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Assessment of combined effect of herbicides and nitrogen fertilizer on weed control efficiency and yield of dry direct seeded rice

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Abstract

Managing diverse weed flora in dry direct seeded rice represents a significant problem currently. Competitive advantage to emerging rice seedlings against weeds with proper management of weeds can result in potential productivity through direct seeded rice (DSR). A field experiment was conducted to evaluate different herbicides and nitrogen levels effect on weed control and rice yield. The treatments were butachlor 1500 g ha⁻¹ (PE) followed by one hand weeding at 40 days after sowing, triafamone + ethoxysulfuron 60 g ha⁻¹ (PoE), penoxsulam 22 g ha⁻¹ (PoE), compared with weedy check, while as nitrogen levels include 0, 90, 120, and 150 kg N ha⁻¹. The experiment was laid out in a factorial randomized block design with three replications. Penoxsulam 22 g ha⁻¹ effectively managed diverse weed flora and resulted in 92% reduction in weed dry matter compared to weedy check and 83.7 and 78.7% compared to triafamone + ethoxysulfuron 60 g ha⁻¹ and butachlor 1500 g ha⁻¹ followed by one hand weeding at 40 DAS, respectively. Similarly, plots receiving penoxsulam at 22 g ha⁻¹ produced significantly higher grain yield (7.3 t ha⁻¹) while lowest yield was recorded in weedy check treatments (1.4 t ha⁻¹). The application of nitrogen at the rate of 150 kg N ha⁻¹ resulted in the highest grain yield (6.2 t ha⁻¹) which was statistically at par with the application of 120 kg N ha⁻¹.

Keywords: Butachlor, direct-seeded rice, penoxsulam, triafamone + ethoxysulfuron, yield

Introduction

Rice (*Oryza sativa* L.) has been one of the most important crops grown, being designated as a staple crop for a significant part of the population globally. In India, rice is grown over an area of 51.2 million hectares with a production of 150.1 million tonnes (Anonymous, 2024-25) ^[1]. Rice is generally cultivated in puddled transplanting system (PTR) including nursery raising, manual uprooting of seedlings at 25-30 days after sowing, puddling of soil in standing water and labour assisted planting of seedlings in the field (Farooq *et al.*, 2009; Kumar and Ladha, 2011) ^[9, 11]. However, sustainability of PTR is challenged by issues like ground water depletion, labor scarcity, increase in the cost of cultivation associated with hike in prices of diesel and inputs etc (Farooq *et al.*, 2009) ^[9].

Therefore, there is an urgency to shift the cultivation practices in rice by adopting efficient establishment method such direct seeded rice. This method offers numerous benefits in terms of reduction in labour and water use, less emission of green-house gases, early maturity and subsequently reduction in the cost of cultivation. However, potential productivity of direct seed rice is curtailed by presence of complex weed flora in aerobic conditions (Chaudhary *et al.*, 2026) ^[4]. Since in direct seeded rice, there is no ponded water and transplanting of rice seedlings, so they don't get a head start over weed seedlings as in case of transplanted rice which leads to severe challenge of complex weed predominance in direct seeded rice. In direct seeded rice weed flora emerge in flushes due to frequent rainfall and irrigation, therefore sequential application of herbicides and manual weeding is required for higher yield (Rao *et al.*, 2007 and Chaudhary *et al.*, 2026) ^[19, 4].

Moreover, competitive advantage for seedlings of rice under DSR can be improved against weeds by increasing fertilizer level especially nitrogen, higher planting density by modification of seed

rate and spacing, and early seedling before rainy season. In this regard, many physiological processes are affected in plants by nitrogen fertilization through faster canopy development, faster synthesis of assimilates, and higher vegetative biomass production which later on decide the sink capacity. Mahajan and Timsina (2011) [12] reported nitrogen at 150 kg ha⁻¹ resulted in maximum yield, net returns and water productivity with herbicide pendimethalin + bispyribac sodium in direct seed rice conditions. Pittelkow *et al.* (2012) [18] also observed that spike of nitrogen level by 30–35 kg N ha⁻¹ improved the rice yield under water seeded with and without stale system in rice as compared to conventional system. Patel *et al.* (2018) [17] also revealed application of nitrogen at the rate of 120 kg ha⁻¹ with pendimethalin 1000 g ha⁻¹/b bispyribac-Sodium 40 g ha⁻¹ or two hand weeding at 20 and 40 DAS resulted in higher yield compared to nitrogen level 80-100 kg ha⁻¹. So, considering these points an experiment was conducted with objectives 1) to study herbicide efficacy on weed control. 2) DSR response to herbicides and nitrogen interactive effect.

Materials and Methods

The field experiment was laid out at Crop Research Farm of Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore during *khariif*, 2024. The experimental site is located at latitude 34° 5' N and longitude 74° 5' E at 1586 meters above mean sea level. Figure 1 displays the weather data collected during the experimental program. The variety of rice used was “Shalimar Rice-4” and sowing and harvesting were done on 29 May, 2024 and 10 October 2024, respectively. The experiment was laid in factorial randomized complete block design including 2 factors (herbicide and nitrogen), each with four levels and three replications. The treatments were pre-emergence application of butachlor 1500 g ha⁻¹ followed by one hand weeding at 40 DAS; post emergence application of triafamone + ethoxysulfuron 60 g ha⁻¹; penoxsulam 22 g ha⁻¹, compared with weedy check, while, nitrogen levels as 0, 90, 120, and 150 kg N ha⁻¹. All recommended practices were followed. Weed indices (Weed density, weed dry matter, weed control efficiency, weed control index, herbicide efficiency index) and yield attributes (Panicle length, test weight and yield) were recorded.

At 30DAS, weeds covered within 0.25 m² quadrant were taken from each plot and after proper identification were counted and denoted as weeds m⁻². Weed dry matter of uprooted weeds taken at 30DAS from each plot, was measured after proper washing which was followed by shade drying for four to five days and oven drying at 60 to 65°C for 48 hours. The weight was confirmed till a constant weight was achieved and was given in grams, then converted to gm⁻².

For various weed control treatments, Weed control efficiency was calculated on density basis as:

$$WCE (\%) = \frac{(WDC-WDT)}{WDC} \times 100$$

Where, WDC = Weed density (no. m⁻²) in control plot; WDT = Weed density (no. m⁻²) in treated plot

Formula given by Gill and Vijayakumar. (1969) [8]. was used for calculating Weed index as:

$$WI (\%) = \frac{(Y - Y_t)}{(Y)} \times 100$$

Where

Y= Yield from weed free plot; Y_t= Yield from treated plot

Weed control index for different weed control treatments was calculated as:

$$WCI (\%) = \frac{(WDC-WDT)}{WDC} \times 100$$

Where, WDC = Weed dry matter accumulation in control plot;

WDT = Weed dry matter accumulation in treated plot

Herbicide efficiency index (HEI) was computed using below mentioned formula:

$$HEI (\%) = \frac{\frac{(Y_T - Y_C)}{Y_T} \times 100}{\frac{WDM_T}{WDM_C} \times 100}$$

Where, Y_T = Yield in treated plot; Y_C = Yield in control plot; WDM_T = Weed dry matter accumulation in treated plot; WDM_C = Weed dry matter accumulation in control plot

Five random panicles were taken from each plot and panicle length of each was measured from neck node to panicle tip. The arithmetic mean of the five panicles per plot was taken and expressed in centimetres. The weight per panicle from each plot was also expressed in grams after averaging panicle weight of five randomly selected panicles. These samples were also evaluated for 1000 grain weight which was also expressed in grams. At maturity, individual plot harvesting and threshing was done followed by recording of weight from each plot and then yield was expressed in t/ha⁻¹. Statistical analysis of the data from various observations was done. “F” test at 5% level of significance was used for testing the significance of treatment differences. The treatment means were compared by critical difference. R- software was used for analysing the observed data.

Results and Discussion

Weed density and dry matter

Herbicide based treatments were able to effectively control diverse weeds in DSR in comparison to weedy check. The application of penoxsulam 22 g ha⁻¹ resulted in significantly minimum weed population (12.7 plants m⁻²) in comparison to triafamone + ethoxysulfuron 60 g ha⁻¹ (20.6 plants m⁻²) and butachlor 1500 g ha⁻¹ followed by one hand weeding at 40 DAS (42.3 plants m⁻²) and untreated control (188.6 plants m⁻²). Significantly lowest weed dry matter (3.3 g m⁻²) was observed in penoxsulam 22 g ha⁻¹ in comparison to butachlor 1500 g ha⁻¹ followed by one hand weeding at 40 DAS (8.9 g m⁻²), and weedy check (42.02 g m⁻²). However, in case of weed dry matter recorded in triafamone + ethoxysulfuron 60 g ha⁻¹ (6.87 g m⁻²), it remained statistically at par with penoxsulam 22 g ha⁻¹. Further, penoxsulam 22 g ha⁻¹ and triafamone + ethoxysulfuron 60 g ha⁻¹ registered 91 and 83 percent reduction of weed dry matter when compared to untreated control, respectively. This might be due to the development of penoxsulam as an overall efficient post-emergent herbicide across different weed species. Moreover, it inhibits ALS enzyme as being a member of triazolopyrimidine sulfonamide family (Kogan *et al.*, 2011) [10]. The results are in confirmity with Ganai *et al.* (2014) [7], Singh *et al.* (2016) [20] and Nazir *et al.* (2020) [15]. However, non-significant effect was reported among nitrogen levels. Interaction was found to be non-significant.

Weed indices

Penoxsulam 22 g ha⁻¹ application resulted in highest weed control

efficiency (89.4%) followed by triafamone + ethoxysulfuron 60 g ha⁻¹ (84.1%), while butachlor 1500 g ha⁻¹ fb hand weeding (40 DAS) (74.0%) recorded in lowest weed control efficiency. Penoxsulam 22 g ha⁻¹ and triafamone + ethoxysulfuron 60 g ha⁻¹ demonstrated 93 and 89 percent lowering of weed count against weedy check, respectively. Herbicide-treated plots recorded higher weed control efficiency because of their higher capability to lower weed population. The results were observed by Gani *et al.* (2014), Singh *et al.* (2016)^[20] and Nazir *et al.* (2020)^[15]. Weedy check recorded numerically maximum weed index (73.9) while other herbicide treated plots recorded lower weed index (Table 1). Reduced weed densities might have resulted in increased uptake of nutrients by rice plants and thus, increased grain yield under herbicide treated plots. The application of penoxsulam 22 g ha⁻¹ reflected highest weed control index (86.4) which was followed by triafamone + ethoxysulfuron 60 g ha⁻¹ and among herbicides lowest weed control index (66.6) was recorded in butachlor 1500 g ha⁻¹ followed by hand weeding (40DAS) (Figure 2). Herbicide application resulted in effective reduction of weed population and therefore, less weed dry matter, eventually resulting in higher weed control index. Gani *et al.* (2014), Singh *et al.* (2016)^[20] and Nazir *et al.* (2020)^[15] reported similar observation. Similarly, penoxsulam 22 g ha⁻¹ application also recorded higher herbicide efficiency index (10.1) which was followed by triafamone + ethoxysulfuron 60 g ha⁻¹ and butachlor 1500 g ha⁻¹ followed by hand weeding (40DAS) (Figure 2).

Yield attributes and Yield

The maximum panicle length (24) and test weight (29.4) was recorded in penoxsulam 22 g ha⁻¹ which was statistically at par with triafamone + ethoxysulfuron 60 g ha⁻¹ and butachlor 1500 g ha⁻¹ followed by hand weeding (40DAS). In weedy check, lowest reading of panicle length (21.0) and test weight (26.3) was observed. Since, there was reduction of weed density and dry matter which might have resulted in better nutrient absorption because of less crop weed competition. Bhat *et al.* (2011b)^[3] have

confirmed similar observations. Regarding nitrogen levels, there was increase in panicle length from 0 kg N ha⁻¹ to 150 kg N ha⁻¹. Significantly highest panicle length (24.4) was recorded in case of 150 kg N ha⁻¹ application in comparison to without nitrogen treatment, and 90 kg nitrogen ha⁻¹. However, the treatments of 120 kg N ha⁻¹ and 150 kg N ha⁻¹ were found to be statistically at par with each other with respect to panicle length, while without nitrogen treatment reported significantly lowest length (21.4) (Table 2). Nitrogen application might have helped in enhancing growth parameters, promoting increased panicle growth by more photosynthates transport and translocation. Mallhareddy and Padmaja (2013) and Dahipahle and Singh (2018)^[5] also confirmed similar reports. However, non-significant effect was reported in case of nitrogen levels. These results are in conformity with Tiwari *et al.* (2017)^[23] and Dahipahle and Singh (2018)^[5]. Moreover, interaction was found to be non-significant. Penoxsulam 22 g ha⁻¹ application recorded significantly highest grain yield (7.3 t ha⁻¹) over no herbicide application and other herbicide treatments. Weedy check recorded significantly lowest grain yield (1.4 t ha⁻¹). The suppression of weed growth due to effective control of herbicides might have facilitated more nutrient absorption and enhanced crop growth, ultimately increasing photosynthates transport and translocation towards grains (sink), and hence, increasing crop yield. Ganai *et al.* (2014)^[7], Omara, A, El-Ghandor, A. (2018)^[16] and Nazir *et al.* (2020)^[15] noted similar observations. The highest grain yield (6.2 t ha⁻¹) was achieved in 150 kg N ha⁻¹ being statistically at par with yield achieved with the application of 120 kg N ha⁻¹ while lowest yield (3.2 t ha⁻¹) was recorded in treatment receiving no nitrogen. Increase in nitrogen application rate resulted in enhanced growth parameters which ultimately might have captured more sunlight energy, along with increased photosynthates translocation to sink, thus increasing yield attributes and grain yield. Similar observations were noted by Nayak *et al.* (2016)^[14], Tiwari *et al.* (2017)^[23], Dahipahle and Singh (2018)^[5], Awan *et al.* (2022)^[2] and Singh *et al.* (2023)^[21].

Table 1: Effect of different herbicides and nitrogen levels on weed density (no. m⁻²), weed dry matter (g m⁻²) and weed index (%) in direct seeded rice at 30 DAS

Treatments	Weed density (no. m ⁻²)	Weed dry matter (g m ⁻²)	WI (%)
Factor A: Herbicide			
Butachlor 1500 g ha ⁻¹ fb HW (40 DAS)	1.6 (42.3)	0.86 (9.0)	24.8
Triafamone + ethoxysulfuron 60 g ha ⁻¹	1.3 (20.7)	0.73 (6.9)	15.4
Penoxsulam 22 g ha ⁻¹	1.0 (12.8)	0.58 (3.4)	0.00
Weedy check	2.2 (188.7)	1.43 (42.0)	73.9
CD (p= 0.05)	0.2	0.2	-
Factor B: Nitrogen			
90 N kg ha ⁻¹	1.6 (89.3)	1.2 (29.8)	-
120 N kg ha ⁻¹	1.5 (68.0)	1.0 (16.4)	-
150 N kg ha ⁻¹	1.5 (60.8)	0.7 (5.7)	-
Without nitrogen	1.5 (46.3)	0.8 (9.3)	-
CD (p = 0.05)	NS	NS	-

Original values in parentheses have undergone logarithmic transformation before data analysis

Table 2: Effect of different herbicides and nitrogen levels on Yield and yield attributes in direct seeded rice

Treatments	Panicle length (cm)	1000 grain weight (g)	Grain yield (t ha ⁻¹)
Factor A: Herbicide			
Butachlor 1500 g ha ⁻¹ fb HW (40 DAS)	23.4	27.7	5.5
Triafamone + ethoxysulfuron 60 g ha ⁻¹	23.5	28.5	6.0
Penoxsulam 22 g ha ⁻¹	24.0	29.4	7.3
Weedy check	21.0	26.4	1.4
CD (p=0.05)	1.4	2.0	1.0
Factor B: Nitrogen			
90 N kg ha ⁻¹	23.0	28.3	5.0
120 N kg ha ⁻¹	23.2	28.4	5.8
150 N kg ha ⁻¹	24.4	28.4	6.2
Without nitrogen	21.4	26.8	3.2
CD (p=0.05)	1.4	NS	1.0

Where, HW = hand weeding

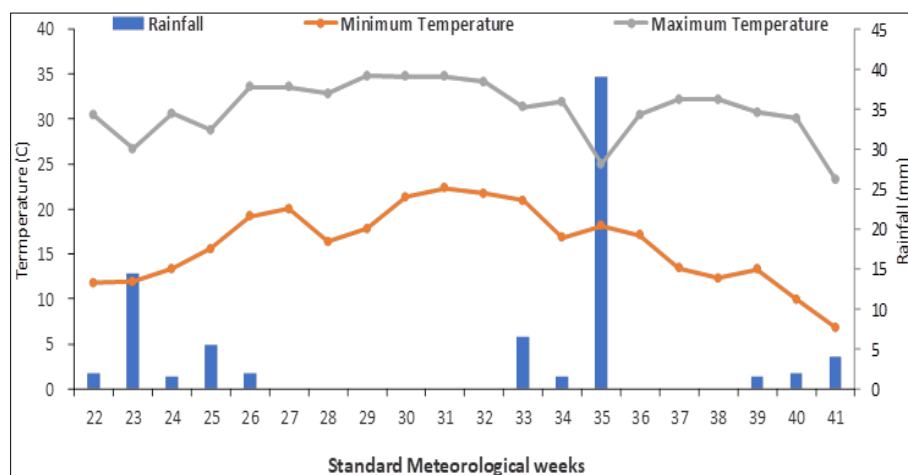


Fig 1: Weather data of experimental site recorded during kharif, 2024

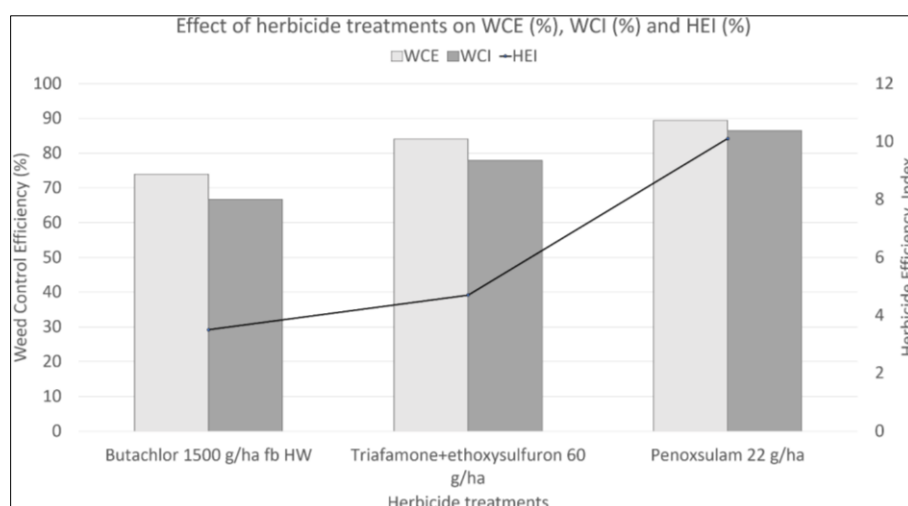


Fig 2: Effect of herbicides on weed control efficiency, weed control Index and herbicide efficiency index at 30 days after sowing.

Conclusion

Penoxsulam 22 g ha⁻¹ was found superior with maximum grain yield (7.3 t ha⁻¹) and weed control efficiency (89.4%). The nitrogen level of 150 kg N ha⁻¹ achieved highest grain yield which remained statistically at par with 120 kg N ha⁻¹, therefore, it suggests latter as a more resource-efficient alternative. Future studies are needed to improve optimisation of nutrients and herbicides herbicides under different soil and climatic conditions.

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