Bangladesh J. Bot. **53**(3): 527-533, 2024 (September) DOI: https://doi.org/10.3329/bjb.v53i3.76269

GROWTH AND YIELD OF DIRECT SEEDED RICE AS INFLUENCED BY IRRIGATION LEVELS AND VARIETIES

Govinakere Sambegowda Sathisha* and Narayana Shivarudrappa Mavarkar[1]

Department of Agronomy, College of Agriculture Shivamogga-577204, Karnataka, India

Keywords: Direct seeded rice, Growth, Yield, Irrigation, Varieties

Abstract

The combined influence of agronomic, environmental and genetic variables results in better crop yield. Among these components, an appropriate irrigation system and varietal choice are crucial. With this background, a field experiment with a split-plot layout was planned during the summer period of 2020 at the Agriculture and Horticultural Research Station, Bhavikere, Karnataka, India, to examine the effects of four different irrigation levels (0.75, 1.00, 1.25 and 1.50 IW/CPE ratio) in the main plot and four different varieties (Local variety, Jyothi, MAS 946-1 and MAS-26) in the subplots on growth and yield performance under direct seeded rice condition. Results of the experiment revealed that among four different levels of irrigation, scheduling irrigation at 1.50 IW/CPE ratio recorded higher growth and yield parameters at harvest viz., plant height (82.76 cm), number of tillers per plant (13.29), leaf area index (2.66), total dry matter accumulation (73.36 g/plant), number of panicle per plant (10.35), panicle length (21.59 cm), number of filled grains per panicle (90.4), grain yield (5569 kg/ha) and straw yield (7514 kg/ha). While, among the varieties used for the study, MAS 946-1 recorded the higher growth and yield parameters at harvest (64.19 cm, 13.96, 2.45, 73.34 g/plant, 10.96, 21.25 cm, 84.3, 5743 kg/ha and 7288 kg/ha, respectively). Hence, scheduling irrigation at 1.50 IW/CPE ratio and use of MAS 946-1 variety demonstrated superior performance, making it most appropriate for maximising higher production under direct seeded rice condition.

Introduction

The most significant crop grown as a staple food in Asia is rice (*Oryza sativa* L.). Three-quarters of the rice harvested globally is produced in irrigated rice fields, which are the major contributor to Asia's food security. However, rice is an inefficient water consumer, using over half of all available freshwater supplies. The sustainability of the irrigated rice production system, and therefore the food security and way of life of rice growers and consumers, are threatened by the rising water shortage (Rao *et al*. 2016). The conventional method of producing rice not only wastes water but also harms the environment by releasing methane gas and destroying the soil's structure, rendering it unusable for the next crop to be grown. Depending on the variety and rice growing techniques, 3000 to 5000 liters of water are needed to produce one kilogram of rice in a puddled transplanted situation (Nayak *et al*. 2015). Future freshwater shortages will make it difficult to produce rice, hence direct seeded rice or aerobic rice culture is replacing transplanting as a preferred method in India (Duary and Pramanik 2019). DSR, which can conserve both labour and water and be commonly employed in India before the green revolution, is regaining popularity. Where direct seeded rice is an upland method of rice cultivation in which rice can be grown in well-drained, unpuddled and non-saturated soils (aerobic soils).

The combined influence of agronomic, environmental and genetic variables results in better crop yield. Among these components, an appropriate irrigation system and varietal choice are crucial. Drip irrigation is one of the best ways to reduce the water requirement of direct seeded

*Author for correspondence: <sathishgvnkagri@gmail.com>. [1]Dean, College of Horticulture Mudigere-577132, Karnataka, India.

rice. When compared to furrow and sprinkler irrigation methods, drip irrigation delivers water more precisely and consistently, potentially boosting yield, lowering subsurface drainage, and improving salinity management (Hanson and May 2007). Understanding the relationship between soil, water, plants and the atmosphere should go along with scientific irrigation planning. Moisture regimes and climatological techniques are two of the many methods for planning the irrigation of field crops that have been proven to be reliable and known. Therefore, the meteorological approach based on pan evaporation is one of the most simple, reliable, cost-effective and time-efficient methods that have been employed in the present experiment (Prihar *et al.* 1976).

Rice varieties appropriate for direct seeding conditions must be assessed, because they should have a high yield potential and be able to tolerate stressful situations. The development of different rice varieties will probably vary depending on the amount of water available in upland aerobic situations as well as in lowland ones. The existing varieties utilized for transplantation do not seem to be widely used, thus research is being done to find varieties that may provide a similar yield to transplanted rice under direct seeding circumstances. Hence, the present study has been undertaken considering all these facts.

Material and Methods

A field experiment was conducted during the summer of 2020 at the AHRS, Bhavikere, Tarikere Taluk, Chikmagalur district, Karnataka, India, belongs to the Southern Transitional Zone (Zone–7) of Karnataka (75°51` E longitude and 13°42` N latitude with an altitude of 695 meters). The experimental area was laid out as per the plan of split plot design with three replications where the main plot consisted of four levels of irrigation based on IW/CPE ratios (I_1:0.75, I_2:1.0, I_3:1.25 and I_4:1.50) and the sub-plot with the four different varieties (V_1: Local variety, V_2: Jyothi, V_3: MAS 946-1 and V_4: MAS-26). The irrigation was given through the drip system by using the IW/CPE ratios. 5 cm depth of irrigation was fixed to give in every time. Since the irrigation was given based on IW/CPE ratio the daily pan evaporation rate was recorded from the standard USWB class A open pan evaporimeter. To apply a 5 cm depth of irrigation the cumulative pan evaporation (CPE) has to reach 33.33, 40, 50, and 66.66 mm for 1.50, 1.25, 1.00 and 0.75 IW/CPE ratios, respectively. If there is any effective rainfall received, it has been deducted from the pre-fixed depth of irrigation and waited till CPE reaches the pre-fixed depth. By multiplying the depth of irrigation and the area of the plot, the volume of water required for each plot was calculated. The water was made to discharge through inline emitters @ 2 lph @ 2 kg/cm^2 pressure. Water was pumped through a 5 HP motor and it was conveyed to the main field using mains after filtering through sand and screen filter which was in turn connected with sub-mains. Further, sub mains were laid perpendicular to replications of the experiment; the laterals were attached to the sub-main at 60 cm intervals in such a way that the laterals were parallel to the rows of direct seeded rice.

The time of operation of the drip system to deliver the required volume of water per plot was computed based on the formula-

$$\text{Time of application} = \frac{\text{Volume of water required (l)}}{\text{Emitter discharge (l/ha)}\times\text{No. of emitters/plot}}$$

The recommended dose of nutrients was farm yard manure (FYM) at 10 t/ha, 100: 50: 50 of N:P_2O_5:K_2O kg/ha and zinc sulphate @ 20 kg/ha, which was applied commonly to all the treatments.

Results and Discussion

The data related to the growth parameters of direct seeded rice at harvest stage influenced by different irrigation levels and varieties are presented in the Table 1.

Table 1. Growth parameters of direct seeded rice at harvest stage influenced by irrigation schedules and varieties.

Main plot: Irrigation (I)	Plant height (cm)	Number of tillers per plant	Leaf area index	Total dry matter accumulation (g/plant)
I_1	57.06	10.64	1.73	57.99
I_2	66.55	11.52	2.00	63.63
I_3	76.55	12.65	2.48	70.84
I_4	82.76	13.29	2.66	73.36
S.Em.±	2.31	0.22	0.08	1.79
CD (P=0.05)	8.01	0.75	0.26	6.18
Sub plot: Varieties (V)				
V_1	97.17	8.41	1.84	55.85
V_2	59.37	12.09	2.19	65.30
V_3	64.19	13.96	2.45	73.34
V_4	62.19	13.63	2.40	71.33
S.Em.±	1.70	0.15	0.06	1.21
CD (P=0.05)	4.95	0.46	0.16	3.54
Interaction (IXV)	NS	NS	NS	NS

NS: Non-significant.

The growth parameters have enhanced as irrigation levels have risen, peaking at an irrigation scheduling ratio of 1.50 IW/CPE and falling to a minimum of 0.75 IW/CPE. Among the various irrigation levels, the plots receiving the 1.50 IW/CPE level of irrigation had significantly higher plant height, number of tiller per plant, leaf area index, and total dry matter accumulation (82.76 cm, 13.29, 2.66, and 73.36 g/plant, respectively), and it was on par with the 1.25 IW/CPE (76.55 cm, 12.65, 2.48 and 70.84 g/plant, respectively). Conversely, irrigation scheduling at 0.75 IW/CPE ratio has shown considerably lower growth parameters (57.06 cm, 10.64, 1.73 and 57.99 g/plant, respectively). Increased irrigation levels may have led to better absorption of water and nutrients, which in turn increased plant height. Conversely, decreased irrigation levels may have decreased cell turgor, which in turn reduces cell enlargement and results in decreased plant height (Shekara *et al.* 2010). Higher irrigation levels may have produced the highest number of tillers due to healthy crop and root development across all growth phases, which eventually boosted tiller density. On the other hand, less tillering in fields with lower irrigation levels may be caused by a lack of water, which causes a decrease in the quantity of photosynthetically active radiation that is intercepted (Maheswari *et al.* 2008). The improvement in nutrient absorption under greater moisture conditions might be the cause of the increase in leaf area with increasing irrigation levels, leading to more leaves and larger leaf area together with more tillers (Mahalakshmi *et al.* 2020). The maintenance of adequate soil moisture as a result of increased irrigation frequency favoured faster cell division and cell elongation, which in turn led to an increase in dry matter production (Narolia *et al.* 2014). The reduction in transpiration rate and normal gas exchange resulted in increased production of photosynthates, which in turn led to better dry matter accumulation.

The growth parameters of direct seeded rice significantly influenced by different rice varieties. Among the four varieties tested for the suitability under direct seeded system of cultivation, significantly higher plant height was recorded in local variety (97.17 cm) and significantly lower plant height (59.37 cm) was recorded in Jyothi variety of rice. Whereas, significantly higher number of tillers, leaf area index, and total dry matter accumulation recorded in MAS 946-1 (13.96, 2.45 and 73.34 g/plant, respectively) and significantly lower has recorded in local variety (8.41, 1.84 and 55.85 g/plant, respectively). The differences in growth parameters of four rice varieties. might be due to the varietal difference i.e., genetic makeup of the plants which could influenced the differential crop growth and physiological behaviour of the plants in response to different soil moisture regimes under direct seeded rice condition determines their ability to accumulate the photosynthates in the vegetative plant parts (Koireng *et al.* 2019).

Effects of different levels of irrigation and varieties on yield parameters and yield of direct seeded rice are represented in the Table 2.

Among the four levels of irrigation significantly higher yield parameters like number of panicle per plant, panicle weight, panicle length, number of grains per panicle and number of filled grains per panicle were recorded in the irrigation scheduling at 1.50 IW/CPE ratio (10.35, 2.35 g, 21.59 cm, 95.5 and 90.4, respectively) and it was on par with 1.25 IW/CPE ratio (9.86, 2.22 g, 20.85 cm, 91.6 and 83.6, respectively). Whereas, significantly lower yield parameters like number of panicle per plant, panicle weight, panicle length, number of grains per panicle and number of filled grains per panicle recorded in the scheduling of irrigation at 0.75 IW/CPE ratio (8.28, 1.86 g, 20.85 cm, 91.6 and 83.6, respectively). On the contrary, number of unfilled grains per panicle and per cent chaffyness were significantly highest in scheduling of irrigation at 0.75 IW/CPE ratio (13.9 and 17.2, respectively) and significantly lowest has recorded in 1.50 IW/CPE ratio (5.1 and 5.4, respectively). The improvement in yield contributing characters with 1.50 IW/CPE ratio might be due to the continuous and uninterrupted moisture supply throughout the crop growth period which resulted in higher cell division and elongation leads to increase in growth characters enables the increased supply of photosynthates from source to sink results in significant increase in yield components like number of panicles per plant, panicle weight with more number of filled grains (Keerthi *et al.* 2018).

Among the different varieties tested, significantly higher number of panicle per plant, panicle length, number of grains per panicle and number of filled grains per panicle were recorded in MAS 946-1 (10.96, 21.25 cm, 93.8 and 84.3, respectively) and lowest was recorded in local variety (6.34, 18.60 cm, 79.8 and 68.9, respectively). The variety MAS 946-1 was at par with MAS-26 (10.87, 21.24 cm, 93.7 and 84.1, respectively). But with respect the panicle weight significantly higher and lower panicle weight recorded in jyothi and MAS-26 variety (2.19 and 2.04 g, respectively). Significantly higher per cent chaffyness recorded in local variety (13.9) and lowest in MAS 946-1 (10.4). The variety MAS 946-1 outperformed and it was at par with MAS 26. This might be attributed to higher affinity of these varieties to produce more number of tillers per plant in early growing period followed by differential ability of cultivars to utilize the nutrients as well applied inputs effectively leads to the better partitioning of photo assimilates to the sink which determines the significant variation in yield contributing characters like number of panicles per plant, number of filled grains per panicle with less per cent chaffyness (Dawadi and Chaudhary 2013).

Results indicated that grain yield and straw yield increased with the increase in levels of irrigation schedules. Grain yield and straw yield was found significantly higher in scheduling of irrigation at 1.50 IW/CPE ratio (5569 kg/ha and 7514 kg/ha, respectively) and it was on par with 1.25 IW/CPE ratio (5268 kg/ha and 7162 kg/ha, respectively). Scheduling of irrigation at 0.75

Table 2. Yield components of direct seeded rice influenced by irrigation schedules and varieties.

Main plot: Irrigation (I)	Panicle/ plant	Panicle weight (g)	Panicle length (cm)	Number of grains/panicle	Number of filled grains/ panicle	Number of unfilled grains/ panicle	Chaffyness (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
I_1	8.28	1.86	18.83	81.0	67.1	13.9	17.2	4143	5821
I_2	9.07	2.01	19.94	86.8	74.8	12.1	14.0	4593	6503
I_3	9.86	2.22	20.85	91.6	83.6	8.0	8.9	5268	7162
I_4	10.35	2.35	21.59	95.5	90.4	5.1	5.4	5569	7514
S.Em.±	0.20	0.05	0.25	2.34	1.96	0.41	0.22	109	163
CD (P=0.05)	0.59	0.15	0.75	8.11	6.78	1.43	0.76	376	564
Sub plot: Varieties (V)									
V_1	6.34	2.16	18.60	79.8	68.9	10.9	13.9	3463	6561
V_2	9.40	2.19	20.12	87.8	78.6	9.2	10.8	4753	6221
V_3	10.96	2.06	21.25	93.8	84.3	9.5	10.4	5743	7228
V_4	10.87	2.04	21.24	93.7	84.1	9.6	10.5	5614	6988
S.Em.±	0.15	0.03	0.34	1.71	1.25	0.51	0.32	76	83
CD (P=0.05)	0.44	0.10	1.00	4.99	3.65	NS	0.93	220	244
Interaction (IXV)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: Non-Significant

IW/CPE ratio recorded significantly lower grain yield and straw yield (4143 kg/ha and 5821 kg/ha, respectively). The higher grain yield was recorded with higher levels of the irrigation regimes might be due to the higher growth and yield attributes as well conducive situation for efficient water and nutrients uptake which boost their growth and yield attributes through supply of more photosynthates towards the reproductive sink. The similar results of reduced levels of irrigation on reduction in grain yield are reported by Ramanamurthy *et al.* (2017).

Varieties of rice significantly influenced the grain yield and straw yield. Significantly higher grain yield and straw yield were recorded in MAS 946-1 variety (5743 kg/ha and 7228 kg/ha, respectively) and it was on par with MAS-26 (5614 kg/ha and 6988 kg/ha, respectively). Whereas, significantly lower grain yield (3463 kg/ha) and lower straw yield (6221 kg/ha) were recorded in the local variety and Jyothi variety respectively. It was mainly due to the potential genetic makeup the variety helps for the increased uptake and utilization of the applied water and nutrients effectively resulting in enhanced growth and yield attributes promote the increased photosynthetic efficiency of the variety leading to greater dry matter production and translocation to sink (Sritharan *et al.* 2015). There was a significant variation in the rice straw yield, where significantly higher straw yield was obtained in MAS 946-1. It happens so due to increase in number of tillers per plant, number of leaves and leaf area which resulted in improvement of biomass production that ultimately reflected the straw yield. Hence, significantly higher straw yield was noticed in the MAS 946-1 variety (Veeresh *et al.* 2011).

Results of the study revealed that cultivation of the MAS 946-1 variety with the irrigation scheduling at 1.50 IW/CPE ratio under direct seeded rice condition gives higher growth and yield parameters in turn highest grain yield.

Acknowledgements

The authors would like to thank the Department of Science and Technology, INSPIRE, Govt. of India for providing a Ph.D. fellowship for the academic and research work.

References

Dawadi KP and Chaudhary NK 2013. Effect of sowing dates and varieties on yield and yield attributes of direct seeded rice in chitwan condition. J. Agric. Environ. **14**: 121-130.

Duary S and Pramanik K 2019. Response of aerobic rice to irrigation and nitrogen management in red and lateritic soil of West Bengal. J. Crop and Weed **15**(1): 108-113.

Hanson B and May D 2007. The effect of drip line placement on yield and quality of drip irrigated processing tomatoes. Irrig. Drainage Syst. **21**: 109-118.

Koireng RJ, Devi NM, Devi KP, Gogoi M and Anal PR 2019. Effect of variety and spacing on the productivity of direct seeded rice (*Oryza sativa* L.) under Manipur condition. Indian J. Pure App. Biosci. **7**(5): 335-341.

Keerthi MM, Babu R, Venkataraman NS, Subramanian E and Kumutha K 2018. Effect of varied irrigation scheduling with levels and times of nitrogen application on yield and water use efficiency of aerobic rice. American J. Plant Sci. **9**(11): 2287-2296.

Mahalakshmi M, Subramanian E, Gurusamy A and Senthil K 2020. Irrigation scheduling and intercropping on growth and yield of aerobic rice. Int. J. Curr. Microbiol. Appl. Sci. **9**: 2867-2872.

Maheswari J, Bose J, Sangeetha SP, Sanjutha S and Priya RS 2008. Irrigation regimes and N levels influence chlorophyll, leaf area index, proline and soluble protein content of aerobic rice (*Oryza sativa* L.). Int. J. Agric. Res. **3**(4): 307-316.

Narolia RS, Singh P, Prakash C and Meena H 2014. Effect of irrigation schedule and weed-management practices on productivity and profitability of direct-seeded rice (*Oryza sativa* L.) in South-eastern Rajasthan. Indian J. Agron. **59**(3): 398- 403.

Nayak BR, Pramanik K, Khanda CM, Panigrahy N, Mohanty AK, Mohapatra S, Samant PK, Panda N and Swain SK 2015. Influence of irrigation regimes and nitrogen levels on aerobic rice during summer season. Oryza **52**(2): 117-122.

Rao VP, Venkateswarlu B, Yadav B, Rao AS, Rao KLN and Prasuna RP 2016. Effect of sub surface drip fertigation on water productivity, nitrogen use efficiency and economics of aerobic rice. Plant Arch. **16**(2): 855-858.

Prihar SS, Khera KL, Sandhu KS and Sandhu BS 1976. Mulch, nitrogen and irrigation effects on growth, yield and nutrient uptake of forage corn 1. Agron. J. **68**(6): 937-941.

Ramanamurthy KV, Ramadass S and Ramanathan SP 2017. Effect of irrigation and nitrogen levels on the growth, yield and economics of rice. Int. J. Curr. Microbiol. Appl. Sci. **4**(2): 280-292.

Shekara BG, Sharnappa and Krishnamurthy N 2010. Effect of irrigation schedules on growth and yield of aerobic rice (*Oryza sativa*) under varied levels of farm yard manure in Cauvery command area. Indian J. Agron. **55**(7): 35-39.

Sritharan N, Vijayalakshmi C, Subramanian E and Boomiraj K 2015. Supremacy of rice genotypes under aerobic condition for mitigating water scarcity and future climate change. African J. Agric. Res. **10**(4): 235-243.

Veeresh, Desai BK, Vishwanatha S, Anilkumar SN, Rao S and Halepyati AS 2011. Growth and yield of rice (*Oryza sativa* L.) varieties as influenced by different methods of planting under aerobic method of cultivation. Res. J. Agric. Sci. **2**(2): 298-300.

(Manuscript received on 22 November, 2023; revised on 12 September, 2024)