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Weed dynamics and yield of kharif paddy as influenced by weed management practices

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Abstract

Rice productivity is significantly affected by weed infestation, which causes severe yield losses and reduces resource-use efficiency. A field experiment was conducted during kharif seasons of 2022–23 and 2023–24 at Regional Research Sub-Station, Raghunathpur, and West Bengal, to evaluate the effectiveness of different weed management practices in transplanted rice. Six treatments comprising different doses of Bispyribac Sodium + Metsulfuron Methyl + Chlorimuron Ethyl mixture, Penoxsulam, hand weeding, and weedy check were evaluated in randomized block design. Results revealed that hand weeding twice recorded superior weed control efficiency and yield performance; however, Bispyribac Sodium + Metsulfuron Methyl + Chlorimuron Ethyl @ 250 ml ha⁻¹ effectively reduced weed density and dry matter accumulation with grain yield comparable to hand weeding. The herbicide mixture also improved soil microbial population and provided broad-spectrum weed control. Therefore, this herbicide combination can be recommended for sustainable weed management in kharif paddy cultivation.

Keywords: Kharif paddy; Weed management; Bispyribac Sodium; Weed control efficiency; Grain yield; Post-emergence herbicide; Transplanted rice

1. Introduction

Rice means livelihood to millions as it is certainly life, tradition and culture to mankind. More than 50% of the world population has chosen rice as their staple food and it accounts 45-70% of total calorie intake in rice consuming countries. 85% of total production of rice is utilized for human consumption as compared to 72% of wheat and 19% of maize. Rice provides nearly 21% human per capita energy and 15% of per capita protein globally. Apart from that rice also provides minerals, vitamins, and fibre. Rice can be cultivated under wide range of climatic conditions and locations. India is the world's 2nd largest producer but recent estimates indicate that in the 2024-25 crop year, India is actually surpassing China in rice output. Rice production plays an important role in the national economy. Looking at the food security of the nation also rice plays an important role. As per Third Advance Estimates for 2020-21, rice is estimated to produce 121.46 million tonnes from nearly 44 million hectares of land in India (Third Advance Estimates of Principal Crops for 2020-21, Ministry of Agriculture and Farmers Welfare). According to 4th advanced estimates in West Bengal during 2019-20, rice is estimated at 118.43 million tonnes of production (Annual report 2020-21, Department of Agriculture, Cooperation & Farmers' Welfare). Like other South Asian countries rice is also the staple food of almost 65% of the Indian population (Barah, 2005) [5]. Weed problem is a major threat to food security in the world and timely management of weed is the easiest way to increase productivity of any crop. Weed causes around 42% loss in rice and in lowland condition it is around 18-20% (Bhan, 1997) [6]. By changing the pH of soil and decreasing the nutrient availability weeds become detrimental to crops, which reduce straw yield by 13-38% and grain yield by 25-47% (Manandhar *et al.*, 2007) [13]. In transplanted rice, weed causes 45-51% yield reduction (Veeraputhiran and Balasubramanian, 2013) [27]. A broad spectrum of grasses and broad leaved weeds infests rice field's viz., *Echinochloa colona*, *Echinochloa crusgalli*, *Digitaria sanguinalis* etc. These weeds can cause substantial loss of yield if not controlled efficiently. Manual and herbicidal methods of weed management techniques are found to be effective in controlling different groups of weeds in agriculture fields (Subbulakshmi *et al.*, 2009) [25]. Manual weeding is

Difficult during some times because of high cost and non-availability of labour at proper time (Singh *et al.*, 2013)^[22] and herbicides are integral part of managing weeds which resulted in high yields (Baghestani *et al.*, 2005)^[2]. Bispyribac Sodium is a post emergence herbicide which can be used as broad spectrum weed control of grasses, annual sedges and broad leaved, with excellent control of *Echinochloa* species. Yadav *et al.* (2009)^[28] reported that due to application of Bispyribac Sodium at 15 and 25 DAT in transplanted rice weed density reduced significantly. Keeping all these in view, the present study was carried out to determine how well selected post emergence herbicides worked when applied at normal use rates for weed control instead of Penoxsulam towards environmental sustainability and increased crop yield in paddy.

2. Materials and methods

2.1 Experimental site

The experiment was conducted at Regional Research Sub-station, Raghunathpur, Bidhan Chandra Krishi Viswavidyalaya, Purulia, and West Bengal in kharif season two consecutive years of 2022-23 and 2024-25. The study area belongs to humid and tropical climate characterised by a wet monsoon season (June to September) followed by dry post monsoon season. The experimental site was situated at 23.55°N latitude and 86.67°E

longitude with the altitude of 155 meters above the mean sea level (MSL) and have sandy loam soil (Red and lateritic soil). The soil characteristics were given in Table 1.

Table 1: Basic physical, chemical and microbiological properties of the soil in the study area

Sand (%)	30.42	Piper, 1966
Silt (%)	48.28	
Clay (%)	21.30	
pH	6.36	Jackson,1973
EC (dsm ⁻¹)	0.16	Jackson,1973
Organic carbon (%)	0.36	Jackson, 1973
Total N (%)	0.0418	Jackson, 1973
Available P ₂ O ₅ (kg ha ⁻¹)	15.12	Jackson, 1973
Available K ₂ O (kg ha ⁻¹)	89.45	Jackson, 1973
Total bacteria (CFU x 10 ⁶ g ⁻¹ of soil)	133.63	Thornton, 1922
Fungi (CFU x 10 ⁴ g ⁻¹ of soil)	16.31	Martin, 1950
Actinomycetes (CFU x 10 ⁵ g ⁻¹ of soil)	127.93	Jensen, 1930

2.2 Experimental design and treatments

The experiment was laid out in Randomized Block Design. There were six treatment combinations with three replications. The treatments are comprising of six treatments:

Table 2: Details of herbicide treatments with their doses (g a.i ha⁻¹) and volume of spray (ml ha⁻¹) evaluated for weed management in rice.

Treatments		Dose (g a.i ha ⁻¹)	Dose (g ml ha ⁻¹)
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	18.2+2.4+2.4	200
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	22.75+3+3	250
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	24.57+3.24+3.24	270
T ₄	Penoxsulam 21.7%SC	22.5	93.7
T ₅	Hand Weeding (Twice)	20 & 40 DAT	--
T ₆	Untreated Control (Weedy Check)	--	---

The individual plot size was 5m × 5m.

2.3 Crop management

The paddy variety DRR-42 was transplanted on 19-08-2022 and 25-08-2023 and harvested on 09-12-2022 and 17-12-2023 respectively. The total crop duration was 112 days and 114 days, respectively. The row to row spacing was 20 cm and plant to plant spacing was 10 cm. Full doses of Phosphorus through Single Super Phosphate and Potash through Muriate of Potash each @ 40 kg ha⁻¹ was applied as basal. Recommended dose of Nitrogen @ 80 kg ha⁻¹ through Urea was applied in 3 splits at basal, 20-25 and 45-50 days after crop transplanting (DAT). Hand weeding was done twice at 20 DAT and 40 DAT. The herbicide Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v at dosages of 200, 250 and 270 ml ha⁻¹ were sprayed at 20 DAT as post-emergence and Penoxsulam 21.7% SC at 93.7 ml ha⁻¹ was sprayed at 12 DAT as post-emergence by using 500 litres of water ha⁻¹ with knapsack sprayer fitted with flat fan deflector nozzle.

2.4 Plant and weed sampling

The populations of different types of weeds (Grasses, Broadleaf & sedge) were recorded at before spraying, 30, 45, 60 and 75 DAT. A quadrat with a dimension of 1 m × 1 m was placed randomly at three places in each plot and the weeds from that area were counted and expressed as number per square meter. Weeds belonging to three categories obtained during population count at 30, 45, 60 and 75 DAT were labelled properly. The labelled samples were then sun dried for 24 hours and then oven dried for 72 hours at 70°C. Then dry weight of weeds was taken and recorded separately. For measuring the grain yield of paddy, the entire produce from the net plot area (from demarcated portion, leaving the border area) was harvested and weighed after proper drying under the sun. Grain yield from that area was converted to yield per unit area (t ha⁻¹). Weed control efficiency is a derived parameter that compares different treatments of weed control on the basis of weed dry weight

across them. It is an estimate of weed control in crops. WCE of different treatments was computed on the basis of weed dry weight by using the following formula,

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

Where,
DWC = Dry weight of weeds in untreated control treatment
DWT = Dry weight of weeds in weed control treatment

2.5 Soil sampling:

After harvesting of the paddy crop soil samples from the experimental plots were collected from the space between the rows at a depth 0-30 cm. The soil sample from the different places per replication for the same weed control treatment was mixed together and then requisite composite samples of each treatment were taken for microbial population count by following standard methods.

2.6 Statistical analysis

Data were analysed using analysis of variance (ANOVA) following randomised block design (Gomez &Gomez, 1984). Differences were considered significant at 5% level of probability.

3. Results

The important weed flora observed in the experimental plot was:

<i>Echinochloa colona</i>	<i>Cyperus difformis</i>	<i>Ludwigia parviflora</i>
<i>Echinochloa crusgalli</i>	<i>Cyperus iria</i>	<i>Ammania baccifera</i>
<i>Ischaemum rugosum</i>	<i>Alternanthera philoxeroides</i>	<i>Lindernia ciliata</i>
<i>Digitaria sanguinalis</i>	<i>Monochoria vaginalis</i>	<i>Marsilea quadrifolia</i>

3.1 Total weed density

Pooled data of two years of weed density is given in table 2, 3, 4 & 5.

3.1.1 Density of *Echinochloa sp.* (m⁻²)

Density of *Echinochloa sp.* was affected significantly by various treatments involving weed management practices (Table 2, 3, 4, 5). At 30 DAT of rice density of *Echinochloa sp.* was observed lowest in treatment T₂ where Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ was applied and in treatment T₄ or hand weeded plot. However, Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 200 ml ha⁻¹ T₁ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ T₃ treated plots were at par. At 45 & 60 DAT hand weeded plots showed lowest weed density followed by T₂ Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹. However at 75 DAT lowest weed density was observed in T₃ treatment Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ and at 75 DAT hand weeded plots showed much higher density of *Echinochloa sp.* Than all the chemical treated plots except Penoxsulam 21.7% SC @ 93.7 ml ha⁻¹.

3.1.2 Density of *Ischaemum rugosum* (m⁻²)

Density of *Ischaemum rugosum* was affected significantly by all the treatments except weedy check (Table 2,3,4,5). At 30 & 45 DAT lowest density was observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and in hand weeded plot while other Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v treated plots were at par. At 60 DAT lowest density was in hand weeded plots followed by Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ while at 75 DAT hand weeded plots showed higher density than Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v treated plots and lowest was observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and 270 ml ha⁻¹.

3.1.3 Density of *Cyperus sp.* (m⁻²)

Density of *Cyperus sp.* was affected significantly by all the treatments except weedy check (Table 2,3,4,5). At 30 DAT lowest weed density was found in hand weeded and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ plots and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v treated plots were at par. At 45 DAT lowest density was in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ followed by hand weeding while at 60 DAT weed density was vice versa of 45 DAT. At 75 DAT lowest weed density was found in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ followed by Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ while hand weeding plots were not even at par with these two treatments.

3.1.4 Density of *Monochoria vaginalis* (m⁻²)

Density of *Monochoria vaginalis* was affected significantly by various treatments involving weed management practices (Table 2, 3, 4, 5). At 30 DAT and 45 DAT lowest density was observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and hand weeding plots and other two Bispyribac Sodium 9.1% +

Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v treated plots were at par. At 60 DAT lowest density was observed in hand weeded plots followed by Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and at 75 DAT lowest was found in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹.

3.1.5 Density of *Alternanthera philoxeroides* (m⁻²)

Density of *Alternanthera philoxeroides* was affected significantly by various treatments involving weed management practices (Table 2,3,4,5). At 30 DAT lowest weed density was observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and hand weeded plots. At 45 DAT and 60 DAT lowest weed density was observed in hand weeding plots followed by Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and at 75 DAT lowest observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ as well as Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹.

3.1.6 Density of *Ludwigia parviflora* (m⁻²)

Density of *Ludwigia parviflora* found lowest in hand weeding and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ at 30 DAT and 45 DAT. However at 60 DAT lowest observed in hand weeded plots followed by all three Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v (@ 200, 250, 270 ml ha⁻¹) plots. At 75 DAT lowest weed density was observed in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹. Penoxsulam 21.7% SC 93.7 ml ha⁻¹ showed significant result at 30, 45 and 60 DAT but at 75 DAT Penoxsulam 21.7% SC treated plots showed much higher density of *Ludwigia parviflora* than all the other treatments including control weedy check.

3.1.6 Density of other weeds (m⁻²)

Density of other weeds were lowest in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and hand weeding plots at 30 DAT while at 45 DAT lowest found in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and at 60 DAT total weed density was lowest in hand weeding followed by Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹. At 75 DAT lowest density was in Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹. In case of density of other weeds Penoxsulam 21.7% SC ml ha⁻¹ showed impactful result at 30, 45 and 60 DAT but at 75 DAT weed density found maximum.

3.2 Weed dry weight

In field crops weeds type and severity of weed infestation are considered the precursor of yield loss. Therefore, for realizing an optimum yield of any crop timely control of weeds is very important. The pooled data of two years pertaining to weed dry weight were given in table 6 to table 9. All the weed management treatments significantly reduced weed dry weight as compared to the weedy-check when observed at 30, 45, 60 and 75 DAT. Among the herbicides Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @

250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ recorded lowest weed dry weight, both the herbicides were at par with each other. Hand weeding twice at 20 and 40 DAT significantly recorded the lowest weed dry weight at 30, 45 and 60 DAT compared to other management practices but at 75 DAT most of the weeds showed lesser or equal dry weight in these two herbicides than hand weeded treatments.

3.3 Weed control efficiency

Data regarding Weed Control Efficiency (%) (Table 10 to 13), revealed that highest weed control efficiency (%) was recorded in hand weeding twice at 20 and 40 DAT while at 60 and 75 DAT Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ recorded highest WCE(%). Penoxsulam 21.7% SC recorded lowest Weed Control Efficiency (%) among all these treatments.

3.4 Crop yield

Pooled data of paddy grain and straw yield were given in Table 14 which reveals that hand weeding at 20 & 40 DAT gives significantly higher grain yield as well as straw yield (4.55 t ha⁻¹

and 5.02 t ha⁻¹ respectively). Lowest grain and straw yield was observed in weedy check plot (3.05 and 3.14 t ha⁻¹). Among herbicide treated plots Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ recorded highest grain and straw yield (4.77 and 4.92 t ha⁻¹) followed by Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ (4.72 and 4.83 t ha⁻¹) and both these treatments were at par with hand weeding plot.

3.5 Microbial population

Data given in Table 15 reveals that total bacteria population in Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ was recorded highest at the time of harvest and lowest in weedy check control plot. In case of fungi and actinomycetes also similar trend was observed except lowest recorded from hand weeding treatment. All the herbicides applied treatments showed higher micro flora population than hand weeding and control plots but the herbicidal treatments did not vary significantly among themselves. Penoxsulam 21.7% SC recorded lowest micro flora population (total bacteria, fungi and actinomycetes) between all the herbicidal treatments but higher than control and hand weeded plots.

Table 3: Population of weed flora (per m²) at 30 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria vaginalis</i>	<i>Alternanthera philoxeroides</i>	<i>Ludwigia parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	200	2.00 (1.58)*	1.33 (1.35)	4.00 (2.12)	1.78 (1.51)	1.00 (1.22)	2.22 (1.65)	2.78 (1.81)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	250	1.33 (1.35)	1.00 (1.22)	3.22 (1.93)	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	1.89 (1.55)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	270	1.78 (1.51)	1.33 (1.35)	4.22 (2.17)	1.56 (1.44)	0.67 (1.08)	0.33 (0.91)	2.44 (1.71)
T ₄	Penoxsulam 21.7% SC	93.7	2.22 (1.65)	1.67 (1.47)	7.56 (2.84)	2.00 (1.58)	1.00 (1.22)	1.44 (1.39)	2.67 (1.78)
T ₅	Hand weeding	20 & 40 DAT	1.33 (1.35)	1.00 (1.22)	3.22 (1.93)	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	1.89 (1.55)
T ₆	Control Weedy check	----	16.22 (4.09)	11.67 (3.49)	26.33 (5.18)	13.00 (3.67)	9.00 (2.92)	5.89 (2.53)	21.22 (4.66)
CD at 5%			0.31	0.26	0.38	0.36	0.31	0.35	0.29

*Data in the parenthesis are transformed value

Square root transformed value of (X+0.5) was used for statistical analysis

Table 4: Population of weed flora (per m²) at 45 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria vaginalis</i>	<i>Alternanthera philoxeroides</i>	<i>Ludwigia parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	200	2.67 (1.78)	2.00 (1.58)	4.33 (2.20)	2.00 (1.58)	3.00 (1.87)	0.67 (1.08)	2.67 (1.78)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	250	2.00 (1.58)	1.33 (1.35)	4.00 (2.12)	1.33 (1.35)	1.00 (1.22)	0.33 (0.91)	2.00 (1.58)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2% + Chlorimuron ethyl 1.2% SC W/v	270	2.33 (1.68)	1.67 (1.47)	4.33 (2.20)	2.00 (1.58)	1.33 (1.35)	0.67 (1.08)	2.67 (1.78)
T ₄	Penoxsulam 21.7% SC	93.7	3.00 (1.87)	2.33 (1.68)	5.67 (2.48)	2.33 (1.68)	1.67 (1.47)	1.33 (1.35)	3.67 (2.04)
T ₅	Hand weeding	20 & 40 DAT	1.67 (1.47)	1.33 (1.35)	4.33 (2.20)	1.33 (1.35)	0.33 (0.91)	0.33 (0.91)	2.33 (1.68)
T ₆	Control Weedy check	----	16.00 (4.06)	18.67 (4.38)	38.00 (6.20)	17.00 (4.18)	11.33 (3.44)	10.33 (3.29)	27.67 (5.31)
CD at 5%			0.27	0.21	0.30	0.33	0.25	0.30	0.24

Table 5: Population of weed flora (per m²) at 60 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> <i>sp.</i>	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> <i>sp.</i>	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	3.00	2.33	5.33	2.33	1.67	1.00	7.67
			(1.87)	(1.68)	(2.42)	(1.68)	(1.47)	(1.22)	(2.86)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	2.33	1.67	4.67	1.67	1.00	1.00	3.33
			(1.68)	(1.47)	(2.27)	(1.47)	(1.22)	(1.22)	(1.96)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	2.67	2.00	5.67	2.33	1.67	1.00	3.67
			(1.78)	(1.58)	(2.48)	(1.68)	(1.47)	(1.22)	(2.04)
T ₄	Penoxsulam 21.7% SC	93.7	3.67	6.67	7.67	3.00	2.33	1.67	7.00
			(2.04)	(2.68)	(2.86)	(1.87)	(1.68)	(1.47)	(2.74)
T ₅	Hand weeding	20 & 40 DAT	1.67	1.33	4.33	1.33	0.33	0.33	2.33
			(1.47)	(1.35)	(2.20)	(1.35)	(0.91)	(0.91)	(1.68)
T ₆	Control Weedy check	----	23.00	22.00	43.00	19.67	14.33	12.00	32.33
			(4.85)	(4.74)	(6.60)	(4.49)	(3.85)	(3.54)	(5.73)
CD at 5%			0.27	0.21	0.30	0.33	0.24	0.23	0.36

Table 6: Population of weed flora (per m²) at 75 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa sp.</i>	<i>Ischaemum rugosum</i>	<i>Cyperus sp.</i>	<i>Monochoria vaginalis</i>	<i>Alternanthera philoxeroides</i>	<i>Ludwigia parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	7.00	6.00	10.33	5.33	4.33	3.00	8.33
			(2.74)	(2.55)	(3.29)	(2.42)	(2.20)	(1.87)	(2.97)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	3.33	2.33	6.33	2.33	1.67	1.33	4.00
			(1.96)	(1.68)	(2.61)	(1.68)	(1.47)	(1.35)	(2.12)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	3.00	2.33	6.00	2.33	1.67	1.33	4.00
			(1.87)	(1.68)	(2.55)	(1.68)	(1.47)	(1.35)	(2.12)
T ₄	Penoxsulam 21.7% SC	93.7	23.67	22.33	44.33	19.00	15.33	12.00	34.00
			(4.92)	(4.78)	(6.70)	(4.42)	(3.98)	(3.54)	(5.87)
T ₅	Hand weeding	20 & 40 DAT	15.33	12.67	28.67	12.33	7.67	6.33	23.00
			(3.98)	(3.63)	(5.40)	(3.58)	(2.86)	(2.61)	(4.85)
T ₆	Control Weedy check	----	16.67	13.33	28.33	15.33	10.33	5.67	22.00
			(4.14)	(3.72)	(5.37)	(3.98)	(3.29)	(2.48)	(4.74)
CD at 5%			0.36	0.26	0.42	0.39	0.33	0.21	0.32

Table 7: Dry mass of weed flora (g per m²) at 30 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> <i>sp.</i>	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> <i>sp.</i>	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	0.73	0.40	1.73	0.83	0.50	0.60	1.67
			(1.11)	(0.95)	(1.49)	(1.15)	(1.00)	(1.04)	(1.47)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	0.30	0.27	1.47	0.40	0.20	0.00	1.07
			(0.88)	(0.87)	(1.40)	(0.95)	(0.82)	(0.71)	(1.25)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	0.33	0.20	1.37	0.33	0.13	0.13	1.03
			(0.90)	(0.83)	(1.36)	(0.90)	(0.79)	(0.79)	(1.22)
T ₄	Penoxsulam 21.7% SC	93.7	0.87	0.70	1.33	0.87	0.87	0.67	0.90
			(1.17)	(1.08)	(1.34)	(1.16)	(1.16)	(1.08)	(1.18)
T ₅	Hand weeding	20 & 40 DAT	0.13	0.10	0.23	0.17	0.03	0.00	0.30
			(0.79)	(0.77)	(0.85)	(0.81)	(0.73)	(0.71)	(0.89)
T ₆	Control Weedy check	----	6.10	4.13	7.37	4.47	3.37	2.87	5.90
			(2.57)	(2.15)	(2.80)	(2.22)	(1.96)	(1.83)	(2.53)
CD at 5%			0.20	0.23	0.20	0.24	0.23	0.20	0.29

Table 8: Dry mass of weed flora (g per m²) at 45 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	1.47 (1.40)	0.93 (1.19)	1.83 (1.52)	0.67 (1.07)	1.20 (1.30)	0.37 (0.92)	1.37 (1.36)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	0.97 (1.21)	0.57 (1.03)	1.20 (1.30)	0.33 (0.91)	0.40 (0.93)	0.23 (0.85)	0.90 (1.18)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	0.83 (1.15)	0.40 (0.94)	0.93 (1.19)	0.37 (0.92)	0.23 (0.85)	0.17 (0.81)	0.93 (1.19)
T ₄	Penoxsulam 21.7% SC	93.7	0.83 (1.14)	1.00 (1.22)	1.17 (1.28)	1.13 (1.27)	1.50 (1.41)	0.53 (1.01)	1.20 (1.30)
T ₅	Hand weeding	20 & 40 DAT	0.43 (0.96)	0.17 (0.81)	0.50 (0.99)	0.20 (0.83)	0.10 (0.77)	0.07 (0.75)	0.33 (0.91)
T ₆	Control Weedy check	----	5.43 (2.43)	3.97 (2.11)	6.83 (2.71)	3.80 (2.07)	5.37 (2.42)	3.23 (1.93)	5.90 (2.53)
CD at 5%			0.21	0.21	0.23	0.25	0.25	0.21	0.17

Table 9: Dry mass of weed flora (g per m²) at 60 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	3.33 (1.96)	2.00 (1.58)	3.67 (2.04)	2.67 (1.78)	1.33 (1.35)	1.67 (1.47)	2.67 (1.78)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	2.67 (1.78)	1.33 (1.35)	3.00 (1.87)	2.00 (1.58)	1.00 (1.22)	1.33 (1.35)	1.67 (1.47)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	3.00 (1.87)	1.33 (1.35)	3.33 (1.96)	2.33 (1.68)	1.00 (1.22)	1.33 (1.35)	2.00 (1.58)
T ₄	Penoxsulam 21.7% SC	93.7	5.33 (2.42)	3.33 (1.96)	8.00 (2.92)	4.00 (2.12)	3.67 (2.04)	2.00 (1.58)	5.67 (2.48)
T ₅	Hand weeding	20 & 40 DAT	2.67 (1.78)	2.33 (1.68)	4.33 (2.20)	2.33 (1.68)	1.33 (1.35)	1.00 (1.22)	3.00 (1.87)
T ₆	Control Weedy check	----	31.00 (5.61)	23.67 (4.92)	46.33 (6.84)	27.33 (5.28)	16.33 (4.10)	13.33 (3.72)	33.33 (5.82)
CD at 5%			(0.36)	0.29	0.39	0.30	0.21	0.18	0.36

Table 10: Dry mass of weed flora (g per m²) at 75 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	4.00 (2.12)	2.67 (1.78)	3.67 (2.04)	3.33 (1.96)	2.00 (1.58)	1.33 (1.35)	3.33 (1.96)
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	3.33 (1.96)	2.33 (1.68)	3.67 (2.04)	2.67 (1.78)	1.67 (1.47)	1.33 (1.35)	2.67 (1.78)
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	3.67 (2.04)	2.33 (1.68)	4.00 (2.12)	3.33 (1.96)	2.00 (1.58)	1.33 (1.35)	2.67 (1.78)
T ₄	Penoxsulam 21.7% SC	93.7	4.67 (2.27)	3.33 (1.96)	5.00 (2.35)	4.00 (2.12)	2.67 (1.78)	2.00 (1.58)	4.33 (2.20)
T ₅	Hand weeding	20 & 40 DAT	3.67 (2.04)	3.00 (1.87)	5.00 (2.35)	3.33 (1.96)	2.00 (1.58)	1.67 (1.47)	3.67 (2.04)
T ₆	Control Weedy check	----	32.00 (5.70)	26.67 (5.21)	37.00 (6.12)	29.00 (5.43)	18.33 (4.34)	13.67 (3.76)	29.67 (5.49)
CD at 5%			0.42	0.36	0.39	0.30	0.24	0.18	0.38

Table 11: Weed control efficiency (%) of weed flora at 30 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	87.98	90.32	76.47	81.34	85.15	79.07	71.75
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	95.08	93.55	80.09	91.04	94.06	100.00	81.92
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	94.54	95.16	81.45	92.54	96.04	95.35	82.49
T ₈	Penoxsulam 21.7%SC	93.7	85.79	83.06	81.90	80.60	74.26	76.74	84.75
T ₉	Hand weeding	20 & 40 DAT	97.81	97.58	96.83	96.27	99.01	100.00	94.92
T ₁₀	Control Weedy check	----	----	----	----	----	----	----	----

Table 12: Weed control efficiency (%) of weed flora at 45 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	73.01	76.47	73.17	82.46	77.64	88.66	76.84
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	82.21	85.71	82.44	91.23	92.55	92.78	84.75
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	84.66	89.92	86.34	90.35	95.65	94.85	84.18
T ₈	Penoxsulam 21.7%SC	93.7	84.66	74.79	82.93	70.18	72.05	83.51	79.66
T ₉	Hand weeding	20 & 40 DAT	92.02	95.80	92.68	94.74	98.14	97.94	94.35
T ₁₀	Control Weedy check	----	----	----	----	----	----	----	----

Table 13: Weed control efficiency (%) of weed flora at 60 days after crop transplanting

	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	89.25	91.55	92.09	90.24	91.84	87.50	92.00
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	91.40	94.37	93.53	92.68	93.88	90.00	95.00
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	90.32	94.37	92.81	91.46	93.88	90.00	94.00
T ₄	Penoxsulam 21.7%SC	93.7	82.80	85.92	82.73	85.37	77.55	85.00	83.00
T ₅	Hand weeding	20 & 40 DAT	91.40	90.14	90.65	91.46	91.84	92.50	91.00
T ₆	Control Weedy check	----	----	----	----	----	----	----	----

Table 14: Weed control efficiency (%) of weed flora at 75 days after crop transplanting

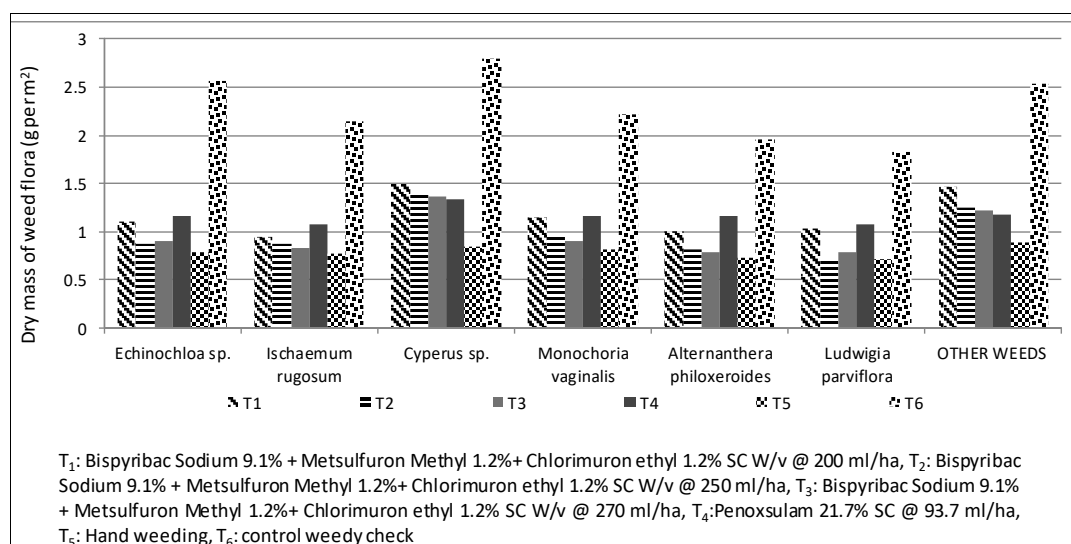
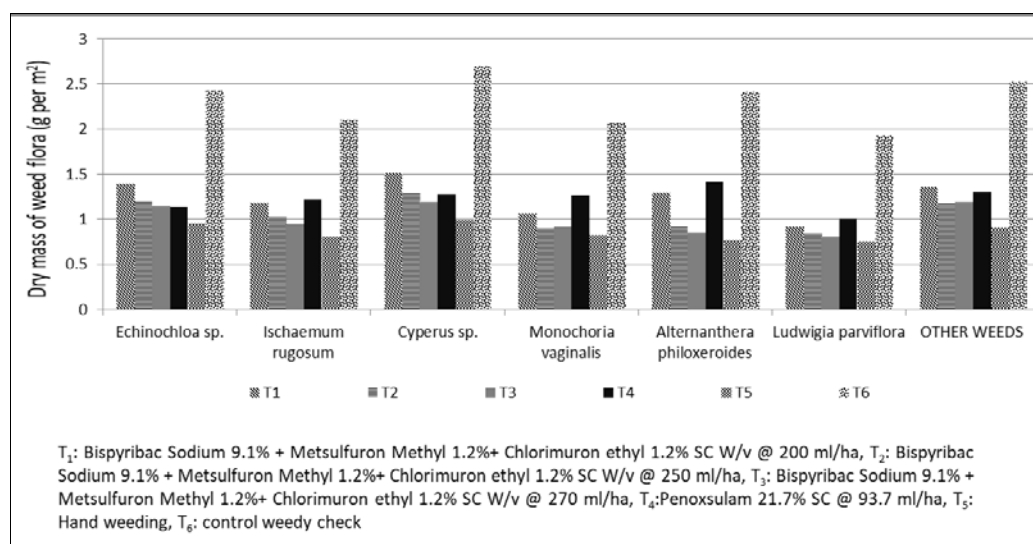
	Treatments	Dose formulation g or ml ha ⁻¹	<i>Echinochloa</i> sp.	<i>Ischaemum</i> <i>rugosum</i>	<i>Cyperus</i> sp.	<i>Monochoria</i> <i>vaginalis</i>	<i>Alternanthera</i> <i>philoxeroides</i>	<i>Ludwigia</i> <i>parviflora</i>	OTHER WEEDS
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	87.50	90.00	90.09	88.51	89.09	90.24	88.76
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	89.58	91.25	90.09	90.80	90.91	90.24	91.01
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	88.54	91.25	89.19	88.51	89.09	90.24	91.01
T ₄	Penoxsulam 21.7%SC	93.7	85.42	87.50	86.49	86.21	85.45	85.37	85.39
T ₅	Hand weeding	20 & 40 DAT	88.54	88.75	86.49	88.51	89.09	87.80	87.64
T ₆	Control Weedy check	----	----	----	----	----	----	----	----

Table 15: Grain and straw yield (t ha⁻¹) of Transplanted Rice

	Treatments	Dose formulation g or ml ha ⁻¹	Yield (t ha ⁻¹)	
			Grain	Straw
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	4.54	4.79
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	4.77	4.92
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	4.72	4.83
T ₄	Penoxsulam 21.7% SC	93.7	4.65	4.78
T ₅	Hand weeding	20 & 40 DAT	4.88	5.02
T ₆	Control Weedy check	----	3.05	3.14
CD at 5%			0.18	0.27

Table. 16: Influence of herbicides on soil micro flora at harvest

	Treatments	Dose formulation g or ml ha ⁻¹	Total bacteria (CFU x 10 ⁶ g ⁻¹ of soil)	Fungi (CFU x 10 ⁴ g ⁻¹ of soil)	Actinomycetes (CFU x 10 ⁵ g ⁻¹ of soil)
T ₁	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	200	152.33	24.33	159.67
T ₂	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	250	151.67	24.33	158.00
T ₃	Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v	270	151.33	23.67	157.67
T ₄	Penoxsulam 21.7% SC	93.7	148.33	23.33	154.67
T ₅	Hand weeding	20 & 40 DAT	136.00	19.67	142.33
T ₆	Control Weedy check	----	135.33	20.00	143.00
CD at 5%			4.1	1.8	4.15

**Fig.1:** Dry mass of weed flora (g per m²) at 30 days after crop transplanting**Fig. 2:** Dry mass of weed flora (g per m²) at 45 days after crop transplanting

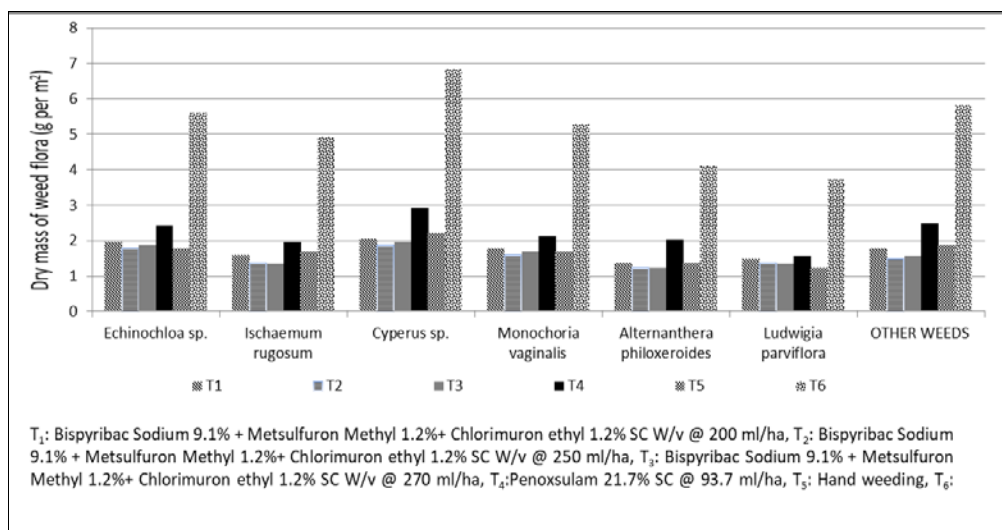


Fig. 3: Dry mass of weed flora (g per m²) at 60 days after crop transplanting

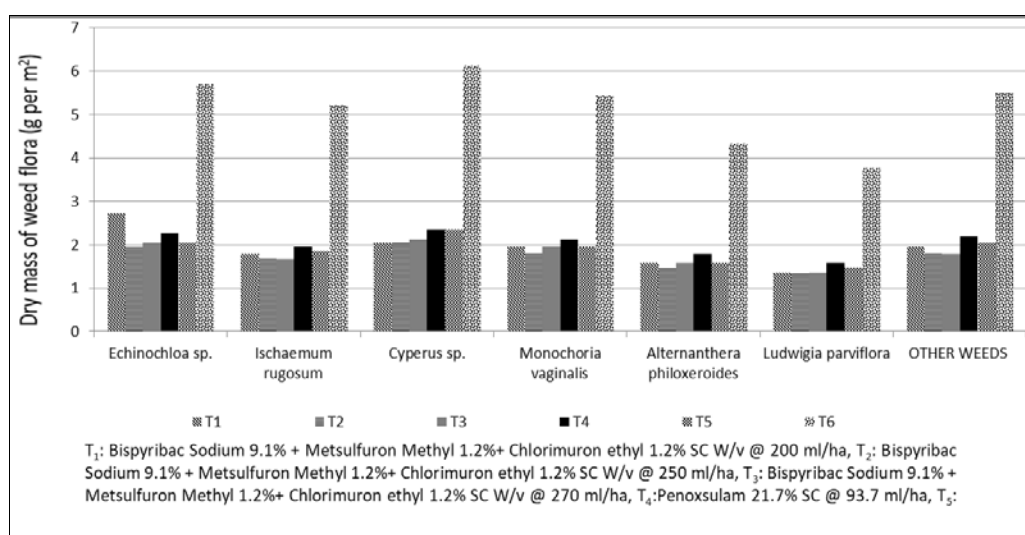


Fig. 4: Dry mass of weed flora (g per m²) at 75 days after crop transplanting

4. Discussion

Herbicides perform well due to better persistence effect. Due to regular removal of weeds there was reduced crop-weed competition (Hawalder & Agasimani, 2012; Shankar *et al.*, 2015) [8, 21]. Also highest weed biomass and highest total weed count were observed in weedy check control plot because of uncontrolled condition which led to luxurious weed growth (Mathukia *et al.*, 2014; Barad *et al.*, 2016; Kumar *et al.*, 2017) [4, 11, 14]. *Echinochloa* spp. was the predominant one among grasses and *Cyperus* sp. among sedges. Hussain *et al.* (2008) [9] and Singh *et al.* (2010) [24] also reported *Echinochloa crusgalli*, *Leptochloa chinensis*, *Cyperus iria*, *Fimbristylis miliacea*, *Ludwigia parviflora* and *Monochoria vaginalis* as the major weeds of rice. Selective post-emergence herbicides significantly reduce weed dry weight and total no. of weeds and all the herbicides were effective against *Echinochloa*, the major weed of rice (Prameela *et al.*, 2014) [17]. Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ showed overall significant result in controlling weeds specially at 75 DAT these two treatments recorded better result in controlling weeds than hand weeded treatment. The broad spectrum action of Bispyribac Sodium was also reported by Yadav *et al.*, (2007). Singh and Tewari (2005) [23] observed excellent control of broad

leaved weeds by application of Metsulfuron Methyl + chlorimuron ethyl @ 4g ha⁻¹.

Hand weeding twice recorded the highest grain yield and weed control efficiency (Tripathi *et al.* 2000) [26]. Significantly higher weed control efficiency, lower weed index, higher yield attributes and higher grain yield were recorded with hand weeding twice (Rekha *et al.*, 2002; Lakshmi *et al.*, 2006) [12, 19]. Manual weeding is very effective but it is time consuming as well as expensive in large scale cultivation and also continuous rains during rainy season and unavailability of skilled man power make manual weeding difficult most of the times (Puniya *et al.*, 2007) [18]. Single herbicide application over a longer period of time led to herbicidal resistance to weeds, therefore application of herbicides mixture shows significantly better result regarding weed control efficiency and yield attributes due broad spectrum of weed control with small dose of herbicides (Singh and Tewari, 2005; Bali *et al.*, 2006; Saha, 2006; Bhowmick *et al.*, 2000; Mukherjee and Singh, 2005) [3, 7, 16, 20, 23]. In our finding we observed Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v shows more promising result than Penoxsulam 21.7% SC sole application and also remain at par or in some cases better than hand weeded treatment, which is similar to the previous findings. After application of herbicides their toxic effects are normally most severe and it affects microbial population but

after few days or at the time of harvesting the microbial population was increased, this was due to the reason that microorganisms initiate degradation process, and then the degraded herbicides release carbon rich substrates which in terms maximize the microbial population in the root zone (Adhikary *et al.*, 2014) ^[1]. There is no direct effect of herbicides on the population of soil microorganisms. Herbicides significantly affect microbial growth and multiplication because they act as a source of nutrient for microbes (Milosevic & Govedarika, 2002) ^[15]. Hand weeding rendered a significant increase in the population of microorganisms in soil is might be due to the influence of available nutrients stimulatory to the soil micro flora (Khuntia *et al.*, 2013) ^[10].

5. Conclusion:

According to the results of this study, hand weeding shown superiority in controlling weed density, dry mass of weed flora and higher WCE (%) and yield when overall compared to remaining treatments. But at 60 and 75 DAT Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and 270 ml/ha remain at par and even better than hand weeded treatments specially for total weed count, dry mass of weed and weed control efficiency. In case of microbial population herbicides mixture shows significantly higher result than all the other treatments including hand weeded treatment. As there is no much difference between Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ and Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 270 ml ha⁻¹ response to microbial count, yield and controlling weeds. Bispyribac Sodium 9.1% + Metsulfuron Methyl 1.2%+ Chlorimuron ethyl 1.2% SC W/v @ 250 ml ha⁻¹ herbicide mixture was recommended as post-emergence herbicide in kharif paddy for effective weed control and higher return.

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