www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 2373-2379

www.thepharmajournal.com
Received: 02-02-2022
Accepted: 12-03-2022

Ram Naresh
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Sanjeev Kumar
ICAR- CISH Lucknow, Uttar Pradesh, India

Shiwanand Panday
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Reenu Kumar
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Vikas Teotia
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Naveen Kumar Maurya
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Pankaj Kumar
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Anuj Pratap Singh
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Vipin Patel
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Prashun Sachan
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Yatendra Singh
Monad University, Hapur, Uttar Pradesh, India

Corresponding Author:
Ram Naresh
Department of Agronomy, C.S. Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Effect of irrigation, nutrients levels and weed management practices on growth of aromatic rice (*Oryza sativa* L.)

Ram Naresh, Sanjeev Kumar, Shiwanand Panday, Reenu Kumar, Vikas Teotia, Naveen Kumar Maurya, Pankaj Kumar, Anuj Pratap Singh, Vipin Patel, Prashun Sachan and Yatendra Singh

Abstract
The experiment was conducted at Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture & technology, Kanpur during *Kharif* 2019 and 2020 on silty clay loam soils. The soil of the experimental field was neutral in reaction, testing medium in available P and K and low in available N with medium organic carbon content of 0.80. The treatments comprising of two irrigations methods: alternative wetting and drying (AWD), and flooding irrigation assigned to main plots, four nutrients levels (RDF+ $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 10 kg ha^{-1}, RDF+ $ZnSO_4$ @ 25 kg ha^{-1} and RDF+ $FeSO_4$ @ 10 kg ha^{-1}) in sub plots and four weed management practices including two herbicidal treatments (Chlorimuron ethyl and Fenoxaprop-p-ethyl), hand weeding along with weedy check to sub-sub-plots replicated were tested in Split-split plot design. On the basis of pooled data of two years revealed that significant increase in growth attributes was recorded during both the years of experimentation by irrigation methods, nutrients levels and weed management practices. Significant increase in growth parameter was recorded due to the effect of irrigation methods. highest plant height, LAI, fresh, dry matter accumulation and tillers plant^{-1} was recorded with alternative wetting and drying (AWD) which was superior to flooded irrigation methods during both the years of experimentation. Among the nutrients RDF + $ZnSO_4$+ $FeSO_4$ at par with RDF + $ZnSO_4$proved excellent resulted in maximum growth comparable to RDF treatment. The data on weed management practices manifest that all the herbicides used for control of weeds including hand weeding found to be maximum growth compared to weedy check.

Keywords: Irrigation, nutrients, management, aromatic, *Oryza sativa* L.

Introduction
Rice (*Oryza sativa* L.) a member of Poaceae, formerly called Gramineae family is one of the most important food crops in the world forms the staple diet of 2.7 billion people. It is grown in all the continents except Antarctica, occupying 150 million ha, the production of 622 million tons of paddy with an average productivity of 3.83 tones ha^{-1}. Cultivation of rice is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed). Rice is one of the major contributors to the food grain production contributing approximately 43 per cent of the total food grain production in India (Upendra *et al.*, 2013) [10]. India is the second largest consumer and producer of rice in world after China. The area, production and productivity of India is 43.78 m ha, 118.4 mt. and 27.05 qha^{-1}, respectively. (Anonymous, 2020-21) [2]. Uttar Pradesh is the 2nd largest rice growing state only after West Bengal in the country, with an area of 58.30 lakh hectares, production 141.18 lakh tones and the productivity of 2421 kg ha^{-1}. Demand for rice is growing every year and it is estimated that by 2025 AD the requirement would be 140 million tones to sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3 per cent per annum.

The FAO estimates that rice crop consumes about 4000- 5000 liters' water per kg of grain produced. Since water for rice production has become increasingly scarce water saving strategies has become a priority in rice research (Raju and Sreenivas, 2008 and Borker *et al.*, 2000) [9]. The scarcity of water for agriculture production is becoming a major problem in many countries, particularly in word's leading rice-producing countries like China and India. Rice cultivation in India is predominantly practiced under transplanting method that involves raising, uprooting and transplanting of seedlings. This technique requires continuous ponding of water. Now a day, water scarcity is a major concern in many regions of the world, as competition between agricultural and industrial consumption of water resources intensifies and climatic unpredictability increases (Hanjar, Quer; leshi, 2010; and Mahajan *et al*., 2011 & 2012).

The long term fertilizer experiment showed that continuous application of imbalance dose of chemical fertilizers alone or in combination to rice crop resulted in the deterioration of soil health. Recommended dose with proper balance of nutrients improve the nutrient status and soil health as well as proved to be a boon in stabilizing the crop yield over a period of time. Since the nitrogen, utilization varies from less than 30% in flooded (low land) crop to about 50-60% phosphorus in utilized by the first crop, with some residual phosphorus available for succeeding crops. Although utilization efficiency of applied potassium is fairly high about 80%, it needs proper and balance application along with over all crop management practices.

Adoption of Alternate Wetting and Dry Irrigation (AWDI) as a part of a new strategy of rice intensification, growing rice under mostly aerobic soil conditions. This approach to cultivating rice, increasingly used in parts of Asia, especially in China, Japan, and India, means that rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice-growing period (Van der Hoek *et al*., 2001) [11]. Alternate Wet and Dry Irrigation (AWDI) can increase the productivity of water at the field level by reducing seepage and percolation during the crop-growth period. While yield increases have been the focus of much of the discussion and evaluation of SRI, here we are also concerned with water productivity (see ''Water savings and water productivity'' section) because of its importance for sustainable rice production. A good indication of plant productivity is seen in the root numbers and panicle characteristics. Although this was mainly affected by the age of seedlings, spacing, and their interactions, it also was contributed to satisfactorily by AWDI. Among other factors, grain weight (1,000-grain weight) and filled grain percentage in intermittently irrigated plots combined with younger seedlings and wider spacing to give better results than did the same combinations under continuous flooding (Chapagain and Yamaji, 2010) [4]. Rice is essential to global food security, but the increasingly unsustainable use of water and inappropriate use of limited nutrient resources means that new agronomic approaches are needed. Sustainable rice cultivation requires approaches that use less irrigation water and nutrient resources whilst maintaining (or improving) grain yields and nutritional quality.

Materials and Methods

The experiment was conducted at the Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during *Kharif* season 2019 and 2020. Geographically located at 26^0 29' 35''N latitude and 80^0 18' 35'' E longitudes at an altitude of 125.9 meters above from mean sea level. It lies in the alluvial belt of genetic plain and is located in the central part of Uttar Pradesh. The experimental field had fairly leveled topography and good drainage system.

the soil of experimental field was alkaline in reaction (7.50 pH), low in organic carbon (0.30%) available nitrogen (211.5 kg ha^{-1}) and available phosphorus (15.68 kg ha^{-1}) while medium in potassium (232.3 kg ha^{-1}), respectively. The treatments comprising of two irrigations methods: alternative wetting and drying (AWD), and flooding irrigation assigned to main plots, four nutrients levels (RDF+ $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 10 kg ha^{-1}, RDF+ $ZnSO_4$ @ 25 kg ha^{-1} and RDF+ $FeSO_4$ @ 10 kg ha^{-1}) in sub plots and four weed management practices including two herbicidal treatments (Chlorimuron ethyl and Fenoxaprop-p-ethyl), hand weeding along with weedy check to sub-sub-plots replicated were tested in Split-split plot design.

Climate and weather condition

Uttar Pradesh enjoys a sub-tropical region of the country. The climate is semi dry type with hot summer and cold winter. The mean annual rainfall is about 926 mm, most of which is received between June to October. During course of investigation since 28th June - 28th October, 2019, and 20th June - 19th October 2020. The total rainfall received was 901.7 mm in the year 2019 received growth period 26-46 (Standard meteorological week) and 945 mm in the second year 2020 received growth period 25-44 (Standard meteorological week) at the growth period of rice after emergence during the growing season. The data regarding weather conditions prevailing during the experiment period was obtained from the meteorological observatory of the university.

Application of fertilizers

After making individual experimental units. The recommended dose of fertilizers was applied as per treatments. Urea, Di-ammonium phosphate, Murate of potash, Zinc sulfate and Ferrus sulphate were used to supply N 120 kg ha^{-1}, P 60 kg ha^{-1}, K 40 kg ha^{-1}, $ZnSO_4$ 25 kg ha^{-1} and $FeSO_4$ 10 kg ha^{-1} respectively. One third dose of nitrogen and total phosphorus, potash and zinc were applied as basal application before puddling and incorporated in the top 15 cm soil. Remaining dose of nitrogen was applied as top dressing in two equal doses, each at tillering and panicle initiation stage respectively.

Plant height (cm)

Plant height recorded with the help of meter scale at 30, 60, 90 days after transplanting and at harvest. For this observation three hills in each plot were tagged. The length between the base of stem touching the ground and the top most tip of the plant was considered as height of plant and averaged.

Leaf area index (Watson 1947)

The total number of leaves of three hills was divided into three groups i.e. small, medium and large and finally measured the maximum length and width of the each leaves of each groups. The leaf area for one leaf from each groups were computed with the help of formula and multiplied with the total leaves from each group.

$$\text{Leaf area} = K \times \text{lenth of leaf} \times \text{width of leaf}$$

Where K is adjustment factor, the adjustment factor of 0.75 was used for all the stages of crop growth except at seedling and at maturity stage, where the value of 0.67 was used. Leaf area $hill^{-1}$ was computed after summing up the values of leaf area index was calculated from the data on the leaf area according to the formula given by Watson (1947).

$$\text{Leaf area index} = \frac{\text{Total leaf area (cm}^{-2}\text{)}}{\text{Unit ground area (cm}^{-2}\text{)}}$$

The LAI was recorded three times during the course of investigation of crop at 30, 60 & 90 DAT and then averaged.

Frees and dry weight

The fresh and dry biomass weight (g) and plant growth of rice plant in response to the application of different concentration. The fresh weight first cut to the after 30, 60, 90 DAT and at harvest stage. For the weight of weighing machine after frees weight. The sample is kept dry for 24 hours at 70 degree in an automatic dryer.

Total number of tillers m^{-2}

Number of tillers were recorded by counting tillers number per 1.0 m row length at five rows in each plot at 30, 60, 90 DAS and at harvest stage, then averaged and expressed in terms of number of tillers m^{-1} row length.

Result and Discussion

Plant Height (cm)

Data pertaining to plant height given in Table 1 Irrigation methods influence the plant height significantly at 30, 60, 90 DAT and at harvest stage. Highest plant height (cm) was recorded under alternate wetting and drying irrigation method (26.89, 70.75, 86.95 and 89.55 cm respectively at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method plant height were 25.45, 67.01, 82.37 and 84.79 cm respectively at 30, 60, 90 DAT in both the year as well as pooled analysis. While under different nutrient levels significantly highest plant height (cm) was recorded under F_4- N_{100} P_{60} K_{40} +$ZnSO_4$ @25 kg+ $FeSO_4$@ 10 kgha^{-1} (27.51, 72.48, 89.04 and 91.68 cm respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ @ 25 kg ha^{-1} (26.66, 70.18, 86.31 and 89.01 cm respectively at 30, 60, 90 DAT and at harvest stage). Whereas, lowest was recorded F_1- $N_{100,}$ $P_{60,}$ K_{40} kg ha^{-1} under (24.81, 65.17, 80.08 and 82.41 cm respectively at 30, 60, 90 DAT and at harvest stage) during both the year and pooled analysis. In case of weed management practices significantly highest plant height (cm) at successive stares of crop growth was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (27.77, 73.17, 89.96 and 92.69 cm respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (26.74, 70.19, 86.27 and 88.74 respectively 30, 60, 90 DAT and at harvest stage). Similar results were also reported that Djaman *et al.* (2018) [6] and Chowdhury *et al.* (2014) [5].

Number of tiller (m^{-2})

Data regarding to number of tiller of rice given in Table 2.It is clear depicted in the table 4.2 and fig 4.2 that irrigation methods influence the number of tillers (m^{-2}) significantly at 30, 60, 90 DAT and at harvest stage. Highest Number of tiller (m^{-2}) was recorded under alternate wetting and drying irrigation method (201.07, 267.25, 289.77 cm) respectively at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method plant height were 190.57, 253.78 and 274.81 cm respectively at 30, 60, 90 DAT in both the year as well as pooled analysis. Under different nutrient levels significantly highest number of tillers (m^{-2}) was recorded under F_4- N_{100} P_{60} K_{40} +$ZnSO_4$ @ 25 kg + $FeSO_4$ @ 10 kg ha^{-1} (206.33, 274.46 and 297.93 cm respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ @ 25 kg ha^{-1} (199.28, 265.47 and 285.38 cm respectively at 30, 60, 90 DAT and at harvest stage) and F_3- $N_{100,}$ $P_{60,}$ K_{40} + $FeSO_4$ @ 10 kg ha^{-1} (192.65, 256.59 and 277.93 cm respectively at 30, 60, 90 DAT and at harvest stage).

In case of weed management practices significantly highest number of tillers (m^{-2}) was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (207.84, 277.09 and 298.15cm respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (193.52, 265.73 and 288.01 respectively 30, 60, 90 DAT and at harvest stage) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1}and (195.73, 260.75 and 282.32 respectively 30, 60, 90 DAT and at harvest stage). It is also clear from the data that significantly highest number of tillers (m^{-2}) was also recorded in W_4 –Weedy Check (180.18, 239.49 and 259.48 cm respectively 30, 60, 90 DAT and at harvest stage). Javier *et al.* (2005) and Frontech *et al.* (2013) [7] also observed similar results.

Number of panicle (m^{-2})

It is clear depicted in table number 3, that irrigation methods influence the number of panicle significantly. Whereas, highest number of panicle was recorded under the alternate wetting and drying irrigation (282.59 m^{-2}) as compared to flooded irrigation method (267.47 m^{-2}) during the both year as well as pooled analysis. Under nutrient levels significantly highest number of panicle was recorded F_4- N_{100} P_{60} K_{40} + $ZnSO_4$ @ 25 kg ha^{-1} + FeSO4 @ 10 kg ha^{-1} (290.17 m^{-2}) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ + @ 25 kg ha^{-1} (280.09 m^{-2}) and N_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ + $FeSO_4$ @ 10 kg ha^{-1} (270.53 m^{-2}) in both the year and pooled basis. Although the lowest number of panicle was recorded in F_1- $N_{100,}$ $P_{60,}$ K_{40} kg ha^{-1} (259.34 m^{-2}) both the year and pooled basis. In case of weed management practices significantly highest number of panicle was recorded in W_3 - Hand weeding 20, 45, and 60 DAT (292.33 m^{-2}) as compared to W_1 - Chlorimuron ethyl 25% WP @ 24g ha^{-1} 280.97 m^{-2}) and W_2 -Fenoxaprop-p- ethyl 9.3% w/w @ 625 ml ha^{-1}(274.53 m^{-2}). It is also clear from the data that significantly the lowest number of panicle was recorded under W_4 –Weedy Check 252.31 m^{-2}) both the year and pooled basis.

Number of productive tillers (m^{-2})

Data pertaining Number of productive tillers (m^{-2}) given in Table 3. Irrigation methods influences the number of productive tillers significantly. Whereas, highest number of panicle was recorded under the alternate wetting and drying irrigation (257.82m^{-2}) as compared to flooded irrigation method (246.68m^{-2}) during the both year as well as pooled analysis.

Under nutrient levels significantly highest number of productive tillers was recorded F_4- N_{100} P_{60} K_{40} $ZnSO_4$@ 25 kg FeSO4 @ 10kg ha^{-1} (290.08 m^{-2}) followed by F_2- $N_{100,}$ $P_{60,}$ K_{40}+ $ZnSO_4$ @ 25 kg ha^{-1} (279.74 m^{-2}) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$ @ 10 kg ha^{-1} (270.54 m^{-2}) in both the year and pooled basis. Although the lowest productive number of productive tillers was recorded in F_1- $N_{100,}$ $P_{60,}$ K_{40} kg ha^{-1} (259.27 m^{-2}) both the year and pooled basis. In case of weed management practices significantly highest number of productive tillers was recorded in W_3 - Hand weeding 20, 45, and 60 DAT (292.42 m^{-2}) as compared to W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (280.60 m^{-2}) and W_2 -Fenoxaprop-p- ethyl 9.3% w/w @ 625 ml ha^{-1} (274.32 m^{-2}). It is also clear from the data that significantly the lowest productive number of productive tillers was recorded under W_4 –Weedy Check (252.25 m^{-2}) both the year and pooled basis. Similar results were also reported that Djaman *et al.* (2018) [6] and Chowdhury *et al.* (2014) [5].

Number of unproductive tillers (m^{-2})

Irrigation method affects the number of unproductive panicle significantly. Whereas, highest number of panicle was recorded under the alternate wetting and drying irrigation (7.77 m^{-2}) as compared to flooded irrigation method (7.46 m^{-2}) during the both year as well as pooled analysis.

Under nutrients levels significantly highest number of unproductive tillers was recorded F_4- N_{100} P_{60} K_{40} $_{ZnSO4}$ @ 25 kg $FeSO_4$ @ 10 kg ha^{-1} (7.85 m^{-2}) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ @ 25 kg ha^{-1} (7.74 m^{-2}) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$ @ 10 kg ha^{-1}(7.39 m^{-2}) in both the year and pooled basis. In case of weed management practices data found significantly with highest number of unproductive tiller was recorded in W_3 - Hand weeding 20, 45, and 60 DAT (7.76 m^{-2}) as compared to W_2 -Fenoxaprop-p- ethyl 9.3% w/w @ 625 ml ha^{-1} (7.99 m^{-2}) and W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (7.47 m^{-2}).

Tiller mortality percent. (M^{-2})

Irrigation influences the tiller mortality significantly. Whereas, highest tiller mortality was recorded under the flooded irrigation method (2.96 m^{-2}) as compared to alternate wetting and drying irrigation (2.75 m^{-2}) during both the year as well as pooled analysis. Under nutrient levels significantly highest tiller mortality was recorded F_1- $N_{100,}$ $P_{60,}$ K_{40} kg ha^{-1} (2.93%) followed by F_2- $N_{100,}$ $P_{60,}$ K_{40}+ $ZnSO_4$ @ 25 kg ha^{-1} (2.87%) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$ @ 10 kg ha^{-1} (2.85%) in both the year and pooled basis. Although the lowest tiller mortality F_4- N_{100} P_{60} K_{40} $ZnSO_4$ @ 25 kg ha^{-1} FeSO4 @10 kg ha^{-1} (2.78%) was recorded in both the year and pooled basis.

In case of weed management practices significantly highest number of tiller mortality was recorded in W_2 -Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1} (2.97%) as compared to W_3-Hand weeding 20, 45 and 60 DAT (2.91%) and W_4 –Weedy Check (2.86%). It is also clear from the data that significantly the lowest tiller mortality was recorded under W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (2.68%) both the year and pooled basis.

Fresh shoot weight (gm^{-2})

The results of fresh shoot weight (gm^{-2}) clearly revealed that Irrigation influences the fresh shoot weight significantly at 30, 60, 90 DAT and at harvest stage. Highest fresh shoot weight (gm^{-2}) was recorded under alternate wetting and drying irrigation method (53.60, 978.63, 782.18 and 547.53 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method were fresh shoot weight (gm^{-2}) were 50.75, 925.80, 747.09 and 519.76 gm^{-2} respectively at 30, 60 and 90 DAT in both of the year as well as pooled analysis.

Under different nutrient levels significantly highest fresh shoot weight (gm^{-2}) was recorded under F_4- N_{100} P_{60} K_{40} + $ZnSO_4$ @ 25 kg $FeSO_4$ @ 10kg ha^{-1} (54.98, 1001.03, 800.99 and 560.66 (g) respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ + $ZnSO_4$ @ 25 kg ha^{-1} (53.10, 967.54, 788.24 and 545.52 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$@ 10 kg ha^{-1} (51.27, 935.62, 748.60 and 524.02 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage). In case of weed management practices significantly highest fresh shoot weight (gm^{-2}) was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (55.37, 1010.56, 808.56 and 865.99 (g) respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (53.22, 970.08, 776.39 and 543.32 respectively 30, 60, 90 DAT and at harvest stage) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1} and (52.09, 951.24, 761.11 and 532.77 respectively 30, 60, 90 DAT and at harvest stage). It is also clear from the data that significantly fresh shoot weight (g m^{-2}) was also recorded in W_4 –Weedy Check (48.00, 876.97, 712.50 and 492.50 (g m^{-2}) respectively 30, 60, 90 DAT and at harvest stage). Similar finding was also reported that Gautam *et al.* (2008) [8], Ali *et al.* (2013) [1], Chowdhury *et al.* (2014) [5].

Dry weight of shoot (gm^{-2})

Data pertaining to dry weight of shoot (gm^{-2})analyzed statistically year wise as well as pooled basis and presented in Table 2, Irrigation influence the dry weight of shoot (gm^{-2}) significantly at 30, 60, 90 DAT and at harvest stage. Highest dry weight of shoot (gm^{-2}) was recorded under alternate wetting and drying irrigation method (9.77, 534.27, 568.38 and 688.92 respectively at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method were dry weight of shoot were 9.22, 503.83, 546.24 and 653.27 gm^{-2}respectively at 30, 60 and 90 DAT in both the year as well as pooled analysis.

Under different nutrient levels significantly highest dry weight of shoot (gm^{-2}) was recorded under F_4- $N_{100,}$ $P_{60,}$$K_{40}$+ $ZnSO_4$@ 25 kg ha^{-1} + $FeSO_4$ @10kgha^{-1} (9.89, 541.80, 582.64 and 695.32 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ + $ZnSO_4$ @ 25 kg ha^{-1} (9.72, 530.42, 564.38 and 682.18 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ + $FeSO_4$ @ 10 kg ha^{-1} (9.31, 510.95, 551.06 and 622.19 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage). In case of weed management practices significantly highest dry weight of shoot (gm^{-2}) was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (10.08, 552.14, 594.04 and 718.73 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (9.66, 530.24, 564.09 and 683.91 (g m^{-2}) respectively 30, 60, 90DAT and at harvest stage) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1} and (9.47, 515.67, 554.84 and 663.74 respectively 30, 60, 90 DAT and at harvest stage).

Fresh weight of root (gm^{-2})

Data pertaining to fresh shoot weight (gm^{-2}) analyzed statistically year wise as well as pooled basis and presented in Table 2, Irrigation influence the fresh weight of root (gm^{-2}) significantly at 30, 60, 90 DAT and at harvest stage. Highest fresh weight of root (gm^{-2}) was recorded under alternate wetting and drying irrigation method (16.21, 18.98, 20.86 and 16.89 respectively at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method were fresh weight of root were 15.38, 18.01, 19.79 and 15.83 gm^{-2}respectively at 30, 60 and 90 DAT in both of the year as well as pooled analysis. Under different nutrient levels significantly highest fresh weight of root (gm^{-2}) was recorded under F_4- $F_{100,}$ $P_{60,\ 40}$ $ZnSO_4$, @ 25 kg FeSO4 @ 10 kg ha^{-1} (16.34, 19.13, 21.02 and 16.81 (gm^{-2}), respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ @ 25 kg ha^{-1}(15.99, 18.73, 20.58 and 14.46 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$ @ 10 kg ha^{-1} (15.62, 18.28, 20.09 and 16.07 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage).In case of weed management practices significantly highest fresh weight of root (gm^{-2}) was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (17.02, 19.93, 21.90 and 17.51 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (15.99, 18.72, 20.58 and 15.46 gm^{-2} respectively 30, 60, 90 DAT and at harvest stage) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml $ha^{-1}$and (15.55, 18.20, 19.20 and 15.99 respectively 30, 60, 90 DAT and at harvest stage). It is also clear from the data that significantly fresh weight of root (gm^{-2}) was also recorded in W_4 –Weedy Check (14.63, 17.13, 18.83 and 15.06 gm^{-2} respectively 30, 60, 90 DAT and at harvest stage).

Dry weight of root (gm^{-2}).

Data pertaining to dry weight of root (gm^{-2}) analyzed statistically year wise as well as pooled basis and presented in Table 2, Irrigation influence the dry weight of root (gm^{-2}) significantly at 30, 60, 90 DAT and at harvest stage. Highest dry weight of root (gm^{-2}) was recorded under alternate wetting and drying irrigation method (5.42, 6.26, 8.76 and 13.35 gm^{-2} at 30, 60, 90 DAT and at harvest stage) as compared to flooded irrigation method were fresh weight of root were 5.14, 9.94, 8.31 and 12.66 gm^{-2} respectively at 30, 60 and 90 DAT in both of the year as well as pooled analysis.

Under different nutrient levels significantly highest dry weight of root (gm^{-2}) was recorded under F_4- N_{100} P_{60} K_{40} +$ZnSO_4$ @ 25 kg FeSO4 @ 10 kg ha^{-1} (5.46, 6.58, 8.83 and 13.45 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$ $ZnSO_4$ @ 25 kg ha^{-1} (5.35, 6.61, 8.64 and 13.17 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage) and N_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$@ 10 kg ha^{-1} (5.22, 6.28, 8.44 and 12.87 (gm^{-2}) respectively at 30, 60, 90 DAT and at harvest stage). In case of weed management practices significantly highest dry weight of root (gm^{-2})was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (5.69, 6.85, 9.19 and 14.02 gm^{-2} respectively at 30, 60, 90 DAT and at harvest stage) followed by W_1 - Chlorimuron ethyl 25% WP @ 24g ha^{-1} (5.35, 6.44, 8.64 and 13.17 gm^{-2} respectively 30, 60, 90 DAT and at harvest stage) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1} and (5.20, 6.26, 8.40 and 12.80 respectively 30, 60, 90 DAT and at harvest stage). It is also clear from the data that significantly dry weight of root (gm^{-2}) was also recorded in W_4 –Weedy Check (4.89, 5.89, 7.91 and 12.05 gm^{-2} respectively 30, 60, 90 DAT and at harvest stage). Ali *et al.* (2013) [1], Chowdhury *et al.* (2014) [5] have also reported similar finding.

Leaf Area Index

Leaf area index tend to increase with advancement in crop age up to 90 days' stage as given in Table 1. During both the year of trial. Perusal of data in Table 4.7 revealed that the treatments receiving alternate wetting and drying irrigation (0.49, 4.66 and 3.68 respectively at 30, 60 and 90 DAT) had higher leaf area index in comparison to flooded irrigation **(**0.46, 4.40 and 3.47 respectively at 30, 60 and 90 DAS), though the difference was significant at all the stages during both the year. Among the different nutrient management practices, greatest value of LAI was observed under treatment F_4- N_{100} P_{60} K_{40}+$ZnSO_4$ @ 25 kg $FeSO_4$ @10 kg ha^{-1} (0.50, 4.78 and 3.79 respectively at 30, 60 and 90 DAT) followed by F_2- $N_{100,}$ $P_{60,}$ $K_{40,}$
$ZnSO_4$ @ 25 kg ha^{-1} (0.48, 4.60 and 3.64 respectively at 30, 60 and 90 DAT) and F_3- $N_{100,}$ $P_{60,}$ $K_{40,}$ $FeSO_4$ @ 10 kg ha^{-1} (0.46, 4.44 and 3.52 respectively at 30, 60 and 90 DAT).In case of
weed management practices significantly highest LAI was recorded under W_3 - Hand weeding 20, 45, and 60 DAT (0.50, 4.80 and 3.79 respectively at 30, 60, 90 DAT) followed by W_1 - Chlorimuron ethyl 25% WP @ 24 g ha^{-1} (0.48, 4.61 and 3.64 respectively at 30, 60 and 90 DAS) and W_2 - Fenoxaprop-p-ethyl 9.3% w/w @ 625 ml ha^{-1} and (0.47, 4.52 and 3.57 respectively at 30, 60 and 90 DAT). It is also clear from the data that significantly LAI was also recorded in W_4 –Weedy Check (0.44, 4.18 and 3.31 respectively and at 30, 60, 90 DAT. The results supported by the finding of Chowdhury *et al.* (2014) [4], Gautam *et al.* (2008) [8].

Table 1: Effect of different methods of irrigation nutrients levels and weed management practices on Plant height, Number of tiller m-2 and LAI of rice

Treatments	Plant height				Number of tiller m^{-2}			L A I		
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
(Irrigation management)										
I_1	25.451	67.014	82.376	84.796	190.579	253.783	274.812	0.46	4.40	3.47
I_2	26.896	70.753	86.953	89.549	201.071	267.256	289.176	0.49	4.66	3.68
SE (d)+	0.091	0.454	0.464	0.318	0.876	1.259	1.803	0.005	0.32	0.025
CD(P=0.05)	0.253	1.26	1.288	0.883	2.431	3.496	5.004	0.014	0.89	0.068
(Nutrients levels)										
F_1	24.81	65.168	80.078	82.406	185.016	246.246	266.723	0.45	4.28	3.38
F_2	26.664	70.178	86.314	89.006	199.288	265.475	285.383	0.48	4.60	3.64
F_3	25.711	67.706	83.224	85.597	192.658	256.593	277.938	0.46	4.44	3.52
F_4	27.509	72.483	89.043	91.681	206.339	274.763	297.933	0.50	4.78	3.79
SE (d) +	0.179	0.656	0.723	0.588	1.391	2.472	3.049	0.005	0.041	0.027
CD(P=0.05)	0.37	1.354	1.493	1.214	2.87	5.103	6.293	0.011	0.084	0.057
(Weed management)										
W_1	26.742	70.199	86.269	88.738	199.529	265.739	288.016	0.48	4.61	3.64
W_2	26.14	68.854	84.608	86.988	195.737	260.752	282.321	0.47	4.52	3.57

W_3	27.769	73.166	89.962	92.692	207.847	277.096	298.151	0.50	4.80	3.79
W_4	24.043	63.314	77.819	80.272	180.187	239.49	259.489	0.44	4.18	3.31
SE (d) +	0.234	0.657	0.631	0.82	1.156	2.475	3.153	0.008	0.040	0.029
CD(P=0.05)	0.464	1.302	0.884	1.624	2.289	4.899	6.243	0.017	0.080	0.057

Table 2: Effect of different methods of irrigation nutrients levels and weed management practices on Fresh shoot weight (g m-2), Dry weight of shoot (gm-2), Fresh weight of root (g m-2), Dry weight of root (g m-2) of rice.

	Fresh shoot weight (g m^{-2})				Dry weight of shoot (gm^{-2})				Fresh weight of root (g m^{-2})				Dry weight of root (g m^{-2})			
Treatments	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
(Irrigation management)																
I_1	50.747	925.796	747.09	519.76	9.216	503.828	546.24	653.27	15.38	18.00	19.78	15.82	5.14	5.94	8.31	12.66
I_2	53.597	978.632	782.18	547.52	9.773	534.273	568.37	688.91	16.21	18.98	20.86	16.68	5.42	6.26	8.76	13.35
SE (d)+	0.373	8.125	5.408	4.04	0.056	2.191	2.837	3.38	0.07	0.09	121	0.10	0.02	0.04	0.054	0.08
CD(P=0.05)	1.03	22.56	15.01	11.22	0.156	6.082	7.876	9.404	0.207	0.269	0.336	0.284	0.078	0.128	0.149	0.368
(Nutrients levels)																
F_1	49.346	902.65	720.77	504.39	8.965	493.026	531.14	644.68	15.244	17.846	19.613	15.687	5.097	6.134	8.237	12.55
F_2	53.1	969.54	788.24	545.51	9.716	530.423	564.38	682.18	15.994	18.726	20.579	14.461	5.346	6.615	8.645	13.17
F_3	51.26	935.62	748.60	524.0	9.312	510.948	551.05	662.19	15.618	18.283	20.089	16.068	5.219	6.284	8.439	12.87
F_4	54.97	1001.03	800.99	560.65	9.895	541.804	582.64	695.32	16.338	19.126	21.018	16.809	5.461	6.576	8.829	13.45
SE (d) +	0.604	11.29	8.47	7.28	0.079	3.005	4.592	4.67	0.148	0.192	0.243	0.204	0.056	0.137	0.107	0.158
CD(P=0.05)	1.24	23.32	17.49	15.02	0.164	6.203	9.477	10.183	0.306	0.396	0.501	0.421	0.116	0.299	0.221	0.326
(Weed management)																
W_1	53.218	970.084	776.38	543.32	9.656	530.241	564.08	683.91	15.993	18.724	20.576	16.458	5.347	6.438	8.643	13.17
W_2	52.098	951.244	761.10	532.76	9.469	515.67	554.83	663.74	15.546	18.199	19.999	15.996	5.197	6.256	8.399	12.8
W_3	55.372	1010.55	808.56	565.99	10.078	552.14	594.03	718.72	17.023	19.928	21.898	17.514	5.689	6.85	9.199	14.02
W_4	48.001	876.969	712.50	492.49	8.774	478.151	516.27	618.00	14.633	17.13	18.826	15.058	4.891	5.887	7.909	12.05
SE (d) +	0.605	11.382	9.31	7.31	0.116	3.184	4.184	5.95	0.191	0.248	0.313	0.264	0.073	0.177	0.138	0.209
CD(P=0.05)	1.19	22.53	18.43	14.48	0.23	6.336	8.327	12.97	0.38	0.493	0.624	0.525	0.145	0.375	0.275	0.146

Table 3: Effect of different methods of irrigation nutrients levels and weed management practices on number of paniclem^{-2}, Number of productive tiller m^{-2}, Number of unproductive tiller m^{-2} and motility percent of rice.

Treatments	Number of panicle m^{-2}			Number of Productive tiller^{-2}			Unproductive tiller^{-2}			Tiller motility percent		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
(Irrigation management)												
I_1	263.206	271.743	267.474	263.60	271.12	246.68	7.298	7.691	7.458	2.983	2.936	2.959
I_2	278.852	286.333	282.593	278.55	286.33	257.82	7.661	7.661	7.778	2.788	2.717	2.753
SE (d) +	1.584	1.834	1.212	1.71	1.99	1.31	0.063	0.060	0.044	0.035	0.034	0.024
CD (P=0.05)	6.817	7.892	3.364	7.35	8.57	3.64	0.272	0.256	0.122	0.15	0.144	0.067
(Nutrients levels)												
F_1	255.412	292.125	259.344	255.20	263.27	259.27	7.755	7.219	7.487	2.959	2.909	2.934
F_2	276.038	284.138	280.088	198.28	283.51	279.74	7.435	8.039	7.737	2.891	2.845	2.868
F_3	266.747	274.316	270.532	266.77	274.32	270.54	7.255	7.534	7.394	2.881	2.81	2.846
F_4	285.919	294.722	290.171	286.35	293.81	290.08	7.472	8.235	7.854	2.811	2.741	2.776
SE (d) +	2.843	3.33	2.189	2.44	2.59	1.78	0.089	0.124	0.076	0.04	0.038	0.028
CD(P=0.05)	6.194	7.255	4.517	5.32	5.65	3.67	0.194	0.27	0.158	0.087	0.083	0.061
(Weed management)												
W_1	277.265	284.669	280.967	277.16	284.05	280.60	7.115	7.832	7.473	2.663	2.705	2.684
W_2	270.444	278.614	274.529	270.03	278.61	274.32	8.162	7.83	7.996	2.942	2.991	2.967
W_3	287.894	296.675	292.329	288.80	296.04	292.42	7.265	8.259	7.762	2.875	2.949	2.912
W_4	248.424	256.195	252.309	248.30	256.20	252.25	7.375	7.106	7.241	2.825	2.898	2.861
SE (d) +	3.238	2.572	2.411	2.49	2.67	1.82	0.249	0.127	0.104	0.056	0.058	0.037
CD (P=0.05)	6.865	7.572	4.773	5.28	5.65	3.63	0.528	0.27	0.206	0.119	0.122	0.073

References

1. Ali MS, Hasa-N MA, Sikder S, Islam MR, Hafiz MHR. Effect of seedling age and water management on the performance of Boro rice (*Oryza sativa* L.) variety BRRI Dhan28. the Agriculturists. 2013;11(2):28-37.
2. Anonymous. Annual report 2020-21, Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture Govt. of India, New Delhi, 2020-21.
3. Borker R, Dawe Toung TP, Bhuiyan SI, Gerra LC. The outlook for water resources in the year 2020: challenges forresearch on water management in rice production. Int. Rice Comm. Newsl. 2000;49:7-21.
4. Chapagain T, Eiji Yamaha E. The effects of irrigation method, age of seedling and spacing on crop performance, productivity and water-wise rice production in Japan. Paddy Water Environ. 2010;8:81–90.
5. Chowdhury MR, Kumar V, Sattar A, Brahmachari K. Studies On the Water Use Efficiency and Nutrient Uptake by Rice Under System of Intensification. An International Quarterly. Journal of Life Sciences.

2014;9(1):85-88, 2014
6. Djaman K, Mel VC, Ametonou FY, El-Namaky R, Diallo MD, Koudahe K. Effect of Nitrogen Fertilizer Dose and Application Timing on Yield and Nitrogen Use Efficiency of Irrigated Hybrid Rice under Semi-Arid Conditions. J Agri Sci Food Res. 2018;9(2):2-7
7. Fontech MF, Tabi FO, Wariba AM, Zie J. Effective water management practices in irrigated rice to ensure food security and mitigate climate change in a tropical climate. Agriculture and Biology Journal of North America. 2013;4(3):284-290.
8. Gautam AK, Kumar D, Shivay YS, Mishra BN. Influence of nitrogen levels and plant spacing on growth, productivity and quality of two inbred varieties and a hybrid of aromatic rice. Archives of Agronomy and Soil Science. 2008;54(5):515-532.
9. Raju, Sreenivas. Agronomic evaluation of system of rice intensification in Godavari delta. Oryza. 2008;45(4):280-283.
10. Upendra A, Murthy KMD, Sridhar TV, Srinivas D. Studies on performance of organic farming and chemical farming in rice-rice system. J Eco-friendly Agric. 2013;8(1):24-27.
11. Van der Hoek W, Sakthivadivel R, Renshaw M, Silver JB, Birley MH, Konradsen F. Alternate wet and dry irrigation in rice cultivation: a practical way to save water and control malaria and Japanese encephalitis? Research Report 47. International Water Management Institute, Colombo, 2001.