46), available phosphorus (21.88 kg $ha^{-1}$), low in available nitrogen (268 kg $ha^{-1}$) and high in available potassium (454 kg $ha^{-1}$). The values of bulk density, particle density and pore space were 1.27 Mg $m^{-3}$, 1.86 Mg $m^{-3}$ and 31.32% respectively.

### 2.2 Experimental Details

The experiment was laid out in a split-plot design with four irrigation levels as main plots and three nitrogen doses as subplots. The irrigation levels consisted of $M_1$: Irrigation at 100% PE daily, $M_2$: Irrigation at 125% PE daily, $M_3$: Irrigation at 150% PE daily and $M_4$: Conventional irrigation (at IW/CPE = 1.25) and nitrogen levels were $S_1$: 100 kg N $ha^{-1}$, $S_2$: 150 kg N $ha^{-1}$ and $S_3$: 200 kg N $ha^{-1}$ which were replicated thrice.

Rice variety ‘PMK 3’ (Paramakudi) of 130-135 days duration was sown by dibbling in raised beds following 20 cm x 10 cm spacing. The Biofertilizer of Azophosmet @ 2.0 kg $ha^{-1}$ was applied as soil application and seed treatment with Azophosmet @ 2 gm $kg^{-1}$ of seeds. Two common irrigations of 60 mm each were given, one at pre-sowing for good germination and second at $10^{th}$ day after sowing for crop establishment. Thinning and gap-filling were done at 14 days after sowing. The blanket fertilizer recommendation of 150:50:50 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$ were followed beside the basal application of 25 kg Zn $So_4$ $ha^{-1}$. The entire quantity of phosphorus and 50 per cent of potassium were applied basally. Different doses of nitrogen and remaining 50 per cent of potassium were being applied as fertigation in weekly intervals from 21 days after sowing as per the treatment schedule.

Drip was laid out with 1.5m lateral spacing with 30 cm of dripper spacing with a discharge rate of 8 lph. Irrigation was given daily basis with daily Pan Evaporation rate. Pre and post-harvest observations in respect of both growth and yield parameters were recorded following standard procedures. The recorded data were analyzed statistically to find out the significance of the treatment. Net return (Rs. $ha^{-1}$) was calculated by deducting the cost of cultivation (Rs. $ha^{-1}$) from the gross returns (Rs. $ha^{-1}$) excluding the cost incurred towards installation of drip system. The other recommended cultural and pest management practices were adopted.

## 3. RESULTS AND DISCUSSION

The grain yield in any crop is dependent upon the photosynthetic source it can build up. A sound source in terms of plant height, number of tillers to support and the number of leaves are logically able to increase the total dry matter and later lead to higher grain yield. Partitioning of dry matter production and its distribution in different parts is important for the determination of total yield of the crop [9]. In this study, irrigation at 150% PE resulted in significantly taller plants (122.9 cm) compared to irrigation levels at 100% PE, 125% PE and conventional irrigation at IW/CPE =1.25 (Table 1). Similarly, a significant number of tillers was recorded with irrigation at 150% PE over the other two irrigation levels at 60 days after sowing (DAS). The number of productive tillers/$m^2$ was significantly higher with irrigation at 150% PE compared to irrigation levels at 100% PE, 125% PE and conventional irrigation. However, the 1000 - grain weight (g) did not differ significantly among the different irrigation levels. The above results on plant growth and yield attributes were by [7,10,11,12]. Among the nitrogen levels, application of 200 kg N $ha^{-1}$ resulted in taller plants over 100 kg N $ha^{-1}$ which in-turn was significant over 150 kg N $ha^{-1}$. A significant number of tillers/$m^2$ and productive tillers/$m^2$ were recorded with nitrogen level at 150 kg N $ha^{-1}$ over the other two nitrogen levels (Fig. 1). These results are akin to the findings of [13]. The interaction effect between the irrigation and nitrogen levels concerning growth and yield attributes by aerobic rice is not significant. Similar findings were reported by [14,15].

The grain yield (5069 kg $ha^{-1}$) of aerobic rice recorded with the irrigation at 150% PE was significantly higher than the other three irrigation levels *i.e.,* 100% PE, 125% PE and conventional irrigation. It was increased by 24 per cent with the 150% PE over 125% PE and 62 per cent over 100% PE respectively (Table 2). Comparatively lower grain yield under conventional irrigation condition with soil application of nutrients might be attributed to a decrease in the synthesis of metabolites and reduction in absorption and translocation of nutrients from soil to plant. The physiological response of plants by decreased cell division and cell elongation under moderate moisture stress at wider irrigation intervals might have also contributed to reduced grain yield [16]. The difference in straw yield due to different irrigation levels was also significant. This is in conformity with [17,18] in rice. Scheduling the irrigation through drip system at 150% PE resulted in 6, 10 and 66 per cent increase in water use efficiency (WUE) over 125% PE, 100% PE and conventional irrigation, respectively due to less water input in the former treatment. The net returns were also higher with the irrigation level of 150% PE (33607 Rs. $ha^{-1}$) compared to 125% PE which was again better than conventional irrigation. Increased yields of aerobic rice with increased frequency and input of water *i.e.,* at 1.2 IW/CPE ratio compared with microsprinkler irrigation were reported by [7,15]. Nitrogen doses applied through drip irrigation *i.e.,* fertigation differed among themselves concerning grain and straw yield of aerobic rice (Table 2 and Fig. 2). Application of 150 kg N $ha^{-1}$ significantly increased the grain (4146 kg $ha^{-1}$) and straw yield (5804 kg $ha^{-1}$) of aerobic rice over 100 kg N $ha^{-1}$ but at on par with 200 kg N $ha^{-1}$. Application of fertilizer nutrients through irrigation systems (fertigation) has been found to increase grain yield [19]. Similarly, 150 kg N $ha^{-1}$ resulted in an improvement of 3 and 13 per cent in WUE, over 200 and 100 kg N $ha^{-1}$, respectively. The net returns also increased by Rs. 2,180/- per ha at 150 kg N $ha^{-1}$ compared to 200 kg N $ha^{-1}$. Highest benefit - cost ratio was recorded at 150% PE on daily basis (1.88) and 150 kg N $ha^{-1}$ (1.53).

Combined effect of irrigation levels with nitrogen levels on yield, WUE, net returns and B:C ratio of aerobic rice under drip irrigation was presented in Table 3. The combined effect of irrigation at 150% PE with 150 kg N $ha^{-1}$ ($M_3S_2$) recorded significantly higher grain yield (5483 kg $ha^{-1}$), WUE (8.18 kg/ha mm), net returns (Rs. 39448 $ha^{-1}$) and B:C ratio (2.03), followed by irrigation at 150% PE with 200 kg N $ha^{-1}$ and irrigation at 125% PE with 150 kg N $ha^{-1}$. The lowest WUE was observed for the crop under conventional irrigation and with application of different nitrogen levels of 100, 150 and 200 kg N $ha^{-1}$ (4.37, 4.50 and 4.42 kg/ha.mm) (Fig. 3). The favourable effect of water and nutrients on crop growth and yield in drip irrigation and fertigation probably resulted in higher water use efficiency. Similar results were noticed by various researchers [20,21,22].

**Table 1. Influence of irrigation levels and nitrogen doses on growth and yield parameters of aerobic rice under drip irrigation**

| Treatment | Plant height at harvest (cm) | Tillers / $m^2$ at 60 DAS | Productive tillers / $m^2$ | 1000 - grain weight (g) |
|---|---|---|---|---|
| **Irrigation levels (M)** | | | | |
| $M_1$ - Irri. @ 100 % PE | 116.4 | 393 | 339 | 24.2 |
| $M_2$ - Irri. @ 125 % PE | 116.6 | 385 | 300 | 24.5 |
| $M_3$ - Irri. @ 150 % PE | 122.9 | 519 | 413 | 24.6 |
| $M_4$ - Con.irri. (IW/CPE =1.25) | 112.8 | 409 | 376 | 24.4 |
| SEd | 2.5 | 39 | 18 | 0.1 |
| CD at 5 % | 6.0 | NS | 40 | NS |
| **Nitrogen levels (S) (kg/ha)** | | | | |
| $S_1$ - 100 | 115.2 | 397 | 326 | 24.1 |
| $S_2$ - 150 | 117.7 | 469 | 394 | 24.7 |
| $S_3$ - 200 | 118.6 | 414 | 351 | 24.4 |
| SEd | 1.2 | 24 | 13 | 0.1 |
| CD at 5 % | 2.6 | NS | 27 | NS |

**Table 2. Yield, WUE, Net return and B:C ratio of aerobic rice as influenced by irrigation levels and nitrogen doses under drip irrigation**

| Treatment | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | WUE (kg/ha mm) | Net return ( Rs. $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| **Irrigation levels (M)** | | | | | |
| $M_1$ - Irri. @ 100% PE | 3137 | 4389 | 6.73 | 6213 | 1.16 |
| $M_2$ - Irri. @ 125% PE | 4076 | 5762 | 6.98 | 19549 | 1.51 |
| $M_3$ - Irri. @ 150% PE | 5069 | 7094 | 7.37 | 33607 | 1.88 |
| $M_4$ - Con.irri.(IW/CPE =1.25) | 3057 | 4910 | 4.43 | 11418 | 1.30 |
| SEd | 93 | 142 | | | |
| CD at 5% | 228 | 348 | | | |
| **Nitrogen levels (S) (kg/ha)** | | | | | |
| $S_1$ - 100 | 3667 | 5133 | 5.93 | 14342 | 1.38 |
| $S_2$ - 150 | 4146 | 5804 | 6.69 | 20464 | 1.53 |
| $S_3$ - 200 | 4028 | 5679 | 6.51 | 18284 | 1.47 |
| SEd | 62 | 86 | - | - | - |
| CD at 5% | 131 | 183 | - | - | - |
| Interaction | | | | | |
| SEd | 137 | 200 | - | - | - |
| CD at 5% | 312 | 458 | - | - | - |

**Table 3. Yield, WUE, Net return and B:C ratio of aerobic rice as influenced by combined effect of irrigation levels with nitrogen doses under drip irrigation**

| Treatment | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | WUE (kg/ha mm) | Net return ( Rs $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| $M_1S_1$ | 3289 | 4604 | 7.06 | 8984 | 1.24 |
| $M_1S_2$ | 3084 | 4319 | 6.61 | 5408 | 1.14 |
| $M_1S_3$ | 3037 | 4245 | 6.53 | 4246 | 1.11 |
| $M_2S_1$ | 3556 | 4976 | 6.17 | 12859 | 1.34 |
| $M_2S_2$ | 4447 | 6226 | 7.48 | 24767 | 1.65 |
| $M_2S_3$ | 4224 | 6083 | 7.30 | 21020 | 1.54 |
| $M_3S_1$ | 4367 | 6117 | 6.13 | 24240 | 1.64 |
| $M_3S_2$ | 5483 | 7659 | 8.18 | 39448 | 2.03 |
| $M_3S_3$ | 5356 | 7506 | 7.79 | 37134 | 1.96 |
| $M_4S_1$ | 3457 | 4834 | 4.37 | 11285 | 1.30 |
| $M_4S_2$ | 3570 | 5013 | 4.50 | 12234 | 1.31 |
| $M_4S_3$ | 3495 | 4884 | 4.42 | 10736 | 1.28 |

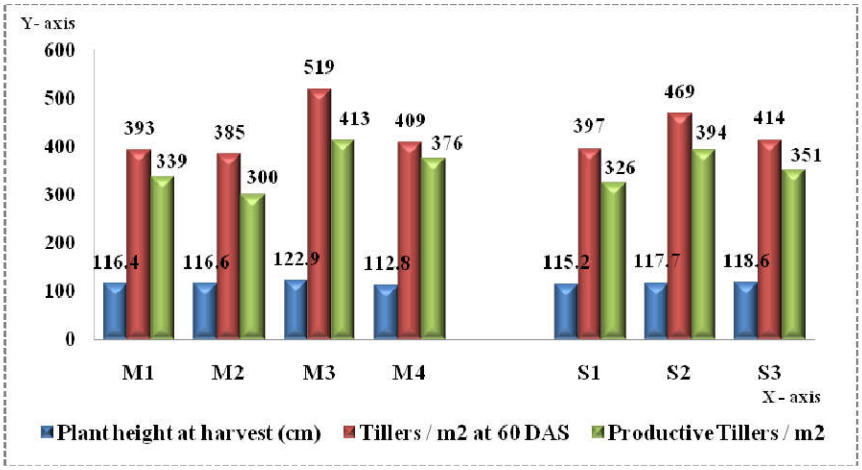


**Fig. 1. Influence of irrigation levels and nitrogen doses on plant height and tillers/m$^2$**

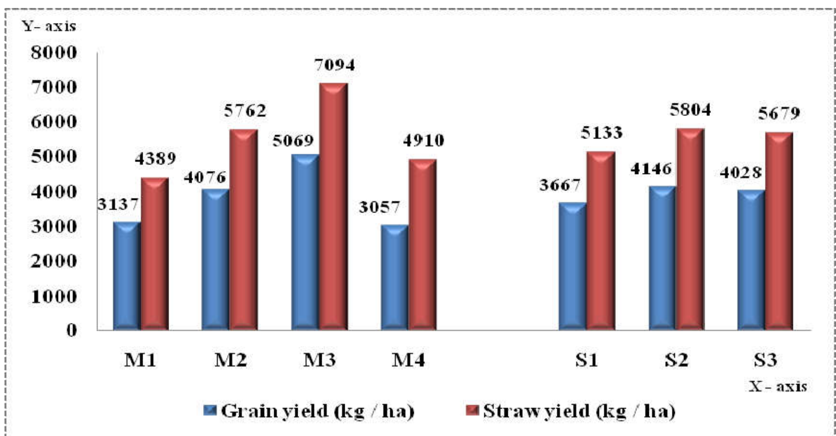


**Fig. 2. Grain and straw yield as influenced by levels of irrigation and fertigation**

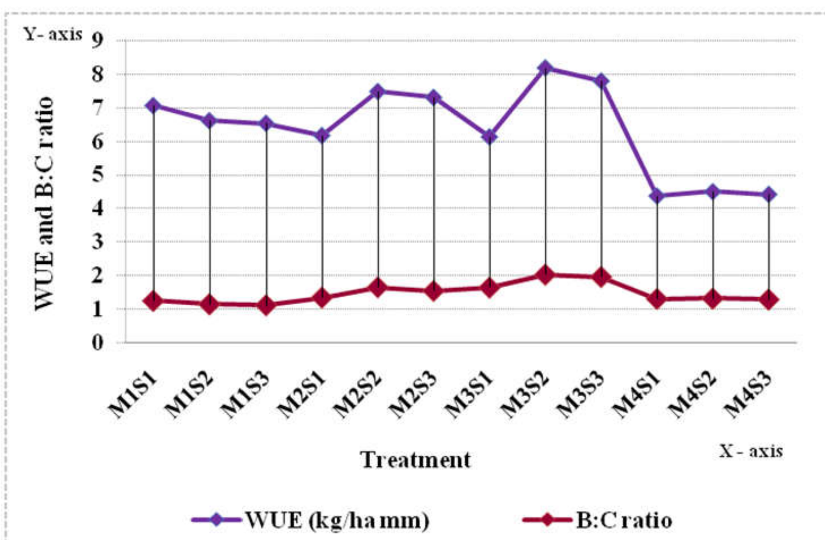


**Fig. 3. WUE and B:C ratio as influenced by combined effect of irrigation levels with nitrogen doses**

## 4. CONCLUSION

The results of this study revealed that in aerobic rice the drip fertigation at 150% daily pan evaporation and 150 kg N $ha^{-1}$ in weekly interval from 21 days after sowing for higher yield and economic returns in the western zone on Tamil Nadu. Comparatively lower grain yield under conventional irrigation condition with soil application of nutrients might be attributed to a decrease in the synthesis of metabolites and reduction in absorption and translocation of nutrients from soil to plant.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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