The Pharma Innovation Journal 2022; 11(9): 1634-1637

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1634-1637

www.thepharmajournal.com
Received: 20-06-2022
Accepted: 26-08-2022

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Studies on weed management under transplanted rice condition

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Abstract
During the kharif season 2021, a field experiment was conducted at the Instructional-cum-Research Farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.) to evaluate the "Studies on weed management under transplanted rice condition." The experiment was laid out with 7 treatments *viz*., T_1: Weed control, T_2: One hand weeding at 20 DAT, T_3: Two hand weeding at 20 and 40 DAT, T_4: Pyrazosulfuron-ethyl @ 20 g a.i./ha as pre emergence, T_5: Bispyribac sodium @ 25 g a.i./ha as post emergence, T_6: Pyrazosulfuron-ethyl @ 20 g a.i./ha as pre emergence at 0-5 DAT + Bispyribac sodium @ 25 g a.i./ha as post emergence and T_7: Weed free in randomised block design with three replications. Among the different weed management practises at 30, 60, 90 DAT and at harvest, weed control (T_7) allowed the lowest total weed density (2.79 and 3.13 m̄²), fresh and dry weight of weed (4.41 and 2.22, 4.97 and 2.47 g m-2), and highest weed control efficiency (75.05 and 80.97%) and was found to be very effective against weed flora in transplanted rice, followed by Pyrazosulfuron ethyl @ 20g a.i./ha as PE at 0-5 DAT + Bispyribac sodium @ 25g a.i./ha as a PoE at 20-25 DAT. According to the data, significant improvements in growth parameters, yield attributes, and seed yield (5066 kgha^{-1}) were obtained.

Keywords: Weed management, transplanted rice, Bispyribac-sodium, Pyrazosulfuron ethyl

Introduction
Rice (*Oryza sativa* L.) is one of the most important food crops on the planet. Currently, rice provides food for more than one-third of the world's population. Rice is a staple for more than half of the world's population, covering117.48 million tonnes ha and producing 498.8 million tonnes in 2019-20. Rice is India's most important crop, covering 117.47 million ha and producing 121.00 million tons per year at a productivity of 2390 kg/ha (Anonymous, 2020). Chhattisgarh is known as the "Rice Bowl of India" because it has the most rice planted during the *kharif* season and contributes the most to national rice production. Rice occupied 0.84 lakh ha in Chhattisgarh state, with a productivity is low at 22.12 q/ha as compared to other state such as Panjab (38.09), Haryana (31.12 q/ha and West Bengal (27.31 q/ha) (Anonymous 2020). The labour requirement for transplanting is very high, with high demand in a short period of time, especially during transplanting and furthermore for hand weeding, but labour availability is decreasing day by day for a variety of reasons.
Weed management is one of the most important factors in yield reduction in transplanted rice, despite the fact that there are several reasons for yield reduction in transplanted rice. The effectiveness and economics of any weed control measures will heavily influence the final decision. The use of herbicides to keep crop weeds at bay during critical crop weed competition stages will help to reduce weeding costs while also keeping weeds below the threshold level. Two to three hand weeding was most effective against all types of weeds in rice in order to maximise the benefit of applied monetary inputs. (Halder and Patra.2007). Hand weeding is simple and environmentally friendly, but it takes time and effort. Furthermore, due to a lack of labour during critical crop periods, farmers frequently fail to remove weeds. However, because grassy weeds and rice seedlings have morphological similarities, identifying weeds in their early stages of growth is difficult (Rahman *et al.*, 2012). Weed infestation is a major biotic factor in transplanted rice, reducing yield by 15-45% depending on soil, rainfall, flora, weed density, and season (Chopra and Chopra, 2003). Crop stand establishment practises and soil types influence the intensity and nature of weed problems.

Weeds alone are estimated to reduce rice yield by 15-20% for transplanted rice, 30-35% for direct seeded puddle rice, and 0-95% or even complete loss for direct seeded rice under severe weed infestation (Gogai *et al.,* 1996). As a result, weed control is necessary during critical crop-weed competition times. Herbicides can effectively control weeds in rice crops, according to many rice researchers. Weed infestation not only reduces yield but also degrades produce quality in transplanted rice. Uncontrolled weed growth reduces yield by 47% in transplanted rice. Rice crops are plagued by a diverse weed flora, including grassy, broadleaf, and sedge weeds, resulting in yield losses of up to 70% (Singh and Singh, 2004). This crop is known to be associated with approximately 100 weed species in India. The most troublesome and widespread of these is *Echinochloa colona.* If paddling and water management are good, the weed problem in transplanted systems is generally less severe. However, timely weed control is critical in the tail end areas of canal irrigated systems and other specific areas where water availability is limited. Weeds germinate a few days after the seedling is transplanted in transplanted rice. Grasses predominate early in the crop, but sedges and broadleaf weeds interfere with crop growth later in the crop. Hand weeding is without a doubt the most effective method of weed control. However, weed management is becoming more difficult due to rising costs and labour shortages. Weeds are typically controlled by farmers in Chhattisgarh by hand. Physical methods are costly and time consuming, and the benefits of manual weeding can only be realised if done on time. Chemical weed control is thought to be superior to hand weeding due to the drudgery of weeding and the scarcity of labour during peak weed infestation periods. In this regard, new broad-spectrum herbicides used alone or in combination may provide adequate weed control. The majority of herbicides have a narrow spectrum of action and control only a subset of plant species while leaving others unaffected.

Chhattisgarh consumes a small number of new herbicides (molecules). As a result, the suitability of these new herbicides in the agro-climatic conditions of the Chhattisgarh plain must be evaluated. In Chhattisgarh, about 15-20% of the rice crop is transplanted. Weeding is regarded as a better option than chemical weed control due to the drudgery of weeding and the scarcity of labour at the appropriate time. Previously, pre-emergence herbicides were used for weed control, but their use was limited due to their timely application with adequate soil moisture. As a result, depending on the weed flora in transplanted rice, appropriate post-emergence herbicides are required.

Keeping these point in view, a field experiment was carried out to evaluate the effect of weed management practices for controlling weed flora in transplanted rice.

Materials and Methods

Field experiment was conducted during 2021-22 at the research farm of Barrister Thakur Chhendilal College of Agriculture and Research Station, Bilaspur (22.07ºN, 82.21ºE, and 282.0 m above mean sea level). Soil with 0.61% organic carbon, 150 kg available N ha1, 12.20 kg available P2O5 ha1, 189.16 kg available K2O ha1. The crop was grown under irrigated conditions. The experimental field had a rice crop history for several years. Weed control, one hand weeding (20 DAT), two hand weeding (20 and 40 DAT), pyrazosulfuron ethyl @ 20g a.i./ha as a PE (0-5 DAT), and bispyribac sodium @ 25 g a.i./ha as a PoE were the seven treatments (20-25 DAT), and weed free. These treatments were laid out in randomized block design with three replication. Rice seedling that is 20 days old Zinco rice was planted on July 11, 2021, at a spacing of 20×10 cm in 5×4 m plots. Except for the weed, which was applied by broadcasting after mixing with 150 kg sand/ha, the crop was grown using all of the recommended practises. Each experimental plot received a uniform dose of 100 kg N, 60 kg P2O5, and 40 kg K2O in the form of urea, diammonium phosphate, and muriate of potash. Asa basal dose, one-third of the nitrogen and full doses of phosphorus and potassium were applied, and the remaining nitrogen was applied in two equal splits at the tillering and panicle initiation stages. Irrigation was given in accordance with crop need. There was no such hung index or disease pest infestation during the time of experiment. The crop were harvested manually with sickle from ground level.

Observation on weeds

In each nursery and main field plot, four permanent quadrate (0.5 m 0.5 m) were earmarked for weed count and weed dry weight. Weed density was calculated as the number of weeds per unit area at 30, 60, 90, and 120 days after harvest in four permanent quadrates based on weed species. The destructed weed sample was washed in clean tap water before being sun dried and oven dried at 70 °C for 48 hours and weighted.. Weed control efficiency (WCE), Weed Index (WI) and weed control Index (WCI) were work out using following equation (Banerjee *et al.,* 2019; Kundu *et al.,* 2020) [3] respectively:

$$WCE = \frac{WDM_1 - WDM_2}{WDM_1} \times 100$$

Where,

WDM_1 is the weed dry weight (gm^2) in control plot (check);
WDM^2 is the weed dry matter (gm^2) in treated plot.

$$WI = \frac{X-Y}{X} \times 100$$

Where,

X is yield from weed free plot; Y is yield from treated plot

Depending on the treatment, herbicides were used as pre- and post-emergence treatments. At the heading stage of the rice crop, the density of weed species and the dry weight of total weeds were measured. At harvest, the crop's yield attributes and grain yield were recorded. Weed density, including grasses, sedges, and broad-leaved weeds, was measured in a 0.25 m2 quadrate at harvest. The dry weight of these weeds was determined by destructive sampling on a 0.25 m2 area. Weed control efficiency (WCE) was determined using weed dry weight.

Results and Discussion

The major weed flora infesting crop field were: Cynodon *dactylon, Echinochloa colona, Echinochloa crusgalli,* among grasses; *Commelina benghalensis, Physalis minima, Phyllanthus fraternus, Euphorbia hirta, Trianthema monogyna Corchorus olitorius, Eclipta alba* among broad-leaved weeds; *Cyperus iria, Cyperus difformis* and *Fimbristylis miliacea* among sedges.

Effect on weeds

Regardless of the dates of observation in both the nursery and main field, the experimental plots were infested with a mixed weed flora, with grassy weeds and sedges dominating, followed by broad leaved weeds (BLW). For all observations, *Echinochloa colona* and *Eclipta alba* covered the most ground area among the grasses and BLW. The experimental results revealed that weed diversity and biomass were significantly higher in the weedy check in both fields. Weed control, on the other hand, recorded lower weed density and weed dry weight than the other weed management practises (Table 1 and Table 2). Among the herbicides tested, bispyribac-sodium 10% SC (25 g a.i./ha) was the most effective against grassy weeds, sedges, broad leaves, and overall weed floras. Throughout the observations, the same treatment significantly (p>0.05) reduced Echinochloa colona densities. *Cyperus sp.* was significantly suppressed by the treatment received 25g a.i.ha-1 bispyribac-sodium for both the observations and also resulted lower biomass accumulation for both broad leaf weed species both the observations. *Cyperus sp.,* the most dominant sedge in main rice field was surprisingly controlled (Table 2) by the application of pyrazosulfuron-ethyl(20g a.i./ha)+bispyribac-sodium with its highest dose (25g a.i. ha-1), depicted 1.89 and 7.00 m-2 (85.31 and 83.64% less than weed control) at 60 DAT and 90 DAT respectively and consequently accumulated lower dry matter (1.79 g m-2). The data shown in Table 4 revealed that among the tested herbicides maximum weed control efficiency in grassy weeds was observed from the pyrazosulfuron-ethyl(20g a.i./ha) + bispyribac-sodium (25g a.i.ha-1) treated plot, depicted more than 80% efficiency for both *Echinochloa colona* and *Eclipta alba* at 60 DAT in transplanted rice. Similar observations were recorded for *Cyperus sp*. as well as BLWs. Data in Table 5 concluded that the *Echinochloa colona*, a dominant grassy weed in rice field was most efficiently managed by Bispyribacsodium (25g a.i.ha-1). Similarly, it was also found that post-emergence application of bispyribac-sodium (25 g a.i. ha-1) recorded significantly lowest weed density (16.8 and 16.5), lowest weed dry weight (2.4 and 2.1 g m-2), lowest weed competition index (6.84 and 7.15) and highest weed control efficiency (83 and 86%) during both the years 2015-16 & 2016-17 respectively (Kumar *et al.*, 2018) [1].

Table 1: Effect of treatments on total weed density (no. m-2) and weed dry weight (g m-2) at 30, 60 and 90 DAT in transplanted rice

Treatment		Total weed density			Weed dry weight		
		30DAT	60DAT	90DAT	30DAT	60DAT	90DAT
T1	Weed control	42.76	42.76	86.99	37.72	37.54	77.51
T2	One hand weeding (20DAT)	12.58	19.25	40.88	11.88	16.28	35.5
T3	Two hand weeding(20&40 DAT)	16.36	17.69	25.11	8.76	8.42	21.92
T4	Pyrazosulfuron-ethyl 20g a.i./ha as PE at 0-5 DAT	19.45	19.67	28.9	8.37	10.06	23.48
T5	Bispyribac-sodium 25g a.i./ha as a POE at 20-25 DAT	15.49	18.16	27.78	7.09	8.97	22.44
T6	Pyrazosulfuron – ethyl 20g a.i./ha as PE at 0-5 DAT + Bispyribac-sodium 25g a.i/ha as a POE at 20-25 DAT	10.85	10.85	23.38	6.99	7.66	21.03
T7	Weed free	0	0	0	0	0	0
LSD (p≤0.05)		0.89	2.44	1.24	0.81	0.79	0.76

Weed control efficiency and weed index

The data shown in Table 2 revealed that among the tested treatment maximum weed control efficiency in grassy weeds was observed from the weed free treated plot, depicted 100% efficiency as compare to other treatment for both *Echinochloa colona* and *Eclipta alba* at 90 DAT in transplanted rice. Similar observations were recorded for *Cyperus sp*. as well as BLWs. Data in Table 2 concluded that the *Echinochloa colona*, a dominant grassy weed in rice field; being statistically at par with pyrazosulfuron-ethyl (200ml ha-1)+ bispyribac-sodium (250 ml ha^{-1}) also proved itself as a most efficient herbicide for controlling *Cyperus iria* and other species exhibiting 77.01% and 79.42% efficiency at 60 and 90DAT respectively and efficiencies were lowest with weed Control followed by one hand weeding at 20 DAT. Further, pyrazosulfuron-ethyl (200ml ha-1) + bispyribac-sodium (250 ml ha-1) was most effective in significantly controlling BLWs like *Eclipta alba* to the tune of 83.19% and 83.66% at initial and later stages, respectively. Similarly, it was also found that weed control recorded significantly lowest weed density (0), lowest weed dry weight (0 g m-2), lowest and highest weed control efficiency (Kumar *et al.*, 2018) [1]. Similar data recorded in weed control index on transplanted rice. Among different tested herbicides, lowest weed index (7.61) was recorded with utmost dose of bispyribac sodium that means it resulted to highest increase of grain yield over control.

Table 2: Effect of treatments on total weed density (no. m-2) and weed dry weight (g m-2) at 30, 60 and 90 DAT in transplanted rice

Treatment		Weed index (%)	Weed control efficiency (%)			Weed control index (%)		
			30DAT	60DAT	90DAT	30DAT	60DAT	90DAT
T1	Weed control	42.00	0	0	0	0	0	0
T2	One hand weeding	17.31	61.66	63.43	53.00	56.63	56.63	78.16
T3	Two hand weeding	3.82	69.56	83.95	71.11	77.54	77.54	83.81
T4	Pyrazosulfuron-ethyl 20g a.i./ha as PE at 0-5 DAT	32.23	63.24	79.73	64.55	73.02	73.20	82.59
T5	Bispyribac-sodium 25g a.i./ha as a POE at 20-25 DAT	11.78	65.61	82.55	68.06	76.10	76.10	81.40
T6	Pyrazosulfuron – ethyl 20g a.i./ha as PE + Bispyribac-sodium 25g a.i/ha as a POE	7.42	83.18	85.84	83.66	79.59	79.59	84.51
T7	Weed free	0	100	100	100	100	100	100

Yield attributes

All the yield attributes of rice were significantly influenced by the weed management practices (Table 3). Highest number of panicles/m^2 respectively were recorded by weed free plot which was at par with all the doses of pyrazosulfuron-ethyl (20ga.i./ha + bispyribac-sodium (25g a.i./ha) application.

Weed control registered though numerically lower number of panicles/ m2, its effect on producing tillers was at par that of higher doses and twice hand weeding and significantly higher than bispyribac sodium 25g a.i./ha application. Regarding panicle length, weed free plot though recorded higher values, it was at par with all the dose of bispyribac-sodium and hand weeding twice. Similarly, number of grains/panicle were also higher with weed free plot but at par with bispyribac-sodium at 50 g/ ha. A similar result of higher yield attributes of transplanted rice under bispyribac-sodium application was reported by Yadav *et al*. (2009) [7]. Grain yield significant variation among weed management practices was found and higher yield was associated with weed free plots (Table 3). Weed free plot registered highest grain yield of 5066 kg/ha during 2021 respectively which was at par with all the doses of pyrazosulfuron ethyl @ 20g a.i./ha + bispyribac-sodium@ 25g a.i./ha. The effect of all the treatments on grain yield was significantly higher than weed control. The per cent yield increment due to weed free than two hand weeding, pyrazosulfuron ethyl, bispyribac sodium and weed control, respectively. The higher grain yield in weed free, pyrazosulfuron ethyl and bispyribac-sodium applied plots was attributed to lesser weed population and weed dry weight which might have caused lesser weed competition with rice resulted in the production of higher yield attributes which was reflected in higher yield. The results of effective weed control along with higher grain yield by bispyribac-sodium against mixed weed flora in transplanted rice (Yadav *et al*. 2009) [7], wet-seeded rice and dry-seeded rice (Walia *et al*. 2008) [8] were in confirmative with the present investigation. Murali *et al*. (2012) [4] obtained similar grain yield of transplanted rice under bispyribac-sodium at both the doses of 50 and 35 g/ha.

Table 3: Effect of treatments on yield attributes and economic of transplanted rice

	Treatment	Grain yield (Kg/ha)	Harvest index (%)	Test weight (g)	Net return (Kg/ha)	Benefit: cost ratio
T1	Weed control	2938.51	33.19	20.9	30923	1.60
T2	One hand weeding	4189.34	41.18	21.73	56654	1.99
T3	Two hand weeding	4872.22	43.12	22.39	67902	2.07
T4	Pyrazosulfuron-ethyl 20g a.i./ha as PE at 0-5 DAT	4067.45	40.96	21.53	58799	2.14
T5	Bispyribac-sodium 25g a.i./ha as a POE at 20-25 DAT	4369.76	42.07	22.02	67452	2.32
T6	Pyrazosulfuron – ethyl 20g a.i./ha as PE + Bispyribac-sodium 25g a.i/ha as a POE	4716.33	43.45	22.73	75965	2.47
T7	Weed free	5066.45	45.54	22.96	69794	2.05
	LSD ($p \leq 0.05$)	502.86	0.86	1.86	13327	0.24

Economics

The economic analysis of weed management practices (Table) revealed that higher economic benefits were realized under weed control. Pyrazosulfuron – ethyl 20g a.i./ha as PE + Bispyribac-sodium 25g a.i/ha as a POE registered highest net profit of 75965 and 2021, respectively followed by bispyribac-sodium at 25g/ha (67452 Rs/ha). Higher benefit-cost ratio was also associated with Pyrazosulfuron – ethyl 20 g a.i./ha as PE + Bispyribac-sodium 25g a.i/ha as a POE which was followed by bispyribac-sodium at 25g/ha Though higher dose of bispyribac-sodium at 25g/ha recorded slightly higher grain yield. It may be concluded that weed free application of pyrazosulfuron – ethyl 20g a.i./ha as PE + bispyribac-sodium 25g a.i/ha as a POE suitable and economical herbicidal weed management for transplanted rice and higher productivity.

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