The Pharma Innovation Journal 2021; 10(11): 876-880

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 876-880
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www.thepharmajournal.com
Received: 19-07-2021
Accepted: 05-08-2021

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# Effect of irrigation regimes and nitrogen levels on weed dynamics in aerobic rice under drip irrigation in Southern - Agroclimatic Zone of Andhra Pradesh

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## Abstract
A field study was conducted during two consecutive *rabi* seasons of 2019-20 and 2020-21 to study the influence of irrigation regimes and nitrogen levels on weed growth in aerobic rice under drip irrigation. The major weed flora observed in the field were *Cyperus rotundus, Celosia argentea, Dactyloctenium aegyptium, Digitaria sanguinalis, Euphorbia hirta* and *Lantana camara*. Weed density was significantly influenced by nitrogen levels at all the stages of crop, but by irrigation regimes at 60 DAS during both years of study and at 90 DAS during second year. Significantly higher weed density was observed with the nitrogen dose of 180 kg N $ha^{-1}$ ($N_4$) and the lower value was recorded with 90 kg N $ha^{-1}$ ($N_1$). Irrigation regime of 2.0 Epan ($I_4$) recorded significantly higher weed density over lowest irrigation regime of 1.25 Epan, but was comparable with 1.75 Epan and 1.5 Epan, at different stages wherever significant variation due to irrigation regimes was observed. Weed dry weight was non-significant with respect to irrigation regimes at 30 and 90 DAS, but was significantly influenced at 60 DAS during first year of study and in the pooled mean where drip irrigation regime of 1.5 Epan recorded significantly higher weed dry weight over lowest irrigation regime of 1.25 Epan, but was at par with remaining irrigation regimes. Nitrogen doses significantly influenced weed dry weight at all the stages of crop with higher weed dry weight values at 180 kg N $ha^{-1}$ ($N_4$) and the lowest at 90 kg N $ha^{-1}$.

**Keywords:** Aerobic rice, drip, irrigation regimes, nitrogen levels, weed density, weed dry weight

## 1. Introduction
Rice is the staple food for more than half of the world population and is generally grown under puddled transplanted conditions. Conventional puddled transplanted rice consumes more than 2000 mm of water and is labour, water and energy intensive. Global water crisis threatens the sustainability of irrigated rice system due to reduced availability of water. Therefore, future production of rice to meet food needs of growing population has to be achieved using fewer resources such as land and water through more efficient production systems. In this direction, aerobic rice can drastically reduce water requirement and improve water use efficiency. Aerobic rice is grown under non-puddled, non-flooded and non-saturated soil conditions as other upland crops (Prasad, 2011) [6]. Growing aerobic rice with drip irrigation will meet water requirement of the crop as and when needed. Nitrogen fertilizer along with irrigation can increase crop yield greatly, however, response of nitrogen varies with the available soil moisture content. As the nitrogen use efficiency of crop varies with various irrigation regimes, dose of nitrogen should be standardized for different irrigation regimes to achieve optimum yield. Weeds pose a major threat to the success of aerobic rice (Kumar and Ladha, 2011) [4]. Weed infestation is a serious biological constraint limiting rice yields. Out of the total 40% yield loss in rice caused by various pests, weeds create nearly 10% of the yield loss, which under directed seeded rice may go up to 32%. Weed flora are diverse and abundant in direct seeded rice compared to transplanted rice, and the simultaneous emergence of weeds along with plants in the former one makes weed control difficult. Hot and humid conditions of tropical Asia are favourable for year-round growth of all weed species, with large number of flushes during the entire crop period.

Weeds are dynamic and their composition varies with moisture regime. Soil moisture status after planting influences weed flora to a larger extent (Drost and Moody, 1982) [2]. Weed seed germination, emergence, population, growth, maturity duration and seed production are strongly influenced by water management. After early establishment, micro-irrigation, especially surface or sub-surface drip irrigation systems may help in reducing the weed menace in aerobic rice to a great extent. Nitrogen is the most important nutrient that has decisive effect on the competitive balance between rice and weeds (Mahajan and Timsina, 2011) [5]. The variable response of weeds to applied nutrients shows that fertilizers influence crop-weed interaction. Manipulation of crop fertilization is an important agronomic practice that can be used in weed management. However, the effect of fertilization, especially nitrogen, on weed interference with crop growth is not fully understood, especially in the newly emerged direct seeded rice systems. As soil moisture regimes and nitrogen levels have significant influence on weeds, the present study was proposed to know the influence of drip irrigation regimes and nitrogen levels on weed dynamics in aerobic rice.

## 2. Material and Methods

The experiment was conducted during two consecutive *Rabi* seasons of 2019-20 and 2020-21 at wetland farm of S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. Soil of the experimental field was analysed using standard procedures. The soil was sandy clay loam with slightly alkaline pH, low in organic carbon and available nitrogen and high in available potassium during both years of study. Whereas, available phosphorus was low in first year, but it was high during second year. Field experiment was laid out in split plot design with three replications. Treatments consisted of four irrigation schedules ($I_1$: Irrigation at 1.25 Epan, $I_2$: Irrigation at 1.50 Epan, $I_3$: Irrigation at 1.75 Epan and $I_4$: Irrigation at 2.0 Epan) as main plot treatments and four nitrogen levels ($N_1$: 75 % RDN (90 kg N $ha^{-1}$), $N_2$: 100 % RDN (120 kg N $ha^{-1}$), $N_3$: 125 % RDN (150 kg N $ha^{-1}$) and 150 % RDN (180 kg N $ha^{-1}$)) as sub plot treatments. The land was prepared by ploughing with mould board plough followed by disc harrow, passing cultivator twice and then Rotavator to bring the soil to fine tilth and land was levelled. The plot size was 6.0 m × 4.0 m (24 $m^2$). Drip irrigation system included pump, filter unit, water meter, control valves, pressure gauge, mains, sub mains and laterals. Laterals were placed 60 cm apart covering 3 crop rows between two lateral lines. Emitters were in-line, placed 40 cm apart with a discharge rate of 4 lph. Healthy and viable seeds of NLR-34449 rice variety were sown by hand dibbling at the rate of two seeds per hill by maintaining spacing of 20 cm × 10 cm. Two uniform irrigations were given to all the treatments during the first 20 days of crop period for proper germination and establishment of crop. Drip irrigation was given on every alternate day based on pan evaporation (Epan) data according to the treatment requirements. Quantified water was supplied by measuring with water meter. The recommended dose of fertilizer was 120:60:40 kg NPK $ha^{-1}$. At the time of sowing, full quantity of phosphorus as SSP along with half dose of potassium as MOP were applied as basal. In addition, $ZnSO_4$ and $FeSO_4$ @ 25kg $ha^{-1}$ were applied before sowing. Nitrogen fertilizer dose in different treatments was applied in three equal splits at 15 DAS, tillering and panicle initiation stages.

Weed management was done through pre-emergence application of pendimethalin 30% EC @ 2.5 litre $ha^{-1}$ along with two hand weeding's at 20 and 40 DAS. An area of one square metre was marked in each plot randomly for recording the observation on weed density and the data was statistically analysed after subjecting these values to square root transformation. The weeds collected from 0.25 $m^2$ area, outside the net plot were dried under shade for 24 hours, followed by oven drying at 60ºC to a constant weight and the dry matter production was expressed as g $m^{-2}$. The dry matter production of weeds was recorded at 30, 60 and 90 DAS.

## 3. Results and discussion

### 3.1 Effect of drip irrigation regimes and nitrogen levels on weed density

Weed density of aerobic rice as influenced by different irrigation regimes and nitrogen levels at different growth stages during both years of study and in the pooled mean is presented in the Table 1.

### 3.2 Weed density at 30 DAS

Irrigation regimes did not show any significant influence on weed density at 30 DAS which might be due to uniform supply of irrigation during initial 20 days crop period. However, higher weed density was noticed with drip irrigation regime of 2.0 Epan ($I_4$) and the lowest value was recorded with 1.25 Epan ($I_1$). During both years of study and in the pooled mean, higher weed density was noticed with the nitrogen application of 180 kg N $ha^{-1}$ ($N_4$) followed by 150, 120 and 90 kg N $ha^{-1}$ in the order of descent with significant disparity between any two of the four nitrogen doses. Whereas, the lowest weed density was observed with 90 kg N $ha^{-1}$ ($N_1$). Interaction effect between irrigation regimes and nitrogen levels was found to be non-significant on weed density at 30 DAS, during both years of study and in the pooled mean.

### 3.2.1 Weed density at 60 DAS

Weed density was significantly influenced by various irrigation regimes and nitrogen levels as well as their interaction at 60 DAS in aerobic rice, during both years of study and in the pooled mean. With regard to irrigation regimes, the higher weed density was registered with scheduling drip irrigation at 2.0 Epan ($I_4$), which was however comparable with 1.75 Epan ($I_3$) and 1.5 Epan ($I_2$), and all these treatments were significantly superior to 1.25 Epan ($I_1$) during both years of study and in the pooled mean. Whereas, the lowest weed density was observed with 1.25 Epan ($I_1$). With respect to nitrogen levels, significantly higher weed density was observed with 180 kg N $ha^{-1}$ ($N_4$), followed by 150 kg N $ha^{-1}$ ($N_3$), 120 kg N $ha^{-1}$ ($N_2$) and 90 kg N $ha^{-1}$ ($N_1$) in the order of descent, with significant disparity between each other during both years of study and in the pooled mean, except the variation between 180 kg N $ha^{-1}$ ($N_4$) and 150 kg N $ha^{-1}$ ($N_3$) was non-significant during first year of study. Whereas, the lowest weed density was recorded with 90 kg N $ha^{-1}$ ($N_1$).

During both years of study, interaction of irrigation regimes and nitrogen levels exerted significant influence on weed density in aerobic rice (Table 2). At any irrigation regime, increase in nitrogen dose resulted in increased weed density, except with scheduling drip irrigation at 1.25 Epan ($I_1$), where the increase in weed density was observed only up to 120 kg N $ha^{-1}$ ($N_2$), thereafter there was a decline. At higher nitrogen levels (150 kg and 180 kg N $ha^{-1}$), with increase in irrigation regime there was an increase in weed density, whereas at lower nitrogen levels, the increase in weed density was observed only up to 1.5 Epan ($I_2$) at 90 kg N $ha^{-1}$ ($N_1$) and was up to 1.5 Epan ($I_2$) at 120 kg N $ha^{-1}$ ($N_2$), thereafter there was a decline. Among the different interaction combinations, higher weed density was recorded with drip irrigation regime of 2.0 Epan in combination with 180 kg N $ha^{-1}$, which was however comparable with $I_3N_4$ and $I_4N_3$ during both years of study and in the pooled mean.

**3.2.2 Weed density at 90 DAS**

During the first year of study and in the pooled mean, weed density was not significantly influenced by irrigation regimes, however higher weed density was recorded with scheduling drip irrigation at 2.0 Epan ($I_4$) followed by 1.75 Epan ($I_3$), 1.5 Epan ($I_2$) and 1.25 Epan ($I_1$) in the order of descent. Whereas during the second year of study, higher weed density was registered with drip irrigation schedule of 2.0 Epan ($I_4$), which was however comparable with 1.75 Epan ($I_3$) and 1.5 Epan ($I_2$) and these three irrigation regimes recorded significantly higher weed density than 1.25 Epan ($I_1$), which recorded the lowest weed density. In both years of study and in the pooled mean, higher weed density was observed with 180 kg N $ha^{-1}$ ($N_4$), which was however comparable with 150 ($N_3$) and 120 kg N $ha^{-1}$ ($N_2$). The above three nitrogen doses recorded significantly higher weed density than the lower dose of 90 kg N $ha^{-1}$ ($N_1$), during second year of study and in the pooled mean, but were comparable during 2019-20. During both years of study and in the pooled mean, interaction of irrigation and nitrogen levels has not exerted significant influence on weed density in aerobic rice.

At different stages of aerobic rice, irrigation regimes, nitrogen levels and their interaction varied the weed density values in an unaltered trend but with varied statistical differences between the treatments. Increase in irrigation regimes from 1.25 Epan ($I_1$) to 2.0 Epan ($I_4$) resulted in an increase in weed density. Higher weed density was observed with scheduling drip irrigation at 2.0 Epan ($I_4$) which was however comparable with 1.75 Epan ($I_3$) and 1.5 Epan ($I_2$) and significantly superior to lowest irrigation regime of 1.25 Epan ($I_1$). More weed density at higher irrigation regimes might be due to availability of adequate soil moisture which is a pre-requisite for weed seed germination. Vairavan *et al*. (1999) [11] also reported similar result in relation to influence of irrigation regimes on weed density. In response to nitrogen levels, increase in nitrogen dose from 90 to 180 kg N $ha^{-1}$ resulted in an increase in weed density. Surface fertilizer applications favour the weed seeds lying on the surface or upper soil layer. More weed density was observed at higher nitrogen levels as nitrate nitrogen status in soil influences germination of weed seeds greatly. Sharma *et al*. (2007) [8] and Singh and Tripathi (2007) [9] also reported increase in weed density with increase in nitrogen levels. Studies conducted with synthetic N fertilizers revealed that they can increase both the rate and the total amount of weed germination and may promote weed growth more than crop growth (Ditomaso, 2015) [1].

With regard to interaction, higher weed density was observed with scheduling drip irrigation at 2.0 Epan in combination with 180 kg N $ha^{-1}$ ($I_4N_4$) which might be due to adequate availability of both moisture and nitrogen which are the important factors affecting weed seed germination. Whereas, the lowest weed density was noticed with drip irrigation schedule of 1.25 Epan in combination with 90 kg N $ha^{-1}$ ($I_1N_1$) due to inadequate availability of moisture and nutrients.

**3.3.3 Weed dry weight**

Weed dry weight in aerobic rice as influenced by different irrigation regimes and nitrogen levels, and their interaction at different stages during both years of study and in the pooled mean is presented in the Table 3.

**3.2.4 Weed dry weight at 30 DAS**

Weed dry weight at 30 DAS was not significantly influenced by various irrigation regimes because of uniform irrigation during initial crop period for proper establishment. However, higher value of weed dry weight was observed with drip irrigation schedule of 2.0 Epan ($I_4$) followed by 1.75 Epan ($I_3$), 1.5 Epan ($I_2$) and 1.25 Epan ($I_1$) in the order of descent during both years of study and in the pooled mean. Among the different nitrogen levels tested, significantly higher weed dry weight was noticed with 180 kg N $ha^{-1}$ ($N_4$) followed by 150 ($N_3$), 120 ($N_2$) and 90 kg N $ha^{-1}$ ($N_1$) in the order of descent with significant disparity between any two of the four nitrogen levels tested during both years of study and in the pooled mean. Interaction effect between irrigation regimes and nitrogen levels was non-significant in influencing weed dry weight at 30 DAS.

**3.2.5 Weed dry weight at 60 DAS**

At 60 DAS, weed dry weight was significantly influenced by irrigation regimes only during the first year of study and in the pooled mean. Among the different irrigation regimes, the higher weed dry weight was registered with scheduling drip irrigation at 1.5 Epan ($I_2$), which was however comparable with 1.75 Epan ($I_3$) and 2.0 Epan ($I_4$), and these treatments recorded significantly higher weed dry weight than irrigation regime of 1.25 Epan ($I_1$) which recorded the lowest weed dry weight. In both years of study and in the pooled mean, significantly higher weed dry weight was observed with 180 kg N $ha^{-1}$ ($N_4$) followed by 150 ($N_3$) and 120 kg N $ha^{-1}$ ($N_2$), which were comparable and significantly higher than 90 kg N $ha^{-1}$ ($N_1$) in recording weed dry weight. During both years of study, interaction effect of irrigation regimes and nitrogen levels on weed dry weight of aerobic rice was found to be non-significant.

**3.2.6 Weed dry weight at 90 DAS**

Weed dry weight of aerobic rice at 90 DAS was not significantly influenced by irrigation regimes during both years of study and in the pooled mean. However, higher weed dry weight was observed with 1.5 Epan ($I_2$) followed by 1.75 Epan ($I_3$), 2.0 Epan and 1.25 Epan ($I_4$) in the order of descent during both years of study and in the pooled mean. In both years of study and in the pooled mean, significantly higher weed dry weight was observed with 180 kg N $ha^{-1}$ ($N_4$) followed by 150 ($N_3$) and 120 kg N $ha^{-1}$ ($N_2$) which were comparable and significantly higher than 90 kg N $ha^{-1}$ ($N_1$) in recording weed dry weight. During both years of study and in the pooled mean, interaction between irrigation regimes and nitrogen levels on weed dry weight of aerobic rice was found to be non-significant.

Weed dry weight at 30 DAS was significantly influenced by nitrogen levels. Higher weed dry weight was observed with 180 kg N $ha^{-1}$ followed by lower levels in the order of descent with significant difference between any two levels. Variation in resource acquisition and dry matter accumulation by a plant is an outcome of interplant competition (Hakansson, 2003). Although fertilization is capable of improving weed competitiveness, weeds, being nutriphilic, usually use more fractions of applied nutrients so that, fertilization definitely favours weed growth to a level that can diminish the crop stand (Raun and Johnson, 1999). Mahajan and Timsina (2011) [5] observed reduced nitrogen-use efficiency and increased weed growth with application of nitrogen over 150 kg N ha$^{-1}$. This infers that aerobic rice suffers additional weed pressure on relatively fertile soils or where intensive fertilization is a common practice. Such a situation makes it imperative to rationalize the use of fertilizer to sustain aerobic rice productivity while avoiding weed competition.

At 60 DAS, higher weed dry weight was registered with 1.5 Epan ($I_2$), which was however comparable with 1.75 Epan ($I_3$) and 2.0 Epan ($I_4$) and significantly higher than irrigation regime of 1.25 Epan ($I_2$). This might be due to higher weed growth because of poor competition from crop in case of 1.5 Epan ($I_2$) irrigation regime, whereas at higher irrigation regimes ($I_3$ and $I_4$) sufficient availability of soil moisture might have increased weed growth, even though the crop has smothering effect on weeds because of luxurious growth. Whereas, the lowest weed dry weight in case of 1.25 Epan ($I_1$) was due to inadequate availability of moisture which might have affected photosynthesis and other physiological processes in weeds leading to lower dry matter accumulation.

At 60 and 90 DAS, higher weed dry weight was noticed with 180 kg N ha$^{-1}$ ($N_4$) which was however comparable with 150 ($N_3$) and 120 kg N ha$^{-1}$ ($N_2$) and significantly superior to 90 kg N ha$^{-1}$ ($N_1$). More weed dry weight at higher nitrogen levels was attributed to greater nitrogen uptake by weeds, as they are more benefitted from addition of N fertilizer because of efficient nutrient usage. Whereas at 120 kg N ha$^{-1}$ ($N_2$), poor competition from the crop because of moderate supply of nitrogen resulted in higher weed growth. lowest weed dry weight at 90 kg N ha$^{-1}$ was due to inadequate availability of nitrogen for weed growth. Subramanian *et al.* (2005) [10] and Sharma *et al.* (2007) [8] also reported similar results of increase in weed dry weight with higher nitrogen levels.

**Table 1:** Effect of drip irrigation regimes and nitrogen levels on weed density at different stages in aerobic rice

| Treatments | 30 DAS | | | 60 DAS | | | 90 DAS | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation regimes (I)** | | | | | | | | | |
| $I_1$: Irrigation at 1.25 Epan | 5.26 (27.42) | 5.89 (34.58) | 5.58 (31.00) | 5.06 (25.17) | 5.66 (31.61) | 5.36 (28.39) | 6.49 (41.83) | 7.39 (54.26) | 6.94 (48.05) |
| $I_2$: Irrigation at 1.50 Epan | 5.34 (28.25) | 6.02 (36.14) | 5.68 (32.20) | 5.72 (32.42) | 6.46 (41.58) | 6.09 (37.00) | 6.76 (45.33) | 7.74 (59.54) | 7.25 (52.44) |
| $I_3$: Irrigation at 1.75 Epan | 5.38 (28.75) | 6.07 (36.74) | 5.72 (32.74) | 5.75 (32.92) | 6.49 (42.09) | 6.12 (37.50) | 6.79 (45.67) | 7.77 (59.90) | 7.28 (52.79) |
| $I_4$: Irrigation at 2.00 Epan | 5.40 (29.11) | 6.08 (36.97) | 5.74 (33.04) | 5.77 (33.25) | 6.53 (42.60) | 6.15 (37.93) | 6.80 (45.83) | 7.78 (60.08) | 7.29 (52.96) |
| SEm± | 0.064 (0.712) | 0.068 (0.83) | 0.065 (0.764) | 0.068 (0.760) | 0.075 (0.941) | 0.067 (0.798) | 0.095 (1.261) | 0.082 (1.244) | 0.087 (1.221) |
| CD | NS | NS | NS | 0.23 (2.63) | 0.26 (3.26) | 0.23 (2.76) | NS | 0.28 (4.31) | NS |
| **Nitrogen levels (N)** | | | | | | | | | |
| $N_1$: 75% RDN (90 kg N ha$^{-1}$) | 4.55 (20.25) | 5.11 (25.74) | 4.83 (22.99) | 4.91 (23.67) | 5.49 (29.65) | 5.20 (26.66) | 6.47 (41.42) | 7.37 (54.01) | 6.92 (47.71) |
| $N_2$: 100% RDN (120 kg N ha$^{-1}$) | 5.24 (27.00) | 5.93 (34.70) | 5.58 (30.85) | 5.56 (30.50) | 6.29 (39.13) | 5.93 (34.81) | 6.70 (44.50) | 7.67 (58.42) | 7.19 (51.46) |
| $N_3$: 125% RDN (150 kg N ha$^{-1}$) | 5.67 (31.69) | 6.36 (40.05) | 6.02 (35.87) | 5.86 (34.00) | 6.60 (43.26) | 6.23 (38.63) | 6.80 (45.83) | 7.78 (60.07) | 7.29 (52.95) |
| $N_4$: 150% RDN (180 kg N ha$^{-1}$) | 5.92 (34.58) | 6.66 (43.94) | 6.29 (39.26) | 5.98 (35.58) | 6.77 (45.84) | 6.37 (40.71) | 6.88 (46.92) | 7.85 (61.28) | 7.36 (54.10) |
| SEm± | 0.070 (0.760) | 0.082 (0.99) | 0.075 (0.865) | 0.059 (0.668) | 0.065 (0.826) | 0.056 (0.684) | 0.095 (1.244) | 0.091 (1.396) | 0.090 (1.276) |
| CD | 0.21 (2.22) | 0.24 (2.89) | 0.22 (2.52) | 0.17 (1.95) | 0.19 (2.41) | 0.16 (2.00) | 0.28 (3.63) | 0.27 (4.07) | 0.26 (3.72) |
| **N at I** | | | | | | | | | |
| SEm± | 0.141 (1.520) | 0.163 (1.977) | 0.150 (2.552) | 0.118 (1.337) | 0.130 (1.651) | 0.113 (1.368) | 0.189 (2.489) | 0.183 (2.791) | 0.180 (2.552) |
| CD | NS | NS | NS | 0.34 (3.90) | 0.38 (4.82) | 0.33 (3.99) | NS | NS | NS |
| **I at N** | | | | | | | | | |
| SEm± | 0.138 (1.496) | 0.157 (1.904) | 0.146 (2.525) | 0.123 (1.385) | 0.135 (1.712) | 0.118 (1.428) | 0.189 (2.497) | 0.178 (2.719) | 0.178 (2.525) |
| CD | NS | NS | NS | 0.28 (3.17) | 0.31 (3.92) | 0.27 (3.27) | NS | NS | NS |

*Data was subjected to square root transformation ($\sqrt{X+0.5}$). Figures in parenthesis are original values.

**Table 2:** Interaction effect of drip irrigation regimes and nitrogen levels on weed density at 60 DAS in aerobic rice

| Treatments | 2019-20 | | | | | 2020-21 | | | | | Pooled | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean (N) | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean (N) | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean (N) |
| $N_1$ | 4.78 (22.33) | 5.05 (25.00) | 4.98 (24.33) | 4.84 (23.00) | 4.91 (23.67) | 5.34 (28.10) | 5.65 (31.50) | 5.54 (30.22) | 5.41 (28.80) | 5.49 (29.65) | 5.06 (25.22) | 5.35 (28.25) | 5.26 (27.27) | 5.13 (25.90) | 5.20 (26.66) |
| $N_2$ | 5.34 (28.00) | 5.61 (31.00) | 5.67 (31.67) | 5.64 (31.33) | 5.56 (30.50) | 6.00 (35.53) | 6.36 (39.97) | 6.42 (40.67) | 6.39 (40.33) | 6.29 (39.13) | 5.67 (31.77) | 5.98 (35.49) | 6.04 (36.17) | 6.01 (35.83) | 5.93 (34.81) |
| $N_3$ | 5.18 (26.33) | 5.99 (35.33) | 6.06 (36.33) | 6.20 (38.00) | 5.86 (34.00) | 5.77 (32.85) | 6.76 (45.24) | 6.82 (46.17) | 7.04 (48.77) | 6.60 (43.26) | 5.47 (29.59) | 6.37 (40.29) | 6.44 (41.25) | 6.62 (43.39) | 6.23 (38.63) |
| $N_4$ | 4.95 (24.00) | 6.23 (38.33) | 6.31 (39.33) | 6.41 (40.67) | 5.98 (35.58) | 5.51 (29.95) | 7.08 (49.61) | 7.19 (51.29) | 7.28 (52.49) | 6.77 (45.84) | 5.23 (26.98) | 6.65 (43.97) | 6.75 (45.31) | 6.85 (46.58) | 6.37 (40.71) |
| Mean (I) | 5.06 (25.17) | 5.72 (32.42) | 5.75 (32.92) | 5.77 (33.25) | | 5.66 (31.61) | 6.46 (41.58) | 6.49 (42.09) | 6.53 (42.60) | | 5.36 (28.39) | 6.09 (37.00) | 6.12 (37.50) | 6.15 (37.93) | |
| | SEm± | | | CD (P=0.05) | | SEm± | | | CD (P=0.05) | | SEm± | | | CD (P=0.05) | |
| I | 0.068(0.760) | | | 0.23(2.63) | | 0.075(0.941) | | | 0.26(3.26) | | 0.067(0.798) | | | 0.23(2.76) | |
| N | 0.059(0.668) | | | 0.17(1.95) | | 0.065(0.826) | | | 0.19(2.41) | | 0.056(0.684) | | | 0.16(2.00) | |
| N at I | 0.118(1.337) | | | 0.34(3.90) | | 0.130(1.651) | | | 0.38(4.82) | | 0.113(1.368) | | | 0.33(3.99) | |
| I at N | 0.123(1.385) | | | 0.28(3.17) | | 0.135(1.712) | | | 0.31(3.92) | | 0.118(1.428) | | | 0.27(3.27) | |

*Data was subjected to square root transformation ($\sqrt{X+0.5}$). Figures in parenthesis are original values.

**Table 3:** Effect of drip irrigation regimes and nitrogen levels on weed dry weight at different stages in aerobic rice

| Treatments | 30 DAS | | | 60 DAS | | | 90 DAS | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation regimes (I)** | | | | | | | | | |
| $I_1$: Irrigation at 1.25 Epan | 2.34 (5.09) | 2.62 (6.53) | 2.48 (5.81) | 3.47 (11.56) | 4.17 (17.06) | 3.82 (14.31) | 4.69 (21.61) | 5.29 (27.61) | 4.99 (24.61) |
| $I_2$: Irrigation at 1.50 Epan | 2.40 (5.40) | 2.69 (6.87) | 2.55 (6.14) | 3.68 (13.09) | 4.42 (19.29) | 4.05 (16.19) | 4.92 (23.73) | 5.53 (30.14) | 5.22 (26.94) |
| $I_3$: Irrigation at 1.75 Epan | 2.42 (5.50) | 2.72 (7.05) | 2.57 (6.27) | 3.66 (12.92) | 4.40 (19.06) | 4.03 (16.00) | 4.88 (23.40) | 5.50 (29.89) | 5.19 (26.65) |
| $I_4$: Irrigation at 2.00 Epan | 2.44 (5.60) | 2.73 (7.13) | 2.58 (6.36) | 3.63 (12.68) | 4.36 (18.73) | 3.99 (15.71) | 4.86 (23.17) | 5.47 (29.48) | 5.16 (26.32) |
| SEm± | 0.041 (0.198) | 0.043 (0.243) | 0.042 (0.22) | 0.037 (0.268) | 0.066 (0.616) | 0.046 (0.386) | 0.051 (0.482) | 0.054 (0.568) | 0.053 (0.524) |
| CD | NS | NS | NS | 0.13 (0.93) | NS | 0.16 (1.33) | NS | NS | NS |
| **Nitrogen levels (N)** | | | | | | | | | |
| $N_1$: 75% RDN (90 kg N $ha^{-1}$) | 1.87 (2.99) | 2.08 (3.83) | 1.97 (3.41) | 3.41 (11.19) | 4.09 (16.33) | 3.75 (13.76) | 4.65 (21.15) | 5.24 (27.01) | 4.94 (24.08) |
| $N_2$: 100% RDN (120 kg N $ha^{-1}$) | 2.37 (5.13) | 2.66 (6.58) | 2.51 (5.85) | 3.62 (12.64) | 4.38 (18.84) | 4.00 (15.74) | 4.87 (23.24) | 5.48 (29.58) | 5.17 (26.41) |
| $N_3$: 125% RDN (150 kg N $ha^{-1}$) | 2.60 (6.27) | 2.92 (8.04) | 2.76 (7.15) | 3.66 (12.92) | 4.40 (19.09) | 4.03 (16.00) | 4.88 (23.39) | 5.50 (29.85) | 5.19 (26.62) |
| $N_4$: 150% RDN (180 kg N $ha^{-1}$) | 2.77 (7.21) | 3.10 (9.12) | 2.94 (8.16) | 3.74 (13.52) | 4.48 (19.88) | 4.11 (16.70) | 4.96 (24.12) | 5.57 (30.69) | 5.26 (27.41) |
| SEm± | 0.030 (0.151) | 0.034 (0.192) | 0.032 (0.17) | 0.046 (0.329) | 0.061 (0.555) | 0.048 (0.399) | 0.068 (0.657) | 0.077 (0.833) | 0.073 (0.744) |
| CD | 0.09 (0.44) | 0.10 (0.56) | 0.09 (0.50) | 0.13 (0.96) | 0.18 (1.62) | 0.14 (1.17) | 0.20 (1.92) | 0.22 (2.43) | 0.21 (2.17) |
| **N at I** | | | | | | | | | |
| SEm± | 0.061 (0.302) | 0.069 (0.385) | 0.064 (0.340) | 0.092 (0.657) | 0.123 (1.109) | 0.097 (0.799) | 0.137 (1.313) | 0.154 (1.665) | 0.145 (1.488) |
| CD | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **I at N** | | | | | | | | | |
| SEm± | 0.067 (0.328) | 0.074 (0.413) | 0.070 (0.368) | 0.088 (0.629) | 0.125 (1.142) | 0.096 (0.792) | 0.129 (1.235) | 0.144 (1.550) | 0.136 (1.391) |
| CD | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*Data was subjected to square root transformation ($\sqrt{X+0.5}$). Figures in parenthesis are original values.

## 4. Conclusion
From the present study it can be concluded that nitrogen levels had significant influence on weed density and dry weight at all the stages of crop, but irrigation regimes had substantial effect only at 60 and 90 DAS on weed density and at 60 DAS on weed dry weight. Increase in the level of irrigation and nitrogen dose resulted in an increase in weed density and dry weight, except with respect to influence of irrigation regimes on weed dry weight where 1.5 Epan ($I_2$) recorded higher weed dry weight, but was comparable with 1.75 Epan ($I_3$) and 1.5 Epan ($I_4$).

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