Indian Journal of Weed Science (2026) **58**(1): 59–64
http://dx.doi.org/10.5958/0974-8164.2026.00007.9

RESEARCH ARTICLE

Performance of pyroxasulfone under simulated rainfall timings in wheat sown with super seeder

Balkaran Singh Sandhu, Tarundeep Kaur*, Makhan Singh Bhullar and Gurinder Singh

Received: 9 October 2025 | Revised: 6 January 2026 | Accepted: 9 January 2026

ABSTRACT

A field experiment was conducted for two-years to study the effect of simulated rainfall on the efficacy of pre-emergence application (PE) of pyroxasulfone in the presence of varying amount of retained rice residues in wheat sown with Super seeder. The study was carried out at Punjab Agricultural University, Ludhiana, Punjab, India using factorial RCBD with treatments including: two levels of rice residue loads (0 and 7 t/ha), two doses of pyroxasulfone (127.5 and 191.25 g/ha) PE and three simulated rainfall timings (2, 5 and 10 days after sowing); and two standard controls: unsprayed and pyroxasulfone 127.5 g/ha. Incorporation of rice residue 7 t/ha recorded higher wheat dry matter accumulation and grain yield (3.8 and 3.7%) over residue removal during both the years. Pyroxasulfone 191.25 g/ha PE recorded significantly lower density and biomass of *Phalaris minor* compared to pyroxasulfone 127.5 g/ha PE. The tested simulated rainfall timings did not significantly affect the weed density, weed biomass and wheat grain yield and did not cause any phyto-toxicity due to pyroxasulfone.

Keywords: *Phalaris minor*, Pyroxasulfone, Rice residue incorporation, Simulated rainfall, Wheat

INTRODUCTION

Rice-wheat (RW) is a major cropping system of India that occupies an area of 9.2 m ha (Dhanda *et al.* 2022) and spread over the Indo-Gangetic Plains. Wheat (*Triticum aestivum* L.) is the world's major food crop that played an outstanding part in global food security. The fertile soils and irrigated ecologies in North-West part of India make it one of the most productive areas for wheat production in India. Wheat is serving as a staple food for 35% of the world's population (Grote *et al.* 2021) and providing 20% of the total dietary calories and proteins (Shiferaw *et al.* 2013). The sustainability of the RW system is becoming a big challenge due to multifarious problems like depleting groundwater, deterioration of surface water resources, degradation of soil health, reducing factor productivity, evolving herbicide-resistant weeds and burning of crop residue. In Punjab, 22 million tons of rice straw are produced annually (Anonymous 2024) from 3 million ha rice area in this intensively cultivated state. Thus, farmers have to manage this huge tonnage of rice residue within a shorter window period of 15-20 days to sow their wheat crop in the stipulated time frame. To clear rice residue promptly, farmers resort to *in-situ* burning of rice straw and usually claim that it is the cheapest option for them to achieve the task of timely wheat sowing up to mid-November. However, late-sown wheat remains on the risk of terminal heat stress (Khan *et al.* 2021). Being a temperate C_3 crop, it gets prone to photorespiration losses during sudden rise in temperature (Sage and Kubien 2007), usually in mid-spring days. For management of rice residue, Super seeder, a tractor operated machine, is available in Punjab which incorporate paddy straw in soil, prepares the land, and sows the wheat seeds, simultaneously. This machine is very eco-friendly with environment by improving soil health (Singh *et al.* 2020). On the other hand, rice residue management is also one of the big opportunities to suppress weeds by laying these residues horizontally *in-situ* as mulch for weed suppression (Gill *et al.* 2025).

In RW cropping system, the yield losses due to weeds infestation are much higher as compared to any other cropping system (Singh *et al.* 2005). Among different weeds, *Phalaris minor* is the important grass weed of the wheat (Liu *et al.* 2021) that is highly competitive with wheat and causes much yield reductions approx. 25-80% (Chhokar and

Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab, India

* Corresponding author email: tarundhaliwal@pau.edu

Malik 2002). Other wheat weeds, such as *Rumex dentatus* have developed resistance to ALS inhibitors (Chaudhary *et al.* 2021). Pre-emergence (PE) herbicides are effective to reduce the herbicide resistance development (Beckie and Hall 2014) but their efficacy depends on soil moisture and tilth (Ahirwal *et al.* 2020).

Crop residue can intercept some proportion of the PE herbicides that may result in the reduced weed control. Higher rate of PE herbicides must be needed for the adequate weed management due to binding of applied herbicides in high organic matter soil (Teasdale *et al.* 2003). The amount and time of rainfall also affect the herbicide wash-off from crop residue and its dissipation and movement. Rainfall can move the herbicide to proper depth of soil profile and also dissolve the herbicide to be available for plant absorption (Singh *et al.* 2002). Keeping these points in view, an experiment was conducted to study the effect of simulated rainfall on the efficacy of pre-emergence herbicide, pyroxasulfone, in the presence of varying amount of rice residue in wheat sown with Super seeder.

MATERIALS AND METHODS

A field experiment was conducted at Research Farm of Department of Agronomy, Punjab Agricultural University, Ludhiana (30° 54½N latitude and 75° 48½E longitude) during 2020-21 and 2021-22. This region is characterized by semi-arid with hot and dry early summer from March to June, hot and humid summer monsoon from July to September, mild winter from October to November and very cold winter from December to February. During the year, mean maximum and minimum temperatures shows significant fluctuations. The minimum temperature during *winter* season falls below 4^{o}C while during *summer* season, temperature exceeds 38^{o}C and many a time reaches 47^{o}C. Average annual rainfall of Ludhiana district of Punjab is 759 mm, 75-80% of which is received during the monsoon period. The soil of the experimental site was sandy loam in texture, normal in reaction (pH 6.7), normal EC (0.14 dS/m), low in available organic carbon (0.33%), medium in available phosphorus (20.5 kg/ha) and medium in available potassium (157.5 kg/ha).

The experiment was conducted in a factorial RCBD with two levels of rice residue quantity retained in the field (rice residue load) (0 and 7 t/ha), pre-emergence application (PE) of pyroxasulfone at 127.5 and 191.25 g/ha and three simulated rainfall timings, *viz.* 2, 5, and 10 days after sowing (DAS). In addition to the factorial treatments, two standard controls, *viz.* an unsprayed control and pyroxasulfone 127.5 g/ha PE were also included. Thus, a total of 14 treatments [(2 × 2 × 3) + 2] were tested and replicated thrice. Amount of simulated rainfall was calculated by taking last 10-year average (2010 to 2019) of November month *i.e.*, 4.94 mm (0, 0, 0, 4.6, 0, 0, 0, 7.0, 2.6, 35.2 mm). With rainfall of 10 mm, every square meter of field receives 0.01 m^3 or 10 litre of rain water. So, with rainfall of 1mm, 1 square meter receives 1 liter of water. Simulated rainfall was given 4.94 mm (4.94 liters/m^2). Gross plot area was 13.2 m^2 and 65.2 liters (4.94 x 13.2) of water was applied from 8 feet height standing on iron ladder with the help of plastic shower of 10 litre capacity. The droplet size of water was large and from 8 feet height it touches the soil with a force just like rain droplet. Sowing of wheat cv. *PBW 725* was done with Super seeder that incorporates paddy residue in soil at row spacing of 20 cm on 3rd and 1st November during 2020 and 2021, respectively. Pyroxasulfone PE was sprayed on the same day after sowing by using 500 litres/ha water. Recommended plant protection measures were taken against insect pests and diseases to ensure a healthy crop. Recommended dose of P, K and half N were applied at sowing while remaining half N was applied at first irrigation. Data on weeds was recorded with a quadrat (1 m × 1 m) from two spots in each of the plots at 90 DAS and at harvest. Different weed species were identified, counted and were cut at collar portion of the plants. The plants were then placed separately in brown paper bags to dry in the sun for 3-5 days. After the excess moisture was properly dried off, these paper bags were placed in an oven at 70±2°C for 72 hours until the weed samples achieved a constant weight, which was considered the weed biomass of the respective weed species. To analyse and interpret weed density and biomass, the average of both quadrats was converted into no./m^2 and g/m^2, respectively. The crop was harvested manually on 8th April, 2021 and 4th April, 2022. Observations on wheat seedling emergence count, leaf area index, dry matter accumulation and grain yield were recorded. Collected data were further analysed by using Proc GLM procedure of SAS version 9.4. To achieve normality in weed data distribution, square root transformation was performed before analysis. Economics of the treatments were carried out on the basis of income obtained from yield, cost incurred for each treatment and prevailing market prices.

RESULTS AND DISCUSSION

Effect on weeds

The dominant weed flora observed in experimental field comprised of grassy weed, *Phalaris minor* and broad-leaved weeds, *Rumex dentatus* and *Medicago denticulata*. The rice residue load has non-significant effect on *P. minor, R. dentatus* and *M. denticulata* density at 90 DAS and at harvest during both the years (**Table 1**). The *P. minor* density in pyroxasulfone 127.5 g/ha PE was significantly lower (91.1% and 89.7% at 90 DAS and 92.0% and 90.6% at harvest) as compared to unsprayed check in 2020-21 and 2021-22, respectively. The application of higher dose of pyroxasulfone 191.25 g/ha PE resulted in significantly better control of *P. minor* (24.0% and 15.9% at 90 DAS and 25.0% and 16.7% at harvest) as compared to recommended dose of pyroxasulfone in 2020-21 and 2021-22, respectively (**Table 1**). Similar observations were made by Kumar *et al.* (2013); Kaur *et al.* (2019); Kumar *et al.* (2021). But both doses of pyroxasulfone had non-significant effect on density of *R. dentatus* and *M. denticulata* at 90 DAS and at harvest during both years of study. Pyroxasulfone herbicide was found to be less effective against *R. dentatus* and *M. denticulata* as compared to *P. minor.* Simulated rainfall at 2, 5 and 10 DAS did not produce significant effect on *P. minor, R. dentatus* and *M. denticulata* density during both years at 90 DAS and at harvest. The recommended dose of pyroxasulfone 127.5 g/ha PE has significantly lesser *P. minor* density than unsprayed check during both the years confirming observations of Johnson *et al.* (2018). The treatment mean indicates significantly less *P. minor, M. denticulata* and *R. dentatus* population at 90 DAS and at harvest than unsprayed check but statistically at par with recommended dose of herbicide without simulated rainfall during both years (**Table 1**).

At 90 DAS and at harvest, different rice residue load and simulated rainfall timings at 2, 5 and 10 DAS had non-significant effect on *P. minor, R. dentatus* and *M. denticulata* biomass during both years (**Table 2**). Pyroxasulfone 191.25 g/ha PE caused significantly lower biomass of *P. minor* (25.0% and 16.7% at 90 DAS and 25.0% and 10.0% at harvest in 2020-21 and 2021-22, respectively) than recommended rate of pyroxasulfone 127 g/ha. The treatment mean indicated significant reduction in

Table 1. Effect of treatments on weed density (at 90 DAS and at harvest) in Super seeder sown wheat

Treatment	Weed density*(no./m^2)											
	At 90 DAS						At harvest					
	Grass		Broad-leaved weeds				Grass		Broad-leaved weeds			
	Phalaris minor		*Medicago denticulata*		*Rumex dentatus*		*Phalaris minor*		*Medicago denticulata*		*Rumex dentatus*	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Rice residue load												
0 t/ha	2.27(4)	2.67(6)	4.78(22)	4.36(18)	2.00(3)	2.23(4)	2.07(3)	2.49(5)	4.54(19)	4.24(17)	1.85(2)	2.05(3)
7.0 t/ha	2.34(5)	2.75(7)	4.68(21)	4.31(18)	1.87(2)	2.14(4)	2.14(4)	2.54(5)	4.55(19)	4.19(17)	1.79(2)	2.00(3)
LSD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pyroxasulfone doses												
Pyroxasulfone 127.5 g/ha	2.44(5)	2.81(7)	4.77(22)	4.38(18)	1.98(3)	2.20(4)	2.21(4)	2.57(6)	4.57(19)	4.26(17)	1.87(3)	2.05(3)
Pyroxasulfone 191.25 g/ha	2.17(4)	2.61(6)	4.68(21)	4.29(17)	1.89(3)	2.16(4)	2.00(3)	2.46(5)	4.52(19)	4.17(16)	1.77(2)	2.00(3)
LSD(p=0.05)	0.18	0.11	NS	NS	NS	NS	0.18	0.07	NS	NS	NS	NS
Simulated rainfall timings												
2 days after sowing	2.21(4)	2.62(6)	4.71(21)	4.33(18)	1.93(3)	2.19(4)	2.01(3)	2.48(5)	4.54(19)	4.21(17)	1.87(3)	2.06(3)
5 days after sowing	2.32(5)	2.73(7)	4.73(21)	4.33(18)	1.93(3)	2.20(4)	2.11(4)	2.51(5)	4.55(19)	4.20(17)	1.82(2)	2.03(3)
10 days after sowing	2.39(5)	2.78(7)	4.74(21)	4.35(18)	1.95(3)	2.15(4)	2.20(4)	2.55(6)	4.55(19)	4.22(17)	1.78(3)	1.99(3)
LSD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control vs Control												
Unsprayed	7.77(59)	8.28(68)	5.51(29)	4.93(23)	2.82(7)	3.16(9)	7.16(50)	8.06(64)	5.29(26)	4.76(22)	2.64(6)	2.89(7)
Pyroxasulfone 127.5 g/ha	2.51(5)	2.82(7)	4.79(22)	4.36(18)	1.80(2)	2.16(4)	2.16(4)	2.58(6)	4.54(19)	4.24(17)	1.82(2)	1.99(3)
LSD(p=0.05)	0.43	0.27	0.34	0.26	0.36	0.31	0.44	0.20	0.31	0.23	0.24	0.32
Treatment vs Control 1												
Treatment mean	2.31(4)	2.71(6)	4.73(21)	4.33(18)	1.93(3)	2.18(4)	2.11(4)	2.51(5)	4.55(19)	4.21(17)	1.82(2)	2.03(3)
Unsprayed	7.77(59)	8.28(68)	5.51(29)	4.93(23)	2.82(7)	3.16(9)	7.16(50)	8.00 64)	5.29(26)	4.76(22)	2.64(6)	2.89(7)
LSD(p=0.05)	0.21	0.12	0.15	0.12	0.15	0.14	0.20	0.09	0.14	0.11	0.11	0.14
Treatment vs Control 2												
Treatment mean	2.31(4)	2.71(6)	4.73(21)	4.33(18)	1.93(3)	2.18(4)	2.11(4)	2.51(5)	4.55(19)	4.21(17)	1.82(2)	2.03(3)
Pyroxasulfone 127.5 g/ha	2.51(5)	2.82(7)	4.79(22)	4.36(18)	1.80(3)	2.16(4)	2.16(4)	2.58(6)	4.54(19)	4.24(17)	1.82(2)	1.99(3)
LSD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Data were subjected to square root transformation. Parentheses are original values; DAS = days after seeding; NS = not significant

Table 2. Effect of treatments on weed biomass (at 90 DAS and at harvest) in Super seeder sown wheat

Treatment	Weed biomass*(g/m^2)											
	At 90 DAS						At harvest					
	Grass		Broad-leaved weeds				Grass		Broad-leaved weeds			
	Phalaris minor		*Medicago denticulata*		*Rumex dentatus*		*Phalaris minor*		*Medicago denticulata*		*Rumex dentatus*	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Rice residue load												
0 t/ha	2.07(3)	2.44(5)	3.89(14)	3.59(12)	1.84(2)	2.04(3)	2.69(6)	3.25(10)	5.27(27)	4.99(24)	2.10(3)	2.35(5)
7.0 t/ha	2.13(4)	2.52(5)	3.82(14)	3.56(12)	1.72(2)	1.96(3)	2.79(7)	3.32(10)	5.22(26)	4.93(23)	2.02(3)	2.30(4)
LSD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pyroxasulfone doses												
Pyroxasulfone 127.5 g/ha	2.21(4)	2.57(6)	3.89(14)	3.61(12)	1.82(2)	2.02(3)	2.89(8)	3.36(10)	5.27(27)	5.02(24)	2.11(4)	2.35(5)
Pyroxasulfone 191.25 g/ha	1.99(3)	2.39(5)	3.82(14)	3.54(12)	1.75(2)	1.99(3)	2.59(6)	3.21(9)	5.21(26)	4.91(23)	2.00(3)	2.30(4)
LSD(p=0.05)	0.16	0.09	NS	NS	NS	NS	0.27	0.10	NS	NS	NS	NS
Simulated rainfall timings												
2 days after sowing	2.01(3)	2.40(5)	3.84(14)	3.57(12)	1.78(2)	2.01(3)	2.60(6)	3.24(10)	5.23(26)	4.96(24)	2.11(4)	2.36(5)
5 days after sowing	2.12(4)	2.50(5)	3.86(14)	3.57(12)	1.78(2)	2.02(3)	2.74(7)	3.28(10)	5.25(27)	4.96(24)	2.05(3)	2.33(5)
10 days after sowing	2.17(4)	2.54(6)	3.87(14)	3.58(12)	1.79(2)	1.98(3)	2.89(7)	3.33(10)	5.26(27)	4.97(24)	2.00(3)	2.28(4)
LSD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control vs Control												
Unsprayed	6.92(47)	7.47(55)	4.48(19)	4.06(16)	3.45(11)	3.82(14)	9.82(96)	10.90(118)	6.11(36)	5.61(31)	3.89(14)	4.18(17)
Pyroxasulfone 127.5 g/ha	2.28(4)	2.58(6)	3.91(14)	3.59(12)	1.67(2)	1.98(3)	2.82(7)	3.38(10)	5.26(27)	5.00(24)	2.06(3)	2.28(4)
LSD(p=0.05)	0.37	0.24	0.27	0.21	0.30	0.27	0.63	0.27	0.31	0.28	0.29	0.40
Treatment vs Control 1												
Treatment mean	2.10(4)	2.48(5)	3.86(14)	3.57(12)	1.78(2)	2.00(3)	2.74(7)	3.28(10)	5.24(27)	4.96(24)	2.06(3)	2.32(5)
Unsprayed	6.92(47)	7.47(55)	4.48(19)	4.06(16)	3.45(11)	3.82(14)	9.82(96)	10.90(118)	6.11(36)	5.61(31)	3.89(14)	4.18(17)
LSD(p=0.05)	0.19	0.11	0.12	0.09	0.13	0.12	0.29	0.12	0.14	0.13	0.13	0.17
Treatment vs Control 2												
Treatment mean	2.10(4)	2.48(5)	3.86(14)	3.57(12)	1.78(2)	2.00(3)	2.74(7)	3.28(10)	5.24(27)	4.96(24)	2.06(3)	2.32(5)
Pyroxasulfone 127.5 g/ha	2.28(4)	2.58(6)	3.91(14)	3.59(12)	1.67(2)	1.98(3)	2.82(7)	3.38(10)	5.26(27)	5.00(24)	2.06(3)	2.28(4)
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Data were subjected to square root transformation. Parentheses are original values; DAS = days after seeding; NS = not significant

biomass of *P. minor* (91.5% and 90.9% at 90 DAS and 92.7% and 91.5% at harvest), *M. denticulata* (26.3% & 25.0% at 90 DAS and 25.0% and 22.6% at harvest) and *R. dentatus* (81.8% and 78.6% at 90 DAS and 78.6% and 70.6% at harvest) in 2020-21 and 2021-22, respectively over unsprayed check. No significant interactive effect of rice residue load, pyroxasulfone doses and timings of simulated rainfall was recorded at 90 DAS and at harvest in 2020-21 and 2021-22.

Effect on wheat growth and grain yield

The emerged wheat population was significantly higher with residue load of 0 t/ha (3.5% in 2020-21 and 6.1% in 2021-22) as compared to residue load of 7 t/ha. Reduced wheat seedling emergence under residue retention was due to physical obstruction/ mechanical hindrance to the shoot emergence (Wuest *et al.* 2000; Ram *et al.* 2013). In 2020-21 and 2021-22, rice residue load 7 t/ha recorded significantly higher wheat leaf area index (8.4% and 8.9%, respectively) confirming Kaur (2022) and wheat dry matter accumulation (7.7% and 6.1%, respectively) over rice residue load of 0 t/ha. Both doses of pyroxasulfone, different treatment combination and simulated rainfall timings at 2, 5 and 10 DAS had non-significant effect on wheat emergence count, LAI and dry matter accumulation during both years (**Table 3**). Rice residue load 7 t/ha recorded significantly higher wheat grain yield (3.8% in 2020-21 and 3.7% in 2021-22) over no residue as reported by Sharma and Acharya (2000).

The pyroxasulfone doses and simulated rainfall timings had non-significant effect on wheat grain yield during 2020-21 and 2021-22 (**Table 3**). Pyroxasulfone PE recorded significantly more wheat grain yield (44.8% in 2020-21 and 51.3% in 2021-22) than unsprayed control due to better control of weeds (Kaur *et al.* 2017).

Economics

All economic parameters were affected by different rice residue load, doses of pyroxasulfone and simulated rainfall timings. Rice residue load 7 t/ha recorded higher gross returns (5.1% and 4.6%), net returns (6.8% and 9.8%) and higher B:C as compared to no residues in 2020-21 and 2021-22, respectively (**Table 4**). The cost of cultivation was higher with rice residue load of 0 t/ha due to addition of residue removal cost over rice residue load of 7 t/ha. Pyroxasulfone doses and timings of simulated rainfall

Table 3. Effect of treatments on growth attributes and grain yield of Super seeder sown wheat

Treatment	Emergence count (no./m²)		Leaf area index (LAI)		Dry matter accumulation (g/m²)		Grain yield (t/ha)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Rice residue load								
0 t/ha	130.1	131.9	5.84	5.74	1339	1249	5.85	5.14
7.0 t/ha	125.7	124.3	6.33	6.25	1442	1325	6.07	5.33
LSD (p=0.05)	4.1	4.5	0.22	0.24	39	15	0.15	0.15
Pyroxasulfone doses								
Pyroxasulfone 127.5 g/ha	128.6	129.2	6.06	5.96	1386	1271	5.90	5.17
Pyroxasulfone 191.25 g/ha	127.2	127.1	6.12	6.03	1395	1302	6.01	5.31
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Simulated rainfall timings								
2 days after sowing	123.5	124.4	6.02	6.07	1394	1286	5.98	5.29
5 days after sowing	130.6	130.8	6.14	5.90	1394	1295	5.94	5.25
10 days after sowing	129.6	129.2	6.10	6.02	1384	1280	5.95	5.17
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Control vs Control								
Unsprayed	128.3	130.0	5.37	5.27	925	770	4.05	3.36
Pyroxasulfone 127.5 g/ha	129.2	131.7	6.10	6.03	1335	1253	5.86	5.08
LSD (p=0.05)	NS	NS	0.57	0.55	91	33	0.38	0.35
Treatment vs Control 1								
Treatment mean	127.9	128.1	6.09	5.99	1391	1287	5.96	5.24
Unsprayed	128.3	130.0	5.37	5.27	925	770	4.05	3.36
LSD (p=0.05)	NS	NS	0.26	0.25	40	15	0.18	0.16
Treatment vs Control 2								
Treatment mean	127.9	128.1	6.09	5.99	1391	1287	5.96	5.24
Pyroxasulfone 127.5 g/ha	129.2	131.7	6.10	6.03	1335	1253	5.86	5.08
LSD (p=0.05)	NS	NS	NS	NS	42.02	15.26	NS	NS

Table 4. Effect of treatments on cost of cultivation, gross returns, net returns and benefit cost ratio of Super seeder sown wheat

Treatment	Gross returns (x10³ ₹/ha)		Cost of cultivation (x10³ ₹/ha)		Net Returns (x10³ ₹/ha)		Benefit: Cost	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Rice residue load								
0 t/ha	126.30	149.64	35.94	39.05	93.86	110.59	3.5	3.8
7.0 t/ha	132.70	156.52	32.44	35.05	100.26	121.47	4.1	4.5
Pyroxasulfone doses								
Pyroxasulfone 127.5 g/ha	128.18	151.66	37.19	39.80	95.74	111.86	3.4	3.8
Pyroxasulfone 191.25 g/ha	130.82	154.48	39.56	42.17	98.38	112.30	3.3	3.7
Simulated rainfall timings								
2 days after sowing	130.61	153.38	32.44	35.05	98.17	118.33	4.0	4.4
5 days after sowing	129.90	152.81	32.44	35.05	97.46	117.76	4.0	4.4
10 days after sowing	128.01	153.03	32.44	35.05	95.57	117.98	3.9	4.4
Control vs Control								
Unsprayed	85.46	103.70	32.44	35.05	53.02	68.65	2.6	3.0
Pyroxasulfone 127.5 g/ha	125.13	150.34	37.19	39.80	92.69	110.54	3.4	3.8

recorded similar B:C. Pyroxasulfone recorded higher gross returns and net returns as compared to unsprayed control during both years confirming Qazizada *et al.* (2022).

It may be concluded that rice residue load 7 t/ha incorporated using Super seeder recorded higher wheat grain yield, net returns and B:C. Pyroxasulfone 127.5 g/ha PE provided good control of *P. minor* and other broad-leaved weeds and produced higher wheat grain yield. However, simulated rainfall timings had no impact on weed biomass, productivity and economics of wheat.

REFERENCES

Ahirwal AL, Sapre N, Singh V and Sharma P. 2020. Efficacy of pyroxasulfone 5% + pendimethalin 40% ready mixture on associated weed flora, growth and yield of soybean (*CV* JS 20-29). *Journal of Pharmacognosy and Phytochemistry* **9**(6): 403–406.

Anonymous. 2024. Package of Practices for Crops of Punjab *Rabi.* Punjab Agricultural University.

Beckie HJ and Hall LM. 2014. Genetically-modified herbicide-resistant (GMHR) crops a two-edged sword? An Americas perspective on development and effect on weed management. *Crop Protection* **66**: 40–45.

Chaudhary A, Chhokar RS, Dhanda S, Kaushik P, Kaur S, Poonia TM, Khedwal RS, Kumar S and Punia SS. 2021. Herbicide resistance to Metsulfuron-Methyl in *Rumex dentatus* L. in north-west India and its management perspectives for sustainable wheat production. *Sustainability* **13**(12): 6947.

Chhokar RS and Malik RK. 2002. Isoproturon resistant *Phalaris minor* and its response to alternate herbicides. *Weed Technology* **16**: 116–123.

Dhanda S, Yadav A, Yadav DB and Chauhan BS. 2022. Emerging issues and potential opportunities in the rice-wheat cropping system of North-Western India. *Frontiers in Plant Science* **13**: 832683.

Gill JS, Singh S, Bhullar MS, Kaur G and Kaur T. 2025. Productivity-profitability-energy-carbon footprint nexus of wheat in relation to its establishment vis-à-vis in-situ rice residue management with a novel Surface Seeding-cum-Mulching technique. *Energy* **17**: 137177.

Grote U, Fasse A, Nguyen TT and Erenstein O. 2021. Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems* **4**: 617009.

Johnson EN, Wang Z, Geddes CM, Coles K, Hamman B and Beres BL. 2018. Pyroxasulfone is effective for management of *Bromus spp*. in winter wheat in western Canada. *Weed Technology* **32**: 739–748.

Kaur G. 2022. *Integrated weed management in wheat and characterization of herbicide resistance in Phalaris minor Retz*. Ph. D. Thesis, Punjab Agricultural University, Ludhiana, India.

Kaur S, Kaur T and Bhullar MS. 2017. Control of mixed weed flora in wheat with sequential application of pre- and post-emergence herbicides. *Indian Journal of Weed Science* **49**(1): 29–32.

Kaur T, Bhullar MS and Kaur S. 2019. Control of herbicide resistant *Phalaris minor* by pyroxasulfone in wheat. *Indian Journal of Weed Science* **51**(2): 123–128.

Khan A, Ahmad M, Ahmed M, Gill KS and Akram Z. 2021. Association analysis for agronomic traits in wheat under terminal heat stress. *Saudi Journal of Biological Sciences* **28**(12): 7404–7415.

Kumar RM, Yamanura and Boraiah B. 2021. Assessment of bioefficacy of novel pyroxasulfone for controlling weeds insummer maize. *Indian Journal of Weed Science* **53(1)**: 99–103.

Kumar S, Bhatoo MS, Punia SS and Singh S. 2013. Evaluation of pinoxaden in combination with 2,4-D against complex weed flora in barley. *Indian Journal of Weed Science* **42**: 120–122.

Liu C, Bhullar MS, Kaur T, Kumar J, Reddy SRS, Singh M and Kaundun SS. 2021. Modelling the effect and variability of integrated weed management of *Phalaris minor* in rice-wheat cropping systems in Northern India. *Agronomy* **11**: 2331.

Qazizada GS, Mal T, Kumar S and Kumar P. 2022. Effect of pre- and post-emergence herbicides on weed infestation, crop growth and economics of wheat. *The Pharma Innovation Journal* **11**(3): 152–157.

Ram H, Dadhwal V, Vashist KK and Kaur H. 2013. Grain yield and water use efficiency of wheat (*Triticum aestivum* L.) in relation to irrigation levels and rice straw mulching in North West India. *Agricultural Water Management* **128**: 92–101.

Sage RF and Kubien DS. 2007. The temperature response of C3 and C4 photosynthesis. *Plant, Cell & Environment* **30**(9): 1086–1106.

Sharma PK and Acharya CL. 2000. Carry-over of residual soil moisture with mulching and conservation tillage practices for sowing of rainfed wheat (*Triticum aestivum* L.) in north-west India. *Soil Tillage Research* **57**: 43–52.

Shiferaw B, Smale M, Braun HJ, Duveiller E, Reynolds M and Muricho G. 2013. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. *Food Security* **5**(3): 291–317.

Singh G, Singh P, Sodhi GPS, Tiwari D. 2020. Adoption status of rice residue management technologies in South-Western Punjab. *Journal of Extension Education* **56**: 76–82.

Singh G, Singh VP, Singh V, Singh SP and Kumar A. 2005. Characterization of weed flora and weed management practices in rice under different cropping systems in western Gangetic plains of India - A Case Study. *Indian Journal of Weed Science* **37**: 45–50.

Singh N, Kloeppel H and Klein W. 2002. Movement of metolachlor and terbuthylazine in core and packed soil columns. *Chemosphere* **47**(4): 409–415.

Teasdale JR, Shelton DR, Sadeghi AM and Isensee AR. 2003. Influence of hairy vetch residue on atrazine and metolachlor soil solution concentration and weed emergence. *Weed Science* **51**: 628–634.

Wuest SB, Albrecht SL and Skirvin KW. 2000. Crop residue position and interference with wheat seedling development. *Soil Tillage Research* **55**: 175–182.