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Aparna Sharma
Department of Agronomy, College of Agriculture Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India

Dr. KK Agrawal
Department of Agronomy, College of Agriculture Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India

Dr. JK Sharma
Department of Agronomy, College of Agriculture Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India

Dr. AK Jha
Department of Agronomy, College of Agriculture Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India

Correspondence
Aparna Sharma
Department of Agronomy, College of Agriculture Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India

Effect of bentazone herbicide on yields and economics of direct seeded rice

Aparna Sharma, Dr. KK Agrawal, Dr. JK Sharma and Dr. AK Jha

Abstract
The experiment was conducted during *kharif* season of 2017 at Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to study the "Effect of Bentazone herbicide on Yields and Economics of Direct Seeded Rice**"** under edaphic and climatic conditions of Jabalpur (M.P.). 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 P^H (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 (*Mullogo pentaphylla, Phylanthus niuri, Eclipta alba, Corchorus olitorius* and *Alternanthera philoxeroides*). Experiment consists 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 randomized block design with 3 replications. Results indicated that the post-emergence application of Bentazone @ 800 g/ha was found economically best suitable for effective control of dicot weeds in direct seeded rice. This treatment also enhanced growth parameters (viz. plant height, number of tillers/m²), yield attributes (viz. effective tillers/m², total and sound grains/panicle) and yields (grain and straw) as compared to rest of the doses. It also produced higher B: C ratio (1.77) therefore application of Bentazone @ 800 g/ha was found more remunerative.

Keywords: Bentazone, direct seeded rice, grain yield, post emergence, yield attributes

Introduction
Rice (*Oryza sativa* L.) is the most important staple food crop of millions of mankind from the dawn of civilization. Rice provides 50-80% daily calorie intake to the consumer (Choudhary *et al*. 2011) [4]. 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 (Agriculture Statistics at a glance, 2016).

Direct seeding of rice (DSR) has evolved as a potential alternative to the current detrimental practice of puddling and nursery transplanting. The associated benefits of DSR include higher water productivity, less labor and energy inputs, less methane emissions, elimination of time and early crop maturity. Realization of the yield potential and sustainability of this resource conserving rice production technique lies primarily in sustainable weed management, since weeds have been recognized as the single largest biological constraint in direct seeded rice. Weeds pose a major threat to the production of DSR crops (Kumar and Ladha, 2011) [5] and 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 per cent (Chauhan and Opena, 2012). Hand weeding is very easy and environment-friendly but tedious, time cosuming and highly labours intensive in controlling weeds. 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. Various herbicides have been found effective for weed control in direct seeded rice. Bentazone as post-emergence herbicide has been found effective for controlling broad-leaf weeds in soybean and maize in different parts of the country. In this context, the effectiveness of a herbicide Bentazone in case of direct seeded rice at different doses is evaluated.

Materials and Methods

The experiment was conducted at Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during kharif season of 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. Experiment was laid out in randomized block design with three replications. All herbicides were applied using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 l/ha. Sowing of seeds in each plot was done in rows 20 cm apart at the depth of 2-3 cm on July 7th, 2017. The crop was raised by following recommended packages of practices for rice. Different observations on crop growth parameters were recorded at different time intervals. Yield and yield attributes were recorded at the time of harvesting. Each experimental plot was threshed manually. Then the grain and straw yields were determined and it is presented as kg/ha. After all the observations recorded economic analysis was carried out.

Results and Discussion

Effect on Yields

Growth parameters of rice (*viz*. plant height, number of tillers/m²) were higher in plots receiving Bentazone @ 800 g/ha among all the weed control 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. These findings are in conformity to those of Chandra and Solanki (2003) [3] and Chauhan *et al.* (2013) [6, 7].

Yield attributes (*viz*. effective tillers/m², panicles/m² and grains/panicle) were significantly higher under hand weeding twice followed by Bentazone as post-emergence @ 800 g/ha. While the test weight of rice was not influenced due to different weed control treatments. These findings are in close collaboration with the findings of Chandra and Solanki (2003) [3] and Dubey *et al*. (2017) [8].

The maximum grain and straw yield was recorded under hand weeding twice and it was significantly higher than the herbicidal treatments and weedy check plots. Among the herbicidal treatments application of Bentazone as post-emergence @ 800 g/ha recorded maximum grain and straw yields (3650.00 and 5736.33 kg/ha respectively) followed by Bentazone @ 1000 and 1200 g/ha. (3400.00, 3145.00 and 5389.67, 5375.00 kg/ha) but it was economically not feasible. The highest grain and straw yields were recorded with hand weeding twice. These results are in collaboration with the findings of Chauhan and Opena (2013) [6, 7], Kumar *et al.* (2014) [9] and Chander and Pandey (2001) [2].

Harvest index was maximum (40.00%) under hand weeding twice followed by Bentazone as post-emergence @ 800 g/ha (38.88%) and minimum with weedy check plots (32.78%). While weed index was minimum under hand weeding twice (0.00%) followed by Bentazone as post-emergence @ 800 g/ha (12.21%). These results are in close conformity to the findings of Chandra and Solanki (2003) [3].

Table 1: Plant height and number of tillers of direct seeded rice as influenced by different treatments at different time intervals

Treatment	Plant height (cm)				Tillers (m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1N Bentazone 600 g/ha/ha	12.40	50.07	78.33	78.15	230.00	324.30	360.30	360.30
T_2N Bentazone 800 g/ha	13.13	52.87	84.73	84.30	232.00	430.45	455.83	455.83
T_3N Bentazone 1000 g/ha	13.09	51.90	82.27	82.17	231.40	419.20	448.71	448.71
T_4N Bentazone 1200 g/ha	12.96	51.57	80.03	79.97	232.00	408.12	442.14	442.14
T_5N Bentazone 1600 g/ha	12.79	50.90	78.07	78.65	232.20	380.15	417.46	417.46
T_6N Bentazone 1800 g/ha	12.67	50.73	78.64	78.57	230.00	360.92	408.75	408.75
T_7N Bentazone 2000 g/ha	12.53	50.23	78.40	78.27	231.00	340.20	388.24	388.24
T_8N 2,4-D 380 g/ha	12.89	51.40	79.63	79.53	232.40	401.79	435.72	435.72
T_9 Hand weeding (20 and 40 DAS)	13.57	55.57	88.55	87.37	231.00	470.50	500.29	500.29
T_{10} Weedy check	12.17	48.70	74.47	75.27	230.00	266.13	325.11	325.11
SEm±	0.04	0.12	0.07	0.12	2.02	6.80	8.25	8.25
CD(P=0.05)	N.S.	0.35	0.20	0.36	N.S.	20.40	24.76	24.76

Table 2: Influence of different treatments on yield attributes of direct seeded rice

Treatment	Effective tillers(m^{-2})	Panicles (m^{-2})	Grains/ panicle	Test weight (g)
T_1N Bentazone 600 g/ha/ ha	341.40	341.40	168.72	21.33
T_2N Bentazone 800 g/ha	434.75	434.75	189.14	21.80
T_3N Bentazone 1000 g/ha	427.62	427.62	185.40	21.50
T_4N Bentazone 1200 g/ha	420.10	420.10	182.14	21.53
T_5N Bentazone 1600 g/ha	398.42	398.42	176.36	21.47
T_6N Bentazone 1800 g/ha	385.50	385.50	174.24	21.30
T_7N Bentazone 2000 g/ha	360.20	360.20	170.68	21.17
T_8N 2,4-D 380 g/ha	412.69	412.69	180.48	21.60
T_9 Hand weeding (20 and 40 DAS)	482.20	482.20	194.54	22.27
T_{10} Weedy check	304.10	304.10	150.80	21.20
SEm±	6.51	6.51	1.05	0.29
CD(P=0.05)	19.55	19.55	3.16	NS

Table 3: Influence of different treatments on grain yield, straw yield and weed index

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Weed index (%)
T_1N Bentazone 600 g/ha/ha	2478.33	4614.88	34.93	40.39
T_2N Bentazone 800 g/ha	3650.00	5736.33	38.88	12.21
T_3N Bentazone 1000 g/ha	3400.00	5389.67	38.78	17.86
T_4N Bentazone 1200 g/ha	3145.00	5375.00	38.74	18.22

T_5N Bentazone 1600 g/ha	3108.33	5167.08	37.56	25.23
T_6N Bentazone 1800 g/ha	3075.00	5150.17	37.38	26.04
T_7N Bentazone 2000 g/ha	2625.67	4688.33	35.89	36.84
T_8N 2,4-D 380 g/ha	3336.00	5279.67	38.72	19.76
T_9 Hand weeding (20 and 40 DAS)	4157.67	6236.50	40.00	0.00
T_{10} Weedy check	1958.67	4015.00	32.78	52.89
SEm±	74.81	34.29	-	-
CD(P=0.05)	224.43	102.85	-	-

Economics

Bentazone @800 g/ha was the economically viable treatment among all the weed control treatments. The cost of cultivation was maximum (Rs 43696 /ha) under hand weeding twice owing to an additional expenditure of Rs 10000 on weeding, showing that control of weeds through hand weeding was more expensive than the use of herbicide in direct seeded rice. But the gross monetary returns was maximum (Rs 70057 /ha) in hand weeding twice among all the treatments but net monetary returns (Rs 26361/ha) and B: C ratio (1.60) under hand weeding twice was lower than Bentazone @ 800 g/ha (1.77).

Table 4: Cost of cultivation, GMR, NMR and B: C ratio as influenced by different treatments

Treatments	Cost of cultivation (Rs/ha)	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	B:C Ratio
T_1N Bentazone 600 g/ha/ha	34696	42567	7871	1.23
T_2N Bentazone 800 g/ha	34896	61738	26842	1.77
T_3N Bentazone 1000 g/ha	35096	57784	22688	1.65
T_4N Bentazone 1200 g/ha	35296	57538	22242	1.63
T_5N Bentazone 1600 g/ha	35696	52824	17128	1.48
T_6N Bentazone 1800 g/ha	35896	52298	16402	1.46
T_7N Bentazone 2000 g/ha	36096	44917	8821	1.24
T_8N 2,4-D 380 g/ha	34229	56460	22231	1.64
T_9 Hand weeding (20 and 40 DAS)	43696	70057	26361	1.60
T_{10} Weedy check	33696	33973	277	1.01

Concussions

Based on the aforesaid discussion the following conclusions could be made:

1. Yield attributes and yields of the crop were significantly more with the application of Bentazone @ 800 g/ha.
2. The application of Bentazone @ 800 g/ha as post-emergence was found more remunerative as it gave highest B: C ratio (1.77).

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