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EFFECACY OF VARIOUS HERBICIDES TO CONTROL WEEDS IN DRY DIRECT SEEDED RICE (*Oryza sativa* L.)

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Abstract

Despite multiple benefits of dry direct seeded rice (DDSR), weed control remains one of the major challenges for its success. A field experiment was conducted at Regional Agricultural Research Station, Parwanipur, Bara during rainy season of 2010 and 2011in randomized complete block design with four replications to evaluate effectiveness of different weed management practices; weedy, weed free and other five practices with pre and post-emergence herbicides; Pendimethalin, Pyrazosulfuron, Penoxsulam, Bispyribac, Azimsulfuran, 2,4-D, plus one to two hand weeding on the performance of DDSR. Results showed that plant growth, yield and yield attributing parameters and weed dynamics were significantly affected and the trend of higher production and lower weed dynamic in different growing stage of DDSR was obtained. Among the weed control practices, application of pendimethalin (1 kg.a.i /ha.) followed by (fb) 2,4-D 1 kg a.i./ha at 25 and hand weeding 45 days after sowing was found the best for obtaining higher yield and weed control efficiency in DDSR.

Key words: *Dry Direct Seeded Rice (DDSR), herbicides, pre and post-emergence, weed management practices.*

1. Introduction

Rice is the world's most important food and more than half of the world's population depends on rice for food, calories and protein, especially in developing countries among all staple food crops. Almost 90 percent area and production of the world's rice accounted and consumed in Asia and grown annually on 145 M ha which produces 654 million tons with an average productivity of 4.49 t ha^{-1}. The world's total rice area is 168 M ha and production is about 722 M tons with the productivity of 4.29 t ha^{-1} (FAOSTAT, 2012). In Nepal, rice stands first position in terms of area (0.14 M ha) and production (0.45 M tones) with an average yield of 3.21 t ha^{-1} (MoAD, 2012/013).

Rice is predominantly grown by transplanting in puddled soil with continuous flooding which provides multiple benefits to rice including reduction in weed population and percolation losses and increases availability of nutrients (Sanches, 1973). However, it deteriorates soil physical properties ultimate adversely affects the growth and productivity of succeeding wheat crop. The increasing cost of labour threatens the sustainability of transplanted rice within the rice-wheat system of Indo-Gangetic Plains. Direct-seeding is cost effective, can save water through rice crop establishment and allows early sowing of wheat (Ladha *et al.,* 2003 and Singh *et al.,* 2003). All these factors have increased the interest of farmers to shift from the conventional practice of puddled transplanting (TPR) to direct seeded rice (DSR) especially dry DSR. Direct seeded rice (DSR) is a cost effective rice establishment method where dry seed is drilled into the non-puddled soil. This provides opportunities of saving irrigation water by 12-35%, labour up to 60% and provides higher net returns (US$ 30-50 ha^{-1}) with similar or slightly lower yield of rice (Kumar and Ladha, 2011). Despite multiple benefits of dry DSR, weed control remains one of the major challenges for its success in South Asia (Kumar and Ladha, 2011; Rao *et al.,* 2007; Singh *et al.*, 2008). Weed control is more difficult in dry- DSR than CT-TPR because of simultaneously emerging rice seedlings with weeds in dry–DSR which are less competitive than 30-35 days old rice seedlings use in CT- TPR and initial flooding used in CT-TPR is effective for weed control but it is lacking in dry- DSR (Kumar and Ladha, 2011 and Rao *et al.,* 2007). In Nepal, Ranjit (2007) observed that weeds caused yield loss in direct seeded rice ranging from 14-93 % where as in transplanted rice it is 17- 47 %.

Irrigated "aerobic rice" is a new system being developed for low land areas with water shortage and for favorable upland areas with access to supplementary irrigation (Tuong and Bouman, 2003; Belder *et al.,* 2005). Aerobic rice systems, where the crop is established via direct seeding in puddled, non-flooded fields are among the most promising approaches for saving water and reduce water application by 44% relative to conventionally transplanted systems, by reducing percolation, seepages and evaporative losses, while maintaining yield at an acceptable level However, aerobic systems are subject to much higher weed pressure than conventional puddled transplanting systems (Rao *et al.,* 2007; Balasubramanian and Hill, *et al.,* 1984; Fuzisaka *et al*., 1993; Rao *et al*., 2007).

Information on weeds and weed management in aerobic rice cultivated on flat land and on raised beds, by either transplanting or direct-seeding is scarce. Since the concept of aerobic rice is new (Belder *et al*., 2005) growing rice under aerobic conditions on raised beds or flat land would require suitable, effective and economic weed-control methods where development of new improved herbicides for aerobic dry-seeded rice is also needed. Farmers in many rice growing areas are likely to have only limited availability of irrigation water and in the future it is predicted that in Asia, 17 million ha of irrigated rice areas may experience "Physical water Scarcity" and 22 million ha may have "economic water Scarcity" by 2025 (Bouman and Tuong, 2001). Water scarcity threatens the sustainability of irrigated rice ecosystems since it may no longer be feasible for farmers to under taken wet cultivation and flood.

Most upland and aerobic rice growers in Asia mechanically weed their crops two or three times per season, investing upto 190 person days ha^{-1} in hand weeding (Roder, 2001) which is very easy and environment-friendly but it is tedious, time consuming and highly labor intensive and expensive. In addition, during peak period, the availability of labor is becoming a serious problem by time. So, herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low cost involvement in comparison to the traditional methods of hand weeding (Mian and Al-Mamun, 1969).

Both pre-emergence and Post-emergence herbicides can be used in aerobic rice fields and they are effective, if properly used (De Datta and Baltazar, 1996; Singh *et al*., 2006). Chemical weed control on puddled flat lands was good but in case of transplanted rice on beds 2-3 hand weeding was required, which increased to 3-4 in direct-seeded rice on beds. Thus weeds are the most severe constraints and timely weed management is crucial for increasing the productivity of aerobic rice (Rao *et al*, 2007). In such situation, the application of pre-emergence herbicides like Pendimethalin plays significant role in controlling weeds (Singh and Singh, 2010). Similarly, several authors reported to Azimsulfuron (Singh *et al.*, 2009), Pyrazosulfuron, Penoxsulam (Chauhan & Seth, 2013) and post emergence Bispyribac (Khaliq *et al*., 2012) herbicides which are considered to be an alternative/ supplement to hand weeding. To the best of our knowledge, a very few experiments were carried out in this line with a view to evaluating the efficacy of herbicides under field conditions for selecting suitable herbicides and their combinations for sustainable weed control in aerobic rice. Therefore, the present experiment was conducted to find out effective herbicide for weed control in direct seeded rice.

2. Materials and Methods

2.1 Experimental Site

The field experiment was conducted at the experimental field of the Regional Agricultural Research Station, Parwanipur, Bara, Nepal during the rainy season of 2010 and 2011. The site is located in the central piedomont of Nepal at 115 meter above sea level, at 27˚21'N and 84˚53'E. The climate of Parwanipur is very hot summers and cold winters. The hottest months are May and June, when the maximum temperature reaches 40^0C, whereas during December and January, the coldest month of the year, the minimum temperature often goes below 10^0C. The average rainfall is 1500 mm, 80% of which is received through the monsoon from June to September. The experiment soil was an Inceptisol formed on Himalayan residium with the following characteristics in the top 15cm profile: clay 8.0%, silt 17.0%, sand 75% (loamy sand), pH (1:2 soil: water) 7.0 total N 0.86 g kg^{-1}, total C 6.5 g kg^{-1}, NH_4OAC-extractable K 0.054 g kg^{-1}, Olsen P 0.015 g kg^{-1}, Saturation extract exchangeable cations 1.4 ds m^{-1}, and bulk density 1.6 Mg m^{-1}.

2.2 Experimental Design and Treatments

The experiment was laid out in randomized block design with four replications. Eight treatments were made up with different combination of herbicides and hand weeding in the following: 1-weedy check, 2-weed free, 3-Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 fb hand weeding 45 DAS, 4-Pre-emergence Pyrazosulfuron 20 g a.i./ha fb hand weeding at 45 DAS, 5-Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one hand weeding at 35 DAS, 6-Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17 .5 g a.i./ha) at 20 DAS and one hand weeding at 35 DAS, 7-Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one hand weeding at DAS 35 & 8-Two hand weeding at 15 DAS fb 35 DAS (Farmer's practice). Herbicides were applied using a power operated Knapsack sprayer with a flat fan nozzle and water as a carrier at 450 liter ha^{-1}. For the weed free treatment, 8-11 hand weedings were (weekly weeding) done to maintain a weed free situation. In the weedy control, no weeding was done.

2.3 Experimental details and measurements

Rice (cv. Prabhat, an early maturity variety) was seeded on 29th June, 2010 and 20th July, 2011 with seed rate of 30 kg ha^{-1} by manually in line. Row to row spacing was kept 20 cm and plant to plant continuous and thinning was done manually at 15 DAS to maintain plant population. Irrigation was applied in the field as per requirement. About 5 cm water was maintained either through deep tube well or by pumping set regularly up to grain filling stage of rice crop. Insecticide Darsban (Chloropyriphos) @ 2 ml/litre of water was sprayed before milking stage of crop to manage sucking insect particularly rice gundhi bug (*Leptocorisa oratorieus*).Nitrogen, phosphorous and potash fertilizers were applied @ 100: 50:30 kg ha^{-1} whereas, nitrogen applied through urea (46% N) and phosphorus through Diammonium phosphate (18% N and 46% P_2O_5) and potash through Muriate of potash (60% K_2O). Half of nitrogen, full dose of phosphorous and potash were applied as basal and remaining half of nitrogen was applied in two split doses first at active tillering and second at panicle initiation stage in all treatments. Observations were taken on weed density, dry weed weight, weed index and weed control efficiency at 30 and 60 days after sowing (DAS) from one meter square area. Plants were harvested from the net plot area (15 m^2) and left in the field for 5-7 days for sun drying. Threshing was done on cemented threshing floor by manually and then grains was cleaned by winnowing and weighed at 12% moisture. The grain yield, straw yield, grain straw ratio and harvest index were recorded from the net plot of 15 m^2 areas. Observations data were analyzed by using standard statistical techniques (MSTAT- C package).

3. Results and Discussion

3.1 Growth Parameters

Data pertaining to growth attributes viz. plant height of rice as influenced by different weed management practices are presented in table-1. It was observed that plant height was progressively increased with the advancement of the growth up to 60 DAS and after that growth rate was gradually slow. The shortest plant height was resulted at 30 DAS in 2011 than 2010 due to hindered growth during initial stage. The initial weather condition around sowing and thereafter up to one month of growth was quite favourable in 2010.

The effect of different weed management practices on plant height showed highly significant in both years 2010 and 2011 at harvesting and 30 DAS in 2010. Only significant differences were observed at 30 & 60 DAS in 2011 and non-significant at 60 DAS in 2010. The highest plant height was measured in weed free plots throughout the cultivation period as compared to T_1. However, it was found significantly at par with all treatments except T_1 at 30 & 60 DAS but in case of harvesting stage, only T_3, T_4, T_5 & T_6 were at par in both years while the lowest plant height was recorded in weedy check in all stages and years.

Mean data of panicle length revealed that different weed management practices significantly influenced the panicle length among the tested treatments. Whereas the longest panicle length was measured in weed free DSR (22.06 cm) in 2010 and 26.17 cm in 2011 and it was significantly at par with all the treatments except T_1 (weedy check) in 2011 while the lowest found in weedy check 18.06 and 22.93 cm in 2010 & 2011 respectively. The initial weather conditions around sowing and thereafter up to one month of growth was quite favourable in 2011, which led to enhance the panicle length more than 2010.

Table 1: Effect of different weed management practices on plant height in different growing period and panicle length in dry direct seeded rice at RARS, Parwanipur, Bara, during 2010-2011.

Treatment No.	Treatments	Plant height (cm)						Panicle length (cm)	
		30 DAS		60 DAS		At harvest			
		2010	2011	2010	2011	2010	2011	2010	2011
T_1	Weedy check	41.88	41.46	69.69	69.88	76.30	75.54	18.06	22.93
T_2	Weed free	51.76	51.12	79.81	80.30	93.70	92.71	22.06	26.17
T_3	Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb HW 45 DAS	51.60	51.10	77.93	78.16	91.90	90.96	20.60	25.97
T_4	Pre-emergence Pyrazosulfuron 20 g a.i./ha at 20 DAS fb HW at 45 DAS	51.55	51.03	77.58	77.77	90.25	89.36	20.43	25.60
T_5	Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one HW at 35 DAS	51.16	50.67	77.27	75.56	90.10	89.05	20.33	25.79
T_6	Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17.5 g a.i./ha at 20 DAS and HW at 35 DAS	50.79	50.28	75.66	77.60	87.85	87.01	20.17	25.46
T_7	Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one HW at 35 DAS	49.28	48.73	77.05	76.41	85.27	84.14	20.08	25.46
T_8	Farmer's practice, two HW at 15 DAS fb 35 DAS	47.69	49.60	75.66	77.24	82.35	81.52	18.70	25.21
Mean		49.46	49.25	76.33	76.61	87.21	86.29	20.05	25.32
CV (%)		6.27	7.75	9.37	8.48	5.96	6.01	3.47	4.63
F-test		**	*	ns	*	**	**	**	*
LSD (<.05)		4.56	5.62	-	9.55	7.65	7.62	1.02	1.72

3.2 Yield attributes

Comparative analysis of major yield attributes of rice as affected by different weed management practices is presented in Table-2. A perusal data on yield attributes as panicles/m^2, panicle weight, filled grain per panicle, unfilled grain per panicle and thousand grain weights were highly significant in both years except panicle weight in 2011 found significant effect among weed management practices and non significant differences was observed under unfilled grain per panicle in 2010. The effect of weed free treatment played significant role in producing the maximum yield attributing parameters except filled grain per panicle in 2011 at T_3 while minimum was noticed in weedy check in all parameters in both the years. This might be attributed to better growth of plants on account of reduced weed competition at critical crop growth stages resulting in increased availability of nutrients, water and light. It was statistically at par with T_3 (pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb hand weeding 45 DAS) besides some treatments in some parameters were also at par with these treatments likewise T_4 & T_5 in number panicle per square meter in 2010; T_4, T_5, T_6 & T_7 in panicle weight in 2011 and filled grain per panicle in 2010; T_4, T_5, T_6 & T_8 in filled grain per panicle; T_4 in unfilled grain; T_4, T_5, & T_6 in thousand grain weight in 2011.

Among the herbicidal treatments, the use of pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb hand weeding 45 DAS produced maximum number of panicles/m^2 (423.1 & 294.6), panicle weight (1.42 & 1.92 gm), filled grains/panicle (70 & 69) and 1000 grain weight (24.89 & 21.68 gm) in 2010 & 2011 respectively which were comparable to that of weed free treatment. Samar Singh *et al.;* (2005) reported similar results with the use of Pendimethalin in dry direct seeded rice.

Table 2: Yield attributing characters as influenced by different weed management practices in dry direct-seeded rice at RARS, Parwanipur, Bara, during 2010-2011.

Treatment No.	Treatments	No. of panicles/m^2		Panicle Weight (g)		Filled grains/Panicle		Unfilled grains/Panicle		Thousand Grain Weight (g)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1	Weedy check	325.3	142.2	0.94	1.53	38.55	47.40	13.55	35.10	24.36	19.63
T_2	Weed free	447.8	309.4	1.42	1.92	70.44	69.0	12.05	24.80	24.89	21.68
T_3	Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb HW 45 DAS	423.1	294.6	1.30	1.89	54.82	64.8	15.67	29.00	24.77	21.03
T_4	Pre-emergence Pyrazosulfuron 20 g a.i./ha at 20 DAS fb HW at 45 DAS	407.7	280.3	1.29	1.76	53.95	63.8	16.10	30.00	24.71	21.02
T_5	Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one HW at 35 DAS	385.7	283.4	1.29	1.75	53.85	61.2	17.40	31.20	24.62	21.01
T_6	Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17.5 g a.i./ha at 20 DAS and HW at 35 DAS	376.0	254.8	1.14	1.67	53.52	61.8	17.87	32.4	24.54	20.55
T_7	Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one HW at 35 DAS	398.1	266.8	1.12	1.64	52.75	60.6	17.85	32.5	24.48	20.48
T_8	Farmer's practice, two HW at 15 DAS fb 35 DAS	381.8	243.8	0.98	1.72	40.47	54.8	18.3	35.00	24.36	19.67
Mean											
CV (%)		4.8	6.6	1.14	1.73	1.20	1.80	6.69	1.85	2.3	3.97
F-test		**	**	**	ns	**	ns	ns	ns	ns	*
LSD (<.05)		33.4	30.0	0.210	-	9.16	-	-	-		1.19

3.3 Grain and Straw Yield

Grain yield, straw yield, grain straw ratio and harvest index as influenced by different weed management practices are presented below in the table 3. The effect of different weed management practices was highly significant for all attributes as grain yield, straw yield and grain straw ratio as well as harvest index. Grain yield: 5131 & 4096 kg ha^{-1} and straw yield: 6929 & 5654 kg ha^{-1} in 2010 & 2011 respectively were highest in weed free treatment followed by use of Pendimethalin, Pyrazosulfuron, Penoxsulam respectively. These were significantly at par with each others. However, Pendimethalin showed effective pre-emergence herbicide for weed control in direct seeded rice. It was closely followed by the use of Pyrazosulfuron, Penoxsulam and Bispyribac + Azimsulfuron + one hand weeding at 35 DAS. The efficacy of Pendimethalin alone is high as reported by several authors (Moody, 1991 and Valverde *et al.,* 2005) or in combination with hand weeding was reported so effective in controlling weeds in dry direct seeded rice (Ramamoorthy *et al.*. 1998 and Singh *et al.,* 2005).

The highest grain straw ratio (0.89) was recorded in 2011 in farmers practice i.e. two hand weeding at 15 DAS followed by 35 DAS in 2011 but in 2010 the highest ratio (0.75) was noticed under Pre-emergence Pendimethalin 1 kg a.i./ha followed by 2,4-D 1 kg a.i./ha at 25 followed by hand weeding at 45 DAS, Post-emergence Penoxsulam 22.5 g ai/ha at 15 DAS followed by one hand weeding at 35 DAS respectively, and it was significantly at par with all treatments except weedy check. Similar results observed in harvest index. In each case, the involvement of Pendimethalin or other herbicide indicates that Pendimethalin seems to be an effective pre-emergence herbicide for weed control in direct dry seeded rice. The efficacy of Pendimethalin alone is high as reported by several authors (Moody, 1991 and Valverde *et al.,* 2005) or in combination with hand weeding was reported so effective in controlling weeds in dry direct seeded rice (Ramamoorthy *et al*., 1998 and Singh *et al*., 2005).

Table 3: Effect of different weed management practices on grain yield, straw yield, grain straw ratio and harvest index at RARS, Parwanipur, Bara, during 2010-2011.

Treatment No.	Treatments	Grain Yield (kg ha^{-1})		Straw Yield (kg ha^{-1})		Grain: Straw		Harvest index	
		2010	2011	2010	2011	2010	2011	2010	2011
T_1	Weedy check	3052	658	5792	3543	0.53	0.19	34.54	15.74
T_2	Weed free	5136	4096	6929	5654	0.74	0.73	42.61	42.00
T_3	Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb HW 45 DAS	4982	4061	6662	5499	0.75	0.74	42.78	42.44
T_4	Pre-emergence Pyrazosulfuron 20 g a.i./ha at 20 DAS fb HW at 45 DAS	4859	4012	6559	5482	0.74	0.73	42.45	42.26
T_5	Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one HW at 35 DAS	4809	3986	6470	5207	0.74	0.77	42.65	43.43
T_6	Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17.5 g a.i./ha at 20 DAS and HW at 35 DAS	4672	3689	6322	4922	0.74	0.75	42.50	42.87
T_7	Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one HW at 35 DAS	4505	3674	6228	4726	0.72	0.78	41.98	43.74
T_8	Farmer's practice, two HW at 15 DAS fb 35 DAS	4303	3582	6178	4038	0.70	0.89	41.06	47.09
Mean		4540	3470	6392	4884	0.71	0.71	41.32	39.95
CV (%)		7	5.09	5.97	6.93	7.7	8.6	4.37	5.16
F-test		**	**	*	**	**	**	**	**
LSD (<.05)		467.3	259.9	561.5	498	0.08	0.093	2.657	3.03

Note: fb = followed by & HW = hand weeding

3.4 Dry Weed Weight

The effect of the various weed management practices on dry weed weight showed highly significant difference at growing stages; i.e. at 30 and 60 DAS during 2010 and 2011 (Table-4). There were remarkable variation in weed density and dry weed weight between two years; both weed density and weed dry weight were observed higher in 2010 as compared to 2011. The crop experienced severe weed competition during 2010 which might be due to favourable weather condition leading to vigorous weed growth. Among herbicides, Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 fb hand weeding 45 DAS yielded the minimum dry weed weight as compared to others while maximum weight observed in weedy check i.e. control followed by farmers practices i.e. two hand weeding at 15 DAS and 35 DAS. Behera and Jena (1998) found similar result while investigating weed control in DSR. In each case, the involvement of pendimethalin showed more effective pre-emergence herbicide in Dry DSR.

Table 4: Dry weed weight at 30 and 60 DAS as influenced by different weed management practices in dry direct seeded rice at RARS, Parwanipur, Bara, during 2010-2011

Treatment No.	Treatments	Dry weed weight (g) 30 DAS						Dry weed weight (g) 60 DAS					
		Broad leaves		Sedges		Grasses		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1	Weedy check	2.16 (1.63)	34.34 (5.89)	11.83 (3.50)	0.50 (0.99)	1.80 (1.52)	21.63 (4.68)	69.88 (8.39)	7.12 (2.76)	51.87 (7.23)	12.94 (3.67)	15.22 (3.95)	40.02 (6.36)
T_2	Weed free	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb HW 45 DAS	0.06 (0.75)	1.10 (1.26)	3.28 (1.92)	0.00 (0.71)	0.70 (1.09)	0.31 (0.89)	24.83 (5.02)	0.00 (0.71)	11.66 (3.48)	0.00 (0.71)	5.03 (2.34)	0.00 (0.71)
T_4	Pre-emergence Pyrazosulfuron 20 g a.i./ha at 20 DAS fb HW at 45 DAS	0.20 (0.83)	1.74 (1.47)	3.16 (1.89)	0.00 (0.71)	0.85 (1.16)	1.07 (1.22)	25.17 (6.77)	0.00 (0.71)	13.89 (3.79)	0.00 (0.71)	7.04 (2.72)	0.99 (1.22)
T_5	Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one HW at 35 DAS	1.23 (1.31)	4.29 (2.14)	6.14 (2.54)	0.02 (0.72)	0.90 (1.17)	1.12 (1.24)	46.60 (7.14)	0.24 (0.86)	15.75 (4.02)	0.00 (0.71)	7.64 (2.82)	1.50 (1.38)
T_6	Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17.5 g a.i./ha at 20 DAS and HW at 35 DAS	1.60 (1.45)	8.02 (2.92)	8.63 (3.01)	0.05 (0.74)	1.19 (1.30)	1.92 (1.54)	50.52 (7.93)	0.48 (0.99)	19.56 (4.46)	0.00 (0.71)	11.04 (3.38)	1.71 (1.47)
T_7	Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one HW at 35 DAS	1.42 (1.37)	11.99 (3.49)	8.82 (3.00)	0.00 (0.71)	1.18 (1.27)	5.11 (2.33)	62.68 (8.08)	11.10 (3.11)	24.64 (5.01)	1.10 (1.26)	13.43 (3.72)	5.65 (2.47)
T_8	Farmer's practice, two HW at 15 DAS fb 35 DAS	1.57 (1.42)	19.77 (3.49	8.83 (3.00)	0.10 (0.78)	1.41 (1.36)	8.70 (3.00)	64.91 (6.13)	1.41 (1.34)	31.07 (4.29)	3.50 (2.00)	14.31 (3.85)	16.26 (4.08)
Mean		1.03 (1.18)	10.15 (2.79)	6.34 (2.45)	0.08 (0.76)	1.00 (1.2)	4.98 (1.95)	43.07 (6.13)	2.52 (1.40)	21.05 (4.29)	2.19 (1.31)	9.21 (2.93)	8.27 (2.30)
CV (%)		45.03 (14.54)	35.13 (17.25)	41.46 (19.44)	180.30 (10.07)	43.49 (14.86)	48.03) 19.75)	21.41 (10.75)	175.39 (42.13)	15.16 (7.85)	16.89 (7.27)	26.62 (12.88	25.21 (11.24)
F-test		**	**	**	**	**	**	**	*	**	**	**	**
LSD (<.05)		0.68 (0.25)	5.25 (0.71)	3.86 (0.70)	0.22 (0.11)	0.64 (0.26)	3.52 (0.57)	13.56 (0.30)	6.36 (0.86)	4.69 (0.49)	0.54 (0.14)	3.61 (0.26)	3.99 (0.38)

Table 5: Weed density at 30 and 60 DAS as influenced by different weed management practices in dry direct seeded rice at RARS, Parwanipur, Bara, during 2010-2011

Treatment No.	Treatments	Dry weed weight (g) 30 DAS						Dry weed weight (g) 60 DAS					
		Broad leaves		Sedges		Grasses		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1	Weedy check	13.45 (3.73)	215.00(14.68)	74.00 (8.63)	3.00 (1.81)	11.60 (3.45)	137.00 (11.66)	74.00 (8.63)	7.50 (2.83)	55.00 (7.44)	13.76 (3.78)	16.00 (4.05)	16.00 (4.05)
T_2	Weed free	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	Pre-emergence Pendimethalin 1 kg a.i./ha fb 2,4-D 1 kg a.i./ha at 25 DAS fb HW 45 DAS	0.40 (0.93)	8.00 (2.92)	24.30 (4.97)	0.00 (0.71)	5.10 (2.26)	2.00 (1.54)	24.60 (5.00)	0.00 (0.71)	11.50 (3.46)	0.00 (0.71)	5.00 (2.34)	5.00 (2.34)
T_4	Pre-emergence Pyrazosulfuron 20 g a.i./ha at 20 DAS fb HW at 45 DAS	1.20 (1.21)	13.00 (3.67)	25.10 (5.04)	0.00 (0.71)	6.90 (2.71)	7.75 (2.81)	25.10 (5.05)	0.00 (0.71)	14.00 (3.81)	0.00 (0.71)	7.00 (2.72)	7.00 (2.72)
T_5	Post-emergence Penoxsulam 22.5 g a.i./ha at 15 DAS fb one HW at 35 DAS	9.90 (3.21)	32.00 (5.67)	47.30 (6.91)	0.25 (0.84)	7.20 (2.75)	8.00 (2.85)	47.30 (6.86)	0.25 (0.87)	16.50 (4.11)	0.00 (0.71)	8.00 (2.88)	8.00 (2.88)
T_6	Post-emergence Bispyribac (25 g a.i./ha) + Azimsulfuron 17.5 g a.i./ha at 20 DAS and HW at 35 DAS	10.10 (3.25)	51.00 (7.16)	53.80 (7.35)	0.25 (0.84)	7.40 (2.81)	12.00 (3.51)	53.80 (7.36)	0.50 (1.00)	20.50 (4.57)	0.00 (0.71)	11.50 (3.46)	11.50 (3.46)
T_7	Post-emergence Bispyribac 25 g a.i./ha at 15 DAS fb one HW at 35 DAS	10.10 (3.25)	89.00 (9.44)	63.30 (7.99)	0.00 (0.71)	7.70 (2.83)	36.75 (6.10)	63.30 (7.98)	12.65 (3.25)	25.00 (5.05)	1.10 (1.26)	13.50 (3.74)	13.50 (3.74)
T_8	Farmer's practice, two HW at 15 DAS fb 35 DAS	11.90 (3.51)	155.00 (12.46)	68.20 (8.26)	1.00 (1.15)	10.40 (3.29)	70.00 (8.35)	68.20 (8.27)	1.40 (1.34)	32.50 (5.74)	3.65 (2.03)	15.00 (3.93)	15.00 (3.93)
Mean		7.13 (2.47)	70.38 (7.09)	44.50 (6.23)	0.56 (0.99)	7.04 (2.61)	34.19 (4.69)	44.54 (6.23)	2.79 (1.43)	21.88 (4.36)	2.31 (1.33)	9.50 (2.98)	9.50 (2.98)
CV (%)		20.41 (11.77)	12.13 (6.44)	14.83 (7.18)	154.57 (30.67	26.49 (1.82)	39.04 (16.86)	17.31 (7.18)	199.12 (47.60)	14.64 (6.98)	25.08 (7.95)	21.55 (10.79)	21.55 (10.79)
F-test		**	**	**	**	**	**	**	*	**	**	**	**
LSD (<.05)		2.14 (0.43)	12.55 (0.67)	9.70 (0.66)	1.28 (0.42)	2.74 (0.45)	19.62 (1.16)	11.34 (0.66)	8.16 (0.99)	4.71 (0.45)	0.85 (0.15)	3.01 (0.48)	3.01 (0.48)

3.5 Weed Density

Data pertaining to weed density as influenced by integrated weed management practices in dry direct-seeded rice showed the significant difference at 30 and 60 DAS. The highest number of weeds per square meter was recorded in weedy check followed by Bispyribac for broad leaves, sedges and grasses in 2010 and 2011 while the lowest weed population were recorded in weed free plot followed by pre-emergence Pendimethalin 1 kg a.i./ha followed by 2,4-D 1 kg a.i./ha at 25 followed by hand weeding 45 DAS. During both years, the proportion of grassy dry weed weight was higher than other weeds. Grasses persist in all of the principal crops and are a major cause for concern. It is also reported that the greatest weed pressure and crop-weed competition occur in aerobic rice and least in transplanted irrigated and rainfed lowland rice (Datta *et al*., 1996; Moody, 1991 and Rao *et al*., 2007). On the other hand, weedy check had significantly the highest weed density and dry weed weight over all treatments

4. Conclusion

Based on the results, yield, yield attributing parameters and weed dynamics were greatly influenced by different weed management practice in higher production and lower weed dynamics in different growing stage of dry direct-seeded rice. Overall manually weeded weed free plots performed better in producing higher plant height, yield and yield attributing parameters followed by the application of pre-emergence Pendimethalin 1 kg a.i./ha followed by 2,4-D 1 kg a.i./ha at 25 followed by hand weeding 45 days after sowing. They were significantly at par with each other. However, manually weeding is tedious, time consuming, highly labor intensive and expensive. In addition, during peak period, the availability of labor is becoming a serious problem by time especially in weed free which required 8-10 times weeding. So, application of pre-emergence Pendimethalin 1 kg a.i./ha followed by 2,4-D 1 kg a.i./ha at 25 followed by hand weeding 45 days after sowing found the best way obtaining higher yield and controlling weeds effectively in dry direct seeded rice.

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