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Effect of drip irrigation and fertigation levels on physiological parameters and yield of aerobic rice

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Abstract

A Field experiment was conducted at Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during *rabi* season of 2019 to study about the changes in the physiological parameters of aerobic rice under different drip fertigation and irrigation levels. Thirteen treatments consists of 75% and 100 % pan evaporation (two irrigation levels) and 75%, 100% and 125% RDF (three fertigation levels), combination with fermented fish waste (FFW) and fermented egg product (FEP), surface irrigation treatment as a check were arranged in randomized block design and replicated thrice. The result showed that significantly higher leaf area index, SPAD values, crop growth rate, relative growth rate and yield during *rabi* season 2019 were observed in drip fertigation at 125% RDF, 100% PE with FFW (3 times) than all other treatments. Which was closely related with drip fertigation at 125% RDF, 100% PE with FEP (3 times). The lower grain yield and physiological parameters were noticed in drip fertigation at 75% RDF, 75% PE with FEP (3 times). This study concluded that drip fertigation at 125% RDF, 100% PE with FFW (3 times) suitable for getting higher physiological parameters and grain yield in aerobic rice.

Keywords: Aerobic rice, drip fertigation, fermented fish waste, fermented egg product, physiological parameters and yield

1. Introduction

Rice is the most predominant staple food, consumed by more than a half of the world's population. In Asia, rice security closely related with food security as 90% of rice is consumed in this region. In India the rice is being cultivated in 43.6 M ha with the production of 118.8 m.t and the average productivity is 2.72 t ha⁻¹. In Tamil Nadu rice is cultivated in an area of 1.90 M ha, production of 7.17 m t and the average productivity of 3.76 t ha⁻¹ (India stat, 2019-20) [8]. Conventional method rice cultivation involving wild flooding consumes more amount of water. Conventional method of irrigation, which not only consumes huge water, but also causes severe water and nutrient losses under anaerobic condition (Naik *et al.*, 2015) [11]. Aerobic rice is a production system in which aerobic rice varieties are grown in well drained, unsaturated and unpuddled soils. Drip fertigation is promising technologies have been proved to increase water and nutrient use efficiency of aerobic rice. The current study was planned to evaluate the effect of drip fertigation levels on physiological parameters and yield aerobic rice.

2. Materials and Methods

A field investigation was conducted during *rabi* season of 2019 at Wetland farms, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The farm is situated at 11°N latitude and 77°E longitude, at an altitude of 426.7 metres above mean sea level (MSL), in Tamil Nadu's western agro-climatic zone. Soil of the experimental field is *Typic Haplustalf* and belongs to the Noyyal series. The soil is clay loam in texture with the pH and EC of 8.1 and 0.41 dS m⁻¹, respectively. Organic carbon content of the soil was 0.70 %. Soil was low in available nitrogen (213.0 kg ha⁻¹), medium in available phosphorous (15.0 kg ha⁻¹) and available potassium (608.0 kg ha⁻¹).

During the aerobic rice grown season, the amount of rainfall received during the aerobic rice grown period was 461.5 mm. The rainfall was received in 28 rainy days. The mean maximum and minimum temperatures were 29.84 °C and 21.87 °C, respectively. The mean relative humidity in the morning and the afternoon was 86.26 per cent and 58.70 per cent, respectively.

The mean sunshine hours (5.81) and solar radiation (319.05 Cal cm⁻² min⁻¹). The experiment comprised of thirteen treatments i.e T₁: Drip fertigation at 75% RDF, 75% PE with FFW (3 times), T₂: DF @ 75% RDF, 75% PE with FEP (3 times), T₃: DF @ 100% RDF, 75% PE with FFW (3 times), T₄: DF @ 100% RDF, 75% PE with FEP (3 times), T₅: DF @ 125% RDF, 75% PE with FFW (3 times), T₆: DF @ 125% RDF, 75% PE with FEP (3 times), T₇: DF @ 75% RDF, 100% PE with FFW (3 times), T₈: DF @ 75% RDF, 100% PE with FEP (3 times), T₉: DF @ 100% RDF, 100% PE with FFW (3 times), T₁₀: DF @ 100% RDF, 100% PE with FEP (3 times), T₁₁: DF @ 125% RDF, 100% PE with FFW (3 times), T₁₂: DF @ 125% RDF, 100% PE with FEP (3 times), T₁₃: Surface irrigation with 100% RDF were evaluated in randomized block design (RBD), which were replicated thrice. Surface irrigation was scheduled based on IW/CPE ratio of 1.2 with manual method of fertilizer application. Recommended dose of fertilizer (RDF) viz., 150: 50: 50 NPK kg ha⁻¹ was adopted. Raised beds were formed with raised bed former the top bed width is 0.9 m and furrows with width of 0.3 m. Aerobic rice variety Anna (R) 4 taken as test variety with spacing of 20 cm x 10 cm. One lateral were laid out on the middle of the raised bed. Spacing between emitter to emitter on a laterals is 0.4 m with a discharge rate of 4 lph at 1 kg cm⁻². At the correct time plant protection and weed management practices were carried out. Physiological parameters and yield observations were recorded as per the standard methodology given below.

2.1. Crop growth rate (CGR)

Crop Growth Rate (CGR) is defined as the rate of increase in dry weight per unit land area per unit time. The mean crop growth rate was calculated as suggested by Enyi (1962)^[5] and expressed in g m⁻² d⁻¹. The time interval of dry weight of plant sample was taken once in 25 days from 35 DAS to harvest stage for aerobic rice were adopted.

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where,

CGR - Crop growth rate

W₁ and W₂ - Dry matter production per plant in 'g' at t₁ and t₂, respectively

P - Ground area covered by plant in m²

2.2. Relative Growth Rate (RGR) (g g⁻¹ d⁻¹)

Relative growth rate (RGR) is defined as the rate of growth per unit plant weight, which provides more informative comparison of the plants relative performance in a given environment. The mean relative growth rate was calculated as suggested by Enyi (1962)^[5] and expressed in g g⁻¹ d⁻¹.

$$\text{RGR} = \frac{\text{Loge } W_2 - \text{Loge } W_1}{(t_2 - t_1)}$$

Where,

W₂ and W₁ - natural logarithm of the total plant dry weight at time t₁ and t₂

t₂ - t₁ - time interval in days

L₁ and L₂ - leaf area of the plant at t₂ - t₁.

2.3. Leaf area index (LAI)

Leaf area index (LAI) is the ratio of leaf area to ground area.

Leaf length and breadth of the third leaf from the top was measured from five randomly selected plants during active tillering (AT), panicle initiation (PI) and flowering (F) stages. The number of leaves was also counted in the same sampling plants and LAI was calculated as suggested by Palaniswamy and Gomez (1974)^[12], using the formula as below:

$$\text{LAI} = \frac{L \times B \times K \times \text{Total numbers of green leaves hill}^{-1}}{\text{Spacing (cm}^2\text{)}}$$

Where,

L - Length of the third leaf from top (cm),

B - Breadth of the third leaf from top (cm), and

K - Constant (0.75).

2.4. Chlorophyll estimation

Chlorophyll content of leaves was recorded as described by Peng *et al.*, (1993)^[13] using the Chlorophyll meter (SPAD – 502, Soil Plant Analysis Development, Minolta Camera Co. Ltd., Japan). The readings were recorded on the upper most fully expanded leaves in five randomly chosen plants at AT, PI and flowering stages. The average values were worked out and expressed as chlorophyll index.

To evaluate the influence of drip irrigation and fertigation levels on physiological parameters and yield of aerobic rice, the data were statistically analysed. The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Gomez and Gomez, 1984)^[6].

3. Results and Discussion

3.1. Crop Growth Rate

Crop growth rate is photosynthetic efficiency of a plant, drip irrigation and fertigation levels significantly influenced the rate of rice crop growth at different stages (Table 1). At AT – PI stage significantly higher CGR was noticed in drip fertigation at 125% RDF, 100% PE with FFW (3 times) (7.96 g m⁻² day⁻¹) however it was closely related with drip fertigation at 125% RDF, 100% PE with FEP (3 times) (7.50 g m⁻² day⁻¹). The lower CGR was noticed under DF @ 75% RDF, 75% PE with FFW (3 times) (5.29 g m⁻² day⁻¹). At PI – Flowering stage significantly higher CGR at was reported in drip fertigation at 125% RDF, 100% PE with FEP (3 times) (25.93 g m⁻² day⁻¹) however it was closely associated with drip fertigation at 125% RDF, 100% PE with FFW (3 times) (25.43 g m⁻² day⁻¹). The lower CGR was noticed under DF @ 75% RDF, 75% PE with FFW (3 times) (17.84 g m⁻² day⁻¹). The higher CGR in drip fertigation was might be due to higher dry matter accumulation at different rice growth stages due to favorable water and nutrient environment during the crop growth stages. These findings are similar with results reported by Anusha *et al.* (2015)^[1], Kombali *et al.* (2017)^[10] and Karthika and Ramanathan (2019)^[9].

3.2. Relative growth rate

RGR measures the increase in dry matter with a given amount of assimilatory material at a given point of time (Table 1). Among drip irrigation DF @ 100% RDF, 75% PE with FFW (3 times) recorded higher RGR (0.0210 g g⁻¹ d⁻¹), which were comparable with 125% RDF, 100% PE with FEP (3 times) (0.0190 g g⁻¹ d⁻¹). The lower CGR was reported under DF @ 125% RDF, 75% PE with FEP (3 times) (0.0157 g g⁻¹ d⁻¹) The reason for increased RGR might be due to frequent application of irrigation and water soluble fertilizers through drip fertigation which favours good aeration at root zone depth of rice with adequate moisture content leads to

sufficient amount of nutrients that did not fluctuate between dry and wet extremes favours optimum growth. Similar results were reported by Badr *et al.*, 2010 [2].

Table 1: Effect of drip irrigation and fertigation levels on CGR and RGR in aerobic rice during *rabi* 2019-20

| Treatments | CGR (g m ⁻² day ⁻¹) | | RGR (g g ⁻¹ d ⁻¹) | |
|---|--|--------|--|--------|
| | AT - PI | PI - F | AT - PI | PI - F |
| T ₁ : DF @ 75% RDF, 75% PE with FFW (3 times) | 5.62 | 18.28 | 0.0210 | 0.0338 |
| T ₂ : DF @ 75% RDF, 75% PE with FEP (3 times) | 5.29 | 17.84 | 0.0206 | 0.0344 |
| T ₃ : DF @ 100% RDF, 75% PE with FFW (3 times) | 6.14 | 19.58 | 0.0210 | 0.0334 |
| T ₄ : DF @ 100% RDF, 75% PE with FEP (3 times) | 5.87 | 19.21 | 0.0210 | 0.0339 |
| T ₅ : DF @ 125% RDF, 75% PE with FFW (3 times) | 6.32 | 22.82 | 0.0180 | 0.0341 |
| T ₆ : DF @ 125% RDF, 75% PE with FEP (3 times) | 5.47 | 22.18 | 0.0157 | 0.0336 |
| T ₇ : DF @ 75% RDF, 100% PE with FFW (3 times) | 6.02 | 21.88 | 0.0185 | 0.0342 |
| T ₈ : DF @ 75% RDF, 100% PE with FEP (3 times) | 5.55 | 21.26 | 0.0178 | 0.0350 |
| T ₉ : DF @ 100% RDF, 100% PE with FFW (3 times) | 6.42 | 24.15 | 0.0162 | 0.0325 |
| T ₁₀ : DF @ 100% RDF, 100% PE with FEP (3 times) | 6.53 | 22.79 | 0.0171 | 0.0316 |
| T ₁₁ : DF @ 125% RDF, 100% PE with FFW (3 times) | 7.96 | 25.43 | 0.0189 | 0.0315 |
| T ₁₂ : DF @ 125% RDF, 100% PE with FEP (3 times) | 7.50 | 25.93 | 0.0190 | 0.0331 |
| T ₁₃ : Surface irrigation with 100% RDF | 6.16 | 23.14 | 0.0213 | 0.0375 |
| SEd. | 0.56 | 1.21 | 0.0011 | 0.0018 |
| CD (5%) | 1.16 | 2.49 | 0.0024 | NS |

3.3. Leaf area index (LAI)

Higher LAI was observed under DF @ 125% RDF, 100% PE with FFW (3 times) (6.21) which were closely related with DF @ 125% RDF, 100% PE with FEP (3 times) (5.70) given in Table 2. Lower LAI was noticed under DF @ 75% RDF, 75% PE with FEP (3 times) (2.52). The photosynthetic activity of plant depends upon leaf area. In the present investigation, the LAI was increased with increase of water and nutrient supply throughout the crop growing period which favours the better translocation of photosynthates. This could be due to production of higher number of leaves with increase in leaf area which was in similar with the findings of Vanitha and Mohandass (2014) [14]. The increased LAI because of increased functional leaf area and delayed leaf senescence by production of phytohormones that increased cell division and elongation (Elankavi *et al.*, 2009) [4].

3.4. Chlorophyll estimation (SPAD - 502)

Significantly higher SPAD meter value (Table 2) was observed under drip fertigation at 125% RDF, 100% PE with FFW (3 times) (39.5) which were comparable with drip

fertigation at 125% RDF, 100% PE with FEP (3 times) (38.9) and DF @ 100% RDF, 100% PE with FFW (3 times) (38.2). Lower SPAD meter value was noticed under drip fertigation at 75% RDF, 75% PE with FEP (3 times) (31.9). Leaf nitrogen content and greenness of leaf are often positively related (Cabrera, 2004) [3].

3.5. Grain yield

The drip fertigation had profound effect on the grain yield of aerobic rice (Table 2). Higher grain yields were recorded with drip fertigation at 125% RDF, 100% PE with FFW (3 times) (4504 kg ha⁻¹) which were comparable to drip fertigation at 125% RDF, 100% PE with FEP (3 times) (4383 kg ha⁻¹) and it was on par with DF @ 100% RDF, 100% PE with FFW (3 times) (4053 kg ha⁻¹). The grain yields were lower under drip fertigation at 75% RDF, 75% PE with FFW (3 times) (2647 kg ha⁻¹). The higher grain yield of aerobic rice might be associated with increase in growth and physiological parameters were observed under higher moisture and nutrient regime. These findings were in similar with results of Gupta *et al.*, (2003) [7].

Table 2: Effect of drip irrigation and fertigation levels on LAI, SPAD meter value and grain yield in aerobic rice during *rabi* 2019-20

| Treatments | Leaf area index | SPAD meter values | Grain yield (kg ha ⁻¹) |
|---|-----------------|-------------------|------------------------------------|
| T ₁ : DF @ 75% RDF, 75% PE with FFW (3 times) | 2.94 | 32.7 | 2783 |
| T ₂ : DF @ 75% RDF, 75% PE with FEP (3 times) | 2.52 | 31.9 | 2647 |
| T ₃ : DF @ 100% RDF, 75% PE with FFW (3 times) | 4.33 | 35.7 | 3101 |
| T ₄ : DF @ 100% RDF, 75% PE with FEP (3 times) | 4.77 | 34.9 | 3098 |
| T ₅ : DF @ 125% RDF, 75% PE with FFW (3 times) | 4.92 | 36.0 | 3534 |
| T ₆ : DF @ 125% RDF, 75% PE with FEP (3 times) | 4.97 | 35.8 | 3458 |
| T ₇ : DF @ 75% RDF, 100% PE with FFW (3 times) | 4.99 | 34.5 | 3205 |
| T ₈ : DF @ 75% RDF, 100% PE with FEP (3 times) | 3.92 | 35.2 | 3281 |
| T ₉ : DF @ 100% RDF, 100% PE with FFW (3 times) | 5.55 | 38.2 | 4053 |
| T ₁₀ : DF @ 100% RDF, 100% PE with FEP (3 times) | 5.57 | 37.4 | 3851 |
| T ₁₁ : DF @ 125% RDF, 100% PE with FFW (3 times) | 6.21 | 39.5 | 4504 |
| T ₁₂ : DF @ 125% RDF, 100% PE with FEP (3 times) | 5.70 | 38.9 | 4383 |
| T ₁₃ : Surface irrigation with 100% RDF | 3.30 | 36.2 | 3371 |
| SEd. | 0.79 | 1.13 | 173 |
| CD (5%) | 1.69 | 2.43 | 372 |

4. Conclusion

The field experimental results revealed that physiological parameters *viz.*, crop growth rate, relative growth rate, leaf and index and SPAD meter values were positively correlated

with different drip irrigation and fertigation levels and higher grain yield was reported in drip fertigation at 125% RDF, 100% PE with FFW (3 times) which was on a par with drip irrigation at 100% RDF, 100% PE with FFW (3 times) in

aerobic rice.

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