Biological Forum – An International Journal 16(3): 202-208(2024)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluating the Impact of Different Irrigation Scheduling and Zinc Application Methods on Growth of Transplanted Summer Rice in Lateritic Soil of West Bengal

Rahul Kumar Gupta, Ruchi Bharti*, Kalipada Pramanik and Sk Naim Aktar
Department of Agronomy,
Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan (West Bengal), India.

(Corresponding author: Ruchi Bharti)*
(Received: 17 January 2024; Revised: 31 January 2024; Accepted: 23 February 2024; Published: 15 March 2024)
(Published by Research Trend)

ABSTRACT: The study was conducted during the *boro* seasons (February–May) of 2021 and 2022 at the Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, India. The experiment was carried out in split-plot design with twenty treatments combinations and three replications. The experiment involved four irrigations scheduling *viz*., I_1- irrigation of 5 cm when water level falls below 5 cm from soil surface in the perforated PVC water tube, I_2- irrigation of 5 cm at one day after disappearance of ponded water, I_3- irrigation of 5 cm at three days after disappearance of ponded water and I_4- irrigation of 5 cm at hair crack stage of the soil in main plot and treatments and five zinc application *viz*., Zn_0- control; Zn_1- 25 kg $ZnSO_4$, $7H_2O$ ha^{-1} as soil application; Zn_2- 0.5 % $ZnSO_4$, $7H_2O$ as foliar application at 15 and 45 DAT; Zn_3- 0.3 % $ZnSO_4$, $7H_2O$ as seed priming; and Zn_4- 0.5 % $ZnSO_4$, $7H_2O$ as nursery root dipping. The results showed that the application of irrigation of 5 cm at one day after disappearance of ponded water (I_2) and irrigation of 5 cm at three days after disappearance of ponded water (I_3) along with application of zinc through 0.3% $ZnSO_4$, $7H_2O$ as seed priming (Zn_3) registered higher plant height, leaf area index (LAI) and dry matter accumulation. Thus, I_2 or I_3 along with Zn_3 has best impact on growth parameters of transplanted summer rice in lateritic soil of West Bengal.

Keywords: Dry matter accumulation, irrigation, plant height, rice, zinc.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food crop in India, occupying an area of 43.82 million hectares with a production of 112.44 million tonnes. West Bengal contributes about 12.38% in area and 13.62% in production of India's total rice cultivation (Agricultural Statistics at a Glance, 2021). However, rice cultivation requires a large amount of water, which is becoming a limiting factor due to diminishing water resources (Dey *et al*., 2018). To address this issue, Alternate Wetting and Drying (AWD), a water-saving technology developed by the International Rice Research Institute, has been introduced (IRRI, 2009). This technology reduces water use by up to 30% and involves alternating periods of flooding and drying in the fields (Tuong *et al*., 2005; Bouman *et al*., 2007). One method of implementing AWD is by installing a perforated water tube, which monitors the water depth in the paddy field and helps to maintain alternate flooding or drying according to the depleting depth of ponded water (IRRI, 2013). Studies have shown that using a field water tube in AWD can save up to 25-35% of water without reducing rice yield (Kulkarni, 2011; Kishor *et al*., 2017). Zinc (Zn) is an essential element for several physiological processes in crops, including growth, metabolism, seed germination, and seedling development (Cakmak, 2008). However, rice grains have been reported to have very low Zn content compared to other cereals, which can result in adverse effects on seedling growth and development and grain yield (Slaton *et al*., 2001). Therefore, increasing seed Zn content prior to sowing has been found to significantly improve seed germination and seedling growth, especially when seeds are sown under Zn deficient soil (Ajouri *et al*., 2004). Agronomical Zn fertilization to cereal crops has been reported as a potential tool to improve seedling germination (Prom-u-thai and Rerkasem 2012) and productivity as well as grain Zn concentration (Phattarakul *et al*., 2016) that could benefit for human health upon eating (Nemeño 2010). Seed priming is a pre-sowing strategy that influences seedling development by modulating pre-germination metabolic activity prior to the emergence of the radicle. It has been found to increase the speed and synchrony of seed germination and improve seedling establishment and plant growth (Bradford, 1986; Taylor *et al*., 1998). Dipping of seedling root in fertilizer solution is considered a more convenient and feasible approach than foliar or soil application of plant nutrients (Yoshida *et al*., 1970; Katyal and Ponnamperuma 1974). Studies have shown that transplanting of nursery seedlings dipped in 1% w/v $ZnSO_4$ resulted in an increase in rice yield compared to foliar Zn application and control with no Zn application (Khan *et al*., 2003).

MATERIALS AND METHODS

Study location details. The experiment was carried out during *boro* seasons (February–May) of 2021 and 2022 at the Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, India (23°39´N, and 87°42´E, 58.9 m above mean sea level). The experimental station lies within typical semi-arid tropical climate. The total rainfall received during the experimental period was 142.2 and 174.0 mm respectively in both the years. The soil of the study site is sandy loam in texture with 63.5% sand, 26.0% clay and 10.5% silt. The experimental soil contains 0.43% organic carbon (Walkley and Black 1934), 296.2 kg ha^{-1} alkaline permanganate oxidizable nitrogen (N) (Subbiah and Asija 1956), 27.3 kg ha^{-1} available phosphorus (P) (Bray and Kurtz 1945), 193.2 kg ha^{-1} 1 N ammonium acetate exchangeable potassium (K) (Hanway and Heidel 1952) and 0.48 ppm available Zn DTPA extraction (Lindsay and Norvell 1978). The pH of the soil was 5.82 (1:2.5 soil: water ratio) (Prasad *et al*., 2006).

Experimental details. Treatments of this study were irrigation schedulingand zinc application methods. Four irrigation scheduling treatments *i.e.,* I_1: Irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube, I_2: Irrigation of 5 cm at one day after disappearance of ponded water, I_3: Irrigation of 5 cm at three days after disappearance of ponded water, and I_4 : Irrigation of 5 cm at hair crack stage of the soil and five zinc application methods *i.e.,* Zn_0: Control, Zn_1: 25 kg $ZnSO_4.7H_2O$ ha^{-1} as soil application, Zn_2: 0.5% $ZnSO_4.7H_2O$ as foliar application at 15 and 45 DAT, Zn_3: 0.3 % $ZnSO_4.7H_2O$ as seed priming, and Zn_4: 0.5 % $ZnSO_4.7H_2O$ as nursery root dipping were studied.The treatments were arranged in a split-plot design by randomly placing irrigation scheduling in main plots and zinc application methods in sub-plots and all the treatments were replicated thrice. The plot size of the main and sub-plots was 5 m × 6m. Experimental plots and replications were separated by bund of 0.75 m width for the purpose to check seepage loss. The width of main irrigation channel and buffer channel in between replications were 1.0 m each.

Crop husbandry. The elite, high-yielding, short duration, widely cultivated mega-variety of transplanted rice "MTU 1010" (Acharya NG Ranga Agricultural University, India) was transplanted with a spacing of 20 × 15 cm (333333 hills ha^{-1}) on 11th February, 2021 during first year and 7th February, 2022 during the second year. The crop was fertilized with 120 kg N $[CO(NH_2)_2]$, 60 kg P_2O_5 $[Ca (H_2PO_4)_2]$ and 60 kg K_2O (KCl) ha^{-1}.

In total, 25% of total N and 100% of P and 75% K were applied at the time of transplanting and the remaining 75% N was applied as a top-dressing in two splits, one at active tillering (50%N) and the second at panicle initiation stage (25% N). The remaining 25% K was applied as top dressing at panicle initiation stage.

Irrigation scheduling. Based on the irrigation treatments, irrigation was scheduled under different zinc application methods throughout the crop growth stage. Before imposing irrigation scheduling treatments each plot was irrigated uniformly for crop uniform crop establishment. The perforated PVC pipe having height 15 cm and diameter 10 cm with a demarcation of 5 cm level from the soil surface was laid in the plot having treatment I_1 before transplanting. A demarcated peg having height of 5 cm from the soil surface was installed in each plot having the treatment I_2, I_3 and I_4. Thereafter, alternate wetting and drying cycle was initiated. In the treatment I_1 when the water level falls 5 cm below the soil surface in the perforated PVC pipe, the field was irrigated up to the soil surface level. In the treatments I_2 and I_3, each plot was irrigated to a demarcated height of 5 cm, one day after disappearance of ponded water and three days after disappearance of ponded water, respectively. Each plot was irrigated to a demarcated height of 5 cm in the treatment I_4 with the development of hairline cracks on the soil surface. The number of irrigation events was recorded throughout the experiment.

Zinc application. For foliar application of zinc, @ 5 g of $ZnSO_4$, $7H_2O$ powder was dissolved in one litre of tap water and prepared solution was poured into the battery-operated sprayer and was applied by evenly spraying the solution until the whole plants were wet at morning at 15 and 45 DAT. The amount of water was 500-750 litres for 1 ha area. For seed priming purpose, seeds were primed with zinc sulphate heptahydrate @ 0.3% solution by using tap water before sowing. The ratio of seed weight to solution volume was 1:1.5 (w/v). Seeds were soaked in respective solution for 18 h at 25±2°C. Thereafter seeds were removed, given three surface washing with fresh water. Afterwards, primed seeds were allowed to re-dry with forced air under shade near to original weight. For root dipping purpose, 0.5% $ZnSO_4$, $7H_2O$ suspension (7500g $ZnSO_4$, $7H_2O$ in 1500 litres water/ha) was prepared and roots of uprooted seedlings of rice were dipped for 24 hours in a plastic-coated tank in the field.

Plant height observation. The plant height of ten randomly selected hills from each plot was measured at 40 DAT. The height of rice crop was measured in centimetre from the ground to the tip of the longest leaf until the panicles began to appear. These ten hills average heights were determined and expressed in centimetres (cm) to determine the average plant height in each treatment.

Dry matter accumulation (g m^{-2}). To determine dry matter accumulation, five hills were selected and cut at ground level in the earmarked area in each plot kept for the purpose of destructive sampling. Plants of each plot were separated into green leaves and stems and dried in a hot air oven, kept at 65°C for 72 hours till constant weights were obtained. The dry weight of leaves and stems were recorded and used for determination of dry matter accumulation. The average weight was calculated and expressed as dry matter accumulation in g m^{-2}.

Leaf area index (LAI). The representative green leaves were taken from randomly selected five hills from each plot during sampling at 40 DAT under study and the area of the leaves were measured with the help of leaf area meter. Thereafter, it was kept in hot air oven at a temperature of 65°C till constant weight was obtained. The dry weights of those leaves were recorded with an electrical balance. The ratio of area/weight of the leaves was used for determining leaf area index as described by Kemp (1960).The leaf area index was obtained by multiplying leaf factor with dry weight of functional leaves per unit land surface. Leaf area index was calculated as per the formula given by Williams (1946).

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Data analysis. All the data were subjected to ANOVA using the SPSS. Before ANOVA, all the data were tested for normality. In the analysis, irrigation scheduling (I) and zinc application methods (Zn) were considered as fixed effects and replication and year as random effects. The mean data for all observations were pooled and subjected to statistical analysis by the Analysis of Variance method (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

A. Plant height

In a study conducted over two years (2021 and 2022), different treatments combinations were applied to rice plants to observe their effects on plant height at 40 DAT in Table 1. The treatment combination with irrigation of 5 cm at one day after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_2Zn_3) consistently recorded the highest plant height in both years, with 65.14 cm in 2021 and 61.16 cm in 2022, resulting in the highest average plant height of 63.15 cm when considering the pooled data from both years. This was closely followed by the treatments combinations, irrigation of 5 cm at three days after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_3Zn_3) and irrigation of 5 cm at one day after disappearance of ponded water and 0.5 % $ZnSO_4.7H_2O$ as nursery root dipping (I_2Zn_4), with average heights of 62.74 cm and 61.44 cm, respectively from pooled analysis of both the years. Whilst, the treatment combination having application of irrigation of 5 cm at hair crack stage of the soil and control (I_4Zn_0) consistently resulted in the lowest plant height in both years, with 50.53 cm in 2021 and 47.66 cm in 2022, leading to the lowest average height of 49.10 cm in the pooled data. The better findings can be attributed to combined effect of alternate wetting and drying along with seed priming.

Table 1: Interaction effect between irrigation scheduling and zinc application on plant height of summer rice at 40 DAT.

Plant height (cm)			
Irrigation scheduling × Method of zinc application	**2021**	**2022**	**Pooled**
$I_1 Zn_0$	53.31	48.11	50.71
$I_1 Zn_1$	60.46	55.41	57.94
$I_1 Zn_2$	60.02	54.47	57.25
$I_1 Zn_3$	62.75	56.70	59.73
$I_1 Zn_4$	60.99	56.16	58.58
$I_2 Zn_0$	59.89	57.56	58.73
$I_2 Zn_1$	63.89	56.45	60.17
$I_2 Zn_2$	62.54	57.79	60.17
$I_2 Zn_3$	65.14	61.16	63.15
$I_2 Zn_4$	64.23	58.64	61.44
$I_3 Zn_0$	59.70	51.55	55.63
$I_3 Zn_1$	62.30	56.21	59.26
$I_3 Zn_2$	60.52	54.57	57.55
$I_3 Zn_3$	64.62	60.85	62.74
$I_3 Zn_4$	62.62	57.29	59.96
$I_4 Zn_0$	50.53	47.66	49.10
$I_4 Zn_1$	57.65	51.94	54.80
$I_4 Zn_2$	55.97	48.08	52.03
$I_4 Zn_3$	62.22	53.53	57.88
$I_4 Zn_4$	60.86	53.49	57.18
Interaction (Irrigation scheduling × Method of zinc application)			
SEm (±)	1.04	1.15	0.77
LSD at 5%	3.03	3.35	2.20

I_1: Irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube, I_2: Irrigation of 5 cm at one day after disappearance of ponded water, I_3: Irrigation of 5 cm at three days after disappearance of ponded water, I_4: Irrigation of 5 cm at hair crack stage of the soil; Zn_0: Control, Zn_1: 25 kg $ZnSO_4$, $7H_2O$ ha^{-1} as soil application, Zn_2: 0.5 % $ZnSO_4$, $7H_2O$ as foliar application at 15 and 45 DAT, Zn_3: 0.3 % $ZnSO_4$, $7H_2O$ as seed priming, Zn_4: 0.5 % $ZnSO_4$, $7H_2O$ as nursery root dipping

Thakur *et al*. (2011) also confirmed that the use of AWD irrigation resulted in an increase in plant height and more tillers m^{-2} as compared with currently recommended scientific management practices (SMP), including continuous flooding (CF) of paddy fields. Dass and Chandra (2012); Kumar *et al*. (2013) concluded that irrigation applied one day after the disappearance of standing water (DADSW) resulted in considerably taller plants. Zn acts as a cofactor for enzymes involved in photosynthesis, such as carbonic anhydrase. Improved photosynthesis due to Zn availability can lead to increased plant height. In addition, seed priming with Zn enhances nutrient uptake and promotes healthy root development, indirectly influencing plant height (Gajalakshmi *et al.*, 2022). Longer internodes contribute to taller plants. Zn influences cell division and elongation. Adequate Zn levels may promote elongation of internodes, resulting in taller plant height.

Table 2: Interaction effect between irrigation scheduling and zinc application on dry matter accumulation of summer rice at 40 DAT.

Dry matter accumulation (g m^{-2})			
Irrigation scheduling × Method of zinc application	**2021**	**2022**	**Pooled**
$I_1 Zn_0$	183.99	189.45	186.72
$I_1 Zn_1$	228.10	215.72	221.91
$I_1 Zn_2$	232.12	197.98	215.05
$I_1 Zn_3$	285.96	273.37	279.67
$I_1 Zn_4$	264.18	221.98	243.08
$I_2 Zn_0$	213.06	218.42	215.74
$I_2 Zn_1$	241.01	232.26	236.63
$I_2 Zn_2$	236.43	259.12	247.78
$I_2 Zn_3$	266.29	319.03	292.66
$I_2 Zn_4$	258.07	227.88	242.97
$I_3 Zn_0$	208.97	211.17	210.07
$I_3 Zn_1$	234.44	227.16	230.80
$I_3 Zn_2$	241.39	244.24	242.82
$I_3 Zn_3$	252.56	309.11	280.83
$I_3 Zn_4$	249.42	250.98	250.20
$I_4 Zn_0$	176.77	166.66	171.71
$I_4 Zn_1$	200.45	230.32	215.39
$I_4 Zn_2$	233.87	245.02	239.45
$I_4 Zn_3$	244.99	259.51	252.25
$I_4 Zn_4$	232.74	247.13	239.94
Interaction (Irrigation scheduling × Method of zinc application)			
SEm (±)	6.74	7.67	5.11
LSD at 5%	19.66	22.40	14.52

I_1: Irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube, I_2: Irrigation of 5 cm at one day after disappearance of ponded water, I_3: Irrigation of 5 cm at three days after disappearance of ponded water, I_4: Irrigation of 5 cm at hair crack stage of the soil; Zn_0: Control, Zn_1: 25 kg $ZnSO_4$, $7H_2O$ ha^{-1} as soil application, Zn_2: 0.5 % $ZnSO_4$, $7H_2O$ as foliar application at 15 and 45 DAT, Zn_3: 0.3 % $ZnSO_4$, $7H_2O$ as seed priming, Zn_4: 0.5 % $ZnSO_4$, $7H_2O$ as nursery root dipping.

B. Dry matter accumulation

The data pertaining to statistical analysis of study conducted over two years (2021 and 2022), showed that irrigation scheduling and zinc management had significant effect on dry matter accumulation (DMA) at 40 DAT in Table 2. In 2021, treatment combination having irrigation of 5 cm, when water level falls below 5cm from soil surface in the perforated PVC water tubealong with 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_1Zn_3) recorded the highest DMA of 285.96 g m^{-2}, followed by irrigation of 5 cm at one day after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_2Zn_3) with DMA 266.29 g m^{-2}, irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube and0.5 % $ZnSO_4.7H_2O$ as nursery root dipping (I_1Zn_4) with DMA 264.19 g m^{-2} and irrigation of 5 cm at one day after disappearance of ponded water and 0.5 % $ZnSO_4.7H_2O$ as nursery root dipping (I_2Zn_4) with DMA of 258.07 g m^{-2}. The lowest DMA of 176.77 g m^{-2} was observed in treatment application of irrigation of 5 cm at hair crack stage of the soil and control (I_4Zn_0). In 2022, similar trends persisted with irrigation of 5 cm at one day after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_2Zn_3) recording the highest DMA of 319.03 g m^{-2}. This was closely followed by treatments included irrigation of 5 cm at three days after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_3Zn_3) having DMA of 309.11 g m^{-2} and irrigation of 5 cm, when water level falls below 5cm from soil surface in the perforated PVC water tube and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_1Zn_3)with DMA 273.37 g m^{-2}. Whilst the treatment combination having application of irrigation of 5 cm at hair crack stage of the soil and control (I_4Zn_0) reported the lowest DMA of 166.66 g m^{-2}. When considering the pooled data from both years, the treatment combination of irrigation of 5 cm at one day after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_2Zn_3) consistently resulted in the highest average DMA at 292.66 g m^{-2}. Moreover, this was closely followed by the treatment combination irrigation of 5 cm at three days after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_3Zn_3), irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_1Zn_3) and irrigation of 5 cm at three days after disappearance of ponded water and 0.5 % $ZnSO_4.7H_2O$ as nursery root dipping (I_3Zn_4) having DMA 280.83, 279.67 and

250.20g m^{-2}, respectively. Conversely, the treatment combination having application of irrigation of 5 cm at hair crack stage of the soil and control (I_4Zn_0) had the lowest pooled DMA of 171.71 g m^{-2}. Kumar *et al.* (2013) confirmed that irrigation at 1 DADPW produced the highest average values for growth characteristics like dry matter accumulation (17.5 g $hill^{-1}$), which were significantly higher than those that was obtained with irrigation at 3 and 5 DADPW. These results are also in conformity with Kumar *et al.* (2014). Gajalakshmi *et al.* (2022) reported that application of zinc sulphate ($ZnSO_4$) through seed priming could enhance zinc uptake by the plant, leading to improved growth and dry matter accumulation. Mondal *et al.* (2020) confirmed similar finding of the combined treatment of irrigation at 100% of cumulative pan evaporation (CPE) and zinc application through seed coating or seed priming resulted in higher dry matter accumulation in rice grown in lateritic soil.

C. Leaf area index

Table 3 presented the different treatments combinations that were applied to rice plants to observe their effects on leaf area index (LAI) at 40 DAT. The treatment combination with irrigation of 5 cm at one day after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_2Zn_3) exhibited the highest LAI, with 4.84 in 2021 and 4.73 in 2022, resulting in the highest average LAI of 4.79 when considering the pooled data from both years. Treatments irrigation of 5 cm at one day after disappearance of ponded water and 0.5 % $ZnSO_4.7H_2O$ as nursery root dipping (I_2Zn_4) and irrigation of 5 cm at three days after disappearance of ponded water and 0.3 % $ZnSO_4.7H_2O$ as seed priming (I_3Zn_3) followed closely, with average LAIs of 4.68 and 3.99 respectively in 2022, and were also with better performance in 2021.

Table 3: Interaction effect between irrigation scheduling and zinc application on leaf area index of summer rice at 40 DAT.

Leaf area index			
Irrigation scheduling × Method of zinc application	**2021**	**2022**	**Pooled**
$I_1 Zn_0$	2.92	2.94	2.93
$I_1 Zn_1$	3.12	2.91	3.02
$I_1 Zn_2$	3.27	3.29	3.28
$I_1 Zn_3$	3.86	3.76	3.81
$I_1 Zn_4$	3.36	3.24	3.30
$I_2 Zn_0$	3.08	3.31	3.20
$I_2 Zn_1$	4.11	3.92	4.02
$I_2 Zn_2$	4.15	3.98	4.07
$I_2 Zn_3$	4.84	4.73	4.79
$I_2 Zn_4$	4.29	4.68	4.49
$I_3 Zn_0$	3.23	3.14	3.19
$I_3 Zn_1$	3.65	3.56	3.60
$I_3 Zn_2$	3.61	3.53	3.57
$I_3 Zn_3$	4.10	3.99	4.04
$I_3 Zn_4$	3.86	3.61	3.74
$I_4 Zn_0$	2.68	2.54	2.61
$I_4 Zn_1$	2.84	2.69	2.77
$I_4 Zn_2$	2.73	2.87	2.80
$I_4 Zn_3$	3.84	3.74	3.79
$I_4 Zn_4$	3.09	3.01	3.05
Interaction (Irrigation scheduling × Method of zinc application)			
SEm (±)	0.12	0.14	0.09
LSD at 5%	0.36	0.41	0.27

I_1: Irrigation of 5 cm, when water level falls below 5 cm from soil surface in the perforated PVC water tube, I_2: Irrigation of 5 cm at one day after disappearance of ponded water, I_3: Irrigation of 5 cm at three days after disappearance of ponded water, I_4: Irrigation of 5 cm at hair crack stage of the soil; Zn_0: Control, Zn_1: 25 kg $ZnSO_4$, $7H_2O$ ha^{-1} as soil application, Zn_2: 0.5 % $ZnSO_4$, $7H_2O$ as foliar application at 15 and 45 DAT, Zn_3: 0.3 % $ZnSO_4$, $7H_2O$ as seed priming, Zn_4: 0.5 % $ZnSO_4$, $7H_2O$ as nursery root dipping

Conversely, the treatment combination having application of irrigation of 5 cm at hair crack stage of the soil and control (I_4Zn_0) consistently resulted in the lowest LAI in both years, with 2.68 in 2021 and 2.54 in 2022, leading to the lowest average LAI of 2.61 in the pooled data. The irrigation practice of applying water one day after disappearance of ponded water (I_2) likely ensured that the rice plants received adequate moisture during critical growth stages. Proper irrigation timing can enhance nutrient uptake, photosynthesis, and overall plant health, leading to better leaf development and higher leaf area index (LAI). Additionally, this approach aligns with the findings of Palanisamy *et al.* (2022), who emphasized the importance of timely irrigation for crop productivity. Reddy *et al.* (2023) also conferred that I_4 (maintaining at 100 % FC) treatment at maximum tillering stage recorded significantly higher leaf area index than in I_1 (scheduling of irrigation at 60-70% field capacity (FC) throughout the season), I_2 (scheduling of irrigation at 80-90 % FC throughout the season) and I_3 (scheduling of irrigation at 60-70 % FC at vegetative stage and at 80-90 % FC at reproductive stage) under different moisture regimes. Significantly lower leaf area index was registered in I_1 (scheduling of irrigation at 60-70 % field capacity (FC) throughout the season). Maragatham and Martin (2010) concluded that the AWD approach was comparatively more successful than aerobic rice and flooded rice by observing plant growth parameters. Adequate zinc availability can enhance leaf expansion, chlorophyll content, and photosynthetic efficiency, contributing to a higher LAI. This finding is consistent with Gajalakshmi *et al*. (2022), who reported positive effects of seed priming with 0.50% $ZnSO_4$.

CONCLUSIONS

From the discussions, it can be concluded that cultivation of summer rice, with the application of irrigation of 5 cm at one day after disappearance of ponded water (I_2) and irrigation of 5 cm at three days after disappearance of ponded water (I_3) along with application of zinc through 0.3% $ZnSO_4$, $7H_2O$ as seed priming (Zn_3) may be recommended for higher productivity in lateritic soil of West Bengal.

FUTURE SCOPE

There is a need to investigatethe effect of alternate wetting and drying in different agro-ecological locations and regions of the state and country for its wide scale application in rice cultivation. Also, evaluation of other sources of micronutrients like nano zinc oxide, etc are to be carried out for finding their optimum dose for rice in lateritic soil. A long-term study spanning multiple years could provide more comprehensive insights into the effects of these practices. The impact of changing climate conditions on the effectiveness of these irrigation and nutrient application methods could also be explored. Additionally, the socio-economic impact of these practices on farmers, including aspects like cost-effectiveness, labor requirements, and potential increase in yield and income could be studied. Finally, the integration of technology, like remote sensing or precision agriculture techniques, to optimize irrigation scheduling and nutrient application could be a promising area of future research.

Acknowledgement. The authors express their heartiest gratitude to Palli Siksha Bhavana, Visva- Bhararti University, West Bengal for giving the resources.
Conflict of Interest. None.

REFERENCES

Agricultural Statistics at a Glance (2021). Ministry of Agriculture & Farmers Welfare. https://desagri.gov.in

Ajouri, A., Asgedom, H. and Becker, M. (2004). Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. *Journal of Plant Nutrition and Soil Science, 167*, 630-636.

Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). Water management in irrigated rice: Coping with water scarcity, IRRI: Los Banos, Philippines, pp: 54.

Bradford, K. J. (1986). Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Horticulture Science*, *21*, 1105–1112.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorous in soil. *Soil Science, 59*, 39-45.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification ? *Plant and Soil, 302*, 1-17.

Dass, A. and Chandra, S. (2012). Effect of different components of SRI on yield, quality, nutrient accumulation and economics of rice (*Oryza sativa*) in tarai belt of northern India. *Indian Journal of Agronomy*, *57*(3), 250-254.

Dey, S., Ram, K., Chhabra, A. K., Lokeshwar Reddy A. and. Janghel, D. K. (2018). Aerobic Rice: Smart Technology of Rice Cultivation. *International Journal of Current Microbiology and Applied Sciences*, *7*(8), 1799-1804.

Gajalakshmi, R. T., Chitdeshwari, S., Maragatham, R. and Ravikesavan. (2022). Seed priming with different levels and sources of zinc on the seed germination and seedling growth of barnyard millet (*Echinochloa frumentacea*). *Journal of Applied and Natural Science, 14*(3), 876-884.

Gomez, K. A., and Gomez, A. A. (1984). *Statistical procedures for agricultural research (2nd Edn.).* pp 680. John Wiley and Sons, New York.

Hanway, J. J. and Heidal, H. (1952). Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Iowa State College of Agriculture Bulletin, 57*, 1-31.

IRRI (2009). Every drop counts. *Rice Today*, *8*(3), 16-18.

IRRI (2013). Tracking climate change and addressing water scarcity through AWD. Los Banos, Philippins: International Rice Research Institute.

Katyal, J. C. and Ponnamperuma, F. N. (1974). Zinc deficiency: a widespread nutritional disorder of rice in Agusan del Norte, Philippines. *Agricultural Journal, 58*, 79–89.

Kemp, C. D. (1960). Methods of estimating the leaf area of grasses from linear measurements. *Annals of Botany, 24*(4)*,* 491-499.

Khan, M. U., Qasim, M., Subhan, M., Jamil, M. and Ahmad, R. D. (2003). Response of rice to different methods of Zn application in calcaerous soils. *Pakistan Journal of Applied Science, 3*, 524–529.

Kishor, M., Praveen Rao, V., Ramulu, V., Avil Kumar, K. and Uma Devi, M. (2017). Standardization of Alternate Wetting and Drying (AWD) method of water management in low land rice (*Oryza sativa* L.). *International Journal of Plant Production*, *11*(4)*,* 515-532.

Kulkarni, S. (2011). Innovative technologies for water saving in irrigated agriculture. International *Journal of Water Resources and Arid Environments, 1*(3), 226-231.

Kumar, S., Singh, R. S. and Kumar, K. (2014). Yield and nutrient uptake of transplanted rice (*Oryza sativa*) with different moisture regimes and integrated nutrient supply. *Current Advances in Agricultural Sciences, 6*(1), 64-66.

Kumar, S., Singh, R. S., Yadav, L. and Kumar, K. (2013). Effect of moisture regime and integrated nutrient supply on growth, yield and economics of transplanted rice. *Oryza*, *50*, 189-191.

Lindsay, W. L. and Norvell, W. A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal***,** *42,* 421-428.

Maragatham, N. and Martin, G. J. (2010). Effect of land configuration techniques, NP levels and bioinoculants on soil available nutrients and soil microorganism in aerobic rice production in South India. 19^{th} World

Congress of Soil Science, Soil Solutions for a Changing World, Brisbane, Australia.
Mondal, B., Pramanik, K. and Sarkar, N. C. (2020). Response of aerobic rice to irrigation regimes and method of zinc application on growth and yield during summer season in lateritic soil. *Research on Crops*, *21*(1), 1-9.
Nemeño A, G. A. (2010). Effect of water management on zinc concentration in rice grains. In Proceedings of the 19th World Congress of Soil Science, Brisbane, Australia, 1–6 August 2010.
Palanisamy, J., Geethalakshmi, V., Ramanathan, S. P. and Balaji Kannan, A. S. (2022). Unravelling the Growth Potential of Rice under Modified Rice Cultivation System in Tamil Nadu, India. *Journal of Agronomy*, *21*(1), 1-11.
Phattarakul, N., Rerkasem, B., Li, L. J., Wu, L. H., Zou, C. Q., Ram, H., Sohu, V. S., Kang, B. S., Surek, H. and Kalayci, M. (2016). Biofortification of rice grain with zinc through zinc fertilization in different, S.E. Enriching rice grain zinc through zinc fertilization and water management. *Soil Science Society of America Journal, 80,* 121–134.
Prasad, R., Shivay, Y. S., Kumar, D. and Sharma, S. N. (2006). *Learning by doing exercise in soil fertility- A practical manual for soil fertility*. New Delhi: Division of Agronomy, IARI. pp 68-70.
Prom-u-thai, C. and Rerkasem, B. (2012). Effect of zinc priming on zinc concentration of germinating rice seed. *Chiang Mai University Journal of Natural Sciences*, *11,* 421–428.
Reddy, K. I., Zaman, A., Pramanick, M., Patra, S. K. and Das, N. C. (2023). Effect of moisture regimes on growth and root characteristics of rice cultivars under aerobic condition in summer season. *Biological Forum – An International Journal, 15*(1)*,* 14-19.
Slaton, N. A., Wilson, C. E., Ntamatungiro, Jr., S., Norman, R. J. and Boothe, D. L. (2001). Evaluation of zinc seed treatments for rice. *Agronomy Journal, 93*, 157-163.
Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in the soils. *Current science, 25,* 779-782.
Taylor, A. G., Allen, P. S., Bennett, M. A., Bradford, K. J., Burris, J. S. and Misra, M. K. (1998). Seed enhancements. *Seed Science Research, 8*, 254–256.
Thakur, A. K. Rath, S., Patil, D. and Kumar, A. (2011). Effects on rice plant morphology and physiology of water and associated management practices of the system of rice intensification and their implications for crop performance. *Paddy and water Environment*, *9*(1), 13-24.
Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. *Plant Production Science, 8*, 231-241.
Walkley, A. J. and Black, I. A. (1934). An examination of the Degtjareff method for determination of soil organic matter and a proposed modification of the chronic acid titration method. *Soil Science, 37*, 29-38.
Williams, R. E. (1946). The physiology of plant growth with special reference to NAR. *Annals of Botany, 10,* 41-72.
Yoshida, S., McLean, G. W., Shafi, M. and Mueller, K. E. (1970). Effects of different methods of zinc application on growth and yields of rice in a calcareous soil, West Pakistan. *Soil Science Plant Nutrition, 16*, 147–149.

How to cite this article: Rahul Kumar Gupta, Ruchi Bharti, Kalipada Pramanik and Sk Naim Aktar (2024). Evaluating the Impact of Different Irrigation Scheduling and Zinc Application Methods on Growth of Transplanted Summer Rice in Lateritic Soil of West Bengal. *Biological Forum – An International Journal, 16*(3): 202-208.