



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(7): 630-633
Received: 24-05-2026
Accepted: 28-06-2026

Shashidhar G
PG Scholar, Department of
Agronomy, College of Agriculture,
PJTUAU, Rajendranagar,
Hyderabad, Telangana, India

Srinivasa Rao S
Senior Scientist, Department of
Agronomy, AICRP on Forage
Crops Unit, Rajendranagar,
Hyderabad, Telangana, India

Malla Reddy M
Professor (AL-15) & Controller of
Examinations, Department of
Agronomy, PJTAU,
Rajendranagar, Hyderabad,
Telangana, India

Chandra Shaker K
Scientist & Coordinator,
Department of Soil Science and
Agricultural Chemistry, TRVK,
Huzurnagar, Suryapet, Telangana,
India

Corresponding Author:
Shashidhar G
PG Scholar, Department of
Agronomy, College of Agriculture,
PJTUAU, Rajendranagar,
Hyderabad, Telangana, India

Integration of new herbicide molecules and mechanical weeder for improving growth and yield of wet direct-seeded rice

Shashidhar G, Srinivasa Rao S, Malla Reddy M and Chandra Shaker K

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7h.5990>

Abstract

Weeds pose a serious challenge in Direct-Seeded Rice (DSR) by competing with the crop for essential resources such as nutrients, water, light and growing space, resulting in considerable yield reduction if not managed effectively. The field experiment was conducted during *kharif* 2025 at Krishi Vigyan Kendra (KVK), Kampasagar, Telangana, to evaluate the effectiveness of newly introduced herbicide molecules integrated with mechanical weeding for weed management in wet direct-seeded rice, using the rice variety KNM-1638. The weed management practices significantly influenced crop growth and productivity. Among the herbicide-based treatments, pre-emergence application of pretilachlor 27.4% + florypyrauxifen-benzyl 0.91% EC @ (600 + 20) g a.i. ha⁻¹ followed by post-emergence application of triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ (T₄) recorded the highest plant height (88.2 cm), dry matter accumulation (14,529 kg ha⁻¹), leaf area (1,030.4 cm² hill⁻¹), tiller density (235 m⁻²), grain yield (6,403 kg ha⁻¹), straw yield (8,523 kg ha⁻¹) and harvest index (42.90%). Pre-emergence application of pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ followed by post-emergence application of triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ (T₃), which was statistically on par with (T₄), recorded plant height (87.0 cm), dry matter accumulation (14,068 kg ha⁻¹), leaf area (1,014.3 cm² hill⁻¹), number of tillers (230 m⁻²), grain yield (6,252 kg ha⁻¹), straw yield (8,352 kg ha⁻¹) and harvest index (42.81%).

Keywords: Wet direct-seeded rice, integrated weed management, sequential herbicides, florypyrauxifen-benzyl, triafamone, penoxsulam, mechanical weeding, grain yield

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops worldwide, providing food and nutritional security to more than half of the global population. It is cultivated in over 100 countries across tropical and subtropical regions, occupying nearly 165 million hectares and producing an annual paddy output exceeding 780 million tonnes. Asia accounts for about 90% of global rice production and consumption (FAOSTAT, 2024 and IRRI, 2024) [5, 7]. India is the second largest producer of rice after China, cultivating the crop on about 51.27 million hectares with a production of 150.18 million tonnes. (Indiastat, 2024-25) [6]. However, the average productivity of rice in India (2.93 t ha⁻¹) remains lower than that of several major rice-producing countries such as China (4.7 t ha⁻¹), Russia (5.4 t ha⁻¹), the United States (7.6 t ha⁻¹) and Australia (10.5 t ha⁻¹), indicating considerable scope for productivity improvement through efficient crop management practices (FAO, 2023 and Yadav *et al.*, 2019) [4, 14]. Telangana is one of the leading rice-growing states in India, with rice cultivated on 48.09 lakh hectares and producing 174.46 lakh tonnes. (Indiastat, 2024-25) [6].

Increasing labour scarcity, rising wage rates and declining availability of irrigation water have prompted a shift from conventional transplanted rice to Direct-Seeded Rice (DSR) systems. Among the different establishment methods, Wet Direct-Seeded Rice (Wet-DSR), which involves sowing pre-germinated seeds in puddled soil, has emerged as a promising alternative owing to its lower labour requirement, reduced cultivation costs and timely crop establishment. Despite these advantages, weed infestation remains a major constraint in wet-DSR because weeds emerge simultaneously with the crop and compete aggressively for nutrients, moisture, light and space

during the critical stages of crop growth, resulting in substantial yield losses.

Although hand weeding is effective, its adoption is often restricted by labour shortages and high operational costs. Mechanical weeders can reduce labour dependence and improve weed control efficiency, while herbicides provide timely and effective control of diverse weed flora. Recently introduced herbicide molecules such as florypyrauxifen-benzyl, triafamone, ethoxysulfuron, bispyribac sodium and penoxsulam have demonstrated promising efficacy against grasses, sedges and broadleaved weeds in rice ecosystems. Integration of these herbicides with mechanical weeding may provide season long weed suppression and create a favourable environment for crop growth and yield improvement. Therefore, the present study was undertaken to evaluate the effectiveness of new herbicide molecules integrated with mechanical weeding for improving the growth and yield of wet direct-seeded rice under the agro-climatic conditions of Telangana.

Materials and Methods

A field experiment was conducted during the *kharif* season of 2025 at Krishi Vigyan Kendra (KVK), Kampasagar, Telangana, on clay loam soils to evaluate the efficacy of new herbicide molecules integrated with mechanical weeding in wet direct-

seeded rice. The experimental soil was slightly alkaline in reaction with low organic carbon, medium available nitrogen and high available phosphorus and potassium status. Pre-germinated seeds of rice variety KNM-1638 were drum-seeded on 17th August 2025, maintaining a row spacing of 20 cm under puddled field conditions. The experiment was laid out in a Randomized Block Design (RBD) comprising eight weed management treatments replicated thrice.

A recommended fertilizer dose of 120:60:40 kg N: P₂O₅: K₂O ha⁻¹ was applied through urea, DAP and muriate of potash. The entire quantity of phosphorus and potassium along with 50% nitrogen, was applied as basal, while the remaining nitrogen was top-dressed in two equal splits at active tillering and panicle initiation stages. All recommended agronomic and plant protection measures were followed uniformly throughout the crop growth period. Five representative plants from each plot were tagged for recording growth observations at different stages of crop growth. The crop was harvested at physiological maturity and grain and straw yields were recorded from the net plot area and converted to a hectare basis. The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design and treatment means were compared at the 5% level of significance.

Table 1: Details of integrated weed management treatments evaluated in wet Direct Seeded Rice

T. No.	Treatment details
T ₁	Pretilachlor 30% + pyrazosulfuron ethyl 0.75%WG @ 600 g a.i ha ⁻¹ as PE <i>fb</i> mechanical weeding at 30 DAS.
T ₂	Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600+20) g a.i ha ⁻¹ as PE <i>fb</i> mechanical weeding at 30 DAS.
T ₃	Pretilachlor 30% + pyrazosulfuron ethyl 0.75%WG @ 600 g a.i ha ⁻¹ as PE <i>fb</i> triafamone 20% + ethoxysulfuron 10% WG @ (44+22.5) g a.i. ha ⁻¹ as PoE (20-25 DAS).
T ₄	Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600+20) g a.i ha ⁻¹ as PE <i>fb</i> triafamone 20% + ethoxysulfuron 10% WG @ (44+22.5) g a.i ha ⁻¹ as PoE (20-25 DAS).
T ₅	Pretilachlor 30% + pyrazosulfuron ethyl 0.75%WG @ 600 g a.i ha ⁻¹ as PE <i>fb</i> bispyribac sodium 9.5% + penoxsulam 7.8% w/v SC @ (23.75 + 19.5) g a.i ha ⁻¹ as PoE (20-25 DAS).
T ₆	Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600+20) g a.i ha ⁻¹ as PE <i>fb</i> bispyribac Sodium 9.5% + penoxsulam 7.8% w/v SC @ (23.75 + 19.5) g a.i ha ⁻¹ as PoE (20-25 DAS).
T ₇	Mechanical weeding at 20 and 40 DAS <i>fb</i> intra-row HW (weed-free).
T ₈	Weedy check

Table 2: Growth parameters of wet DSR as influenced by integrated weed management treatments

Treatment	Plant height (cm)	Dry matter (kg ha ⁻¹)	Leaf area (cm ²) hill ⁻¹	Number of tillers m ⁻²
T ₁	77.9	13112	980.8	210
T ₂	75.4	13188	991.0	206
T ₃	87.0	14068	1025.2	231
T ₄	88.2	14529	1030.4	235
T ₅	85.9	13310	1010.1	212
T ₆	86.4	13896	1013.3	215
T ₇	89.3	15244	1055.4	250
T ₈	71.5	5936	833.8	121
S.E (m) ±	3.47	588.8	37.7	8.76
CD (P =0.05)	10.54	1749.4	114.5	26.57

fb: Followed by; a.i.: Active ingredient; DAS: Days After Sowing

Table 3: Yield of wet-Direct Seeded Rice as influenced by integrated weed management treatments

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
T ₁	5886	7986	42.43
T ₂	5869	8019	42.26
T ₃	6252	8352	42.81
T ₄	6403	8523	42.9
T ₅	5916	8066	42.31
T ₆	6196	8296	42.75
T ₇	6600	8750	43
T ₈	1750	3900	30.97
S.E (m) ±	231	245.1	1.52
CD (P =0.05)	687	743.4	4.52

Results and Discussion

Weed flora in the experimental field

Leptochloa chinensis, *Echinochloa colonum*, *Echinochloa crusgalli*, *Cynodon dactylon*, *Cyperus difformis*, *Cyperus iria*, *Commelina benghalensis*, *Alternanthera sesilis* and *Xanthium strumarium* were the dominant weeds observed.

Crop growth parameters

The data presented in Table 2 indicated that plant height at harvest varied significantly among the weed management treatments. Among the herbicidal treatments, pretilachlor 27.4% + florypyrauxifen-benzyl as PE fb triafamone + ethoxysulfuron as PoE (T₄) recorded the highest plant height (88.2 cm), followed by pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as pre-emergence followed by triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as post-emergence (T₃) with (87.0 cm) and it was statistically on par with (T₆: 86.4 and T₅: 85.9 cm). However, (T₇) mechanical weeding at 20 and 40 DAS fb intra-row hand weeding recorded the highest plant height (89.3 cm) and it was significantly superior to all other treatments. In contrast, the lowest plant height was recorded under the weedy check (T₈: 71.5 cm). The higher plant height under (T₇) was attributed to effective season long weed control, which minimized crop-weed competition for nutrients, moisture, light and space, resulting in improved crop growth. Similar findings were reported by Yogananda *et al.* (2021) [15] and Dhaker *et al.* (2022) [3].

The data presented in Table 2 indicated that dry matter accumulation at harvest differed significantly among the weed management treatments. Among the herbicidal treatments, pretilachlor 27.4% + florypyrauxifen-benzyl 0.91% EC @ (600 + 20) g a.i. ha⁻¹ as PE followed by triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₄) recorded the highest dry matter accumulation (14,529 kg ha⁻¹), which was on par with pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₃) (14,068 kg ha⁻¹) and pretilachlor 27.4% + florypyrauxifen-benzyl 0.91% EC @ (600 + 20) g a.i. ha⁻¹ as PE fb bispyribac sodium + penoxsulam @ (23.75 + 19.5) g a.i. ha⁻¹ as PoE (T₆: 13,896 kg ha⁻¹). The weedy check (T₈) recorded the lowest dry matter accumulation (5,936 kg ha⁻¹). Mechanical weeding at 20 and 40 DAS followed by intra-row hand weeding (T₇) recorded the highest dry matter accumulation (15,244 kg ha⁻¹), which was significantly superior to all other treatments. Higher dry matter accumulation under effective weed management treatments was attributed to better weed suppression and improved resource availability (Choudhary *et al.*, 2018) [1].

The data presented in Table 2 indicated that significant variation in leaf area was observed among the weed management practices. Among the chemical control practices, Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₄) recorded the highest leaf area (1030.4 cm² hill⁻¹), followed by Pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₃: 1025.2 cm² hill⁻¹). These treatments were statistically comparable with (T₆: 1013.3 and T₅: 1010.1 cm² hill⁻¹). The lowest leaf area was observed under the weedy check (T₈: 833.8 cm² hill⁻¹). Mechanical weeding at 20 and 40 DAS fb intra-row hand weeding (T₇), recorded the highest leaf area (1055.4 cm² hill⁻¹) and was significantly superior to all other treatments. Effective weed management enhanced leaf area by reducing crop-weed competition and improving resource utilization, as also reported

by Das *et al.* (2024) [2] and Nagarajan *et al.* (2025) [9].

The data presented in Table 2 indicated that significant differences in number of tillers m⁻² were observed among the weed management treatments. Among the herbicidal treatments, Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₄) recorded the highest number of tillers (235 m⁻²), followed by Pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₃: 231 m⁻²). However, both treatments were on par with mechanical weeding at 20 and 40 DAS followed by intra-row hand weeding (T₇), which recorded the highest number of tillers (250 m⁻²). The lowest number of tillers was recorded in the weedy check (T₈: 121 m⁻²). The increased number of tillers under effective weed management treatments might be attributed to reduced crop-weed competition for nutrients, moisture, light and space, resulting in better tiller initiation and survival. Similar findings were reported by Dhaker *et al.* (2022) [3] in direct-seeded rice.

Yield parameters and yield

The data presented in Table 3 showed that grain yield varied significantly among the weed management treatments. Among the herbicidal treatments, Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₄) recorded the highest grain yield (6403 kg ha⁻¹), followed by Pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as PE fb triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₃: 6252 kg ha⁻¹) and Pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ as PE fb bispyribac sodium 9.5% + penoxsulam 7.8% w/v SC @ (23.75 + 19.5) g a.i. ha⁻¹ as PoE (T₆: 6196 kg ha⁻¹). However, these treatments were on par with Mechanical weeding at 20 and 40 DAS followed by intra-row hand weeding (T₇), which recorded the highest grain yield (6600 kg ha⁻¹). The lowest grain yield was recorded in the weedy check (T₈: 850 kg ha⁻¹). The higher grain yield resulted from effective weed suppression, which improved crop growth and grain production. Similar findings were reported by Das *et al.* (2024) [2] and Nagarajan *et al.* (2025) [9].

Straw yield differed significantly among the weed management treatments. Among the herbicidal treatments, the pre-emergence application of pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ followed by post-emergence application of triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ (T₄) recorded the highest straw yield (8,523 kg ha⁻¹), which was on par with pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 g a.i. ha⁻¹ as PE followed by triafamone 20% + ethoxysulfuron 10% WG @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₃: 8,352 kg ha⁻¹) and pretilachlor 27.4% w/w + florypyrauxifen-benzyl 0.91% w/w EC @ (600 + 20) g a.i. ha⁻¹ as PE fb bispyribac sodium 9.5% + penoxsulam 7.8% w/v SC @ (23.75 + 19.5) g a.i. ha⁻¹ as PoE (T₆) (8,296 kg ha⁻¹). The lower straw yields were recorded with (T₅: 8,066 kg ha⁻¹), (T₂: 8,019 kg ha⁻¹) and (T₁: 7,986 kg ha⁻¹), while the weedy check (T₈) recorded the lowest straw yield (3,900 kg ha⁻¹). Mechanical weeding at 20 and 40 DAS followed by intra-row hand weeding (T₇) recorded the highest straw yield (8,750 kg ha⁻¹), which was significantly superior to all other treatments. The higher straw yield resulted from effective weed suppression, which improved crop growth and biomass production. Similar findings were reported by Das *et al.* (2024) [2] and Nagarajan *et al.* (2025) [9].

Harvest index differed significantly among the weed management treatments, ranging from 30.97 to 43.00%. Mechanical weeding at 20 and 40 DAS followed by intra-row hand weeding (T₇), recorded the highest harvest index (43.00%). Among the herbicidal treatments, pretilachlor 27.4% + florypyrauxifen-benzyl 0.91% EC @ (600 + 20) g a.i. ha⁻¹ as PE followed by triafamone + ethoxysulfuron @ (44 + 22.5) g a.i. ha⁻¹ as PoE (T₄) recorded the highest harvest index (42.90%), which was on par with (T₃: 42.81 and T₆: 42.75%). The weedy check (T₈) recorded the lowest harvest index (30.97%). The higher harvest index under effective weed management was attributed to reduced crop-weed competition and better partitioning of assimilates towards grain yield, corroborating the findings of Sunil *et al.* (2010) ^[12] and Upasani *et al.* (2012) ^[13].

Conclusion

The results of the present investigation showed that the sequential application of Pretilachlor 27.4% + florypyrauxifen-benzyl 0.91% EC as pre-emergence, fb triafamone 20% + ethoxysulfuron 10% WG as post-emergence (T₄), proved to be the most effective herbicidal weed management practice. This treatment ensured efficient weed control, promoted better crop growth and enhanced rice productivity. Hence, it can be recommended as a suitable herbicide-based weed management strategy for wet direct-seeded rice under Telangana agro-climatic conditions.

Acknowledgement

I take immense pleasure in expressing my sincere gratitude to the Department of Agronomy, College of Agriculture, Rajendranagar, Hyderabad, Professor Jayashankar Telangana Agricultural University (PJTUA), Telangana, India.

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