Leaf area index of Dry Direct Seeded Rice (*Oryza sativa* L.) as influenced by different Nitrogen levels and Weed management practices under temperate conditions.

Abstract

Dry direct-seeded rice (DDSR) is an increasingly important cultivation method in regions facing water scarcity and labour constraints. Optimizing nitrogen application is instrumental in determining the environmental sustainability and economic feasibility of a farming system, making its management a top priority. In addition, the weed problems in dry direct-seeded rice account for the yield reduction and diminish the market value by reducing the product quality and raising the postharvest cost. Considering this, the present investigation titled "Response of Dry Direct Seeded Rice to Nitrogen Levels and Weed Management Practices under Temperate Conditions" was accomplished at MRCFC, SKUAST-K, Khudwani during Kharif 2022 and 2023. The experiment encircled the employment of four nitrogen levels: 0 kg N ha^{-1}(N_0), 60 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2), and 150 kg N ha^{-1} (N_3). Additionally, seven weed management practices were employed encircling Pendimethalin at 1 kg a.i. ha^{-1}, 2,4-D at 0.75 kg ha^{-1} (W_1), penoxsulam at 22.5 g ha^{-1} (W_2), Pyrazosulfuron combined with Pretilachlor at 30 g + 0.75 g a.i. ha^{-1} (W_3), Bensulfuron Methyl combined with Pretilachlor at 30 g + 0.75 g a.i. ha^{-1} (W_4), and Triafamone combined with Ethoxysulfuron at 40 g + 20 g a.i. ha^{-1} (W_5). The treatments also included a weedy check (W_6) and a weed-free control (W_7). The experiment was designed in line with the factorial randomized complete block design (RCBD) possessing three replications. The acquired results elucidated a considerable increase in growth attributes such as leaf area index in response to various nitrogen levels as well as weed management approaches. Employment of nitrogen @ 150 kg ha^{-1} and Triafamone + Ethoxysulfuron (40+20 g a.i ha^{-1}) (12-15 DAS) application, in addition to weed-free treatment, recorded the highest values for Leaf area index during 2022 and 2023.

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Key words: Nitrogen levels, Rice, Weed management, Yield

Introduction

Rice is a vital cereal crop in the developing world, serving as the prime food resource for over half the worldwide population. India ranks first in terms of rice cultivation area and stands second only to China in production (Deivasigamani, 2016). Rice is a crucial component of India's economy and holds a prominent place in the country's agricultural policies and food security framework (Dangwal *et al.*, 2011). On a global scale, rice is cultivated over approximately 165.04 million hectares, yielding an annual production of around 776.46 million tonnes. In India, it occupies about 46.40 million hectares, contributing to a production of 196.24 million tonnes (Food and Agricultural Organization of the United Nations, 2023). In the Union Territory of Jammu and Kashmir, rice has been cultivated for centuries and remains a staple food. The region has approximately 274.47 thousand hectares under rice cultivation, producing around 604.7 thousand tonnes annually (Anonymous, 2023). It has been projected that 17 million hectares of irrigated rice fields in Asia might encounter water shortages. With the global population growing, developing nations must prioritize efficient rice production on limited arable land by leveraging genetic improvements, optimizing management practices, and addressing socio-economic challenges. Additionally, around 22 million hectares are expected to experience economic water scarcity (Materu *et al.*, 2018), raising concerns about the sustainability of traditional flooded rice cultivation. Transplanted rice significantly contributes to greenhouse gas (GHG) emanations, particularly

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nitrous oxide (N_2O), and methane (CH_4), exacerbating global warming. To address this issue, adopting alternative cultivation methods has become essential to reduce harmful emissions associated with rice production. In recent years, direct-seeded rice (DSR) has gained prominence as a sustainable and promising approach. This method addresses water and labour shortages while maintaining productivity (Saharawat *et al*., 2010).

Nitrogen is a critical nutrient for rice growth, influencing its yield, quality, and biomass production (Jahan *et al*., 2020). Weed infestations are known to affect the nitrogen demand in direct-seeded rice (DSR) systems (Kumawat *et al*., 2017). Therefore, precise nitrogen application is essential for achieving optimal rice yields (Hussain *et al*., 2018). Nitrogen fertilization imparts an indispensable part in balancing competition between weeds and rice, making it a valuable practice for reducing weed interference in crops. Devi and Singh, 2018). Weeds represent one of the most significant biological restraints that limit the direct-seeded rice (DSR) productivity, leading to substantial economic losses. In dry direct-seeded rice (DDSR), yield losses can reach up to 75%, and weed management accounts for more than 30% of the total cost of rice cultivation. The introduction of newer, low-dose, high-efficacy pre- and post-emergent broad-spectrum herbicides has provided new opportunities for direct-seeded rice (DSR), helping to address labour and water shortages while offering an early weed-free start for crops, thus enhancing competitiveness and weed control effectiveness (Jehangir *et al*., 2023). It is essential to develop optimal management strategies for DDSR that consider nitrogen and herbicide applications, aiming to enhance grain yield, water use efficiency, and profitability. These benefits can be realized both directly through improved nitrogen supply and indirectly by reducing crop-weed competition (Chaudhary *et al*., 2011).

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Experimental Methodology

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The experiment was performed at MRCFC, SKUAST-K, Khudwani during Kharif 2022 and 2023. The field is located at 34^o 21' N latitude and 74^o 23' E longitude possessing an altitude of 1560 meters above mean sea level. The area experiences a temperate climate, characterized by hot weather in summer, and freezing temperatures in winter. The soil in the experimental field exhibited silty clay loam as the dominant textural class and exhibited medium status with regard to organic carbon, available nitrogen, phosphorus, and potassium content. In addition, the respective soil was observed to possess a neutral soil reaction. The current experiment comprised of four nitrogen levels viz., 0 kg N ha^{-1} (N_0), 60 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2) and 150 kg N ha^{-1} (N_3) and seven weed management practices viz., Pendimethalin 1kg a.i ha^{-1} fb 2,4-D 0.75 kg ha^{-1} (W_1), penoxsulam 22.5 g ha^{-1} (W_2), Pyrazosulfuron + Pretilachlor 30g + 0.75g a.i ha^{-1} (W_3), Bensulfuron Methyl + Pretilachlor 30g + 0.75g a.i ha^{-1} (W_4), Triafamone + Ethoxysulfuron 40+20 g a.iha^{-1} (W_5), weedy check (W_6) and weed free (W_7), designed in alignment with the factorial randomized complete block design (RCBD) possessing three replications. The Cochran and Cox technique (1936) was employed to appraise the acquired observations statistically, while treatment differences were assessed using the F-test.

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Leaf area index

The periodic measurements of leaf area were conducted at 40, 55, 70, 85, 100, 115 days, and at harvest using a leaf-area meter.

$$\text{Leaf Area Index (LAI)} = \frac{Total\ leaf\ area}{Ground\ area}$$

RESULTS AND DISCUSSION

Leaf area index (LAI) represents the total leaf area per unit ground area and increases in accordance with the compound interest law. The maximum value of LAI is observed around heading with a subsequent decline and senescence of lower leaves (Murata and Matsushima, 1978). In the current study, the LAI was marked to increase upto 85 DAS with a subsequent decline after this. The enhancement in LAI might be in debt of the direct correlation between LAI and leaf area while the subsequent decline might be accredited the withering of leaves after 85 DAS. In addition, the shading to lower leaves of the crop due to weeds caused their senescence and death. A perusal of data indicated that among the different nitrogen levels, N150 kg ha^{-1} (N_3) documented significantly higher leaf area index at 40, 55, 70 and 85 DAS as compared to rest of the treatments across both the years. The acquired observations elucidated that the highest leaf area index was observed under N_3 (150 kg ha^{-1}) at 85 DAS was 5.29 and 5.45. whereas the lowest leaf area index of 4.54 and 4.67 at 85 DAS was recorded with control during 2022 and 2023, respectively. The data revealed that nitrogen fertilization significantly influenced the LAI with maximum values recorded under 150 kg N ha^{-1} (N_3) and lowest values of LAI found in 0 kg N ha^{-1}(N_0). These observations might be accredited to the increase in leaf number in hand with elevated shoot number per unit area in response to enriched nutrition with 150 kg N ha^{-1} (N_3) application. Sufficient nutrient in balanced proportion in 150N kg ha^{-1} (N_3) treatment directed to the maximum growth rates through cell division and cell elongation, resulting in improved leaf expansion and the highest leaf area index. The results align with the observations put forward by Hussain *et al.* (2018) and Dahipahle and Singh (2018).

The appraisal of weed management practices demonstrated that all treatments significantly increased leaf area index (LAI) in contrast to the control group. The weed-free treatment marked a notably higher LAI than the weedy check. The glance of data elucidated that the weed-free treatment noted the highest LAI at 40, 55, 70, and 85 DAS during both years. Among the different herbicides used, Triafamone + Ethoxysulfuron 40+20 g a.i. ha^{-1} (W_5) recorded significantly highest LAI at 40, 55, 70 and 85 DAS as compared to Pendimethalin 1kg a.i ha^{-1} fb 2,4-D 0.75 kg ha^{-1} (W_1), Penoxsulam 22.5 g ha^{-1} (W_2), Pyrazosulfuron + Pretilachlor 30g + 0.75g a.i ha^{-1} (W_3), Bensulfuron Methyl + Pretilachlor 30g + 0.75g a.i ha^{-1} (W_4) and weedy check (W_6) during both the years of experiment, respectively. However, significantly lowest LAI was recorded by weedy check treatment at all the intervals during both the years. Superiority exhibited by Triafamone + Ethoxysulfuron 40+20 g a.i. ha^{-1} (W_5) in amplifying the leaf area index compared to the weedy check was 31.72 % and 30.84 % , respectively.

The application of herbicides may have facilitated better growth by providing the crop with sufficient light, water, and nutrients, which in turn resulted in a higher leaf area index. These findings are consistent with those of Shan *et al.* (2012), Ganai *et al.* (2017), and Kumar *et al.* (2018).

Fig. 1. Effect of different nitrogen levels on LAI of dry direct seeded rice

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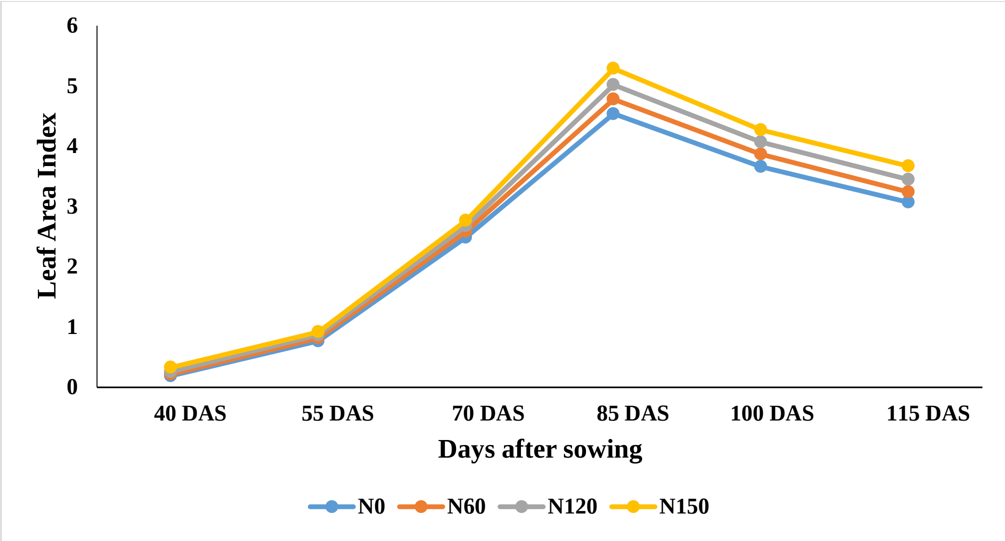

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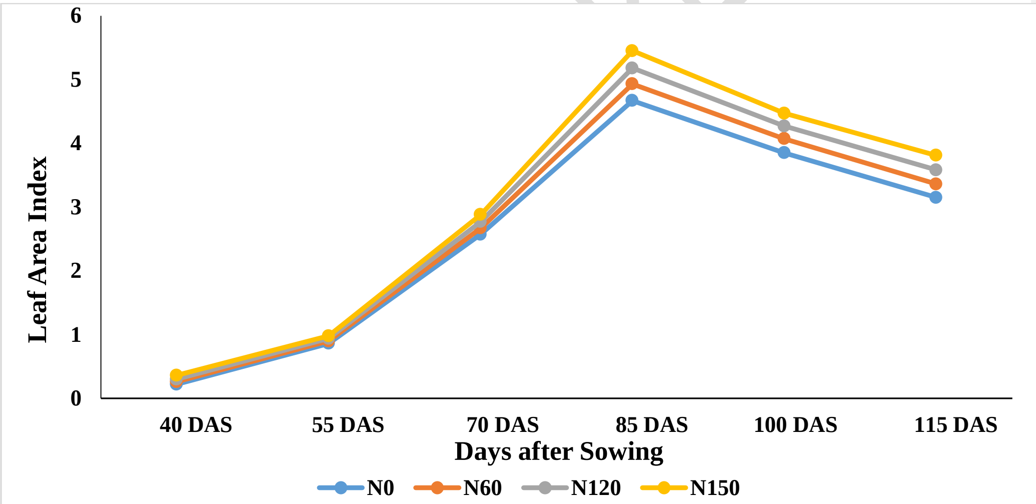

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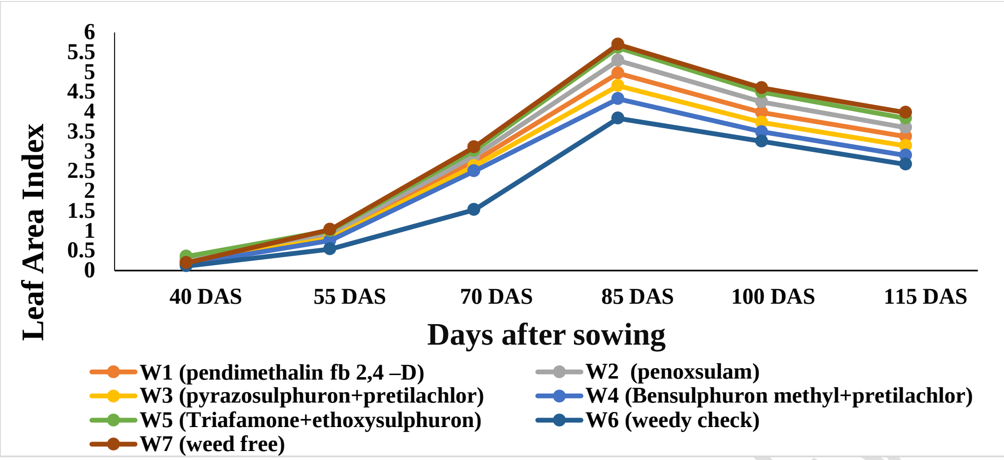
Fig. 2. Effect of different weed management practices on LAI of dry direct seeded rice



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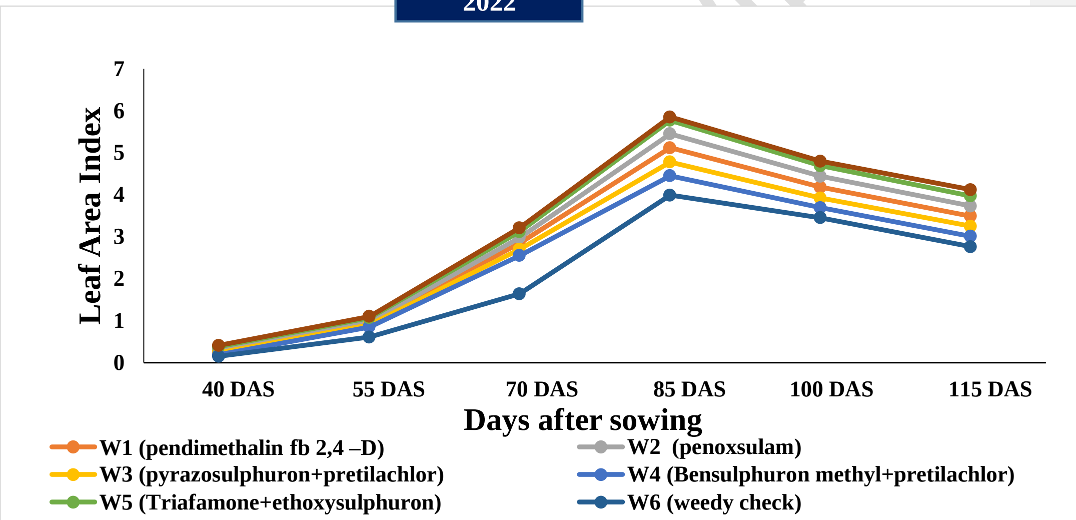

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CONCLUSION

These findings led to the conclusion that for realizing higher LAI of dry direct seeded rice under temperate conditions of Kashmir Valley, employment of 150 kg N ha^{-1} proved to be effective. Similarly, among different herbicides Triafamone + Ethoxysulfuron 40+20 g a.i ha^{-1} (W_5) performed well in contrast to other herbicides over the two-year experimentation period.

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REFERENCES

Anonymous. 2023. Directorate of Economics and Statistics, Government of J&K. Digest of Statistics.

Chaudhary, S.K., Singh, J.P. and Jha, S. 2011. Effect of integrated nitrogen management on yield, quality and nutrient uptake of rice (*Oryza sativa*) under different dates of planting. *Indian Journal of Agronomy* **56**(3): 228- 231.

Dahipahle, A.V. and Singh, U.P. 2018. Effect of crop establishment, nitrogen levels and time of nitrogen application on growth and yield attributing parameters of direct seeded rice (*Oryza sativa* L.). *International Journal of Chemical Studies* **6**(2): 2889-2893.

Dangwal, L.R, Singh T, SharmaA. 2011 Effercts of weeds on the yield of rice. *International journal of current research* **3**:69-70

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Deivasigamani, S. 2016. Study of bioefficacy and phytotoxicity of new generation herbicides triafamone and ethoxysulfuron in direct seeded rice (*Oryza sativa*). *International Journal of Applied Science* **3**(2): 106–112.

Devi, R.B. and Singh, Y. 2018. Nutrient uptake and yield of direct seeded rice as influenced by nitrogen and weed management practices. *Indian Journal of Pure & Applied Biosciences* **6**(5):34-40.

Food and Agriculture Organization of the United Nations - FAO. Crops and livestock products. Faostat. 2022 [accessed on October 23; 2023]. Available from: https://www.fao.org/faostat/en/#data/QCL

Ganai, M.A., Bhat M.A., Hussain, A., Kanth, R.H., Teli, N.A., Hussian, T., Lone, A.H. and Ahmad, T. 2017. Effect of water regimes and weed-management practices on growth, yield and weed-control efficiency of rice under system of rice intensification. *Indian Journal of Agronomy* **62** (4): 114-120.

Gomez, K. A. 1972. Techniques for Field Experiments with Rice, International Rice Research Institute, Los Banos.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York

Jehangir, I.A., Raja, W., Hussain. A., Al-Shuraym, L.A., Sayed, S.M., Lone, A.H., Shah, Z.A. and Dar, E.A. 2023. Herbicide effectiveness and crop yield responses in direct seeded rice. insights into sustainable weed management

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Hussain, A., Lone, A.H., Bhat, M.A., Ganai, M.A., Ahmad, L., Mehdi, S.S. and Jehangir, I.A. 2018. Moderate drying and higher nitrogen increase the yield and water use efficiency of rice established through system of rice intensification (SRI) method. *International Journal of Current Microbiology and Applied Sciences* **7**(12): 809-818.

Kumar, C. 2017. Nitrogen and weed management in direct-seeded rice (*Oryza sativa* L.). Thesis submitted to Bihar Agriculture University, Sabour, Bhagalpur.

Kumar, S., Shivani, Mishra, J. S., Kumar, S., Kumar, U. & Bharati, R. C. 2018. Efficacy of pre- and postermergence herbicides on complex weed flora in direcet seeded rice (*Oryza sativa*) in the eastern plains. *Indian Journal of Agricultural Sciences* **88**(3):387-392.

Murata, Y. and Matsushima, S. 1978. "Rice," In: Crop Physiology, Some Case Histories. [Ed. L.T. Evans]. Cambridge University Press, London, pp. 73- 99.

Seharwat, Y.S., Bhagat S., Malik, R., Ladha J.K., GathalaM.,Jsat, M.L. and Kumar, V. 2010 evaluation of alternative tillage and crop establishmentmethods in a rice wheat rotation in north westernIGP. *Field crops research* 116:260-267

Shan, F. A., Bhat, M. A., Ganai, M. A., Hussain, A. and Bhat, T. A. 2012. Effect of crop establishment and weed control practices on the performance of rice (*Oryza sativa* L.). *Applied Biological Research* **14**(1): 79–85.

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