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Evaluation of Physiological Parameters and Growth Phenology in Rice Cultivars under Irrigated Conditions of Raipur Plain

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to examine the physiological and growth parameters of various rice *(Oryza sativa.*L.) varieties under irrigated conditions in the Raipur plain during *kharif* season 2023-24. The research focused on key metrics including crop growth rate (CGR), absolute growth rate (AGR), net assimilate rate (NAR), and relative growth rate (RGR) to evaluate the performance of different rice varieties in this region. Results showed significant variation among the rice varieties in their growth and physiological responses. Varieties with higher CGR and AGR demonstrated superior biomass accumulation and overall growth performance. Those with elevated NAR and RGR exhibited more efficient conversion of assimilates into plant

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biomass, reflecting better productivity. The findings underscore the importance of selecting rice varieties based on their growth metrics and physiological efficiency under specific irrigated conditions.

Keywords: Food crop; photosynthates; plant biomass; crop growth rate.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an important source of food for more than half of the world population and 90% of the rice area worldwide is in Asia. (Jabran *et al.*, 2015; Ullah *et al.*, 2018). As the most important food crop in the world, rice is grown on over 165 million hectares and produces around 596 million metric tons (paddy). As per Third Advance Estimates for 2022-2023 shows that rice production in the country is estimated at 1355.42 lakh metric tonnes, which is higher by 60.71 lakh tonnes as compared to previous year. The estimated total production of *kharif* rice for 2023–2024 is 1063.13 lakh metric tons, which is 13.23 lakh metric tons more than the previous year of *Kharif* rice. According to the First Advance Estimates for 2023–2024 (*Kharif* Only) production of 1063.13 lakh metric tons (Pib. 2023) the estimated production. Chhattisghar known as the "Rice Bowl" of India, is a prominent state in the rice-producing industry (Dos et al., 2024). According to Agricultural Statistics at a Glance (Government of India, 2022), the state of Chhattisgarh reported a total rice yield of 2052 kg/hectare in 2021-2022. In rice, biomass accumulation is a major factor in determining grain production which is directly influenced by photosynthates. Further improvement of yield potential in rice will have to involve an increase in biomass production (). The efficiency of photosynthesis significantly impacts crop yield (Xu et al., 2018). In rice, yield is influenced by several key traits (Li et al., 20140, including the number of panicles per unit area, the number of filled grains per panicle, and the weight of 1,000 grains. In rice, grain yield is influenced by physiological characteristics like net assimilation rate (NAR), crop growth rate(CGR), relative growth rate(RGR), absolute growth rate(AGR) and total dry matter production.

2. MATERIALS AND METHODS

The experiment was executed in Instructional farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during the *kharif* season 2023–2024. Experimental details are RBD design, fifteen varieties NRRI0, IGKV02, IGKV03, MTU03, IGKV05, MTU05, NRRI05, NRRI06, IGKV10, IGKV11, NRRI11, IGKV09, MTU12, NRRI03, IGKV07, two replications and spacing 15cm × 20cm. Physiological parameters like growth rate and relative growth rate were derived from these measurements and further analysed to understand their contributing factors.

Crop growth rate (CGR): The rate of dry matter production in crop stands was determined by calculating the average daily increment of shoot biomass (W1 and W2) per unit growth area (P) over a specific time interval (t1 and t2). This approach, described by Poter and Jones in 1977, allowed for the estimation of the rate of dry matter production in the crop stands. W2 and W1 are the total dry weight of the plant at times t2 and t1, respectively

$$\mathrm{CGR} = \frac{W_2 - W_1}{P\,(t_2 - t_1)} \ \mathrm{g\ m^{-2}\ day^{-1}}$$

Net assimilation rate (NAR): The Net Assimilation Rate (NAR) serves as an indirect indicator of the rate of net photosynthesis. It quantifies the amount of dry matter produced per square centimetre of leaf area in a single day. To calculate NAR, the leaf area of each individual plant must be utilized, as outlined by Leopold and Kriedmann (1975). Where L1 and w1 represent the plant's leaf area and dry weight at time t1, and L2 and w2 represent the plant's leaf area and dry weight at time t2.

$$\mathrm{NAR} = \frac{w_2 - w_1\,(\ln L_2 - \ln L_1)}{(t_2 - t_1)\,(L_2 - L_1)} \ \mathrm{g\ cm^{-2}\ day^{-1}}$$

Relative growth rate (RGR): Leopold and Kriedmann (1975) developed an index that measures the amount of growth material per unit dry weight of plant per unit time.

$$\mathrm{RGR} = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)} \ \mathrm{g\ g^{-1}\ week^{-1}}$$

Absolute growth rate (AGR): In plant growth refers to the total increase in plant size, biomass, or other measurable traits over a defined time interval. It provides a direct measure of the actual numeric change in growth.

W2 – W1 ÷ t2 – t1

3. RESULTS AND DISCUSSION

3.1 Growth Analysis

3.1.1 Absolute growth rate (cm g/day)

Absolute growth rate was differed significantly in all the varieties of rice. The maximum AGR was achieved by var IGKV-11 (0.30) which was at par with IGKV-07 (0.27), IGKV-02(0.23), NRRI-03 (0.23), MTU-03(0.23) and NRRI-05(0.23).While minimum AGR was achieved by variety MTU-05 (0.18) followed by IGKV-03 (0.19), IGKV-09 (0.20) and MTU-12(0.22). (Fig. 1).

3.1.2 Crop growth rate (g/m^2/day)

The crop growth rate (g/m^2/day) showed significant variation among rice varieties, ranging from 2.69 to 4.51 (g/m^2/day) under irrigated conditions. Amongst these varieties, IGKV11 (4.51 g/m^2/day) exhibited highest crop growth rate, followed by IGKV02 (4.23g/m^2/day), IGKV07 (4.20g/m^2/day). Conversely, the lowest rates was observed in MTU05 variety at (2.69 g/m^2/day), followed by IGKV03 (2.71g/m^2/day), NRRI11 (2.74g/m^2/day), and NRRI06 (2.87g/m2/day). (Fig. 2).

The increased CGR can be attributed to elevated leaf area index values and light interception, which in turn boost photosynthetic rate and dry matter production (Ahmed et al., 2014). As crop growth rate represents dry matter production per unit area over a period of time and it is considered as the most critical and meaningful growth function [6].

3.1.3 Net assimilation rate (NAR) g / cm2 /day

The net assimilation rate (NAR) exhibited significant variation among all rice varieties. The highest NAR was recorded in IGKV11 (0.86), followed by IGKV02 (0.64), IGKV07 (0.60), NRRI03 (0.55). Conversely, the lowest NAR was observed in NRRI01 (0.14), followed by NRRI11 (0.16). (Fig. 3) (Sridhar et al., 2018, Hussain et al., 2010).

Increase in net assimilation rate enhances photosynthetic capacity of leaves with improved nutrition of the plants thereby increasing dry matter accumulation at final harvest (-).NAR is the physiological potential for converting the total dry matter into grain yield. The NAR is used as a measure of the rate of photosynthesis minus respiration losses Reddy *et al.*, reported that the genotype having high NAR value had higher assimilation rate and grain yield with greater stability (Kumar et al., 2013).

3.1.4 Relative growth rate (RGR) g /g /day

Relative growth rate was differed significantly in all varieties of rice. However,IGKV11 (0.002769) have shown significant higher value of RGR followed by IGKV02 (0.002664), IGKV07 (0.002581), NRRI03 (0.002534), MTU03 (0.002387) while minimum relative growth rate recorded in variety NRRI01 (0.001711) followed by NRRI11 (0.001761) MTU05 (0.001792). (Fig. 4)

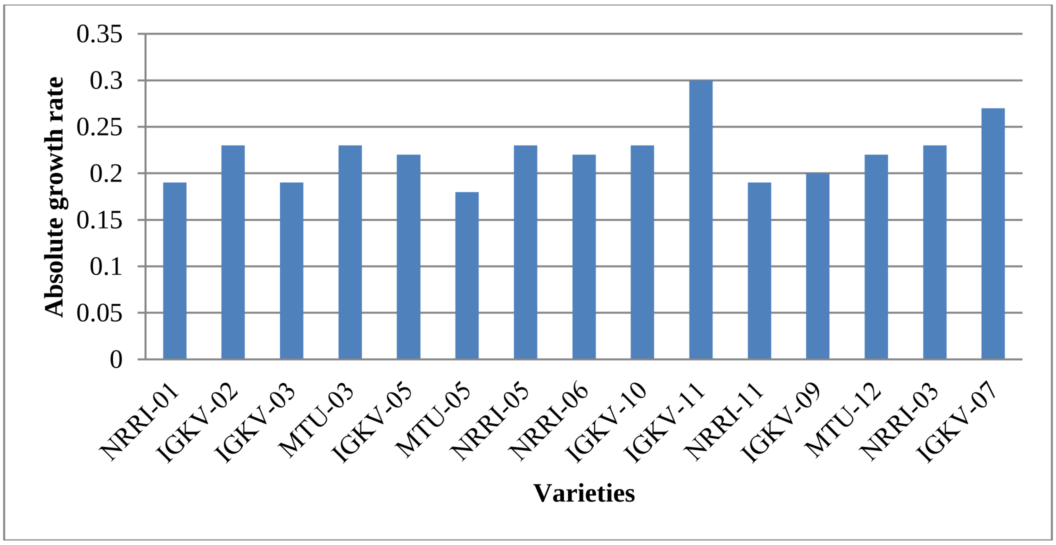

Fig. 1. AGR of plant height at interval of 50% flowering and maturity stage

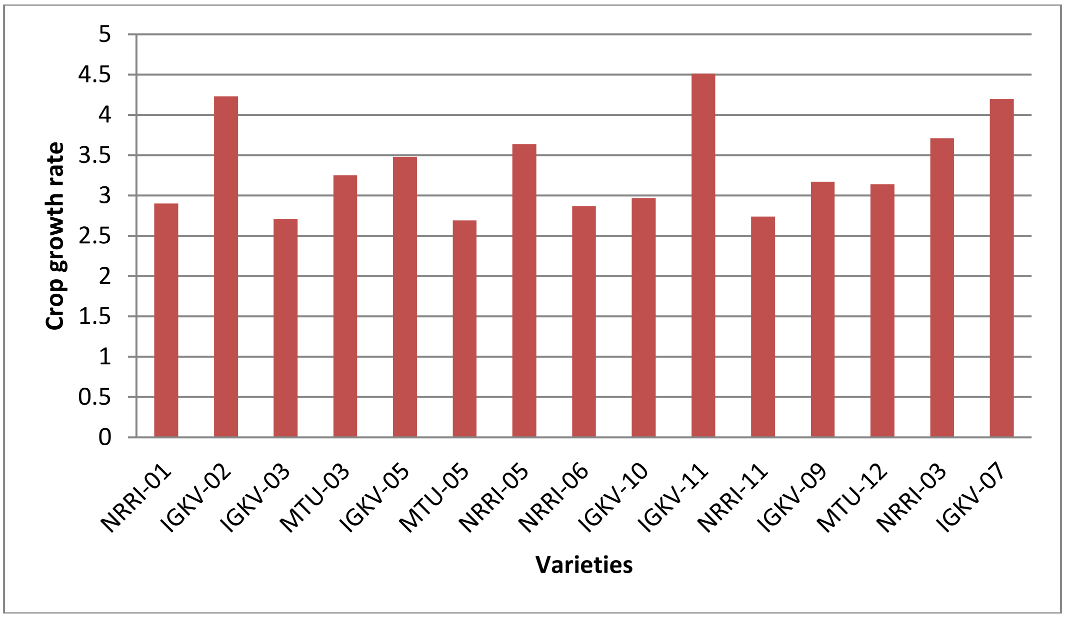

Fig. 2. CGR of plant weight at interval of 50% flowering and maturity stage

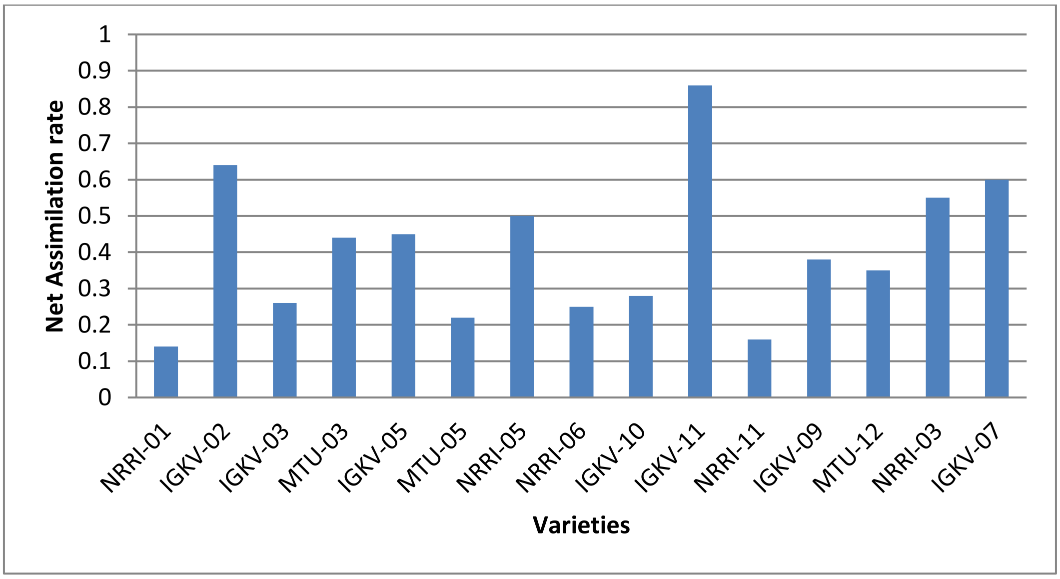

Fig. 3. NAR of 50% flowering and maturity stage rice varieties rice varieties

Overall respiration scales with total biomass, but photosynthesis only scales with photosynthetic biomass and as a result of which biomass accumulates more slowly as total biomass increases.

3.1.5 Correlation studies

The CGR, AGR, NAR, RGR were measured between 50% flowering and physiological maturity and there was a significant positive association of absolute growth rate (0.809**), crop growth rate (0.926**) net assimilate rate (0.974**) relative growth rate (0.97**), with. NAR (0.523*) and RGR (0.586*) have significant and positive association with biological yield. RGR also have highly significant and positive association with absolute growth rate (0.798***), crop growth rate (0.91***) and net assimilate rate (0.952***), plant biomass (0.586*) whereas relative growth rate is highly significant and negatively associated with number of leaves at 50% flowering as well as maturity stage (-0.8**). NAR has highly positively significant correlations

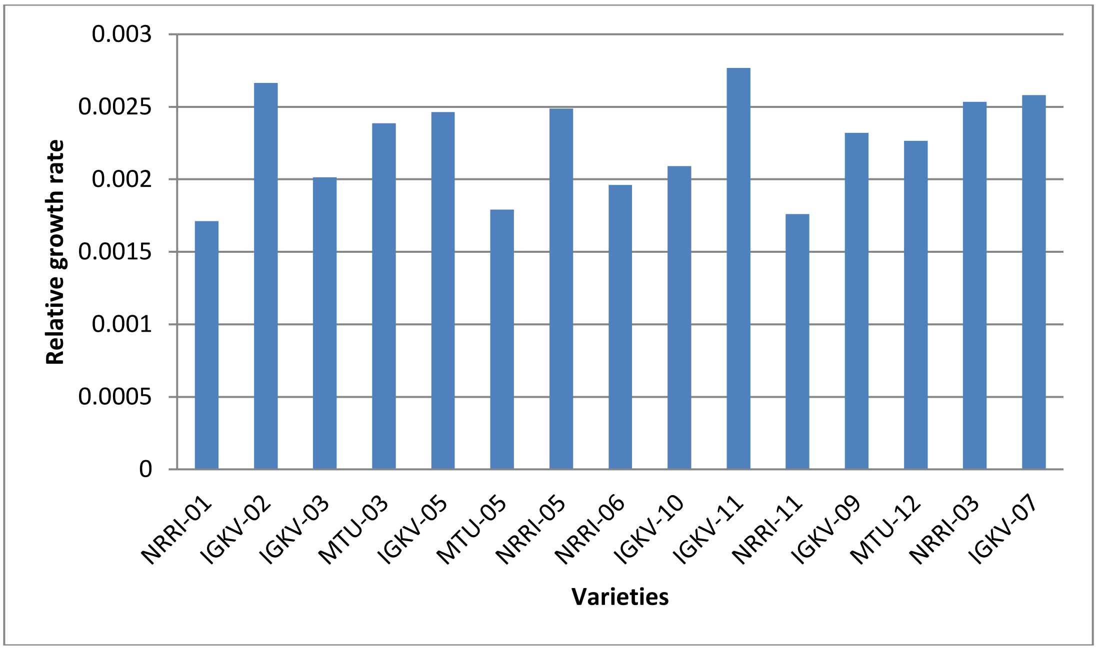

Fig. 4. RGR of rice varieties

with number of tillers at both the stages (0.762***), number of productive tillers (0.935***) and crop growth rate (0.961***) (Nagarajan et al., 2024). CGR have highly positively significant correlation with number of tillers at both stages (0.646**) and absolute growth rate (0.86***) (Ying et al., 1998).

4. CONCLUSIONS

Plant growth parameters, *i.e.*, CGR and NAR play significant role in photo assimilate partitioning and productivity. Variety IGKV12 having highest CGR (4.51/m^2/day) and NAR (0.86g/cm^2/day). The variety IGKV11 also exhibited more harvest index (47.07%) followed by IGKV02 (42.79).These growth parameters positively associated with grain yield and harvest index. From the above experiment it is observed that varieties NRRI01 and NRRI11 which had less AGR,NAR,CGR,RGR had low grain yield and low harvest index. All the growth parameters i.e. AGR, CGR, NAR, RGR showed significant positive correlation with each other.

The correlation analysis of morpho-physiological, growth, and yield attributes revealed significant associations between various traits. net assimilation rate (NAR) showed positive correlations with Economic yield (seed yield) and harvest index. Whereas crop growth rate (CGR) exhibited highly positive correlations with harvest index.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ahmed, F., Mollick, M. P., Pervin, O. A., Rezuana, & Hoque, M. A. (2024). Yield performance of different aromatic rice genotypes and their morpho-physiological attributes. *International Journal of Biosciences, 24*(4), 91-100.

Choudhary, S., Baghel, S. S., Upadhyay, A. K., Singh, A., Rani, M., & Choudhary, S. (2021). Growth indices of direct-seeded rice (*Oryza sativa* L.) as influenced by STCR-based integrated nutrient management. *The Pharma Innovation Journal, 10*(12), 3036-3041.

Dos Santos, M. P., Heinemann, A. B., Stone, L. F., da Silva, M. A., Lanna, A. C., & dos Santos, A. B. (2024). Phenology, gas exchange, biomass accumulation, and irrigated rice yield under alternative irrigation managements. *Agronomy Journal, 116*(2), 542-562.

Government of India, Ministry of Agriculture and Farmers Welfare. (2022). *Agricultural Statistics at a Glance* (pp. 49-125).

Hussain, I., Khan, M. A., & Khan, H. (2010). Effect of seed rates on the agro-physiological traits of wheat. *Sarhad Journal of Agriculture, 26*(2).

Kumar, R., Pandey, A. K., Singh, A. K., Choubey, M., & Verma, A. K. (2013). Magnitude of rice (*Oryza sativa* L.) performance as influenced by genotype under an agro-ecosystem. *Environment & Ecology, 31*(4A), 1816-1822.

Li, G., Zhang, J., Yang, C., Song, Y., Zheng, C., Wang, S., Liu, Z., & Ding, Y. (2014). Optimal yield-related attributes of irrigated rice for high yield potential based on path analysis and stability analysis. *The Crop Journal, 2*(4), 235-243.

Nagarajan, K., Geethalakshmi, V., Thirukumaran, K., Prabhukuma, G., Vijayalakshmi, D., & Prasanthrajan, M. (2024). Evaluation of growth and yield parameters of rice under different cultivation methods. *Agricultural Science Digest, 44*(2), 232-237.

Sridhar, K., Srinivas, A., Kumar, A. K., Ramprakash, T., & Rao, R. P. (2018). Physiological growth parameters of rabi rice (*Oryza sativa* L.) under alternate wetting and drying irrigation with varied nitrogen levels. *International Journal of Current Microbiology and Applied Sciences, 8*, 1-15.

Xu, Z., Li, M. H., Zimmermann, N. E., Li, S. P., Li, H., Ren, H., Sun, H., Han, X., Jiang, Y., & Jiang, L. (2018). Plant functional diversity modulates global environmental change effects on grassland productivity. *Journal of Ecology, 1941-1951*.

Ying, J., Peng, S., He, Q., Yang, H., Yang, C., Visperas, R. M., & Cassman, K. G. (1998). Comparison of high-yield rice in tropical and subtropical environments: I. Determinants of grain and dry matter yield. *Field Crops Research, 57*(1), 71-84.

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