*Indian Journal of Weed Science* **51**(3): 236–239, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

# Weed management in transplanted rice with special reference to *Commelina benghalensis* in the Kymore Plateau Satpura hills region of Madhya Pradesh

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**Article information**

**DOI:** 10.5958/0974-8164.2019.00050.9

**Type of article:** Research article

**Received** : 7 June 2019
**Revised** : 5 September 2019
**Accepted** : 14 September 2019

**Key words**

Bispyribac-sodium, *Commelina benghalensis*, Farmers practice, Pendimethalin, Pyrazosulfuron, Rice, Weed

**ABSTRACT**

During 2014-17, an on-farm research trial was conducted at five farmer fields in Katni district of Madhya Pradesh to validate, refine and popularize the technology for managing *Commelina benghalensis* L. The study aimed to find out the efficacy of bispyribac-sodium 20 g/ha, pyrazosulfuron 20 g/ha and pendimethalin 1.5 kg/ha over farmers practice (hand weeding twice at 30 and 60 DAT) and unweeded control on the management of weeds and profitability of rice (*Oryza sativa*) sown in transplanted condition. Bispyribac-sodium 20 g/ha at 20-21 DAT reduced the density of *C. benghalensis* upto 9.8 no./m$^2$ and dry weight upto 6.9 g/m$^2$ and also reduced the infestation of other weeds to a significant extent. Higher values of yield attributes such as number of panicles (229/m$^2$), grain yield (3.46 t/ha) and net returns (` 31820/ha), as well as less values of nutrient uptake by weeds (5.8 kg N, 1.1 kg P and 6.9 kg K/ha) were recorded with this herbicide compared to farmers practice.

## INTRODUCTION

Weeds are considered as the more harmful than insects, fungi or other crop pests in many situations as far as economic loss is concerned. Among all biotic constraints, they cause more harm to agricultural production besides affecting agro biodiversity and natural aquatic bodies. They also have a negative effect on the crop production indirectly by competing with the crop plants for inputs, providing shelter to crop pests, negatively affecting water management, reducing the yield and quality of produce, and subsequently increasing the cost of processing (Zimdahl 2013). In a recent study, total actual economic loss due to weeds alone in 10 major field crops of India was estimated as USD 11 billion (Gharde *et al*. 2018a and b).

Rice is the most widely cultivated rainy season's cereal in Madhya Pradesh. Owing to favourable weather and soil moisture regime, *Commelina* spp. infestation is a major biotic constraint to rainy rice production. In the Kymore Plateau Satpura hills region of Katni district of Madhya Pradesh, four species of *Commelina*, notably *C. communis* L., *C. diffusa* Burm., *C. elegans* Kunth. and *C. benghalensis* L. as well as their biotypes are present. They are perennial herbs and considered as important problem in prevalent cropping systems where they have become continual and become difficult to control. *Commelina benghalensis* is the most important among four and it occurs as a major weed in 25 different crops in 28 countries (Holm *et al.* 1977). *C. benghalensis* has been found infesting different field crops during rainy season especially rice fields. Season-long infestation of this weed alone causes grain yield reduction by 13-40% and removes considerable amount of soil nutrients (Shukla *et al.* 2014).

Therefore, present investigation was conducted at selected farmers' fields with the objective to validate, assess and refine the technology, to test its sustainability and energy-use efficiency over traditional farmers practice in terms of growth, yield and economics of rice as influenced by various herbicides.

## MATERIALS AND METHODS

*Commelina* spp, a serious constraint in the Kymore Plateau Satpura Hills Region of Katni district of Madhya Pradesh, causes poor rice yield and high cost of production due to its heavy infestation. Therefore, replicated on-farm trials were conducted at five farmers fields in five villages (similar agro-climatic conditions) namely Deori ($23^0$89'N $80^0$29'E), Umariyapan ($23^0$50'N $80^0$27'E), Banda ($23^0$68'N $80^0$34'E), Lakhapateri ($23^0$69'N $80^0$32'E) and Dhundhari ($23^0$73'N $80^0$30'E) of Katni district of

Madhya Pradesh during 2014-17 and means were used for further interpretation. The soil of the sites was sandy loam to silt clay loam, acidic in pH and medium in available N (385 kg/ha), P (14.7 kg/ha) and high in K (308 kg/ha). The bulk density of the soil was 1.25 Mg/m$^3$. The experiment comprised of five treatments, *viz*. bispyribac-sodium 20 g/ha, pyrazosulfuron 20 g/ha as post-emergence and pendimethalin 1.5 kg/ha as pre-emergence, farmers practice (hand weeding twice at 30 and 60 DAT) and unweeded control. These were laid out in a randomized block design at each farmer's field. Rice '*MTU 1010*' was sown by transplanting (SRI) at seed rate of 20 kg seed/ha during second fortnight of July in all the three years. The crop was fertilized with 15 t/ha of well decomposed FYM only.

Herbicides were applied with a manually operated knapsack sprayer delivering a spray volume of 500 litres/ha through flat-fan nozzle. Data on weed density and dry weight were recorded at 70-90 days after sowing in each plot in two quadrates, each of 1 x 1m. Species–wise, weeds were counted and removed for recording their dry weight. Crop was manually harvested on first fortnight of October in all the years. The grain yield data were recorded and adjusted to 14% of the moisture content. Data on weed count were subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis. Data were analyzed using ANOVA, and the least significant difference (LSD) values at 5% level of significance were calculated and used to test significant difference between treatment means. At harvest, grain and straw samples of rice were collected and analyzed for total N using a micro-Kjeldahl method, whereas total P and K were determined using sulphuric-nitric perchloric acid digest as suggested in Prasad and Rafey (1995). Nutrient removal was obtained by multiplying the N, P and K concentration (%) of grain and straw with their respective yield (kg/ha) and ultimately the nutrient uptake by grain and straw was sum up in order to obtain total nutrient uptake. Nutrient harvest index was computed using the formula given below:

$$\text{Nutrient harvest index} = \frac{\text{Uptake of a particular nutrient by the grain}}{\text{Total uptake of that nutrient in biomass}}$$

The weed index was calculated by using the following formula (Gill and Kumar 1969).

$$WI = \frac{YWF - Yt}{YWF} \times 100$$

where, WI = Weed index, YWF = Average yield of crop in weed free plot, Yt = Average yield of crop in treated plot.

Weed control efficiency (WCE) was calculated by using following formula (Mani *et al*. 1973 and Das 2008):

$$WCE(\%) = \frac{WP_U - WP_T}{WP_U} \times 100$$

where, $WP_U$ is the weed population (no./m$^2$) in unweeded plot and $WP_T$ is the weed population (no./m$^2$) in treated plot.

The post-harvest soil samples were collected from 0-20 cm depth in the fields for analyzing available nutrient status and analysed for their respective dry weights across treatments. Treatment-wise data were computed using the prevailing market price of inputs such as bispyribac-sodium ` 5800/- per litre, pyrazosulfuron ` 1000/- per kg and pendimethalin ` 600/- per litre, labour wages ` 164/ man-day and outputs, *viz*. rice foundation seeds ` 27/ kg and straw ` 4/kg. Economics were calculated based on the prevailing market price of the input and produce. Energy balance was computed based on the equivalent values of input and output in energy terms (MJ/ha) as per Mittal *et al*. (1985).

## RESULTS AND DISCUSSION

### Effect on weeds

The weed flora recorded from the unweeded control plots consisted of *Commelina* spp. (71%) and others (29%) as *Echinochloa crus-galli*, *E. colona, Cyperus iria*, *Eclipta alba*, *Fimbristylis* sp. and *Marsilea quadrifolia*. All herbicidal treatments significantly reduced population of weed compared to farmers' practice (**Table 1**). It was mainly because of effective weed control during early stages of crop growth. In farmers' practice (hand weeding twice at 30 and 60 DAT), weeds particularly *Commelina* were not controlled due to its deep-tap root system and faster regrowth soon after weeding as well as cutting also having capacity to reproduce self. Application of bispyribac-sodium being at par with pyrazosulfuron and pendimethalin spray significantly reduced weed density and dry weight of total weeds compared to other treatments and resulted in the highest weed control efficiency (93.8%). Similarly, spray of pyrazosulfuron 20 g/ha resulted in the lowest weed index (3.2) in comparison to other treatments. Dry weight of *C. benghalensis* was remained at par with all herbicidal treatments while it was significantly lesser with application of bispyribac sodium over farmers' practice. Total weed dry weight was significantly less with all herbicidal treatments in comparison to farmers' practice, however, individual application of bispyribac-sodium behaved similarly in terms of weed population and biomass. Shukla *et al.* (2014) also observed the same results in similar agro-climatic conditions.

### Effect on rice

Lesser weed-crop competition due to effective control of weeds (**Table 2**) in all herbicidal treatments resulted in significant improvement in crop growth, yield attributes and grain yield of rice in comparison to farmers' practice due to spray of bispyribac sodium which managed both broad-leaved weeds as well as other weeds. Among herbicidal treatments, application of bispyribac produced significantly higher panicles/m$^2$ of rice over other herbicidal treatments due to lesser crop-weed competition (Singh *et al.* 2013).

In **Table 2**, year-wise yield data is presented with different treatment applications. Results from **Table 4** indicated that among all herbicidal treatments, bispyribac-Na 20 g/ha reported highest grain yield among all other treatments. However, there were no significant difference between pyrazosulfuron 20 g/ha and bispyribac-Na 20 g/ha in all the years. Further, application of bispyribac-Na 20 g/ha produced the highest yield attributes among all herbicidal treatments which concurrently recorded the highest average grain yield of rice (65% higher over farmers' practice). Grain yield of rice had a significant negative correlation (0.51 to 0.99) with weed parameters such as total weed population/m$^2$, total dry matter production (DMP) of weeds and N removal by the weeds, as well as a positive linear correlation with rice DMP and N uptake (0.97 and 0.39) (**Table 4**). Data on straw yield also showed same trend. Further, association between weeds, yield parameters and grain yield was also confirmed through correlation as given by Shukla *et al.* (2014).

### Economic returns

Due to higher crop yields and low cost of herbicides application over farmers' practice of expensive manual weeding, all herbicidal treatments produced higher net returns and B: C ratio (**Table 2**). Application of bispyribac-Na produced higher net returns (` 31820/ha) and B:C ratio (3.15) which was ` 15500/-and 1.56, respectively in farmers' practice. This was mainly due to higher cost of cultivation due to high cost involved in hand weeding and poor grain yield in farmers' practice. These findings are in confirmation with the findings of Singh *et al.* (2013).

### Nutrient uptake by weeds and rice

Unweeded control recorded the highest N, P and K by weeds (**Table 3**) mainly because of higher dry matter accumulation by weeds which enabled them to absorb more nutrients in this treatment. Application of bispyribac-sodium recorded significantly the lowest N, P and K uptake by weeds over other treatments due to efficient control of weeds. Similar results were also reported by Kolo and Umaru (2012). Similarly,

**Table 1. Effect of different weed control treatments on density and dry weight of weeds, weed control efficiency and weed index in rice at 90 DAS (mean data of five farmers' fields)**

| Treatment | Weed density (no./m$^2$) | | | Dry weight of weed (g/m$^2$) | | | Weed control efficiency (%) | Weed index (%) |
|---|---|---|---|---|---|---|---|---|
| | *Commelina benghalensis* | Others | Total | *Commelina benghalensis* | Others | Total | | |
| Pendimethalin 1.5 kg/ha as PE | 4.7(21.4) | 3.9(14.9) | 6.1(36.4) | 3.5(12.1) | 3.8(13.9) | 5.1(26.0) | 78.8 | 7.9 |
| Bispyribac-sodium 20 g/ha PoE | 3.2(9.8) | 2.2(4.3) | 3.8(14.1) | 2.7(6.9) | 2.1(4.1) | 3.4(11.0) | 93.8 | - |
| Pyrazosulfuron 20 g/ha as PoE | 3.4(11.1) | 3.3(10.3) | 4.7(21.4) | 3.4(10.8) | 3.1(9.0) | 4.5(19.8) | 89.9 | 3.2 |
| Unweeded control | 8.5(71.4) | 5.4(29.2) | 10.0(10.6) | 10.0(99.7) | 5.4(28.8) | 11.3(128.4) | - | 27.8 |
| Two hand weedings at 30 and 60 DAT | 8.5(72.6) | 5.9(34.7) | 10.4(107.3) | 4.7(21.6) | 5.9(34.1) | 7.5(55.7) | 59.7 | 17.7 |
| LSD (p=0.05) | 1.41 | 1.23 | 2.1 | 1.75 | 1.58 | 1.39 | - | - |

*Figures in parentheses are original values; data were transformed through ($\sqrt{x+0.5}$); PE = Pre-emergence; PoE = Post-emergence

**Table 2. Effect of weed control treatments on yield attributes, grain yield and economics of rice**

| Treatment | Panicles/ m$^2$ | Grains/ panicle | 1000-grain weight (g) | Grain yield (t/ha) | | | | Gross return (x10$^3$ `/ha) | Net return (x10$^3$ `/ha) | B:C ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2014-15 | 2015-16 | 2016-17 | Average grain yield | | | |
| Pendimethalin 1.5 kg/ha as PE | 178 | 58.71 | 25.01 | 2.21 | 2.09 | 2.39 | 2.23 | 47.99 | 25.90 | 2.25 |
| Bispyribac-sodium 20 g/ha as PoE | 229 | 76.8 | 32.12 | 3.49 | 3.61 | 3.27 | 3.46 | 58.82 | 31.82 | 3.15 |
| Pyrazosulfuron 20 g/ha as PoE | 201 | 65.43 | 29.82 | 3.16 | 3.00 | 3.2 | 3.12 | 53.04 | 26.54 | 2.31 |
| Unweeded control | 140 | 42.10 | 17.22 | 1.08 | 1.07 | 1.19 | 1.11 | 32.47 | 10.42 | 1.26 |
| Two hand weedings at 30 & 60 DAT | 152 | 50.21 | 21.09 | 2.01 | 1.98 | 2.3 | 2.10 | 37.59 | 15.50 | 1.56 |
| LSD (p=0.05) | 89 | 10.2 | 8 | 0.88 | 0.95 | 0.99 | 0.94 | - | - | - |

PE = Pre-emergence; PoE = Post-emergence

**Table 3. Effect of different weed control treatments in rice on nutrient uptake by weeds and rice (mean data of three years)**

| Treatment | Nutrient uptake by weeds (kg/ha) | | | Nutrient uptake by rice (kg/ha) | | |
|---|---|---|---|---|---|---|
| Pendimethalin 1.5 kg/ha as pre-emergence | 8.2 | 1.9 | 10.2 | 55.7 | 9.6 | 47.8 |
| Bispyribac-sodium 20 g/ha post-emergence | 5.8 | 1.1 | 6.9 | 65.9 | 10.8 | 54.9 |
| Pyrazosulfuron 20 g/ha as post-emergence | 7.6 | 1.6 | 9.7 | 61.3 | 10.2 | 52.1 |
| Unweeded control | 15.2 | 2.8 | 24.4 | 51.4 | 9.1 | 41.8 |
| Two hand weedings at 30 and 60 DAT | 12.8 | 2.3 | 18.3 | 53.1 | 9.3 | 43.2 |
| LSD (p=0.05) | 3.1 | 0.7 | 2.4 | 8.2 | 0.9 | 5.9 |

**Table 4. Correlation between grain yield and weed parameters in rice (mean data of three years)**

| y | x | Correlation coefficient (r) (n=25) |
|---|---|---|
| Grain yield (kg/ha) | Total weed population/m$^2$ | -0.51* |
| Grain yield (kg/ha) | Total weed DMP (g/m$^2$) | -0.85** |
| Grain yield (kg/ha) | N removal by weed (kg/ha) | -0.99** |
| Grain yield (kg/ha) | Rice DMP (g/m$^2$) | 0.97** |
| Grain yield (kg/ha) | N uptake by rice (kg/ha) | 0.39 |

DMP: Dry matter production; *Significant at 5% level of significance; **Significant at 1% level of significance

N, P and K uptake by rice (grain and straw) were significantly higher in treatment involving application of bispyribac over farmers' practice because of greater weed control due to their lower density and dry weight of weeds and higher grain and straw yields (**Table 3**). The lower N, P and K uptake by weeds allowed rice to grow more vigorously and accumulate more dry matter, which consequently led to higher uptake of these nutrients. Kolo and Umaru (2012) also reported that N uptake by grain and straw was inversely proportional to the nutrient depletion by weeds supports our finding on nutrient uptake by rice and weeds. It can be concluded from present investigation that *C. benghalensis* and other associated weeds of transplanted rice in the Kymore Plateau Satpura Hills Region of Katni district of Madhya Pradesh conditions can be effectively managed with the spray of bispyribac-sodium (20 g/ha) at 20-21 DAT.

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