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Bio-efficacy of bentazone 48% SL as post-emergence against weeds in direct-seeded rice

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ABSTRACT

The experiment was conducted during *Kharif* season of 2017 at Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. The soil of experimental site was sandy clay loam in texture, medium in organic carbon (0.62%), available nitrogen (285 kg/ha), available phosphorus (17.45 kg/ha) and potassium (260 kg/ha) with neutral pH (7.1). The dominant weeds associated with direct-seeded rice in the experimental field were mainly comprised of monocot (*Echinochloa colona*), sedge (*Cyperus iria*) and dicot weeds (*Mollugo pentaphylla*, *Phylanthus niruri*, *Eclipta alba*, *Corchorus olitorius* and *Alternanthera philoxeroides*).Experiment consisted of total ten treatments comprising of seven doses of bentazone 600, 800, 1000, 1200, 1600, 1800 and 2000 g/ha, 2,4-D 380 g/ha as post-emergence, hand weeding twice (20 and 40 DAS) including weedy check, were laid out in a randomized block design with 3 replications. The post-emergence application of bentazone at higher doses *i.e.* 1800 and 2000 g/ha was found effective in reducing the weed density of dicot weeds to a great extent.

Rice (*Oryza sativa* L.) is the most important staple food crop of millions of mankind from the dawn of civilization. India is the 2nd largest producer and consumer of rice in the world. Rice provides 50-80% daily calorie intake to the consumer (Choudhary *et al*. 2011). In India, it is grown in nearly 43.39 mha area with the production of 104.32 MT and productivity of 2404 kg/ha. In Madhya Pradesh, it occupies an area of 2.02 mha with production of 3.58 MT and productivity of 1768 kg/ha (Anonymous 2016).

Direct seeding of rice (DSR) has more benefits as compared to traditional transplanting like easier planting, timely sowing, less drudgery, early crop maturity by 7 to 10 days, less water requirement better soil physical condition for next crop and low production cost and more profit. Weeds are the number one biological constraint and major threat to the production and adoption of DSR system (Chauhan 2012) and can cause yield losses up to 50 per cent and the risk of yield loss is greater than transplanted rice and as high as 50-90% (Chauhan and Opena 2012a). Use of herbicides to keep the crop weed free at critical crop weed competition stages will help in minimizing the cost of weeding as well as managing the weeds below the damaging level. Hand weeding is very easy and environment-friendly but tedious and highly labour intensive. Farmers very often fail to remove weeds due to unavailability of labour at peak periods. Therefore, hand weeding becomes difficult at early stages of growth due to morphological similarity.Generally pre-emergence herbicides like pretilachlor, butachlor, anilophos, and post-emergence herbicides like 2,4-D, Almix and Bispyribac-Na are used frequently to control grassy and broad-leaf weeds in DSR. Continuous application of these herbicides may also result in weed flora shift and development of herbicidal resistance in weeds. This situation warrants for initiating research efforts to develop and evaluate new and alternate herbicides to overcome the problem of herbicidal resistance in weeds.

Bentazone has been found effective post-emergence herbicide for controlling broad-leaf weeds in soybean in different parts of the country. In this context, the effectiveness of bentazone in case of DSR at different doses was planned to be evaluated in present investigation.

The present experiment was conducted at Product Testing Unit, Adhartal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). during *Kharif* 2017. Ten treatments, *viz*. bentazone at

different doses (600, 800, 1000, 1200, 1600, 1800 and 2000 g/ha) and 2,4-D 380 g/ha as well as hand weeding at 20 and 40 DAS and weedy check were evaluated. Experiment was laid out in a randomized block design with three replications. All herbicides were applied using knap-sack sprayer fitted with flat-fan nozzle at spray volume of 500 l/ha at 15 days after sowing. Sowing of seeds in each plot was done in rows 20 cm apart atthe depth of 2-3 cm on July 7th 2017. The crop was raised by following recommended packages of practices for rice. The data on weed density and weed dry weight were collected from each unit plot before application, 15, 30, 45 DAA and at harvest by quadrate count method. The quadrate of 0.25 square meters' (0.5 x 0.5 m) was placed randomly twice or thrice and weed species within the quadrate were identified and their number was counted. The weeds uprooted, cleaned and then oven dried for further investigation. Dry matter of weeds was recorded. The data on weed count and weed biomass were subjected to square root transformation i.e. $\sqrt{x+0.5}$, before carrying out analysis of variance and comparisons were made on transformed values. Weed control efficiency (WCE) was calculated on the basis of weed biomass as per the formula recommended by Mani *et al*. (1968).

Effect on weeds

Weed density of grassy weeds and sedge was not affected due to different weed control treatments except in hand weeding treatments, where weeds were uprooted manually. Weed density was almost similar in all the herbicidal treatments including weedy check plots where no herbicides were applied (**Table 1**). It was observed that different weed control treatments did not cause any adverse effect on weed density of the grassy weeds. However, hand weeding twice reduced the density of grassy weeds to the maximum extent and was appreciably superior over all the weed control treatments (**Table 1**).

Weed control treatments caused significant reduction in the density of broad-leaf weeds like *Mullogo pentaphylla, Phylanthus niruri, Eclipta alba, Corchorus olitorius* and *Alternanthera philoxeroides* on the application of the herbides (**Table 1**). The density of these weeds was maximum under weedy check plots where no herbicides were applied. The application of bentazone at different doses (600 and 2000 g/ha) and 2,4-D (380 g/ha) caused reduction in the density of broad-leaf weeds and proved significantly superior to weedy check plots where weeds were not controlled throughout the growing season. However, none of the herbicidal treatments surpassed the hand weeding twice which reduced the density of dicot weeds to the maximum extent. Almost similar views were endorsed by Tiwari and Mathew (2002), Christopher *et al.* (2005) and Zeinab and Saeedipur (2015).

Effect on dry weight of weeds

The dry weight of monocot weeds were not affected due to various herbicidal treatments. Dry weight was almost similar in all the herbicidal treatments including weedy check plots where weeds were not controlled by any means (**Table 2**). However, hand weeding twice at 20 and 40 DAS was found superior to other herbicidal treatments as it curbed the dry weight of monocot weeds to great extent. Data on dry weight of broad-leaf weeds at 30 days after application (DAA) under different weed control treatments are shown in **Table 2**. All the weed control treatments including hand weeding twice had significantly reduced the dry weight of broad-leaf weeds when compared with the weed control

Table 1. Density of grassy weed, sedge and broad-leaf weeds at different intervals as influenced by different treatments

Treatment	Weed density (m^2)/ 30 days after application						
	Grassy weed	Sedge	Broad-leaf weeds				
	Echinochloa colona	*Cyperus iria*	*Mollugo pentaphylla*	*Phylanthus niruri*	*Eclipta alba*	*Corchorus olitorius*	*Alternanthera philoxeroides*
Bentazone 600 g/ha	7.40(54.25)	5.96(35.00)	4.04(16.08)	3.58(12.33)	2.74(7.00)	2.77(7.17)	2.94(8.17)
Bentazone 800 g/ha	7.46(55.17)	5.92(34.58)	3.94(15.00)	3.39(11.00)	2.58(6.17)	2.55(6.00)	2.74(7.00)
Bentazone 1000 g/ha	7.51(55.83)	5.91(34.42)	3.83(14.17)	3.25(10.08)	2.35(5.00)	2.40(5.25)	2.60(6.25)
Bentazone 1200 g/ha	7.41(54.42)	5.93(34.67)	3.65(12.83)	3.05(8.83)	2.20(4.33)	2.27(4.67)	2.50(5.75)
Bentazone 1600g/ha	7.48(55.50)	6.01(35.67)	3.39(11.00)	2.77(7.17)	1.87(3.00)	1.94(3.25)	2.12(4.00)
Bentazone 1800 g/ha	7.42(54.58)	5.90(34.33)	3.26(10.08)	2.55(6.00)	1.73(2.50)	1.73(2.50)	1.89(3.08)
Bentazone 2000 g/ha	7.50(55.75)	5.94(34.83)	2.25(6.00)	2.12(4.00)	1.55(1.92)	1.58(2.00)	1.41(1.50)
2,4-D 380 g/ha	7.51(55.92)	5.99(35.42)	3.54(12.00)	2.93(8.08)	2.06(3.75)	2.12(4.00)	2.35(5.00)
Hand weeding (20 and 40 DAS)	1.52(1.83)	1.44(1.58)	1.35(1.33)	1.38(1.42)	1.29(1.17)	1.26(1.08)	1.22(1.00)
Weedy check	7.49(55.58)	6.00(35.50)	7.47(55.33)	6.79(45.67)	5.99(35.33)	5.85(33.67)	5.55(30.33)
LSD(p=0.05)	0.15	0.09	0.08	0.06	0.10	0.10	0.07

Figures in parentheses are original values

treatments. Maximum dry weight of dicot weeds was recorded under weedy check plots (5.56, 4.83, 4.26, 4.55 and 4.11 g/m^2) due to uninterrupted growth of weeds during critical period of crop-weed competition. Post-emergence application of bentazone at different doses (600 to 2000 g/ha) and check herbicide 2,4-D (380 g/ha) reduced the dry weight of broad-leaf weeds. However, hand weeding twice was appreciably superior among all the weed control treatments in reducing the dry weight of *Mollugo pentaphylla*, *Phylanthus niruri, Eclipta alba, Corchorus olitorius* and *Alternanthera philoxeroides* (0.94, 0.96, 0.91, 0.93 and 0.89 g/m^2 respectively) to a great extent. Singh *et al.* (2012) and Chauhan and Opena (2013) also made similar observations and reported minimal density and dry weight of weeds under hand weeding.

The weed control efficiency was maximum (98.3%) under hand weeding twice. Whereas weed control efficiency on the application of bentazone 800 g/ha was 81.37%, which increases when applied at higher doses *i.e.* 1000, 1200, 1600, 1800 and 2000 g/ha (83.92, 85.38. 89.38, 91.67 and 94.99%, respectively) in case of dicot weeds but higher doses are not economically feasible. The similar observations weremade by Soni *et al.* (2012).

Effect on yield

Growth parameters of rice were higher in plots receiving bentazone 800 g/ha among all the herbidal treatments. Whereas, maximum values of these parameters and dry matter accumulation in plants were recorded under hand weeding twice (20 and 40) due to complete elimination of weeds (**Table 3**). These findings were in conformity to those of Chandra and Solanki (2003) and Chauhan *et al.* (2013).

Among different weed control treatments significantly higher yield attributes were observed under hand weeding twice followed by bentazone as

Table 2. Dry weight of grassy weed, sedge and broad-leaf weeds at different intervals as influenced by different treatments

Treatment	Dry weight (m^2)/ 30 days after application						
	Grassy weed	Sedge	Broad-leaf weeds				
	Echinochloa colona	*Cyperus iria*	*Mollugo Pentaphylla*	*Phylanthus niruri*	*Eclipta alba*	*Corchorus olitorius*	*Alternanthera philoxeroides*
Bentazone 600 g/ha/ha	8.68(74.87)	6.83(46.20)	2.75(7.08)	2.43(5.40)	1.89(3.08)	2.07(3.80)	1.98(3.43)
Bentazone 800 g/ha	8.85(77.78)	6.79(45.65)	2.64(6.45)	2.24(4.52)	1.77(2.65)	1.90(3.12)	1.84(2.87)
Bentazone 1000 g/ha	8.87(78.16)	6.75(45.10)	2.51(5.80)	2.13(4.03)	1.62(2.12)	1.79(2.72)	1.71(2.43)
Bentazone 1200 g/ha	8.76(76.29)	6.80(45.76)	2.42(5.38)	2.00(3.52)	1.52(1.81)	1.70(2.38)	1.60(2.07)
Bentazone 1600 g/ha	8.81(77.15)	6.92(47.44)	2.15(4.13)	1.79(2.72)	1.32(1.25)	1.43(1.56)	1.40(1.47)
Bentazone 1800 g/ha	8.87(76.41)	6.77(45.32)	1.98(3.44)	1.63(2.16)	1.20(0.95)	1.27(1.11)	1.26(1.10)
Bentazone 2000g/ha	8.89(78.60)	6.84(46.32)	1.57(1.98)	1.35(1.32)	1.08(0.67)	1.13(0.78)	1.01(0.52)
2,4-D 380 g/ha	8.91(78.84)	6.90(47.11)	2.22(4.42)	1.92(3.19)	1.42(1.51)	1.61(2.08)	1.50(1.74)
Hand weeding (20 and 40 DAS)	1.45(1.61)	1.33(1.26)	0.94(0.39)	0.96(0.42)	0.91(0.33)	0.93(0.37)	0.89(0.30)
Weedy check	8.85(77.81)	6.91(47.22)	5.56(28.21)	4.83(22.83)	4.26(17.66)	4.55(20.20)	4.11(16.37)
LSD (p=0.05)	0.17	0.11	0.06	0.05	0.08	0.07	0.08

Figures in parentheses are original values

Table 3. Number of tillers and effective tillers of direct-seeded rice as influenced by different treatments at different time intervals

Treatment	Tiller (m^2)				Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Bentazone 600 g/ha	230.00	324.30	360.30	360.30	12.40	50.07	78.33	78.15
Bentazone800 g/ha	232.00	430.45	455.83	455.83	13.13	52.87	84.73	84.30
Bentazone1000 g/ha	231.40	419.20	448.71	448.71	13.09	51.90	82.27	82.17
Bentazone1200 g/ha	232.00	408.12	442.14	442.14	12.96	51.57	80.03	79.97
Bentazone1600 g/ha	232.20	380.15	417.46	417.46	12.79	50.90	78.07	78.65
Bentazone1800 g/ha	230.00	360.92	408.75	408.75	12.67	50.73	78.64	78.57
Bentazone2000 g/ha	231.00	340.20	388.24	388.24	12.53	50.23	78.40	78.27
2,4-D 380 g/ha	232.40	401.79	435.72	435.72	12.89	51.40	79.63	79.53
Hand weeding (20 and 40 DAS)	231.00	470.50	500.29	500.29	13.57	55.57	88.55	87.37
Weedy check	230.00	266.13	325.11	325.11	12.17	48.70	74.47	75.27
LSD (p=0.05)	N.S.	20.40	24.76	24.76	N.S.	0.35	0.20	0.36

Table 4. Influence on grain yield, straw yield, harvest index, weed index and yield attributes under different treatments

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed index (%)	Effective tillers (no./m^2)	Panicles (no./m^2)	Grains/ panicle	Test weight (g)
Bentazone 600 g/ha/ha	2.48	4.61	34.93	40.39	341.40	341.40	168.72	21.33
Bentazone 800 g/ha	3.65	5.74	38.88	12.21	434.75	434.75	189.14	21.80
Bentazone 1000 g/ha	3.40	5.39	38.78	17.86	427.62	427.62	185.40	21.50
Bentazone 1200 g/ha	3.14	5.37	38.74	18.22	420.10	420.10	182.14	21.53
Bentazone 1600 g/ha	3.11	5.17	37.56	25.23	398.42	398.42	176.36	21.47
Bentazone 1800 g/ha	3.07	5.15	37.38	26.04	385.50	385.50	174.24	21.30
Bentazone 2000 g/ha	2.63	4.69	35.89	36.84	360.20	360.20	170.68	21.17
2,4-D 380 g/ha	3.34	5.28	38.72	19.76	412.69	412.69	180.48	21.60
Hand weeding (20 and 40 DAS)	4.16	6.24	40.00	0	482.20	482.20	194.54	22.27
Weedy check	1.96	4.01	32.78	52.89	304.10	304.10	150.80	21.20
LSD (p=0.05)	0.22	0.10	-	-	19.55	19.55	3.16	NS

post-emergence 800 g/ha (**Table 4**). These findings were in close collaboration with the findings of Chandra and Solanki (2003) and Dubey *et al*. (2017).

The maximum grain and straw yield were observed under hand weeding twice (4.16 and 6.24 t/ha respectively) followed by the application of bentazone 800 g/ha as post-emergence (3.65 and 5.74 t/ha, respectively) and was found to be the economical viable treatment among all the weed control treatments (**Table 4**). Similar results were also reported by Chauhan and Opena (2013), Kumar *et al.* (2014) and Chander and Pandey (2001). Harvest index was maximum (40.0%) under hand weeding twice followed by bentazone as post-emergence 800 g/ha (38.88%) and minimum with weedy check plots (32.78%). While the lowest weed index was recorded under hand weeding twice (0.00%) followed by bentazone as post-emergence 800 g/ha (12.21%). These results were in close conformity to the findings of Chandra and Solanki (2003).

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