RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 60 Issue 6: 861-868 (June 2026)

Assessing the Impact of Quinchlorac 35% SC on Weed Flora, Soil Nutrient and Microbial Status in Transplanted *Boro* Rice (*Oryza sativa* L.)

Munmun Nesha[1], Dhananjoy Dutta[1], V.V.S. Jaya Krishna[1],
Manimala Mahato[1], Madhurima Dey[1]

10.18805/IJARe.A-6472

ABSTRACT

Background: Rice is India's staple food, but *boro* rice cultivation often uses intensive irrigation and fertilizers, leading to severe weed infestation and yield losses. To manage this, modern herbicides like Quinclorac 35% SC, a post-emergent, selective and systemic herbicide, has been identified, which effectively controls diverse weed flora.

Methods: A field trial was conducted during the *boro* seasons of 2021-2022 and 2022-2023 at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, to assess the effectiveness of Quinclorac 35% SC at different doses for weed control in transplanted *boro* rice (variety IET 4786/Satabdi) compared to hand weeding and bispyribac sodium. Seven treatments were laid out in a randomized block design with three replications. Herbicides were applied at 15 DAT and crop growth, weed suppression, soil microbial populations and nutrient status were monitored before sowing and after harvest.

Result: The results revealed that treatment T_6 (hand weeding twice at 20 and 40 DAT) achieved the highest weed control efficiency, followed by T_5 (Quinchlorac 35% SC @ 1400 ml ha^{-1}) and T_3 (Quinchlorac 35% SC @ 700 ml ha^{-1}). However, T_6 recorded a lower benefit-cost ratio due to higher labour costs. Although T_5 effectively suppressed weeds, it caused severe phytotoxicity. In contrast, T_3 provided strong weed control with minimal crop injury and the highest benefit-cost ratio, making it the most effective and economical herbicide treatment for managing weed flora in *boro* rice.

Key words: Bispyribac sodium, *Boro* rice, Phytotoxicity, Quinchlorac, Soil microbiota.

INTRODUCTION

Nearly half of the global population depends primarily on rice (*Oryza sativa* L.) as a key source of nutrition (Kumar *et al*., 2016) and it serves as a staple food in India as well (Pathak *et al*., 2019). India has the world's largest area under rice cultivation, where West Bengal is the leading rice-growing state, producing 16.65 million tonnes from 5.58 million hectares, with an average productivity of 2,984 kg ha^{-1} (*boro* season: 3,570 kg ha^{-1}), accounting for 13.62% of India's total production (Government of India, 2022).

Boro rice cultivation in West Bengal relies heavily on irrigation and fertilizers, which often encourages severe weed infestations, causing significant yield losses. Unchecked weed growth in *boro* rice can reduce yields by 33-45% (Manhas *et al*., 2012). Early growth stages are especially vulnerable due to slow rice growth at low temperatures, giving fast-growing weeds an advantage. Although cultural, physical and biological methods exist, manual weeding remains common due to its effectiveness and safety. However, labour shortages and high costs make this less viable. On the other hand, herbicides provide rapid and cost-effective weed control. However, repeated large-scale use of the same herbicides in rice fields have caused weed resistance, reduced beneficial soil microbes and contaminated water resources. Therefore, there is a need for new herbicide formulations at optimal doses that are both ecologically safe and economically viable for farmers.

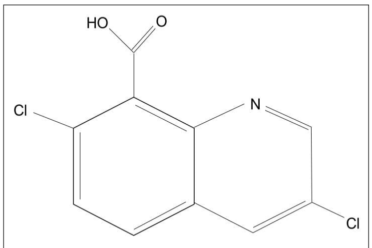
Quinchlorac (3,7-Dichloroquinoline-8-carboxylic acid) (Fig 1) is a post-emergent, systemic herbicide classified under Group 4 (synthetic auxins) with selective, broad-spectrum action. It disrupts weed growth by mimicking natural auxins, increasing ethylene production, inhibiting cell wall formation (Koo *et al*., 1997) and generating reactive oxygen species, intensifying its effect on grassy weeds (Grossmann, 2010; Sunohara *et al*., 2011). It was first introduced in 1992 for controlling *Echinochloa* spp. in rice

[1]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Nadia-741 252, West Bengal, India.

Corresponding Author: Munmun Nesha, Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Nadia-741 252, West Bengal, India. Email: munmunnesha25@gmail.com

How to cite this article: Nesha, M., Dutta, D., Krishna, V.V.S.J., Mahato, M. and Dey, M. (2026). Assessing the Impact of Quinchlorac 35% SC on Weed Flora, Soil Nutrient and Microbial Status in Transplanted *Boro* Rice (*Oryza sativa* L.). *Indian Journal of Agricultural Research*. **60(6):** 861-868. doi: 10.18805/IJARe.A-6472.

Submitted: 13-10-2025 **Accepted:** 14-05-2026 **Online:** 29-05-2026



(Source: Fipke, *et al*., 2016).

Fig 1: Chemical structure of quinchlorac (3,7-dichloroquinoline-8-carboxylic acid).

(Talbert and Burgos, 2007). But since then, it was not widely popular due to its certain disadvantages.

The new soluble concentrate (SC) formulation of quinclorac is claimed to overcome these limitations by offering ease of handling, minimal visible residues and no need for agitation during application. Therefore, in this experiment, the new formulation at different doses was compared with manual hand-weeding and widely used rice herbicide, bispyribac sodium, which is also a post-emergent-systemic herbicide, to assess the impact of quinchlorac 35% SC on weed flora, soil nutrient, microbial status and production economics in transplanted *boro* rice.

MATERIALS AND METHODS

The field study was carried out in 2021-22 and 2022-23 during the *rabi* season at Jaguli Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya in Nadia, West Bengal, India. The experiment was carried out on the sandy loam textured soil of order *Inceptiso*l with proper drainage facility, neutral pH, medium organic carbon, low available nitrogen, medium available phosphorous and potassium. The experimental design employed was randomized complete block design (RCBD) consisting of seven treatments, replicated thrice. The plot size was 4 m × 3 m each. Seedlings were transplanted in the main field at 43 DAT in 2-3 cm puddled soil depth, at 20 cm × 15 cm spacing. Recommended dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O were applied respectively through Urea, Single Superphosphate (SSP) and Muriate of Potash (MOP) in the experimental plot. From transplanting to the maximum tillering stage, a shallow water depth of 2-3 cm was maintained. Thereafter, the water level was increased to 5 cm and kept at this depth until the flowering stage. Subsequently, the irrigation depth was gradually reduced and finally discontinued 10 days before harvest. In this process, 8 irrigations were given.

The treatments are T_1: Quinchlorac 35% SC @ 175 g a.i. ha^{-1} (500 ml ha^{-1}), T_2: Quinchlorac 35% SC @ 210 g a.i. ha^{-1} (600 ml ha^{-1}), T_3: Quinchlorac 35% SC @ 245 g a.i. ha^{-1} (700 ml ha^{-1}), T_4: Standard Bispyribac Sodium 10% SC @ 25 g a.i. ha^{-1} (250 ml ha^{-1}), T_5: Quinchlorac 35% SC @ 490 g a.i. ha^{-1} (1400 ml ha^{-1}), T_6: Hand weeding twice at 20 and 40 DAT, T_7: Weedy check. The herbicides applications were done at 15 days after transplanting (DAT). The observations for weed density, weed biomass and weed control efficiency were taken at 30, 60 and 90 DAT respectively. Weed control efficiency (WCE) was calculated on the basis of weed dry weight as per the formula (Mani *et al.,* 1973) given below:

$$\text{WCE \%} = \frac{\text{DWC - DWT}}{\text{DWC}} \times 100$$

Where;
WCE = Weed control efficiency (%).
DWT = Dry weight of weed in treated plot (g m^{-2}).
DWC = Dry weight of weed in control plot (g m^{-2}).

Visually the phytotoxicity symptoms were observed in the experimental field at 7, 15, 22 and 30 days after application of the herbicides and rated using a 0-10 rating scale based on the percentage of crop injury, where 0 = no injury (0%), 1 = 1-10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7 = 61-70%, 8 = 71-80%, 9 = 81-90% and 10 = 91-100% injury (Rao, 2000). Severe yield loss can be seen after 5 scale. The soil samples were collected from the inter-row space of the field at a depth of 0-15 cm and the microbial counts and soil nutrient status were analysed chemically before treatment application (baseline) and during harvest. The microbial counts were analysed using the pour plate method in accordance with Pramer and Schmidt (1965). The available nitrogen is analysed by using alkaline potassium permanganate (Subbiah and Asija, 1956), available phosphorus by using 0.5 M sodium bicarbonate solution (Olsen *et al*., 1954) and available potassium by using 25 ml neutral ammonium acetate (1N). Following the steps outlined by Gomez and Gomez (1984), the collected data for all parameters from the experimental site were statistically analyzed. The weed data were subjected to square root transformation to fulfil the assumptions required for valid statistical inference, as recommended by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Weed growth

It was observed that in the experimental site, the grassy weeds (58%) dominated, followed by the sedge weeds (35%). The dominance order of the weeds present in the field were *Cynodon dactylon* (L.)> *Cyperus rotundus* (L.)> *Echinochloa colona* (L.)> *Cyperus difformis* (L.)> *Echinochloa crusgalli* (L.)> *Leersia hexandra* (L.)> *Fimbristylis miliacea*> *Marsilea quadrifolia*> *Alternanthera philoxeroides* > *Ammania baccifera* (L.)> *Ludwigia parviflora*> *Monochoria vaginalis.* Presence of similar types of weed flora were being reported by many researchers in *boro* rice such as Banerjee *et al*. (2008); Prashanth *et al*. (2016); Bhattacharya *et al*. (2025) and Ghosh *et al*. (2025).

Weed growth

The treatment T_6 (hand weeding twice at 20 and 40 DAT) recorded the lowest weed density as well as biomass, followed by treatment T_5 and T_3 (Table 1 and 2). Irrespective

Table 1: Effect of weed control methods on grassy, sedge and broad-leaf weed dry weight (g m^{-2}).

Treatments	Weed dry weight (g m^{-2})																	
	Grassy weeds						Sedge weeds						Broad-leaf weeds					
	30 DAT		60 DAT		90 DAT		30 DAT		60 DAT		90 DAT		30 DAT		60 DAT		90 DAT	
	2021 -22	2022 -23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23
T_1: Quinchlorac	1.44	2.18	1.70	4.78	2.85	5.92	1.76	2.89	2.53	5.24	3.44	6.54	1.39	1.88	2.09	2.81	2.52	4.32
500 ml ha^{-1}	(1.57)	(4.25)	(2.39)	(22.35)	(7.62)	(34.55)	(2.60)	(7.85)	(5.90)	(26.96)	(11.33)	(42.27)	(1.43)	(3.03)	(3.87)	(7.40)	(5.85)	(18.16)
T_2: Quinchlorac	1.39	2.01	1.66	4.13	2.80	5.63	1.72	2.34	2.49	4.83	3.39	6.09	1.37	1.52	2.04	2.62	2.46	4.01
600 ml ha^{-1}	(1.43)	(3.54)	(2.26)	(16.56)	(7.34)	(31.20)	(2.46)	(4.98)	(5.70)	(22.83)	(10.99)	(36.59)	(1.38)	(1.81)	(3.66)	(6.36)	(5.55)	(15.58)
T_3: Quinchlorac	1.32	1.48	1.50	3.72	2.09	4.72	1.55	1.89	2.18	4.21	3.20	5.59	1.23	1.29	1.76	2.32	2.32	3.52
700 ml ha^{-1}	(1.24)	(1.69)	(1.75)	(13.34)	(3.87)	(21.78)	(1.90)	(3.07)	(4.25)	(17.22)	(9.74)	(30.75)	(1.01)	(1.16)	(2.60)	(4.88)	(4.88)	(11.89)
T_4: Bispyribac	1.53	2.21	1.84	4.68	3.19	7.41	1.88	3.21	2.62	5.72	3.66	7.36	1.69	1.93	2.20	2.91	2.68	5.19
sodium 250 ml ha^{-1}	(1.84)	(4.38)	(2.89)	(21.40)	(9.68)	(54.41)	(3.03)	(9.80)	(6.36)	(32.22)	(12.90)	(53.67)	(2.36)	(3.22)	(4.34)	(7.97)	(6.68)	(26.44)
T_5: Quinchlorac	1.30	1.38	1.45	2.94	2.00	4.13	1.44	1.08	2.13	3.69	3.10	5.05	1.16	1.11	1.67	1.82	2.25	3.37
1400 ml ha^{-1}	(1.19)	(1.40)	(1.60)	(8.14)	(3.50)	(16.56)	(1.57)	(0.67)	(4.04)	(13.12)	(9.11)	(25.00)	(0.85)	(1.73)	(2.29)	(2.81)	(4.56)	(10.86)
T_6: Hand-weeding	1.15	1.05	1.27	1.12	1.83	2.83	1.20	1.20	1.54	1.81	2.47	3.78	1.03	1.09	1.53	1.66	2.13	2.68
at 20 and 40 DAT	(0.82)	(0.60)	(1.11)	(0.75)	(2.85)	(7.51)	(0.94)	(0.96)	(1.87)	(2.78)	(5.60)	(13.79)	(0.56)	(0.69)	(1.84)	(2.26)	(4.04)	(6.68)
T_7: Weedy	2.25	4.21	2.66	6.78	4.16	8.34	3.20	5.79	4.14	7.72	4.60	9.54	2.25	2.93	2.79	4.32	3.34	6.28
Check	(4.56)	(17.22)	(6.58)	(45.47)	(16.81)	(69.06)	(9.74)	(33.02)	(16.64)	(59.10)	(20.66)	(90.51)	(4.56)	(8.08)	(7.28)	(18.16)	(10.66)	(38.94)
SEm±	0.03	0.07	0.02	0.11	0.04	0.17	0.05	0.12	0.03	0.18	0.04	0.23	0.04	0.09	0.03	0.12	0.03	0.15
CD (P≤0.05)	0.10	0.20	0.06	0.32	0.11	0.49	0.15	0.35	0.08	0.52	0.11	0.67	0.12	0.26	0.10	0.35	0.08	0.43

* Data were subjected to square root transformation ($\sqrt{x + 0.5}$); values in parentheses represent the original data.

Table 2: Effect of weed control methods on total weed density (no. m^{-2}), total weed dry weight (g m^{-2}) and weed control efficiency (%).

Treatments	Total weed density (no. m^{-2})						Total weed dry weight (g m^{-2})						Weed control efficiency (%)					
	30 DAT		60 DAT		Harvest		30 DAT		60 DAT		Harvest		30 DAT		60 DAT		Harvest	
	2021 -22	2022 - 23	2021 -22	2022 -23	2021 -22	2022 -23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23	2021 -22	2022 - 23
T_1: Quinchlorac 500 ml ha^{-1}	4.52 (19.93)	3.95 (15.13)	8.26 (67.73)	12.83 (56.71)	10.91 (118.53)	16.78 (94.98)	2.54 (5.95)	2.21 (4.40)	3.56 (12.17)	3.33 (10.56)	5.15 (26.02)	4.86 (23.14)	70.33	72.36	59.88	63.37	46.58	49.61
T_2: Quinchlorac 600 ml ha^{-1}	4.41 (18.95)	5.87 (10.33)	8.00 (63.50)	1.58 (45.75)	10.60 (111.86)	15.73 (83.37)	2.48 (5.65)	2.14 (4.08)	3.48 (11.61)	3.23 (9.94)	5.00 (24.50)	4.72 (21.80)	71.88	74.37	62.06	65.52	49.65	52.53
T_3: Quinchlorac 700 ml ha^{-1}	3.08 (8.99)	4.66 (5.92)	6.39 (40.33)	10.25 (35.44)	8.97 (79.96)	13.83 (64.42)	2.25 (4.56)	1.98 (3.44)	3.01 (8.56)	2.82 (7.44)	4.37 (18.60)	4.10 (16.31)	79.86	78.39	71.94	74.19	62.23	64.48
T_4: Bispyribac sodium 250 ml ha^{-1}	5.40 (28.66)	7.35 (17.40)	8.92 (79.07)	13.31 (61.59)	12.56 (157.25)	19.96 (134.52)	2.78 (7.23)	2.48 (5.64)	3.75 (13.56)	3.52 (11.86)	5.45 (29.20)	5.13 (25.80)	61.76	64.57	55.57	58.86	40.01	43.82
T_5: Quinchlorac 1400 ml ha^{-1}	2.79 (7.28)	3.57 (2.80)	6.12 (36.95)	8.45 (24.07)	8.61 (73.63)	12.55 (54.42)	2.14 (4.08)	1.94 (3.27)	2.88 (7.79)	2.60 (6.26)	4.22 (17.31)	3.80 (13.95)	82.24	79.45	75.76	78.28	66.17	69.62
T_6: Hand-weeding at 20 and 40 DAT	2.21 (4.38)	3.35 (2.25)	3.03 (8.68)	4.59 (5.79)	6.60 (43.06)	9.29 (27.98)	1.74 (2.53)	1.88 (3.02)	2.30 (4.79)	2.05 (3.72)	3.60 (12.46)	3.30 (10.41)	87.49	81.03	84.59	87.09	74.42	77.33
T_7: Weedy check	9.13 (82.86)	12.93 (58.32)	11.76 (137.80)	18.82 (122.73)	15.46 (238.51)	24.16 (198.51)	4.40 (18.86)	4.05 (15.92)	5.57 (30.52)	5.42 (28.83)	7.02 (48.78)	6.81 (45.93)	-	-	-	-	-	-
SEm±	0.16	0.07	0.11	0.12	0.14	0.18	0.04	0.03	0.05	0.05	0.06	0.08	0.96	1.43	1.39	1.41	1.59	1.33
CD (P≤0.05)	0.48	0.20	0.31	0.35	0.40	0.52	0.12	0.08	0.15	0.14	0.18	0.23	2.84	4.18	4.10	4.12	4.68	3.88

* Data were subjected to square root transformation ($\sqrt{x + 0.5}$); values in parentheses represent the original data.

of treatments, the increasing population of weeds with the crop period might be due to the regeneration of grasses after its initial control by hand weeding or herbicides. This reduction could be attributed to the diminishing effectiveness of hand weeding over time or the gradual loss of herbicidal activity due to microbial degradation of chemical residues in the soil. A similar pattern was observed for weed control efficiency, with hand weeding being most effective, followed by T_5 and T_3; the higher dose in T_5 resulted in superior weed control among herbicidal treatments, while T_1 and T_2 remained statistically at par across observations in both seasons. These findings corroborate earlier reports by Moorthy and Saha (2002); Reddy *et al*. (2006); Parthipan and Ravi (2014); Anusha *et al*. (2016) and Arthanari *et al*. (2017).

Soil microbial status

The results (Table 3) indicated that the highest application rate of quinchlorac (T_5) generally led to the reduction in the populations of bacteria, fungi and actinomycetes when compared to the initial levels. Conversely, lower herbicide concentrations were associated with the increased microbial abundance, with the highest populations observed in the hand-weeded treatment and the weedy check. These findings align with the conclusions of Rathod *et al*. (2017) and Rani *et al*. (2024) who reported minimal long-term adverse effects of herbicides on soil microbiota, except when applied at rates exceeding recommended levels. This resilience may be attributed to the capacity of soil microorganisms to metabolise herbicides and utilise them as sources of essential nutrients, as suggested by Bera *et al*. (2016).

Soil nutrient status

Available nitrogen, phosphorus and potassium has changed more or less among various treatments during harvest of the rice (Table 4). Its availability value in the harvested soil is less in T_6, followed by weedy check and more for the herbicidal treatment having higher dose of Quinchlorac (T_5). It is due to the fact that the higher herbicidal dose has even created phytotoxicity in the soil microbiota, which lowers their proliferation in the soil, as a result, less utilization of the available nutrients by the micro-organisms as compared to the non-herbicidal treatments. Also, the application of higher herbicide dose resulted in effective weed suppression (Table 1 and 2), thereby improving the availability of soil nutrients for crop utilization. Although the hand-weeded treatment has controlled weeds efficiently, its negligible adverse effect on soil microbiota allowed greater microbial growth and nutrient immobilization, resulting in comparatively lower soil nutrient status in T_6. Similar impact of herbicide on soil nutrient status was found by Jaysawal *et al*. (2023) and Hirwe *et al*. (2025).

Phytotoxicity

The treatment T_5 caused the highest crop injury (10-60%) up to 30 days after application (DAA), in the form of chlorosis,

Table 3: Effect of weed control methods on microbial population in *boro* rice.

Treatments	Microbial population (initial)						Microbial population (at harvest)					
	Total bacteria ($CFU \times 10^6$)		Total fungi ($CFU \times 10^4$)		Total actinomycetes ($CFU \times 10^5$)		Total bacteria ($CFU \times 10^6$)		Total fungi ($CFU \times 10^4$)		Total actinomycetes ($CFU \times 10^5$)	
	2021-22	2022- 23	2021-22	2022- 23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1: Quinchlorac 500 ml ha^{-1}	244.13	250.13	3.79	3.19	101.37	103.62	229.13	253.32	4.09	4.10	99.36	112.45
T_2: Quinchlorac 600 ml ha^{-1}	238.82	247.82	3.65	2.97	93.78	98.81	220.82	250.51	3.71	3.97	95.44	123.61
T_3: Quinchlorac 700 ml ha^{-1}	242.38	244.83	3.74	3.51	96.43	101.79	214.38	255.64	3.81	4.14	96.78	117.38
T_4: Bispyribac Sodium 250 ml ha^{-1}	239.64	251.64	3.45	3.32	94.92	97.56	234.64	256.72	4.18	4.19	102.62	114.11
T_5: Quinchlorac 1400 ml ha^{-1}	240.43	248.43	4.00	2.85	95.22	99.52	204.43	247.48	3.68	3.82	93.18	107.74
T_6: Hand-weeding at 20 and 40 DAT	241.81	246.81	3.57	3.69	100.08	102.82	250.81	259.22	4.62	4.30	108.67	120.32
T_7: Weedy check	245.11	250.11	3.85	3.05	98.19	104.52	241.11	248.91	4.07	3.91	99.31	110.84
SEm±	2.22	2.52	0.20	0.30	2.08	2.41	2.08	3.15	0.16	0.21	1.95	2.97
CD ($P \leq 0.05$)	NS	NS	NS	NS	6.08	NS	6.09	9.21	0.46	NS	5.70	8.68

Table 4: Effect of weed control methods on soil nutrient status in *boro* rice.

Treatments	Soil nutrient status (initial)						Soil nutrient status (at harvest)					
	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		AvailableK_2O (kg ha^{-1})		Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2021-22	2022- 23	2021-22	2022- 23	2021-22	2022- 23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1: Quinchlorac 500 ml ha^{-1}	170.72	180.56	28.33	30.37	170.31	169.31	168.42	175.34	28.52	30.83	180.28	176.42
T_2: Quinchlorac 600 ml ha^{-1}	172.12	176.33	27.91	33.91	168.92	174.92	170.81	178.59	29.14	32.72	181.92	180.15
T_3: Quinchlorac 700 ml ha^{-1}	168.37	175.46	29.52	30.52	173.03	167.82	175.69	180.45	30.01	33.03	182.38	183.61
T_4: Bispyribac Sodium 250 ml ha^{-1}	170.82	185.21	28.71	31.71	169.78	171.78	165.28	172.82	25.71	31.46	179.03	174.24
T_5: Quinchlorac 1400 ml ha^{-1}	171.69	178.38	30.01	28.81	172.38	180.13	178.55	183.10	31.37	34.21	183.31	189.37
T_6: Hand-weeding at 20 and 40 DAT	169.89	182.74	29.14	33.14	170.28	170.28	157.46	168.29	24.22	29.63	177.73	170.51
T_7: Weedy Check	168.71	188.19	30.22	29.22	171.33	177.33	160.34	168.61	26.91	30.55	178.78	172.48
SEm±	1.23	4.45	0.87	1.84	1.16	4.30	1.36	4.52	0.98	1.69	1.25	5.07
CD (P≤0.05)	NS	NS	NS	NS	NS	NS	3.97	13.21	2.86	NS	3.66	14.82

Table 5: Effect of weed control methods on phytotoxicity in *boro* rice.

Treatment	Phytotoxicity parameters observed (Day after application)																															
	Chlorosis								Wilting								Necrosis								Stunted growth							
	2021-22				2022-23				2021-22				2022-23				2021-22				2022-23				2021-22				2022-23			
DAA	7	15	22	30	7	15	22	30	7	15	22	30	7	15	22	30	7	15	22	30	7	15	22	30	7	15	22	30	7	15	22	30
T_1: Quinchlorac 500 ml ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2: Quinchlorac 600 ml ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
T_3:Quinchlorac 700 ml ha^{-1}	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
T_4: Bispyribac sodium 250 ml ha^{-1}	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0
T_5: Quinchlorac 1400 ml ha^{-1}	6	4	3	3	6	5	3	2	5	4	3	2	5	3	2	2	6	5	4	3	6	5	3	3	7	6	3	2	5	4	2	1

Table 6: Effect of weed control methods on yield and production economics of *boro* rice (pooled data of two years).

Treatment	Yield (t ha^{-1})		Production economics		
	Grain	Straw	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	B:C ratio
T_1: Quinchlorac 500 ml ha^{-1}	4.19	5.97	45824	86279	1.88
T_2: Quinchlorac 600 ml ha^{-1}	4.29	6.06	45759	87529	1.91
$T_{3:}$ Quinchlorac 700 ml ha^{-1}	4.39	6.27	45828	91249	1.99
T_4: Bispyribac Sodium 250 ml ha^{-1}	4.09	5.89	53329	84429	1.58
T_5: Quinchlorac 1400 ml ha^{-1}	2.79	4.49	46339	58432	1.26
T_6: Hand-weeding at 20 and 40 DAT	4.87	6.94	55169	101197	1.83
T_7: Weedy check	2.39	4.09	44029	49680	1.13
SEm±	0.04	0.03	-	-	-
CD (P≤0.05)	0.08	0.10	-	-	-

necrosis, wilting and stunted growth, due to its higher dose, which effectively controlled weeds but adversely affected the crop (Table 5). Other herbicidal treatments exhibited minimal phytotoxicity, limited to the initial days after application, owing to their lower doses. Similar phytotoxic effect is shown on rice crop by various post-emergent herbicides as reported by Anwar *et al*. (2012), Mahapatra *et al*. (2017) and Shivashenkaramurthy *et al*. (2020).

Production economics

The production economics under different weed control methods are presented in Table 6. Among the treatments, twice hand weeding incurred the highest cost of cultivation and also produced the maximum gross and net returns; however, it resulted in a comparatively lower benefit-cost (B:C) ratio due to the high labour cost involved. Among all treatments, the highest B:C ratio was recorded with T_3, whereas the lowest was observed in the weedy check. This goes in line with the findings of Reddy *et al*. (2006) and Ramesha *et al*. (2017).

CONCLUSION

Hand weeding twice at 20 and 40 DAT effectively controlled weeds in *boro* rice; however, it resulted in a lower benefit-cost ratio. The treatment T_5 (Quinclorac 35% SC @ 1400 ml ha^{-1}) achieved the highest level of weed control but caused severe phytotoxicity to the crop. In contrast, treatment T_3 provided effective weed suppression with minimal crop injury. Therefore, application of Quinclorac 35% SC @ 700 ml ha^{-1} at 15 DAT (T_3) appears to be an effective and economical option for weed management in *boro* rice, subject to further validation across varieties and seasons.

Confilt of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. All authors have read and approved the final version of the manuscript and have no competing financial interests, personal relationships, or conflicts of interest that could have appeared to influence the work reported in this manuscript.

REFERENCES

Anusha, S., Madhavi, M., Pratibha, G. and Prakash, T. (2016). Growth and yield of transplanted rice (*Oryza sativa* L.) as influenced by new generation of herbicides. *A Progressive Research*. **11:** 6072-6074.

Anwar, M.P., Juraimi, A.S., Puteh, A., Man, A. and Rahman, M.M. (2012). Efficacy, phytotoxicity and economics of different herbicides in aerobic rice. *Soil and Plant Science.* **62:** 604-615.

Arthanari, P.M., Gowthami, S., Chinnusamy, C., Priya, R.S. and Hariharasudhan, V. (2017). Early post emergence herbicide and their influence on weed population dynamics in transplanted rice (*Oryza Sativa* L.). *Chemical Science Review and Letters.* **6(21):** 561-566.

Banerjee, P., Maiti, D. and Bandyopadhyay, P. (2008). Production potential and economics of hybrid rice during *boro* season under new alluvial zones of West Bengal*. Journal of Crop and Weed*. **4(1):** 28-30.

Bera, P.S., Bandyopadhyay, S., Kundu, C.K., Bandopadhyay, P. and Pramanick, B. (2016). Interaction reaction between different sowing date and weed management methods in drum-seeded *boro* rice (*Oryza sativa* L.). *International Journal of Bioresource and Stress Management*. **7:** 206-211.

Bhattacharya, U., Ghosh, A., Sarkar, S. and Maity, S. (2025). Response of rice (*Oryza sativa* L.) to weed management methods in the lower gangetic plain zone. *Indian Journal of Agricultural Research*. **59(1):** 31-37. doi: 10.18805/IJARe.A-5919.

Fipke, M.V. and Vidal, R.A. (2016). Integrative theory of the mode of action of quinclorac: Literature review. *Planta Daninha.* **34(2):** 393-402.

Ghosh, S., Reddy, M.D., Sarkar, S. and Sagar, L. (2025). Pre and post emergence herbicides influence on productivity of transplanted rice. *Bhartiya Krishi Anusandhan Patrika.* **40(1):** 105-109. doi: 10.18805/BKAP778.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd ed.). John Wiley and Sons, New York. pp. 680.

Government of India. (2022). Agricultural statistics at a Glance 2021. Government of India, Ministry of Agriculture and Farmers Welfare. Directorate of Economics and Statistics, Krishi Bhawan, New Delhi.

Grossmann, K. (2010). Auxin herbicides: Current status of mechanism and mode of action. *Pest Management Science.* **66(2):** 113-120.

Hirwe, O.R., Singh, U.K., Rajeev, Kumar, S., Naz, S. and Bhaumik, S. (2025). Evaluating the effects of herbicide on growth, yield and soil attributes of maize crop in the trans-gangetic region. *Indian Journal of Agricultural Research.* **59(8):** 1236-1245. doi: 10.18805/IJARe.A-6164.

Jaysawal, P.K., Verma, S.K., Pratap, V., Yadav, D.K., Tirkeya, N. and Singh, S. (2023). Impact of herbicides on soil fertility and nutrient uptake by transplanted rice (*Oryza sativa* L.) in Eastern U.P, India. *International Journal of Environment and Climate Change.* **3(11):** 1570-1575.

Koo, S., Neal, J. and Ditomaso, J. (1997). Mechanism of action and selectivity of quinclorac in grass roots. *Pesticide Biochemistry and Physiology*. **57(1):** 44-53.

Kumar, A., Sen, A. and Kumar, R. (2016). Micronutrient fortification in crop to enhance growth, yield and quality of aromatic rice. *Journal of Environmental Biology.* **37(5):** 973-977.

Mahapatra, A., Saha, S., Munda, S. and Shukla, R.K. (2017). Studies on phytotoxicity of herbicides and herbicide mixtures and its effect on yield of direct-sown rice (*Oryza sativa* L.). *International Journal of Bio-resource and Stress Management.* **8(6):** 853-856.

Manhas, S.S., Singh, G. and Khajuria, V. (2012). Effect of tank-mixed herbicides on weeds and transplanted rice *(Oryza sativa* L). *Annals of Agricultural Research.* **33:** 25-31.

Mani, V.S., Mala, M.L, Gautam, K.C. and Bhagavandas. (1973). Weed killing chemicals in potato cultivation. *Indian Farming.* **23(1):** 17-18.

Moorthy, B.T.S. and Saha, S. (2002). Evaluation of pre- and post-emergence herbicides for their effects on weeds and upland direct seeded rice. *Indian Journal of Weed Science.* **34:** 197-200.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorous in soils by extraction with sodium bicarbonate. *Circular of the United States Department of Agriculture*. 939.

Panse, V.G. and Sukhatme, P.V. (1978). Statistical Methods for Agricultural Workers (3rd ed.). Indian Council of Agricultural Research, New Delhi.

Parthipan, T. and Ravi, V. (2014). Productivity of transplanted rice as influenced by weed control methods. *African Journal of Agricultural Research.* **9(29):** 2250-2254.

Pathak, H., Pradhan, S.K., Mondal, B., Jambhulkar, N.N., Parameswaran, C., Tripathi, R., Chakraborti, M., Kumar, G.A.K., Samal, P. and Sahu, R.K. (2019). Assessing area, production and return with rice varieties of NRRI, Cuttack. *Oryza- An International Journal on Rice.* **56:** 169-173.

Pramer, D. and Schmidt, E.L. (1965). Experimental Soil Microbiology (2nd ed.). Burgess Publishing Co., Minneapolis.

Prashanth, R., Kalyana, K.N., Kumar, M.V.M., Murali, M. and Sunil, C.M. (2016). Bispyribac-sodium influence on nutrient uptake by weeds and transplanted rice. *Indian Journal of Weed Science*. **48:** 217-219.

Ramesha, Y.M., Bhanuvally, M., Gaddi, A.K., Krishamurthy, D. and Umesh, M.R. (2017). Effect of quinchlorac on grassy weeds in transplanted rice. *Int. J. Curr. Microbiol. App. Sci.* **6(8):** 3773-3778.

Rani, B.S., Chandrika, V., Reddy, G.P., Nagamadhuri, K.V., Sudhakar, P. and Sagar, G.K. (2024). Response of weed management practices on yield loss, soil enzyme activity and microbial populations in maize (*Zea mays* L.). *Indian Journal of Agricultural Research*. **58(3):** 474-479. doi: 10.18805/IJARe. A-6068.

Rao, V.S. (2000). Principles of Weed Science. Mohan Primlini for Oxford and IBH Publishing Co. Pvt. Ltd (2nd ed.). pp. 84-85.

Rathod, B.G.S. and Somasundaram, E. (2017). Effect of organic rice to weed management practices on yield parameters and microbial population grown under lowland condition. *Int. J. Curr. Microbiol. App. Sci.* **6(7):** 2154-2162.

Reddy, B.G.M., Pattar, P.S., Ravishankar, G. and Joshi, V.R. (2006). Efficacy of quinclorac in transplanted rice. *Indian Journal of Weed Science.* **38(1 and 2):** 29-32.

Shivashenkaramurthy, M., Patil, R.S., Neeralagi, A. and Agasimani, A.D. (2020). Evaluation of bio efficacy and phytotoxicity of quinchlorac (facet) for control of grassy weeds and sedges in rainfed transplanted rice. *Journal of Pharmacognosy and Phytochemistry.* **9(3):** 1148-1153.

Subbiah, B. and Asija, G.L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science.* **25:** 259-260.

Sunohara, Y., Shirai, S., Wongkantrakorn, N., Shirai, S. and Matsumoto, H. (2011). Involvement of antioxidant capacity in quinclorac tolerance in *Eleusine indica*. *Environmental and Experimental Botany.* **74(8):** 74-81.

Talbert, R.E. and Burgos, N.R. (2007). History and management of herbicide resistant barnyard grass (*Echinochloa crusgalli*) in Arkansas rice. *Weed Technol.* **21(2):** 324-33.