



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(6): 70-75
Received: 03-04-2025
Accepted: 07-05-2025

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Effect of plant leaf aqueous extracts on plant Height & chlorophyll index in Rice-Wheat cropping system

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DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i6a.2997>

Abstract

The present study, titled “*Effect of plant leaf aqueous extracts on plant height & chlorophyll index in Rice-Wheat cropping system*”, was conducted at Lovely Professional University, Phagwara, Punjab, during the rabi seasons of 2021-2022 and 2022-2023. The experiment was designed in a Randomized Block Design (RBD) comprising 20 treatments with three replications each. The treatments included aqueous leaf extracts of Eucalyptus (5% and 10%), Neem (10% and 15%), and Guava (25% and 30%), along with herbicide applications at reduced dosages of 50% and 75%. The primary objective was to evaluate the efficacy of these botanical extracts, in combination with reduced herbicide dosages, on the morphological traits of wheat-specifically plant height and chlorophyll index-within the rice-wheat cropping system.

Keywords: Plant extracts, wheat, herbicide reduction, plant height, chlorophyll index

Introduction

The rice-wheat cropping system (RWCS) is one of the most extensively adopted agricultural systems across South Asia, especially in the Indo-Gangetic plains, including Punjab. It plays a pivotal role in ensuring food security for millions. However, this intensive system faces several challenges such as declining soil fertility, stagnating yields, increased incidence of pests and weeds, and heavy dependency on chemical inputs, particularly herbicides. The excessive and continuous use of synthetic agrochemicals not only leads to environmental degradation but also poses serious threats to human health, soil microbiota, and long-term sustainability of the ecosystem.

In light of these concerns, the agricultural community is progressively turning towards eco-friendly and sustainable alternatives to conventional chemical-based farming. Among such alternatives, plant-based biopesticides and bio-stimulants derived from leaf extracts have emerged as promising options due to their biodegradability, lower toxicity, and broad-spectrum activity against various plant stressors. Botanical extracts, when used in appropriate concentrations, can influence several physiological and morphological traits of crops, such as germination, growth rate, plant height, photosynthetic efficiency, and chlorophyll content.

The present study, titled “*Effect of plant leaf aqueous extracts on plant height & chlorophyll index in Rice-Wheat cropping system*,” was conducted at the experimental farm of Lovely Professional University, Phagwara, Punjab, during the rabi seasons of 2021-2022 and 2022-2023. The main objective of the study was to investigate the effects of aqueous leaf extracts from selected plant species-namely Eucalyptus (*Eucalyptus globulus*), Neem (*Azadirachta indica*), and Guava (*Psidium guajava*)-on key growth parameters of wheat, specifically plant height and chlorophyll index, when grown in the rice-wheat system.

A total of 20 treatments were formulated and laid out in a Randomized Block Design (RBD) with three replications. The treatments included two concentrations each of Eucalyptus (5% and 10%), Neem (10% and 15%), and Guava (25% and 30%) leaf aqueous extracts. Additionally, reduced herbicide application levels (50% and 75% of recommended dose) were integrated into the design to evaluate their interaction with the plant extracts. This combinatorial approach aimed to explore the potential of integrating natural plant-based formulations with minimized herbicide use to achieve effective weed management and crop enhancement without compromising ecological balance.

By analyzing the resulting variations in plant height and chlorophyll index, the study provides insight into the physiological influence of these botanical treatments. The outcomes are expected to contribute to sustainable crop management practices and support the development of integrated weed and crop growth management strategies with reduced dependency on chemical herbicides (Kumar *et al.*, 2023).

Methodology

During the rabi seasons of 2021-2023, an experiment entitled “Effect of plant leaf aqueous extracts on plant height & chlorophyll index in Rice-Wheat cropping system” was conducted to assess the impact of various botanical treatments on wheat growth parameters. This chapter provides a comprehensive description of the experimental methodologies, including the criteria employed for treatment evaluation and the techniques adopted for data collection and analysis throughout the entire duration of the investigation.

Experimental Site Selection

The present study was carried out at the research farm of Lovely Professional University, located in Kapurthala district, Punjab, during the rabi seasons of 2021-2022 and 2022-2023. The geographical coordinates of the experimental site are 31°22'31.81" N latitude and 75°23'03.02" E longitude. The region falls under a semi-arid climatic zone, characterized by cool winters and hot summers. During the winter season (December to February), temperatures typically range between 10°C and 15°C, occasionally dropping further during peak winter months, although they rarely fall below 0°C. In contrast, the summer months (April to June) witness extreme temperatures, ranging from 35°C to 45°C, with the maximum often reaching up to 45°C.

Rainfall in this region is primarily monsoonal, occurring predominantly from the last week of June through September. The southwest monsoon is the chief source of precipitation, with July being the wettest month. However, variations in monsoon onset and intensity are common. The overall climate and soil conditions of the site make it suitable for conducting field trials within a rice-wheat cropping system.

Field Preparation and Layout

Following site selection, the experimental field was prepared by performing standard tillage operations to ensure a fine seedbed. The field layout was prepared based on a Randomized Block Design (RBD), comprising 20 treatments with three replications each. The wheat variety PBW 550 was used for sowing during the rabi season, and PR 126 was used during the preceding rice season. Sowing was done using the recommended agronomic practices, including the application of a standard dose of fertilizers as per regional guidelines.

The experimental treatments included various concentrations of aqueous leaf extracts from Eucalyptus, Neem, and Guava, along with reduced herbicide applications at 50% and 75% of the recommended doses. These combinations were intended to evaluate their effects on wheat morphological traits under a sustainable crop management approach.

Data Collection

Observations were recorded at different growth stages of the wheat crop. Key parameters assessed included plant height and chlorophyll index, which were measured using standard techniques to ensure accuracy and reproducibility. The objective

was to understand the influence of each treatment on crop physiology and to assess the potential of plant-based extracts in combination with lower herbicide use as an alternative crop enhancement strategy.

Treatment Details

Total treatments were 20 with 3 replications in the field. Treatments detail are; T₁ (Absolute control i.e. no herbicide application), T₂ (100% of recommended dose of Herbicide), T₃ (Eucalyptus Leaf Aqueous Extract 5% + 50% Herbicide), T₄ (Eucalyptus Leaf Aqueous Extract 5% + 75% Herbicide), T₅ (Eucalyptus Leaf Aqueous Extract 10% + 50% Herbicide), T₆ (Eucalyptus Leaf Aqueous Extract 10% + 75% Herbicide), T₇ (Neem Leaf Aqueous Extract 10% + 50% Herbicide), T₈ (Neem Leaf Aqueous Extract 10% + 75% Herbicide), T₉ (Neem Leaf Aqueous Extract 15% + 50% Herbicide), T₁₀ (Neem Leaf Aqueous Extract 15% + 75% Herbicide), T₁₁ (Guava Leaf Aqueous Extract 25% + 50% Herbicide), T₁₂ (Guava Leaf Aqueous Extract 25% + 75% Herbicide), T₁₃ (Guava Leaf Aqueous Extract 30% + 50% Herbicide), T₁₄ (Guava Leaf Aqueous Extract 30% + 75% Herbicide), T₁₅ (Eucalyptus Leaf Aqueous Extract 5%), T₁₆ (Eucalyptus Leaf Aqueous Extract 10% sole), T₁₇ (Neem Leaf Aqueous Extract 10% Sole), T₁₈ (Neem Leaf Aqueous Extract 15% Sole), T₁₉ (Guava Leaf Aqueous Extract 25% Sole) and T₂₀ (Guava Leaf Aqueous Extract 30% Sole). For wheat crop herbicides used in the field 2,4 D + Fenoxaprop and rice Crop herbicides used in the field Bispyribac Sodium + Metsulfuron Methyl 10% + Chlorimuron Methyl 10%.

Result & Discussion

Plant height (cm) of Wheat crop

Plant height is a key morphological trait in crop development, providing insights into growth dynamics and potential yield. In wheat, plant height showed a consistent increase with crop age. Measurements were recorded at 30, 60, 90, and 120 days after sowing (DAS) across two cropping seasons (2021-2022 and 2022-2023). At 30 DAS, plant height ranged from 10.6 cm to 17.2 cm (2021-2022) and from 10.7 cm to 17.1 cm (2022-2023). In the first year, the maximum plant height was recorded under treatment T₁₂ (17.2 cm), significantly greater than other treatments, while the minimum was at T₂₀ (10.6 cm), a 62.26% difference. In the second year, T₁₉ recorded the maximum height (17.1 cm), significantly higher than T₂₀ (10.7 cm), representing a 59.81% increase. Averaging both years, T₁₂ recorded the maximum mean plant height (17.0 cm), while T₂₀ remained the minimum (10.6 cm), indicating a 60.37% increase. At 60 DAS, plant height ranged from 15.0 cm to 30.2 cm (2021-2022) and 13.8 cm to 29.7 cm (2022-2023). Treatment T₁₃ consistently produced the maximum plants across both years, showing a 101.3% increase over T₉ (2021-2022) and a 115.21% increase in the following year. On average, T₁₃ resulted in the highest plant height (30.0 cm), with T₉ showing the least (14.4 cm), an increase of 108%. At 90 DAS, the height varied between 56.8 cm and 74.6 cm (2021-2022) and 55.6 cm to 75.6 cm (2022-2023). The maximum plants were observed under T₈ (2021-2022) and T₁₄ (2022-2023), while the minimum were under T₁₉ and T₁, respectively. Combined data showed T₁₄ as the most effective (74.6 cm), with T₁₉ being the least (56.6 cm), reflecting a 31.80% increase. At 120 DAS, plant height ranged from 61.8 cm to 79.7 cm (2021-2022) and 61.2 cm to 80.0 cm (2022-2023). Treatments T₁₄ and T₈ produced the maximum plants in both years, with T₁₉ consistently recording the minimum. The average data revealed T₈ (79.7 cm) as the top performer,

yielding a 29.59% increase over T₁₉ (61.5 cm).

These findings indicate that plant height in wheat varied significantly across treatments and growth stages. Notably, treatments involving aqueous extracts of guava and neem leaves contributed positively to plant height. These botanical extracts are rich in macro-nutrients (N, P, K) and bioactive compounds such as flavonoids (quercetin, kaempferol, myricetin), tannins, and phenolics (e.g., gallic acid, catechin, epicatechin), which

possess growth-promoting and stress-protective properties.

These results align with earlier findings by Arifin *et al.* (2017), who highlighted the potential of such phytochemicals in enhancing plant vigor and development. The use of guava and neem leaf extracts, therefore, offers a promising, eco-friendly strategy for improving wheat growth through natural bio-stimulants.

Table 1: Effect of treatments on plant height of wheat (cm) at 30, 60 Das during 2021-2022 & 2022-2023

Treatments	30 Das			60 Das		
	2021-2022	2022-2023	AVG.	2021-2022	2022-2023	AVG.
T ₁ -ABSOLUTE CONTROL	15.2±0.52	16.2±0.54	15.7	19.2±0.43	19.7±1.179	19.5
T ₂ -100% RDH**	15.9±0.54	15.5±0.83	15.7	26.1±1.37	25.9±1.05	26.0
T ₃ -ELE 5% + 50% H**	14.4±0.64	15.1±0.66	14.8	17.5±1.04	17.9±1.88	17.7
T ₄ -ELE 5% + 75% H**	12.2±1.28	11.8±0.75	12.0	20.9±1.13	19.7±1.25	20.3
T ₅ -ELE 10% + 50% H**	15.9±0.17	15.4±0.75	15.7	19.5±0.28	18.0±0.40	18.8
T ₆ -ELE 10% + 75% H**	13.8±1.56	15.0±1.47	14.4	23.2±0.52	21.9±0.92	22.5
T ₇ -NLE 10% + 50% H**	14.2±0.60	15.1±0.61	14.7	19.0±0.57	17.6±0.40	18.3
T ₈ -NLE 10% + 75% H**	13.3±0.66	13.9±1.20	13.6	19.7±0.38	19.8±1.05	19.8
T ₉ -NLE 15% + 50% H**	15.7±0.88	17.0±0.38	16.4	15.0±0.57	13.8±0.23	14.4
T ₁₀ -NLE 15% + 75% H**	14.6±0.52	14.3±0.52	14.5	25.3±0.17	25.4±0.41	25.4
T ₁₁ -GLE 25% + 50% H**	14.2±0.69	14.5±0.96	14.4	25.6±0.38	27.2±0.49	26.4
T ₁₂ -GLE 25% + 75% H**	17.2±0.52	17.1±0.78	17.1	27.2±0.90	26.5±0.53	26.9
T ₁₃ -GLE 30% + 50% H**	15.7±1.41	14.8±1.03	15.3	30.2±0.67	29.7±0.96	30.0
T ₁₄ -GLE 30% + 75% H**	17.1±0.43	16.5±0.59	16.8	28.2±0.64	27.7±1.30	28.0
T ₁₅ -ELE 5%	13.7±1.16	12.2±1.03	13.0	28.4±0.54	29.1±0.60	28.8
T ₁₆ -ELE 10%	15.8±0.90	14.2±0.90	15.0	17.4±0.11	28.4±0.58	22.9
T ₁₇ -NLE 10%	14.3±0.48	14.4±0.65	14.4	25.6±1.02	27.3±0.49	26.5
T ₁₈ -NLE 15%	12.2±0.25	12.6±0.20	12.4	23.0±1.03	23.1±0.66	23.0
T ₁₉ -GLE 25%	16.5±0.89	16.8±0.51	16.8	24.3±1.20	21.5±0.57	22.9
T ₂₀ -GLE 30%	10.6±0.72	10.7±0.47	10.6	24.0±1.15	27.3±0.47	25.7
CD	2.405	2.318		2.216	2.477	
SE(m ±)	0.837	0.807		0.771	0.862	

Note-RDH-recommended dose of herbicide, ELE- eucalyptus leaf extract, NLE- neem leaf extract, GLE- guava leaf extract, SE- standard error and CD- critical difference, **2,4 D + Fenoxaprop.

Table 2: 4.17.1 Effect of treatments on plant height of wheat (cm) at 90, 120 Das during 2021-2022 & 2022-2023

Treatments	90 Das			120 Das		
	2021-2022	2022-2023	AVG.	2021-2022	2022-2023	AVG.
T ₁ -ABSOLUTE CONTROL	56.8±0.91	55.6±1.75	58.5	70.3±0.20	63.4±1.398	66.9
T ₂ -100% RDH**	69.4±1.41	65.5±1.36	67.5	74.5±1.76	73.6±0.78	74.1
T ₃ -ELE 5% + 50% H**	72.0±0.97	70.6±0.91	71.3	76.8±0.73	70.6±0.85	73.7
T ₄ -ELE 5% + 75% H**	62.0±0.89	63.9±0.81	63.0	69.9±0.73	71.3±0.55	70.6
T ₅ -ELE 10% + 50% H**	65.2±0.64	65.7±0.71	65.5	75.6±1.56	73.8±1.05	74.7
T ₆ -ELE 10% + 75% H**	67.0±0.75	61.2±0.66	64.1	77.0±0.14	72.6±0.82	74.8
T ₇ -NLE 10% + 50% H**	67.0±0.87	67.9±0.76	67.5	78.2±0.18	77.0±1.04	77.7
T ₈ -NLE 10% + 75% H**	74.6±0.38	75.6±0.43	73.4	79.4±1.00	80.0±0.79	79.7
T ₉ -NLE 15% + 50% H**	65.3±0.54	63.8±0.65	64.5	74.7±0.57	72.7±1.42	73.7
T ₁₀ -NLE 15% + 75% H**	73.7±0.29	73.0±1.06	73.3	73.1±0.61	71.7±0.85	72.4
T ₁₁ -GLE 25% + 50% H**	60.9±1.15	61.3±0.63	61.1	68.7±0.12	66.1±0.83	67.4
T ₁₂ -GLE 25% + 75% H**	65.3±0.46	62.6±0.63	64.0	71.9±0.29	71.0 ^{cd} ±0.75	71.4
T ₁₃ -GLE 30% + 50% H**	60.7±1.11	62.2±1.18	61.5	69.6±0.81	66.2±1.27	67.9
T ₁₄ -GLE 30% + 75% H**	73.6±0.84	72.1±1.10	72.8	79.7±0.82	79.3±1.15	79.5
T ₁₅ -ELE 5%	64.5±1.08	62.8±0.60	63.7	74.9±0.70	72.5±0.63	73.7
T ₁₆ -ELE 10%	59.2±0.52	60.3±0.46	59.8	66.7±0.61	67.3±1.34	67.0
T ₁₇ -NLE 10%	62.6±0.90	61.7±0.75	62.2	73.9±0.64	72.3±1.12	73.1
T ₁₈ -NLE 15%	62.0±0.97	59.9±0.94	60.9	73.4±0.40	71.1±0.95	72.3
T ₁₉ -GLE 25%	61.2±0.72	56.3±0.32	56.6	61.8±0.35	61.2±1.01	61.5
T ₂₀ -GLE 30%	60.3±0.55	61.1±0.86	60.7	67.8±1.62	66.3±1.10	67.0
CD	2.477	1.996		2.466	1.563	
SE(m ±)	0.862	0.695		0.858	0.544	

Note-RDH-recommended dose of herbicide, ELE- eucalyptus leaf extract, NLE- neem leaf extract, GLE- guava leaf extract, SE- standard error and CD- critical difference, ***2,4 D Fenoxaprop.

Chlorophyll index of Wheat crop

Chlorophyll index, a critical measure of chlorophyll content in plant leaves, reflects the photosynthetic capacity and overall health of crops. It provides valuable insights for optimizing nutrient management and improving productivity. Periodic chlorophyll index data recorded at 30 and 60 days after sowing (DAS) during the 2021-2022 and 2022-2023 seasons revealed considerable variation across treatments. At 30 DAS in 2021-2022, the chlorophyll index ranged from a minimum of 31.6 (T₁₃) to a maximum of 36.8 (T₁₈), showing a 16.45% increase. In 2022-2023, the minimum was 20.3 (T₁₃) and the maximum was 39.1 (T₁₀), representing a 92.61% increase. Based on the average of both years, the highest chlorophyll index was observed at T₄ (36.6), and the lowest at T₁₃ (26.0), indicating a 40.76% increase. At 60 DAS in 2021-2022, the chlorophyll index ranged from a minimum of 35.1 (T₆) to a maximum of 49.4 (T₄), with a 40.74% increase. In 2022-2023, the values ranged from 35.3 (T₆) to 45.1 (T₁₄), showing a 20.91% increase. The two-year average revealed T₄ with the highest index (46.3) and T₆ with the lowest (36.2), accounting for a 27.90% increase. These results demonstrate that chlorophyll index varies significantly with treatment and time, highlighting the potential of specific treatments in enhancing photosynthetic efficiency and crop performance.

Plant height (cm) of Rice crop

Plant height is a crucial morphological trait that indicates the growth rate and potential yield of a crop. In rice, plant height showed a consistent increase with crop age, measured periodically at 30, 60, 90, and 120 days after transplanting (DAT) during the 2021-2022 and 2022-2023 seasons.

At 30 DAT in 2021-2022, plant height ranged from a minimum

of 19.7 cm (T₄) to a maximum of 34.3 cm (T₁₆), reflecting a 74.11% increase. In 2022-2023, it ranged from a minimum of 20.0 cm (T₄) to a maximum of 32.9 cm (T₃), with a 64.5% increase. Based on the average of both years, the minimum plant height was 19.8 cm (T₄), and the maximum was 32.9 cm (T₃), showing a 66.16% increase. At 60 DAT in 2021-2022, values ranged from a minimum of 33.1 cm (T₈) to a maximum of 44.5 cm (T₁₀), showing a 34.44% increase, while in 2022-2023, the minimum was 31.0 cm (T₁) and the maximum was 43.1 cm (T₉), indicating a 39.03% increase. The two-year average showed T₁₀ with the maximum plant height (43.6 cm) and T₈ & T₁₆ with the minimum (32.3 cm), marking a 32.98% increase. At 90 DAT in 2021-2022, plant height varied from a minimum of 38.2 cm (T₁) to a maximum of 51.0 cm (T₂), a 33.50% increase. In 2022-2023, the minimum was 32.1 cm (T₈) and the maximum was 44.2 cm (T₂₀), showing a 37.69% increase. The average data showed the minimum plant height at 35.6 cm (T₁) and the maximum at 45.6 cm (T₂₀), with a 28.08% increase. At 120 DAT in 2021-2022, plant height ranged from a minimum of 44.0 cm (T₁) to a maximum of 58.1 cm (T₂₀), reflecting a 32.05% increase. In 2022-2023, it ranged from 37.9 cm (T₁₆) to 48.9 cm (T₂), a 29.02% increase. The two-year average revealed a maximum of 52.8 cm (T₂ & T₂₀) and a minimum of 45.0 cm (T₁), indicating a 17.33% increase. The enhanced plant height could be attributed to the use of different leaf extracts, which potentially improve nutrient absorption. Specifically, neem leaf extract, rich in azadirachtin, may act as a growth stimulant, influencing root development and overall growth. Similarly, guava leaf extract, possibly containing gibberellins, is known for promoting root growth, thereby enhancing plant height under field conditions.

Table 3: Effect of treatments on plant height of rice (cm) at 30, 60 Dat during 2021-2022 & 2022-2023

Treatments	30 Dat			60 Dat		
	2021-2022	2022-2023	AVG.	2021-2022	2022-2023	AVG.
T ₁ -ABSOLUTE CONTROL	22.6 ±2.02	23.1±2.16	22.8	36.2±0.59	31.0±1.19	33.6
T ₂ -100% RDH*	24.8 ±1.87	24.1±1.87	24.4	38.8±1.51	35.7±1.10	37.2
T ₃ -ELE 5% + 50% H*	33.0 ±1.52	32.9±1.56	32.9	40.6±2.96	38.5±2.93	39.5
T ₄ -ELE 5% + 75% H*	19.7 ±0.40	20.0±0.37	19.8	43.0±2.08	40.4±1.40	41.7
T ₅ -ELE 10% + 50% H*	20.5 ±0.28	20.3±0.39	20.4	35.2±0.64	33.6±0.73	34.4
T ₆ -ELE 10% + 75% H*	24.3 ±1.37	24.3±0.94	24.3	34.6±0.29	33.1±0.50	33.8
T ₇ -NLE 10% + 50% H*	26.0 ±2.18	25.9±1.88	25.9	40.7±0.13	38.3±0.40	39.5
T ₈ -NLE 10% + 75% H*	25.0 ±0.57	25.0±0.78	25.0	33.1±1.69	31.5±1.45	32.3
T ₉ -NLE 15% + 50% H*	24.6 ±1.50	24.7±1.53	24.6	43.1±1.48	43.1±1.45	43.1
T ₁₀ -NLE 15% + 75% H*	20.5 ±2.05	20.6±2.14	20.5	44.5±0.76	42.7±0.52	43.6
T ₁₁ -GLE 25% + 50% H*	20.3 ±1.56	20.4±1.6	20.3	40.0±0.96	38.7±0.29	39.3
T ₁₂ -GLE 25% + 75% H*	26.6 ±1.2	24.5±1.56	25.5	35.7±3.68	33.5±3.42	34.6
T ₁₃ -GLE 30% + 50% H*	28.7 ±0.63	26.3 ±2.14	27.5	38.1±2.12	35.9±1.95	37.0
T ₁₄ -GLE 30% + 75% H*	26.3 ±2.16	25.0 ±2.61	25.6	35.2±1.60	33.7±2.19	34.4
T ₁₅ -ELE 5%	33.4 ±1.13	29.0 ±3.53	31.2	43.0±1.48	40.2±0.43	41.6
T ₁₆ -ELE 10%	34.3 ±0.72	30.1 ±4.12	32.2	33.5±2.34	31.1±2.44	32.3
T ₁₇ -NLE 10%	26.9 ±1.06	25.0 ±1.76	25.9	35.3±2.84	34.5±2.45	34.9
T ₁₈ -NLE 15%	24.0 ±1.15	23.2 0±1.54	23.6	35.0±0.57	32.6±1.23	33.8
T ₁₉ -GLE 25%	24.3 ±1.01	23.0 ±0.48	23.6	40.6±0.88	38.0±0.15	39.3
T ₂₀ - GLE 30%	33.0 ±1.52	32.1 ±5.07	32.5	44.3±0.88	42.7±0.84	43.5
CD	4.05	6.09		5.13	4.81	
SE(m ±)	1.407	2.120		1.788	1.674	

Note-RDH-recommended dose of herbicide, ELE- eucalyptus leaf extract, NLE- neem leaf extract, GLE- guava leaf extract, SE- standard error and CD- critical difference, *Bispyribac Sodium + Metsulfuron Methyl 10% + Chlorimuron Methyl 10%.

Treatments	90 Dat		
	2021-2022	2022-2023	AVG.
T ₁ -ABSOLUTE CONTROL	44.0 ±2.25	46.1±0.83	45.0

T ₂ -100% RDH*	56.7±1.54	48.9±1.65	52.8
T ₃ -ELE 5% + 50% H*	52.1±0.90	44.0±1.04	48.0
T ₄ -ELE 5% + 75% H*	56.4±2.66	44.6±0.43	50.5
T ₅ -ELE 10% + 50% H*	53.4±0.55	41.9±2.66	47.6
T ₆ -ELE 10% + 75% H*	53.5±0.23	40.9±3.14	47.2
T ₇ -NLE 10% + 50% H*	52.5±0.72	40.9±0.55	46.7
T ₈ -NLE 10% + 75% H*	55.1±2.33	39.6±1.77	47.3
T ₉ -NLE 15% + 50% H*	51.6±1.35	43.6±1.33	47.6
T ₁₀ -NLE 15% + 75% H*	52.6±0.39	42.1±1.11	47.3
T ₁₁ -GLE 25% + 50% H*	55.7±2.53	40.4±0.97	48.0
T ₁₂ -GLE 25% + 75% H*	53.7±2.42	39.1±2.51	46.4
T ₁₃ -GLE 30% + 50% H*	53.1±2.32	42.7±1.11	47.9
T ₁₄ -GLE 30% + 75% H*	53.5±1.57	38.3±1.93	45.9
T ₁₅ -ELE 5%	57.1±2.33	42.0±0.32	49.5
T ₁₆ -ELE 10%	54.8±0.99	37.9±1.42	46.3
T ₁₇ -NLE 10%	53.8±2.89	38.5±3.19	46.1
T ₁₈ -NLE 15%	52.9±0.56	41.4±3.85	47.1
T ₁₉ -GLE 25%	51.8±2.90	40.7±0.68	46.2
T ₂₀ -GLE 30%	58.1 ±1.99	47.5±1.14	52.8
CD	5.04	5.49	
SE(m ±)	1.754	1.91	

Note-RDH-recommended dose of herbicide, ELE- eucalyptus leaf extract, NLE- neem leaf extract, GLE- guava leaf extract, SE- standard error and CD- critical difference. *Bispyribac Sodium + Metsulfuron Methyl 10% + Chlorimuron Methyl 10%.

Chlorophyll index of Rice crop

Chlorophyll index is a key indicator of the chlorophyll content in plant leaves and plays a crucial role in assessing photosynthetic efficiency and overall plant health. Since chlorophyll is essential for photosynthesis, monitoring its index helps researchers and farmers make informed decisions regarding crop management, particularly in optimizing fertilizer application to enhance productivity. Periodic observations of chlorophyll index were recorded at 30, 60, 90, and 120 days after transplanting (DAT) during the 2021-2022 and 2022-2023 seasons.

At 30 DAT (2021-2022), the chlorophyll index ranged from a minimum of 23.1 (T₁₆) to a maximum of 36.7 (T₂), showing a 58.87% increase. T₂ was significantly higher than all other treatments, followed by T₁₀ (35.5), and was at par with T₄, T₈, T₁₀, T₁₄, and T₁₉. T₁₆ was significantly lower than all other treatments and at par with T₁₇.

In 2022-2023, the chlorophyll index at 30 DAT ranged from a minimum of 23.0 (T₁₆) to a maximum of 36.4 (T₂), representing a 58.26% increase. Similar to the previous year, T₂ recorded the highest value, followed by T₁₀ (35.5), and was at par with T₁, T₄, T₈, T₁₀, T₁₄, and T₁₉. T₁₆ remained the lowest and was at par with T₁₇.

Based on the average of both years at 30 DAT, the maximum chlorophyll index was recorded at T₂ (36.5), followed by T₁₀ (35.5), while the minimum was at T₁₆ (23.0). This reflected a 58.69% increase in chlorophyll index from minimum to maximum.

At 60 DAT (2021-2022), the chlorophyll index ranged from a minimum of 23.0 (T₁₇) to a maximum of 36.0 (T₂), indicating a 56.52% increase. T₂ was significantly higher than other treatments, followed by T₁₀ (35.0), and at par with T₃, T₄, T₈, T₁₀, T₁₄, and T₁₉. The lowest value was recorded at T₁₇, at par with T₁₂, T₁₆, T₁₈, and T₂₀.

In 2022-2023, the values ranged from a minimum of 23.4 (T₁₇) to a maximum of 36.0 (T₂), resulting in a 53.84% increase. T₂ again recorded the highest chlorophyll index, followed by T₁₀ (35.7), and was at par with T₃, T₄, T₈, T₁₀, and T₁₄. T₁₇ remained the lowest and was at par with T₁₂, T₁₅, T₁₆, and T₂₀.

Based on the average data from both years at 60 DAT, the maximum chlorophyll index was observed at T₂ (36.0), followed

by T₁₀ (35.7), while the minimum was at T₁₇ (23.0), resulting in a 56.52% increase.

This consistent increase in chlorophyll index with T₂ and T₁₀ as top performers suggests their potential effectiveness in enhancing photosynthetic capacity, likely due to the influence of treatments such as leaf extracts. These treatments may have played a role in stimulating physiological functions and nutrient uptake, contributing to improved chlorophyll synthesis in rice plants.

Conclusion

The study revealed that both plant height and chlorophyll index in wheat and rice crops were significantly influenced by various treatments, particularly those involving aqueous leaf extracts of guava and neem. Across different growth stages (30, 60, 90, and 120 DAS/DAT) over two consecutive seasons (2021-2022 and 2022-2023), treatments such as T₂, T₁₀, T₁₃, and T₁₄ consistently enhanced plant height and chlorophyll content, indicating improved growth and photosynthetic efficiency. Maximum increases in plant height reached over 100% in wheat (T₁₃ at 60 DAS) and up to 74% in rice (T₁₆ at 30 DAT), while chlorophyll index improvements peaked at 92.61% (wheat, T₁₀ at 30 DAS) and 58.87% (rice, T₂ at 30 DAT). These enhancements are attributed to the presence of macro-nutrients and bioactive phytochemicals like flavonoids, tannins, and phenolics in the botanical extracts, which promote nutrient uptake, growth stimulation, and stress protection. Overall, the findings underscore the potential of natural leaf extracts as eco-friendly biostimulants for improving crop growth and productivity.

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