Journal of Advances in Biology & Biotechnology

Volume 28, Issue 1, Page 408-417, 2025; Article no.JABB.129455
ISSN: 2394-1081

Influence of Different Nitrogen Levels and Weed Management Practices on Leaf Area Index of Dry Direct Seeded Rice (*Oryza sativa L.*) Under Temperate Conditions

Seerat Jan [a*], Ashaq Hussain [b], Waseem Raja [a], Shakeel A. Mir [c], Fehim Jeelani Wani [d], Imtiyaz A. Lone [e], Amal Saxena [a] and Ishfaq Majeed [f]

[a] Division of Agronomy, FoA, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, J&K, India.
[b] Mountain Research Centre for Field Crops, Khudwani Kulgam, SKUAST-K, J & K, India.
[c] Division of Soil Science & Agricultural Chemistry, SKUSAT-K, Shalimar, Jammu and Kashmir, India.
[d] Division of Agricultural Economics & Statistics FOA, Wadura, Sopore, J&K, India.
[e] Centre of Excellence on Walnut Research, Kulangam Kupwara, SKUAST-K, J & K, India.
[f] Division of Soil Science & Agricultural Chemistry, SKUSAT-K, wadura, Jammu and Kashmir, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2025/v28i11894

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/129455

Original Research Article

Received: 07/11/2024
Accepted: 09/01/2025
Published: 15/01/2025

**Corresponding author: E-mail: Seeratjan1996@gmail.com;*

Cite as: *Jan, Seerat, Ashaq Hussain, Waseem Raja, Shakeel A. Mir, Fehim Jeelani Wani, Imtiyaz A. Lone, Amal Saxena, and Ishfaq Majeed. 2025. "Influence of Different Nitrogen Levels and Weed Management Practices on Leaf Area Index of Dry Direct Seeded Rice (Oryza Sativa L.) Under Temperate Conditions". Journal of Advances in Biology & Biotechnology 28 (1):408-17. https://doi.org/10.9734/jabb/2025/v28i11894.*

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 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 ha^{-1} (3-4 DAS) + 2,4-D at 0.75 kg ha^{-1} (20 DAS), penoxsulam at 22.5 g ha^{-1} (12-15 DAS), Pyrazosulfuron combined with Pretilachlor at 30 g + 0.75 g ha^{-1} (3-4 DAS), Bensulfuron Methyl combined with Pretilachlor at 30 g + 0.75 g ha^{-1} (3-4 DAS), and Triafamone combined with Ethoxysulfuron at 40 g + 20 g ha^{-1} (12-15 DAS). The treatments also included a weedy check and a weed-free control. 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 ha^{-1}) application, in addition to weed-free treatment, recorded the highest values for Leaf area index during 2022 and 2023.

Keywords: Nitrogen levels; Rice; weed management; yield; dry direct seeded Rice; leaf area index.

1. INTRODUCTION

Rice is a vital cereal crop in the developing world, serving as the prime food resource for over half of the worldwide population. India ranks first in terms of rice growing 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 being cultivated over approximately 165.04 million hectares, providing 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. Transplanted rice significantly contributes to greenhouse gas (GHG) emanations, particularly 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*., 2022). 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). 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 due to weeds can reach up to 75%, and weed management accounts for more than 30% of the total cost of rice cultivation. The introduction of newer, more efficient pre- and post-emergent broad-spectrum herbicides has provided new opportunities for direct-seeded rice (DSR), helping to address labor and water shortages while offering an early weed-free start for crops, thus enhancing crop 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).

2. EXPERIMENTAL METHODOLOGY

The experiment was performed at MRCFC, SKUAST-K, Khudwani during *Kharif* 2022 and 2023. The field is located at 34º 21' N latitude and 74º 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 variety selected for this experiment was SR-4 and the duration of this variety is 135 days. Four nitrogen application levels were employed: 0, 60, 120, and 150 kg N per hectare, implemented through split applications. The initial nitrogen application, corresponding to the treatment levels of 0, 30, 60, and 75 kg N ha^{-1}, was applied at the time of sowing via urea. The remaining nitrogen was applied in two additional splits during the active tillering and panicle initiation stages at rates of 0, 15, 30, and 37.5 kg N ha^{-1}, as dictated by the specific treatments and seven weed management practices viz., Pendimethalin 1kg a.i ha^{-1} (3-4 DAS) fb 2,4-D 0.75 kg ha^{-1} (20 DAS), penoxsulam 22.5 g ha^{-1} (12-15 DAS), Pyrazosulfuron + Pretilachlor 30g + 0.75g a.i ha^{-1} (3-4 DAS), Bensulfuron Methyl + Pretilachlor 30g + 0.75g a.i ha^{-1} (3-4 DAS), Triafamone + Ethoxysulfuron 40+20 g a.iha^{-1} (12-15 DAS), weedy check and weed free, 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.

2.1 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.

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

3. 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 with the corresponding values of 0.33,0.92, 2.77, 5.29 during 2022 and 0.36, 0.98, 2.88, 5.45 during 2023 respectively. 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 with elevated shoot number per unit area in response to enriched nutrition with 150 kg N ha^{-1} (N_3) application. Sufficient nutrient 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. These results align with the observations put forward by Hussain *et al*. (2018), Liu *et al*. (2019) 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 with the corresponding values recoded as 0.38, 1.03, 3.11, 5.69 during 2022 and 0.41, 1.10, 3.21 and 5.85 during 2023 respectively. Among the different herbicides used, Triafamone + Ethoxysulfuron 40+20 g ha^{-1} (W_5) recorded significantly higher LAI at 40, 55, 70 and 85 DAS as compared to Pendimethalin 1kg a.i ha^{-1} fb 2,4-

Table 1. Effect of different Nitrogen levels and weed management practices on LAI of dry direct seeded rice

Treatments	40 DAS		55 DAS		70 DAS		85 DAS		100 DAS		115 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Nitrogen Levels												
N0	0.19	0.22	0.77	0.86	2.49	2.57	4.54	4.67	3.66	3.85	3.07	3.15
N60	0.22	0.26	0.82	0.90	2.59	2.67	4.78	4.93	3.87	4.07	3.24	3.36
N120	0.26	0.30	0.87	0.94	2.68	2.77	5.02	5.18	4.07	4.27	3.45	3.58
N150	0.33	0.36	0.92	0.98	2.77	2.88	5.29	5.45	4.27	4.47	3.67	3.81
SEm ±	0.01	0.01	0.01	0.01	0.03	0.03	0.08	0.08	0.06	0.06	0.06	0.06
CD ($p \leq 0.05$)	0.03	0.02	0.04	0.031	0.084	0.10	0.236	0.24	0.17	0.17	0.17	0.17
Weed management practices												
W1 (pendimethalin fb 2,4 –D)	0.26	0.29	0.87	0.94	2.75	2.85	4.97	5.12	3.98	4.18	3.37	3.49
W2 (penoxsulam)	0.30	0.33	0.92	0.98	2.88	2.98	5.29	5.45	4.24	4.44	3.60	3.73
W3 (pyrazosulphuron+pretilachlor)	0.21	0.24	0.81	0.90	2.63	2.70	4.65	4.78	3.73	3.92	3.14	3.25
W4 (Bensulphuron methyl+pretilachlor)	0.16	0.19	0.75	0.85	2.50	2.55	4.32	4.45	3.49	3.69	2.90	3.01
W5 (Triafamone+ethoxysulphuron)	0.35	0.38	1.00	1.07	3.02	3.12	5.61	5.77	4.49	4.69	3.83	3.97
W6 (weedy check)	0.11	0.15	0.54	0.61	1.53	1.64	3.83	3.99	3.25	3.45	2.67	2.76
W7 (weed free)	0.38	0.41	1.03	1.10	3.11	3.21	5.69	5.85	4.60	4.80	3.98	4.12
SEm ±	0.01	0.01	0.02	0.01	0.04	0.05	0.11	0.11	0.08	0.08	0.08	0.08
CD ($p \leq 0.05$)	0.04	0.03	0.05	0.041	0.111	0.13	0.312	0.32	0.23	0.22	0.22	0.23

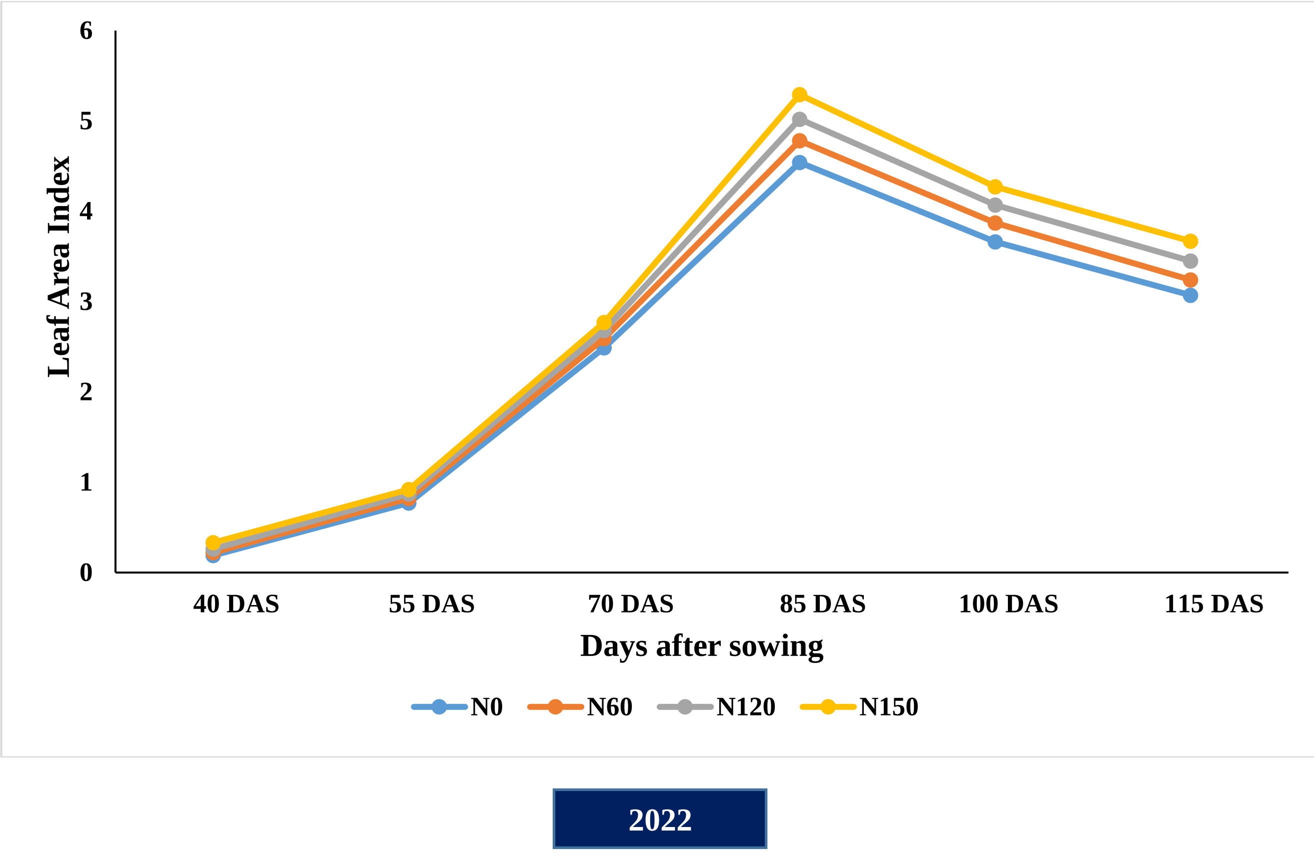

Fig. 1. Effect of different nitrogen levels on LAI of dry direct seeded rice

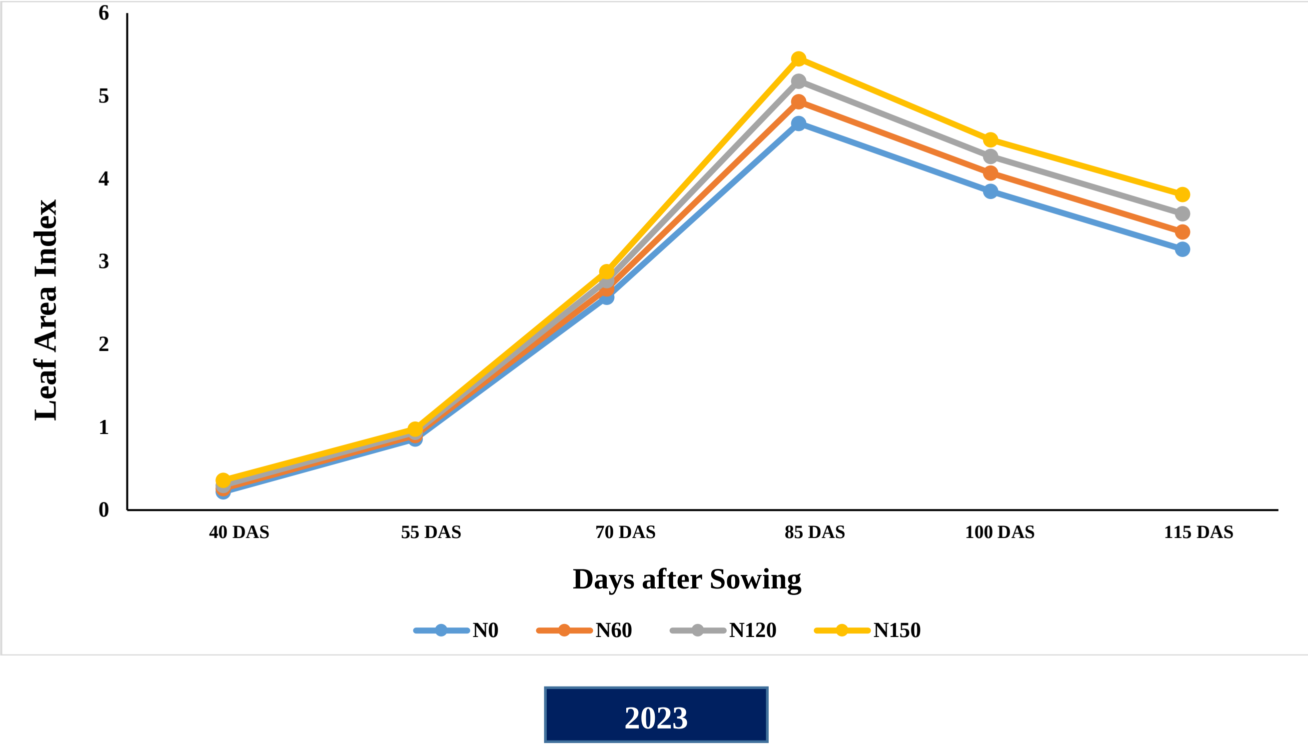

Fig. 2. Effect of different weed management practices on LAI of dry direct seeded rice

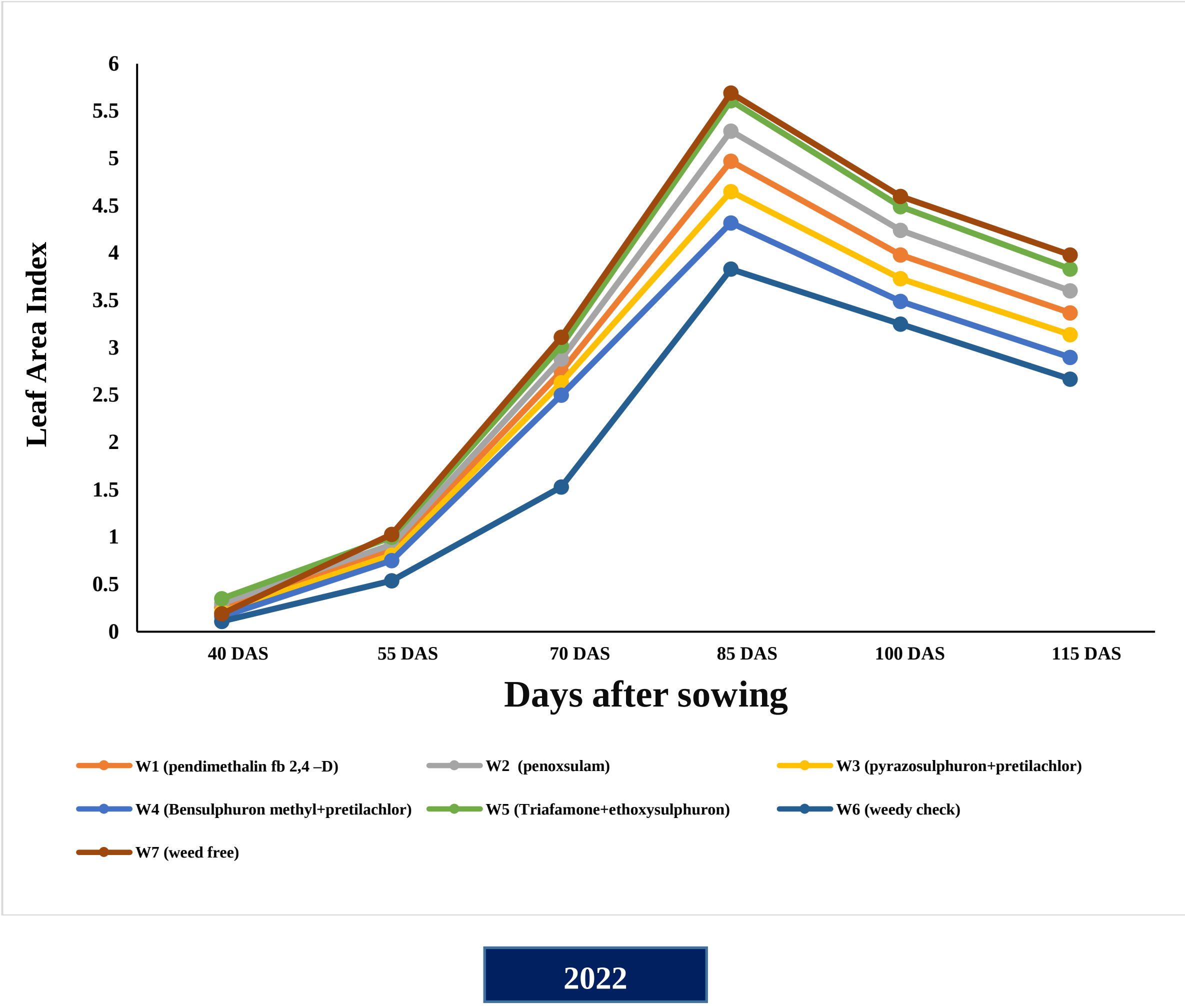

Fig. 3. Effect of different weed management practices during 2022

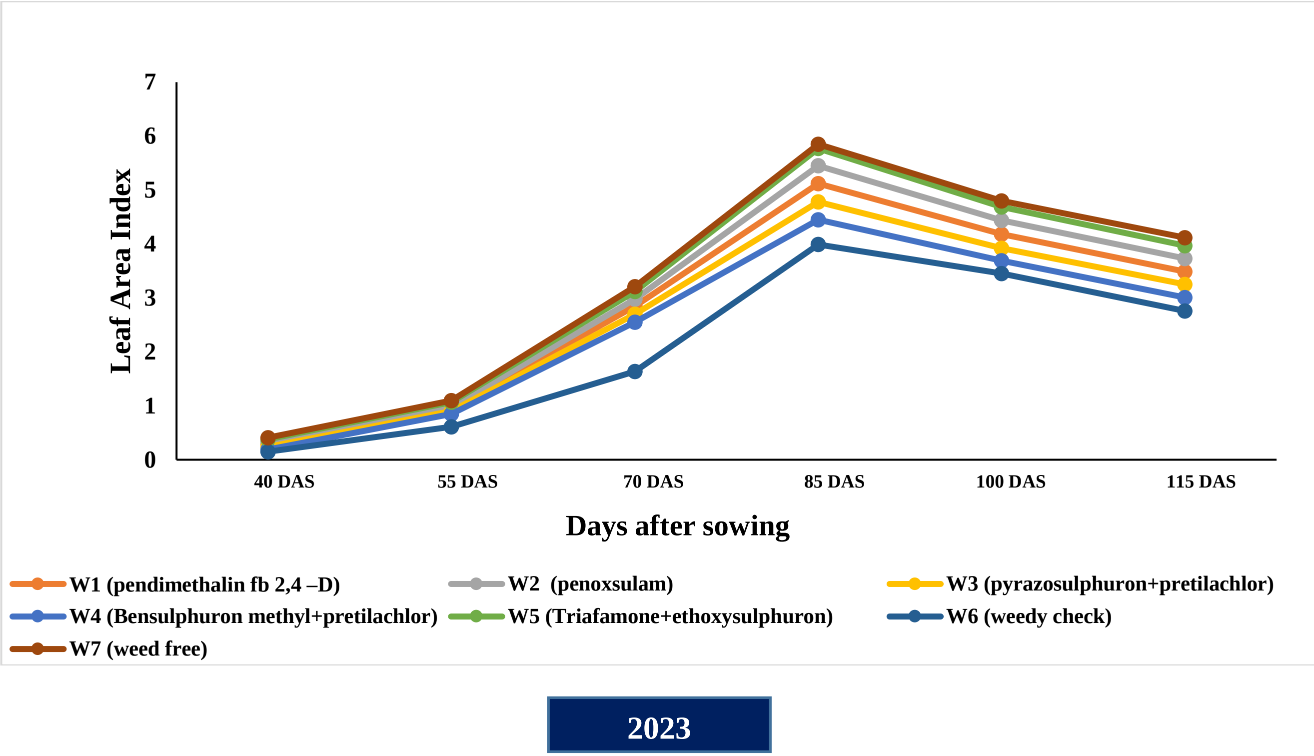

Fig. 4. Effect of different weed management practices during 2023

D 0.75 kg ha^{-1} (W_1), Penoxsulam 22.5 g ha^{-1} (W_2), Pyrazosulfuron + Pretilachlor 30g + 0.75g ha^{-1} (W_3), Bensulfuron Methyl + Pretilachlor 30g + 0.75g 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 ha^{-1} (W_5) in amplifying the leaf area index compared to the weedy check was 31.72 % and 30.84 % in 2022 and 2023 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).

4. 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 ha^{-1} (W_5) performed better in contrast to other herbicides over the two-year experimentation period. Understanding the influence of nitrogen levels and weed management practices on the LAI of dry direct seeded rice is critical for optimizing crop productivity, sustainable weed management, resource use efficiency, reducing input costs, and enhancing profitability for farmers, dry direct seeded rice is gaining importance as a water saving rice cultivation technique insights into nitrogen and weed management interactions can help improve its resilience under changing climatic conditions, ensuring food security. the findings contribute to the scientific understanding of plant soil nutrient interactions and weed ecology in dry direct seeded rice systems, aiding in the development of region specific, data driven recommendations for agricultural practices. This research provides a foundation for developing integrated nutrient and weed management strategies, ensuring the sustainability of rice farming systems.

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 the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/129455