RESEARCH ARTICLE Agricultural Science Digest, Volume 45 Special Issue: 66-72 (November 2025)

Optimizing Late-sown Wheat (*Triticum aestivum* L.) Performance Through Rice Residue and Weed Management Practices in Western U.P.

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10.18805/ag.D-6320

ABSTRACT

Background: A field experiment was carried out at the Crop Research Centre (CRC), Chirodi, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) for growing season 2020-21 and 2021-22 cropping seasons. The focus of the research was to improve the performance of late-sown wheat by implementing effective rice residue and weed management practices in western Uttar Pradesh.

Methods: A split-plot design (SPD) with three replications was employed for the experimental conducted. The study's main plots evaluated four distinct rice residue management strategies: residue burning, residue removal, PUSA decomposer treated residue and *Trichoderma* treated residue. In sub plots, five weed management practices were assessed: Hand weeding twice at 30 and 45 DAS, sulfosulfuron 75% WG @ 25 g a.i. ha^{-1}, fenoxaprop-p-ethyl 10% EC @ 0.1 kg a.i. ha^{-1} + metsulfuron-methyl 20% WP @ 4 g a.i. ha^{-1}, brown manuring followed by clodinafop-propargyl 15% WP @ 60 g a.i. ha^{-1}.

Result: The results indicated that rice residue and weed management practices significantly influenced growth attribute such as plant height, number of tillers per meter row length (pmrl), dry matter, yield attributes and grain yields. Based on the findings, a combination of rice PUSA decomposer treated residue and brown manuring followed by clodinafop-propargyl (15% WP) is recommended for achieving better growth and yield in late-sown wheat.

Key words: Brown manuring, PUSA decomposer, Rice residue, Weed management.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is crucial for maintaining food security and meeting nutritional needs. After rice, it is the cereal that is grown most extensively in India. It is a primary source of carbohydrates and protein, making it an essential component of human diets. Uttar Pradesh is contributing significantly to the national production. However, the productivity of wheat in late-sown conditions remains a concern, especially in regions like western Uttar Pradesh, where climatic variability, residue management and weed infestation are critical challenges.

Rice straw, a widely available agricultural byproduct, represents one of the most abundant lignocellulosic wastes in the world (Yadav *et al.,* 2025). The accumulation of rice residues following the harvest is a challenge in rice-wheat cropping systems. Farmers in many regions, including western Uttar Pradesh, resort to residue burning as a quick and inexpensive method for clearing fields for succeeding crop; it results in the loss of valuable organic matter, greenhouse gas emissions and extreme air pollution (Chaudhuary *et al.*, 2020). Sustainable management of rice residues is therefore essential to improve soil health, enhancing crop productivity and mitigating environmental hazards. Innovative solutions, such as the application of microbial decomposers like PUSA Decomposer and *Trichoderma*-based products, have shown promise in accelerating residue breakdown while enriching soil fertility (Choudhary *et al.,* 2021). Despite their potential, there is a need for field-based studies to evaluate their effectiveness

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How to cite this article: Pachauri, R.K., Yadav, R.B., Dubey, S., Bajpai, S., Rohit and Tripathi, B. (2025). Optimizing Late-sown Wheat (*Triticum aestivum* L.) Performance Through Rice Residue and Weed Management Practices in Western U.P. *Agricultural Science Digest*. **45 (Special Issue):** 66-72. doi: 10.18805/ag.D-6320.

Submitted: 28-02-2025 **Accepted:** 02-06-2025 **Online:** 22-07-2025

under different agro-climatic conditions, particularly for late-sown wheat.

Weed infestation poses another significant constraint to wheat productivity, particularly under late-sown conditions where weeds compete aggressively for resources like nutrients, water and light. Traditional manual weeding methods, while effective, are labor-intensive and often impracticable due to shortages of labor during critical agricultural seasons. Grain yield was decreased in wheat fields about 20-40% that were severely infested with both narrow- and broad-leaved weeds (Sumitra *et al.,* 2025). Consequently, chemical weed management practices, including herbicide applications, have gained widespread acceptance due to their efficiency and cost-effectiveness. Pre-and post-emergence herbicides such as sulfosulfuron, fenoxaprop-p-ethyl and metsulfuron-methyl used extensively for weed control in wheat fields (Singh *et al.*, 2018). Herbicide resistance has been a problem as a result of relying solely on one herbicide for a very long time to control weeds in wheat. The 1998 recommendation of new herbicides (Fenoxaprop-P-ethyl, Clodinafop-proparyl and Sulfosulfuron) to control weeds resistant to isoproturon proved more successful against grasses, and their constant use caused the weed flora to shift toward dominance of broad-leaved weeds, especially Clodinafop and Fenoxaprop (Kumar *et al.,* 2018). Additionally, integrated approaches like brown manuring, which combine herbicide application with cover cropping, have emerged as sustainable alternatives that suppress weed growth while enhancing soil fertility and structure (Kumar *et al.,* 2020). Late sowing of wheat, often necessitated by delayed harvesting of preceding rice crops, leads to suboptimal growing conditions, including lower temperatures during germination and shorter growing periods (Ali *et al.,* 2021). These factors adversely affect wheat's growth, yield parameters and grain quality of wheat. Under such conditions, the choice of residue management and weed control practices becomes critical to maximize productivity. Effective residue management improves soil organic matter and nutrient availability, while efficient weed control minimizes resource competition and ensures better crop establishment and growth (Yadav *et al.,* 2020).

MATERIALS AND METHODS

Experiment site

At Crop Research Centre (CRC), Sardar Vallabhbhai Patel University of Agriculture and Technology in Chirodi, Meerut (U.P.), the experiment was conducted in 2020-21 and 2021-22. Meerut lies between latitudes 28.57°N and 29.02°N and longitudes 77.40°E and 77.44°E, at an elevation of 237 meters above mean sea level. This area experiences hot summers and extremely cold winters due to its sub-tropical, semi-arid environment. Summer temperatures often reach 43-45°C, while winter temperatures drop to 3-4°C with frost occurring from mid-December to late February. The annual rainfall received approximately 886 mm.

For the experiment, the split-plot design (SPD) with three replications was employed. Four different approaches to managing rice residue were assessed in the study's primary plots; Residue burning (RB), Residue removal (RR), PUSA decomposer treated residue (RTD), *Trichoderma* treated residue (RTT) and in the sub-plots, five weed management practices; Weedy (W_1), Hand weeding twice @ 30 and 45 DAS (W_2), Sulfosulfuron @ 25 g a.i. ha^{-1} (W_3), Fenoxaprop-p-ethyl + Metsulfuron methyl @ 100 g + 4 g a.i. ha^{-1} (W_4), Brown manuring fallowed by Chlodinofop @ 60 g a.i. ha^{-1} (W_5). All the herbicide treatments were applied as post-emergence.

The soil of 15 cm depth was classified as texture sandy loam with pH (7.6 and 7.5), EC (0.16 and 0.20 dS/m at 25°C) low organic carbon (0.41 and 0.44 %) and available nitrogen (214.00 and 220.39) kg ha^{-1} medium in phosphorus (15.98 and 16.08 kg ha^{-1}) and potassium (168.85 and 172.39 kg ha^{-1}) during before sowing in both years.

The field was prepared using conventional tillage practices, including plowing and leveling, to achieve a fine seedbed. In both years, late-sown wheat cultivar DBW 173 was planted with a 20-cm row spacing during the first week of December. 125 kg ha^{-1} seed rate was applied. Rice residue management treatments were applied prior to sowing. For residue burning, the stubbles were burnt uniformly on the respective plots. In residue removal plots, rice residues were manually removed. For residue decomposition treatments, PUSA Decomposer and *Trichoderma* formulations were applied at recommended doses to accelerate residue degradation. Six tonnes per hectare of straw were incorporated and the recommended dose of PUSA decomposer was applied at the rate of 25 liters per hectare using its liquid formulation. The PUSA decomposer was developed by the Indian Agricultural Research Institute (IARI), located in New Delhi for rapid decomposition of paddy straw, it is available in both liquid and capsule forms, to facilitate. This product allows for scaling up four capsules into 25 liters of liquid formulation, which can be used *in situ* on one hectare of rice fields containing 6 tonnes of paddy straw (Manu *et al.*, 2024). The brown manuring treatment involved broadcasting *Sesbania rostrata* seeds at time of wheat sowing, followed by application of 2,4-D at 30 DAS to suppress the green manure crop. Nutrients apply to recommended dose of fertilizer as 120:60:40 kg ha^{-1} through di ammonium phosphate, urea and muriate of potash, respectively.

Growth attributes

Data of growth parameters *viz.* plant height, number of tillers and dry matter were observed at different stage such as 30, 60 and 90 DAS and harvest.

Yield and yield attributes

Effective tillers, spike length (cm), number of grains per spike and 1000-grain weight at harvest stage are the yield variables that are used to obtain the data. Grain was weighed and expressed in quintal ha^{-1} after yield data was collected from the individual plot and the net plot was harvested and harvest index.

RESULTS AND DISCUSSION

The present study evaluated the impacts of different rice residue management techniques and weed management strategies on wheat growth parameters, yield attributes, grain and straw yield. The results indicate significant influences of both residue management and weed control on wheat yield and quality as well as on a number of growth indices, indicating that residue management is essential to the growth and yield of crops.

Growth parameters

The current study's findings demonstrate that weed control and rice residue management techniques have a substantial impact on wheat growth attributes such plant height Fig 1, number of tillers and dry matter accumulation Table 1. These parameters increased progressively with crop growth, becoming more noticeable at later stages. Similar results have been revealed by Vijayaprabhakar *et al.* (2017), where wheat growth was increase with residue treatments like PUSA decomposer, owing to enhanced mineralization and improved nutrient availability. The higher growth parameters under treatments such as PUSA decomposer and *Trichoderma* can be attributed to the superior microbial breakdown of organic matter, which leads to increased nutrient cycling and reduced weed competition, thereby providing better growing conditions for wheat (Kumar *et al.*, 2017).

Among the various rice residue treatments, the highest plant height, no. of tillers and dry matter accumulation were obtained by residue treated with PUSA decomposer, which was statistically comparable to residue burning and *Trichoderma* treatment. On the other hand, residue removal resulted in the lowest growth parameters, likely due to the reduced availability of organic matter, which is critical for nutrient supply and moisture retention (Rajkhowa and Borah, 2008).

Yield attributes

The results also shown a significant improvement in yield attributes such as effective tillers, spike length, number of spikelets per spike, number of grains per spike and 1000-grain weight under different rice residue and weed control treatments (Fig 2). The highest values were recorded for PUSA decomposer treated residue, followed by residue burning and *Trichoderma* treatment, all of which were superior to residue removal. The increase in yield attributes under PUSA decomposer treatment is likely due to its positive impact on dry matter accumulation, as noted by Ali *et al.* (2019).

Among the weed management strategies, the maximum growth and yield attribute values were observed under the hand weeding twice at 30 and 45 DAS, which was statistically similar to Brown manuring fallowed by Clodinafop Propargyl @ 60 g a.i. ha^{-1}. Weed-free conditions led to better growth parameters and nutrient uptake, thus improving wheat growth, which corroborates findings by Samant (2017), who noted that hand weeding reduces weed pressure, thereby improving crop performance. Conversely, the lowest values of growth and yield attributes were recorded in the weedy treatment, confirming the detrimental impact of weed competition on wheat growth and yield (Singh and Walia, 2014).

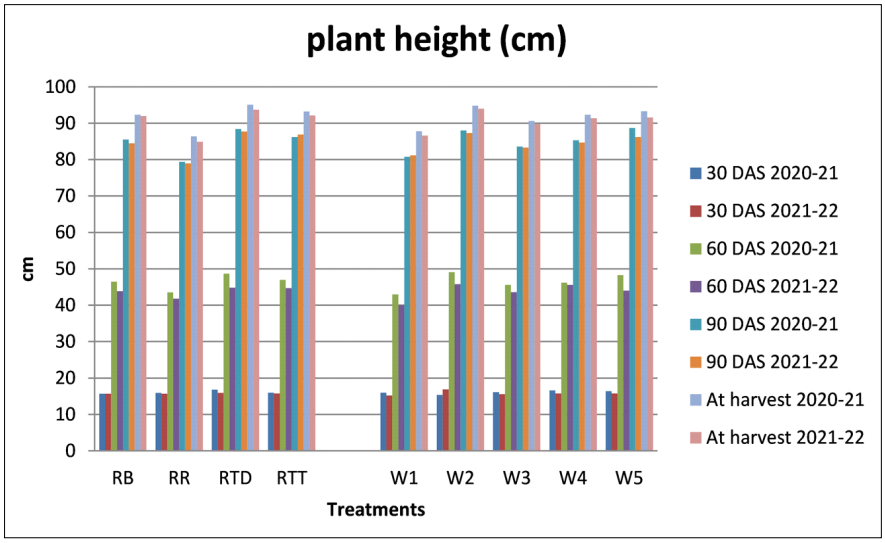


Fig 1: Effect of rice residue and weed management on plant height (cm) at different stages of crop growth of wheat.

Table 1: Effect of rice residue and weed management on number of tillers (pmrl) and dry matter accumulation (g m^{-2}) at different stages of crop growth of wheat.

Treatment	Number of tillers (pmrl)								Dry matter accumulation (g m^{-2})							
	30 DAS		60 DAS		90 DAS		At harvest		30 DAS		60 DAS		90 DAS		At harvest	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
RB	40.2	38.0	85.1	80.6	77.7	77.4	73.2	72.1	47.1	44.4	230.4	221.9	652.4	632.0	934.6	887.1
RR	40.3	37.3	80.8	76.0	73.2	71.2	68.0	69.0	47.7	45.6	204.1	197.8	609.7	598.9	843.6	818.8
RTD	41.0	38.1	88.6	85.0	81.6	78.8	77.1	75.3	51.9	46.1	240.9	238.2	662.8	658.8	977.3	950.6
RTT	39.6	37.7	85.8	83.3	78.8	78.1	74.3	72.6	50.1	46.0	233.1	230.1	654.5	641.0	954.9	896.6
SEm±	0.96	0.80	1.46	1.09	1.56	1.26	1.64	0.93	1.04	0.97	6.95	5.89	10.01	9.19	19.49	21.82
C.D.(P=0.05)	NS	NS	5.15	3.86	5.50	4.46	5.78	3.27	NS	NS	24.5	20.77	35.32	32.41	68.75	76.97
W1	39.9	37.5	78.6	78.0	71.2	73.0	66.6	65.5	48.3	44.9	197.2	188.2	581.0	583.9	816.0	771.1
W2	40.9	38.2	89.5	84.8	82.5	79.8	77.8	76.5	49.8	46.0	249.0	242.6	683.9	666.7	989.69	959.9
W3	40.0	38.2	83.9	79.7	76.3	74.9	71.7	70.4	49.5	46.3	214.98	213.5	643.1	624.0	896.4	869.7
W4	40.1	37.8	85.8	80.8	78.9	76.2	74.2	74.2	48.8	45.2	234.1	229.8	652.7	635.8	955.0	906.4
W5	40.6	37.4	87.5	82.9	80.2	78.0	75.5	74.6	49.7	45.2	240.4	235.9	663.4	655.3	980.8	934.3
SEm±	1.3	0.73	1.31	1.59	1.34	1.13	1.34	1.34	1.31	0.91	5.39	5.31	13.98	9.27	25.98	31.41
C.D.(P=0.05)	NS	NS	3.79	4.60	3.88	3.26	3.88	3.87	NS	NS	15.58	15.37	40.44	26.83	68.75	90.88

Grain yield and harvest index

Meteorological conditions during crop growth significantly impact wheat growth and yield is shown in Table 2. In 2020-21, wheat performed better than in 2021-22, with a mean yield of 44.8 q ha^{-1} compared to 42.6 q ha^{-1}, despite fluctuations in maximum and minimum temperatures adversely affecting yield. Higher temperatures cause heat stress, which lowers grain yield by triggering floret abortion (Wardlaw and Wrigley, 1994), pollen sterility, tissue dryness, decreased CO, absorption and increased photorespiration. The ideal temperature range for pollination and grain filling is 12-22°C. Heat stress reduces resource uptake and grain filling length by speeding up growth but shortening phenological phases (Fischer, 1980). Total sterility may result from floret generation at temperatures higher than 30°C (Saini and Aspinal, 1982). According to Tahir and Nakata (2005), a 1°C increase beyond the ideal temperature shortens grain filling by 0.4 days, lowering kernel weight and yield. For every degree celsius that the temperature rises, wheat yields are expected to decrease by 3-7% (Aggarwal, 2009).

The data reveals that the maximum grain and straw yield were recorded with treatment of PUSA decomposer treated residue which was at par with the treatment of *Trichoderma* treated residue and residue burning (during 2020-21 and 2021-22), respectively (Table 3). The lowest grain yield was observed with residue removal which was significantly lower than the rest of treatments during both years. These findings align with earlier studies emphasizing the role of residue decomposition in enhancing crop productivity (Kaur *et al.*, 2020). An increase in grain yield was observed by 18 and 22%, 15 and 16% and 12 and 13% with PUSA decomposer, *Trichoderma* and residue burning over residue removal, respectively, during 2020-21 and 2021-22.

All weed management practices produced significantly maximum grain yields over the weedy. The maximum grain was observed with the treatment of two hand weeding at 30 and 45 DAS, which was significantly at par with the treatment of Brown manuring followed by clodinafop propargyl @ 60 g a.i. ha^{-1} and fenoxaprop + metsulfuron @ 100 g + 4 g a.i. ha^{-1}. The lowest grain yield was obtained with the weedy check which was significantly lower than rest of the treatments in both years. These results corroborate findings from previous research on the efficacy of integrated weed management strategies in enhancing wheat yield (Yadav *et al.*, 2017). An enhance in grain yield over the weedy was calculated to be 26% and 25%, 23% and 23%, 20% and 19% and 12% and 13% by treatments of two hand weeding, brown manuring fallowed by clodinafop propargyl, fenoxaprop + metsulfuron and sulfosulfuron @ 25 g ha^{-1} during 2020-21 and 2021-22, respectively (Yadav *et al.,* 2017).

The maximum harvest index was observed in treatment of PUSA decomposer treated residue which was at par with other the treatments except residue removal during both the years. Among weed management, the highest harvest index

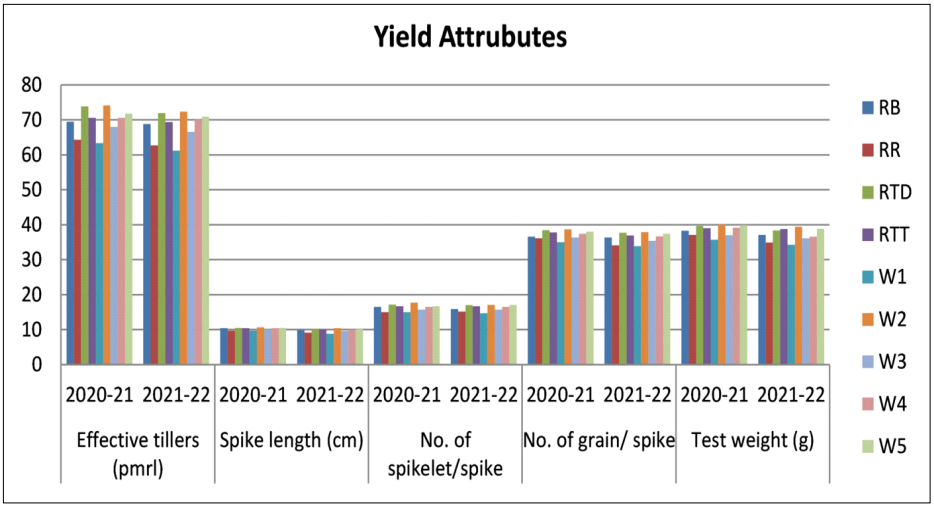


Fig 2: Effect of rice residue and weed management on yield attributes of wheat.

Table 2: Temperature data during the crop season from November to April.

Standard week	2020-21		2021-22	
	Temp (°C)		Temp (°C)	
	Max.	Min.	Max.	Min.
43	33.0	16.1	30.9	18.0
44	31.0	13.4	30.1	14.9
45	28.4	11.3	28.7	12.9
46	27.6	9.9	29.0	13.9
47	25.0	9.5	28.1	11.0
48	25.8	8.4	26.8	9.7
49	26.3	7.9	23.1	11.6
50	22.9	6.4	22.4	9.4
51	20.3	6.0	20.7	7.2
52	18.7	4.9	20.0	6.5
1	19.0	6.2	20.6	7.5
2	18.8	5.7	17.7	5.3
3	18.1	7.2	16.2	4.7
4	18.8	6.5	16.6	5.3
5	21.6	7.1	20.1	6.0
6	23.9	7.7	20.5	7.3
7	26.6	9.8	24.3	8.3
8	29.4	12.0	25.9	9.9
9	30.5	14.1	26.0	10.5
10	32.3	14.5	30.3	13.4
11	31.7	15.7	34.2	17.1
12	33.0	16.6	37.5	20.1
13	34.0	16.9	38.7	20.3
14	35.1	17.8	39.8	21.7
15	38.3	19.3	41.0	20.4
16	37.0	20.8	41.2	20.6
17	37.3	20.9	41.6	23.5
18	38.8	24.2	43.1	23.8

Table 3: Effect of rice residue and weed management on grain yield and harvest index of wheat crop.

Treatment	Grain yield (q ha^{-1})		Harvest index (%)	
	2020-21	2021-22	2020-21	2021-22
Rice residue management				
RB - Residue burning	45.18	42.68	43.46	43.27
RR - Residue removal	40.23	37.81	42.85	42.40
RTD - PUSA decomposer treated residue	47.59	46.28	43.77	43.92
RTT - Trichoderma treated residue	46.34	43.93	43.62	43.81
SEm±	1.05	1.05	0.10	0.12
C.D. (P=0.05)	3.71	3.69	0.51	0.42
Weed management				
W_1 - Weedy	38.65	36.76	42.57	42.95
W_2 - Hand weeding twice at 30 and 45 DAS	48.22	46.22	43.82	43..63
W_3 - Sulfosulfuron @ 25 g a.i. ha^{-1} PoE	43.16	41.38	43.29	42.93
W_4 - Fenoxaprop-p-ethyl + Metsulfuron methyl @ 100 g + 4g a.i. ha^{-1} PoE	46.42	43.83	43.70	43.59
W_5 - Brown manuring fb Clodinafop Propargyl @ 60 g a.i. ha^{-1} PoE	47.72	45.17	43.75	43.43
SEm±	1.42	1.02	0.18	0.17
C.D. (P=0.05)	4.10	3.77	0.51	0.48

recorded with two hand weeding which was statistically at par with Brown manuring fallowed by clodinafop propargyl at 60 g a.i. ha^{-1} and fenoxaprop + metsulfuron at 100 g + 4 g a.i. ha^{-1}. The lowest value of harvest index was noted in weedy in during 2020-21 and 2021-22.

In this study, PUSA decomposer treated residue recorded higher grain comparable to residue burning and *Trichoderma* treatments and significantly better than residue removal. The improvement in yields under residue-treated plots can be attributed to the positive effects of residue decomposition, which enhances nutrient cycling. The herbicidal treatment Brown manuring fallowed by clodinafop propargyl @ 60 g a.i. ha^{1} demonstrated the highest grain yield, likely due to better weed control and improved yield attributes.

CONCLUSION

In conclusion, the results of this study suggest that both effective rice residue management and integrated weed control practices are essential for improving wheat growth and yield. Incorporation of rice residues, particularly with PUSA decomposer and strategic weed management through hand weeding or brown manuring with herbicides can significantly enhance wheat productivity.

ACKNOWLEDGEMENT

The authors were thankful to the Sardar Vallabhbhai University of Agriculture and Technology, Meerut, Uttar Pradesh, India for providing the necessary facilities and support to conduct this research.

Conflict of interest

The authors declare that they have no conflict of interest.

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