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# Bio Efficacy Evaluation of Bentazone against Major Weeds of Rice Grown in Direct Seeded Condition of South Eastern Rajasthan, India

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**A B S T R A C T**

A field experiment was carried out at Agricultural Research Station, Kota, Rajasthan during rainy (*Kharif*) season of 2016 and 2017, to evaluate bio efficacy of bentazone against major weeds of rice grown in direct seeded condition of south eastern Rajasthan. Treatments included post emergence application of bentazone @ 0.6 to 1.6 kg a.i/ha, 2,4 D@ 0.38 kga.i/ha, hand weeding twice (20 and 40 DAS) and weedy check, was laid out in randomized block design with three replications. The pooled data of two years revealed that application of bentazone @ 1.2 kg a.i/ha resulted in significantly higher weed control efficiency, plant height, dry matter accumulation at 45 DAS and at harvest, tillers/plant, panicles/plant, panicles length, panicle weight/plant, grains/panicle and test weight, grain and straw yield, net return and B:C ratio than weedy check without any residual effect on succeeding wheat crop. However, maximum, growth and yield attributes, grain and straw yields, net return and B:C ratio were recorded in hand weeding twice at 20 and 40 DAS in paddy as compared to all weed management practices of herbicides.

## Introduction

Rice (*Oryza sativa* L.) is staple food of more than 60 % of world's population and grown as a *kharif* cereal crop in South-Eastern Rajasthan. It is also grown in different agro-ecosystems and physical condition of soil. Cultivation of transplanted rice in different parts of India is most popular, but it is highly labour intensive and expansive method, requiring huge quantities of water for puddling, transplanting and establishment of rice seedling. Most of the farmers in south-eastern Rajasthan are marginal and face many problems in carrying out these operations. Besides these unpredictable and insufficient monsoon rains greatly affect the rice productivity. Direct seeding in non-puddled condition eliminates the need of raising, maintaining and subsequent transplanting of seedlings. Direct-seeded rice crop is subjected to more weed competition for light, nutrient, water and space than transplanted rice. Hence, direct seeded rice, control of weeds is utmost important to reduce the weed competition and to enhance crop productivity. Yield reduction

in rice due to weeds is about 50-90 per cent. Therefore, weed control is an important management practice for rice production that should be carried out to ensure optimum rice yield. Weeds are one of the severest constraints to widespread adoption of aerobic direct-seeded rice (Sreedevi *et al.*, 2018).

Most of the herbicides available and used by the farmers for controlling weeds in rice are Pre-emergence (PE). However, these applications control weeds in rice crop but there are so many limitations in their ways of efficacy requires various pre-requisites i.e. ideal soil moisture, temperature, mixing in soil and if not fulfilled, thereby hampering their efficacy. Besides this, many weed species do not germinate at the planting time and have un-germinated reserve seeds in the soil which germinate in the staggered manner in direct-seeded rice crop. The pre emergence herbicides are unable to take care of weeds completely as these are applied indiscriminately and injudiciously as such likewise blind application without due consideration of specific weed species prevails in the specific field in a specific period of time. Looking to the facts it is envisaged that, post emergence herbicides can provide a better choice to the direct- seeded rice growers according to the efficacy to control specific or mixed weed flora, having more flexibility to controlling weeds in rice crop. In view of the above facts, it is envisaged that, there is an urgent need to find out the effective post emergence herbicide to overcome the problem of weeds in direct-seeded rice without any adverse effect. Hence, an experiment was planned to bio efficacy evaluation of Bentazone against major weeds of rice grown in direct seeded condition of south eastern Rajasthan.

## Materials and Methods

The field experiment was conducted during rainy seasons of 2016 & 2017 at Agricultural Research Station, Kota (26º North latitude, 76º-6' East longitude and 260 m above mean sea level), Rajasthan. The study area falls under humid south eastern plain zone of Rajasthan. The soil of the experimental field was in order of vertisols having bulk density 1.51 $Mg/m^3$, pH 7.76 and Cation exchange capacity 35 Cmol/kg. The soil had a very low infiltration rate (0.25 cm/hr) on surface but at deeper layer (1.2 to 1.5 m) was impermeable. The potential moisture retention capacity of soil is 120 mm of water in 1 m depth. The soil of the experimental field was medium in organic carbon 5.5 g/kg, available nitrogen (280 kg/ha), available phosphate (22.8 kg $P_2O_5$/ha) and high in available potash (315 kg $K_2O$ /ha). The maximum and minimum temperature during the paddy crop period ranged $36.3^0$C&$21.9^0$C in 2016 and $34.6^0$C&$15.3^0$C in 2017, respectively. The effective rainfall received during the growing seasons of 2016 and 2017was823 mm and 341 mm, respectively. Irrigation requirement of the crop was fulfilled by ground water irrespective of rainfall.

The experiment was laid out in randomized block design with 3 replications. Treatments comprised *viz*; $T_1$: Bentazone @0.6 kga.i/ha; $T_2$: Bentazone@0.8 kga.i/ha; $T_3$: Bentazone@ 1.0 kg a.i/ha; $T_4$: Bentazone@ 1.2 kg a.i/ha; $T_5$: Bentazone@ 1.6 kg a.i/ha; $T_6$: 2,4-D @ 0.38 kg/ha; $T_7$: Hand weeding twice (20 & 40 DAS) and $T_8$:Weedy Check (Unweeded). All the herbicides were applied as Post emergences (POE) at 2-6 leaf stage in standing paddy crop.Recommended package of practices viz. high yielding variety (Pusa sugandha-4), crop geometry (20 cm x 10 cm), seed rate (30 kg/ha), seed treatment, recommended dose of fertilizer (120:60:40: NPK.Paddy crop was sown directly in unpuddled condition on 17 and 7 July and harvested on 5 and 1 November in 2016 and 2017, respectively. All the plant protection measures were adopted to ensure healthy crop. Basal application of nitrogen and full

doses of P and K were applied through diammonium phosphate and muriate of potash, respectively. The remaining nitrogen was top dressed as urea in two equal splits at tillering and before panicle initiation stage. A common basal dose of zinc sulphate (21 % Zn) @25 kg/ha was applied uniformely to all the plots. The required quantity of herbicide as per treatment was applied with manually operated knapsack sprayer using a spray volume of 500 liter water/ha. A thin film of water was maintained in the field at the time of application of herbicides. Weed density (number/$m^2$) and weed dry weight (g/$m^2$) were sampled randomly at 2 places in each plot with the help of 0.25 $m^2$ quadrates at 15, 30 and 45 days after sowing. Weed control efficiency (WCE) was also calculated on the basis of dry-matter production of weeds. Data were transformed using $\sqrt{X+0.5}$ before statistical analysis. Samples were oven dried at $70^0$C for 72 hr and dry weight was recorded. Plant height of rice was measured from the base of the plant at ground surface to the tip of the tallest leaf panicle using meter scale. Tillers number was noted by counting from sampling unit at harvesting stage. Dry matter accumulation was recorded in one meter square area of each plot. These samples were sun dried and further oven dried at $70^o$C till constant weight. The sun dried bundles were threshed and winnowed and seed so obtained was weighed. Total number of tillers and panicle bearing tillers of the marked 5 hills were counted at harvesting. The length of the panicle was measured from sample of 10 panicles drawn randomly from the marked 5 hills. Length was measured from neck to the tip of the panicle and average panicle length was computed. The selected 10 panicles, which were used for panicle length, also used to record the weight of the panicles and mean panicle weight was computed, and number of grains/panicle was counted. The selected panicles were cleaned and the filled and unfilled (chaffy) grains were separated. The 1,000-filled grains, taken from sampled panicles, were first counted by a seed counter and then weighed to compute the 1,000-grain weight. Straw yield was obtained by subtracting the seed yield from the biological yield. After harvesting, threshing, cleaning and drying, the grain yield of rice was estimated at 14 % moisture content. Yield was expressed in kg/ha. Gross and net returns were calculated based on the grain and straw yield and prevailing market prices of rice in respective seasons. The benefit: cost ratio was calculated by dividing the net returns from the total cost of cultivation. All the observation were statistically analyzed for its test of significance of the individual years and pooled over years through standard procedures.

To study persistence/phyto-toxicity of herbicides, wheat was sown with 100 kg/ha seed rate in *Rabi* season of 2016-17 and 2017-18 as succeeding crop after harvesting of paddy crop. Wheat crop was raised as irrigated condition with full package of practices and harvested to record tillers/plant and grain yield.

## Results and Discussion

### Weeds

During investigation, rice was infested mainly with grassy weeds viz; *Cynadon dactylon* (L.) Pers, *Echinocloa colonum*, *Cyperus rotundus* (L.) (sedge) *and broad leaved weeds viz; Trianthema monogyana, Digera arvensis, Celosia argentia, Amaranthus viridis, Commelina bengalensis.* All the weed control treatment substantially reduced the weed count and their dry weight at 15, 30 and 45 days after sowing (DAS) of observations as compared to weedy check (Table 1). Lowest weed count and their dry weight and highest weed control efficiency at all the stages of observations were observed with hand

weeding twice at 20 &40 DAS. Significantly lower and minimum weed dry weight (68.6, 71.0 & 68.3 g/m$^2$) and maximum weed control efficiency (49.9, 51.4 & 54.1 %) were recorded at 15, 30 & 45 days after application (DAA), respectively with application of Bentazone 48 % SL @ 1.6 kg kga.i./ha over its lower doses i.e. 0.6, 0.8, 1.0 kg a.i./ha & weedy check and being on par with Bentazone 48 % SL @ 1.2 kg kga.i./ha. However, application of 2,4-D 38 % EC @ 0.38 kg a.i./ha as post emergence (Standard Check) was found also statistically on par with Bentazone 48 % SL @ 0.6 kg kga.i./ha with respect to weed dry weight and weed control efficiency. The highest weed control efficiency may be due to effective control of weeds which indicated lower weed count and their dry weight at different stages of observations. The variation in weed count and their dry weight and weed control efficiency might be due to differences in effectiveness of herbicides against weeds in field. The similar results were also reported by Murthy and Reddy (2013).

## Growth and yield attributes

A perusal of data (Table 2) revealed that application of graded dose of Bentazone 48 % SL @ 0.6 to 1.6 kg a.i./ha had significant effect on growth and yield attributing characters of the paddy crop grown in direct seeded condition.

Application of Bentazone 48 % SL @ 1.6 kg a.i./ha gave significantly maximum plant height (85.4 cm), dry matter accumulation at 45 DAS (418.7 g/m$^2$) and harvest (587.6 g/m$^2$), total tillers/plant (3.99), effective tillers/plant (3.90), panicles/plant (3.97), panicle length (23.8 cm), panicle weight (1.73 g) and grains/panicle (53) as compared to weedy check and statistically on par with Bentazone 48 % SL @ 1.2 kg a.i./ha. Application of Bentazone 48 % SL @ 0.8 kg a.i./ha also remained statistically on par with 2,4-D 38 % EC @ 0.38 kg a.i./ha as PoE which was standard Check in relation to growth and yield attributing characters. However, hand weeding twice at 20 & 40 DAS proved effective for managing weed competition in paddy compared to weedy check. This was owing to significant reduction in weed density and weed dry weight. Effective control of weeds with Bentazone 48 % SL @ 1.6 kg a.i./ha as post emergence application (PoE) might have resulted in growth and yield attributing characters of the paddy crop, which reduces the water and nutrients uptake by weeds. Severe weed infestation decreased the growth and yield attributes in weedy check. These results are in accordance with the finding of Singh and Singh (2010) and Narolia *et al.*, (2014).

## Yields

Among herbicides treatments, higher grain and straw yields were recorded with the Bentazone 48 % SL @ 1.6 kg a.i./ha. Application of Bentazone 48 % SL @ 0.6, fb 0.8 and 1.0 kg a.i/ha were found significantly superior remained statistically on par with each other in enhancing grain and straw yields as compared to unweeded control, However, maximum grain and straw yields were recorded in hand weeding twice at 20 & 40 DAS in paddy as compared to all weed management practices of herbicides. Thus, application of Bentazone 48 % SL @ 1.2 kg a.i/ha increased grain and straw yields by 143.7,144.2 and 32.3,31.9 % over unweeded control and 2,4-D 38 % EC @ 0.38 kg a.i./ha, respectively. Weed management practices did not influence on test weight and harvest index. The increased grain and straw yields by Bentazone 48 % SL @ 1.2 kg a.i/ha were owing to reduced weed density, weed dry weight and higher weed control efficiency resulted higher panicle/unit area (Table 2).

**Table.1** Effect of herbicides application on weed count, dry weight and weed control efficiency in direct seeded rice (Pooled data of 2016 & 2017)

| Treatment | Total weed count (Nos/$m^2$) | | | Total weed dry weight ($g/m^2$) | | | Weed control efficiency (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 15 DAA | 30 DAA | 45 DAA | 15 DAA | 30 DAA | 45 DAA | 15 DAA | 30 DAA | 45 DAA |
| Bentazone 48 % SL @ 0.6 kg a.i./ha as PoE | 235 | 241 | 243 | 110.39 | 115.9 | 110.18 | 20.26 | 20.88 | 26.26 |
| Bentazone 48 % SL @ 0.8 kg a.i./ha as PoE | 195 | 204 | 208 | 82.28 | 85.95 | 86.88 | 40.27 | 41.32 | 42.24 |
| Bentazone 48 % SL @ 1.0 kg a.i./ha as PoE | 155 | 162 | 164 | 78.95 | 82.89 | 83.50 | 42.67 | 43.28 | 44.04 |
| Bentazone 48 % SL @ 1.2 kg a.i./ha as PoE | 113 | 118 | 120 | 77.61 | 81.29 | 82.55 | 43.64 | 44.37 | 44.68 |
| Bentazone 48 % SL @ 1.6 kg a.i./ha as PoE | 95 | 100 | 101 | 68.60 | 71.00 | 68.33 | 49.91 | 51.42 | 54.15 |
| 2,4-D 38 % EC @ 0.38 kg a.i./ha as PoE(Standard Check) | 225 | 233 | 235 | 116.94 | 119.40 | 120.61 | 15.26 | 18.33 | 19.20 |
| Hand weeding Twice at 20 & 40 DAS | 59 | 60 | 62 | 38.05 | 38.32 | 37.68 | 72.52 | 74.02 | 74.95 |
| Weedy Check | 280 | 290 | 294 | 138.78 | 146.50 | 149.55 | 0.00 | 0.00 | 0.00 |
| SEm± | 36.41 | 36.71 | 35.5 | 3.78 | 4.02 | 5.46 | 2.57 | 2.54 | 3.39 |
| C.D. (P=0.05) | 105.5 | 106.3 | 102.8 | 10.9 | 11.6 | 15.81 | 7.43 | 7.35 | 9.8 |

*DAA- Days after applications

**Table.2** Effect of herbicides application on growth and yield attributes of direct seeded rice (Pooled data of 2016 & 2017)

| Treatment | Plant height at harvest (cm) | DM at 45 DAS ($g/m^2$) | DM at harvest ($g/m^2$) | Tillers/ plant at harvest | Effective tillers/plant at harvest | Panicle length (cm) | Panicles/plant | Panicle weight (g) | Grains/ Panicle |
|---|---|---|---|---|---|---|---|---|---|
| Bentazone 48 % SL @ 0.6 kg a.i./ha as PoE | 74.4 | 362.0 | 377.6 | 3.14 | 3.00 | 23.4 | 2.87 | 1.52 | 34 |
| Bentazone 48 % SL @ 0.8 kg a.i./ha as PoE | 76.8 | 384.6 | 415.4 | 3.54 | 3.48 | 23.5 | 3.51 | 1.55 | 37 |
| Bentazone 48 % SL @ 1.0 kg a.i./ha as PoE | 79.6 | 395.9 | 454.1 | 3.67 | 3.60 | 23.5 | 3.65 | 1.59 | 41 |
| Bentazone 48 % SL @ 1.2 kg a.i./ha as PoE | 84.6 | 406.4 | 564.4 | 3.76 | 3.68 | 23.6 | 3.72 | 1.64 | 52 |
| Bentazone 48 % SL @ 1.6 kg a.i./ha as PoE | 85.4 | 418.7 | 587.6 | 3.99 | 3.90 | 23.8 | 3.97 | 1.73 | 53 |
| 2,4-D 38 % EC @ 0.38 kg a.i./ha as PoE(Standard Check) | 63.8 | 308.8 | 427.1 | 3.35 | 3.50 | 23.5 | 3.30 | 1.57 | 37 |
| Hand weeding Twice at 20 & 40 DAS | 94.0 | 449.4 | 672.4 | 6.00 | 5.22 | 24.1 | 5.91 | 2.28 | 69 |
| Weedy Check | 69.1 | 340.3 | 231.3 | 2.90 | 2.80 | 22.9 | 3.06 | 1.11 | 29 |
| SEm± | 2.81 | 18.39 | 21.8 | 0.13 | 0.42 | 0.57 | 0.11 | 0.155 | 2.65 |
| C.D. (P=0.05) | 8.1 | 53.3 | 63.1 | 0.37 | 1.22 | NS | 0.33 | 0.45 | 7.7 |

DM= dry matter accumulation

**Table.3** Effect of herbicides application on test weight, grain and straw yield, net return and B: C ratio of direct seeded rice (Pooled data of 2016 & 2017)

| Treatment | Test weight (g) | Grain yield (kg/ha) | Straw yield (kg/ha) | HI (%) | Cost of cultivation (Rs./ha) | Gross return (Rs./ha) | Net return (Rs./ha) | B:C ratio | Effect on succeeding wheat crop | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Effective tillers/$m^2$ | Grain yield (kg/ha) |
| Bentazone 48 % SL @ 0.6 kg a.i./ha as PoE | 24.8 | 1663 | 2112 | 44.02 | 29700 | 56200 | 23678 | 1.89 | 104 | 5820 |
| Bentazone 48 % SL @ 0.8 kg a.i./ha as PoE | 24.7 | 1823 | 2330 | 43.95 | 30402 | 61601 | 28683 | 2.03 | 102 | 5870 |
| Bentazone 48 % SL @ 1.0 kg a.i./ha as PoE | 24.9 | 1990 | 2551 | 43.75 | 30995 | 67258 | 37201 | 2.17 | 103 | 5934 |
| Bentazone 48 % SL @ 1.2 kg a.i./ha as PoE | 24.7 | 2481 | 3162 | 43.98 | 31650 | 83876 | 51085 | 2.65 | 103 | 5930 |
| Bentazone 48 % SL @ 1.6 kg a.i./ha as PoE | 24.9 | 2574 | 3302 | 43.87 | 32898 | 87048 | 53448 | 2.65 | 102 | 5978 |
| 2,4-D 38 % EC @ 0.38 kg a.i./ha as PoE(Standard Check) | 24.7 | 1875 | 2396 | 43.94 | 28250 | 63344 | 35826 | 2.24 | 101 | 6015 |
| Hand weeding Twice at 20 & 40 DAS | 24.9 | 2948 | 3777 | 43.95 | 37350 | 99693 | 62289 | 2.67 | 103 | 5930 |
| Weedy Check | 24.6 | 1018 | 1295 | 43.99 | 27750 | 34331 | 6589 | 1.24 | 100 | 6012 |
| SEm± | - | 81.35 | 105.9 | - | - | 2729 | 1892 | 0.091 | 2.11 | 100 |
| C.D. (P=0.05) | NS | 235.6 | 306.7 | NS | - | 7905 | 5480 | 0.26 | NS | NS |

The minimum yield and yield attributes in unweeded check were the result of severe weed competition. Maity and Mukherjee (2008) and Sreedevi *et al.,* (2018) also reported similar results.

## Economics

Implication of any weed management practices results in better monetary return when compared with weedy check. Unweeded control was observed as a futile practice, as it gave only Rs. 6598/ha against investment of Rs. 27750/ha. Application of Bentazone 48 % SL @ 1.2 kg a.i./ha resulted in significantly maximum net return (Rs. 51085/ha) and B:C ratio (2.65 than other doses of Bentazone. However, maximum net return and B:C ratio was found in hand weeding twice at 20&40 DAS of paddy crop. The lowest net return and B:C ratio obtained in weedy check were due to high infestation of weeds resulting in low weed control efficiency. These results are in conformity with those reported by Narolia *et al.*, 2014 and Maity and Mukherjee (2008).

## Residual effect of herbicides

Application of bentazone @ 0.6 to 1.6 kg a.i/ha in paddy crop as post emergence did not have any adverse effect on succeeding wheat crop in relation to tillrs/$m^2$ and grain yield of wheat (Table 3). The similar results were also reported by Billore (2017) Mishra and Singh, (2009) in soybean.

On the basis of two years pooled data results, it could be concluded that in rice-wheat cropping sequence, weeds in rice can be managed by post emergence application of Bentazone @ 1.2 kg a.i/ha at 2 to 6 leaf stage of weeds without any harmful carry over effect on the succeeding wheat crop.

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