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ORIGINAL RESEARCH ARTICLE

Evaluation of different weed management practices in dry direct seeded spring rice at Baniyani, Jhapa, Nepal

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ABSTRACT

A field experiment was conducted during the spring season of 2020 to evaluate the different weed management practices in dry directed seeded spring rice under Prime Minister Agriculture Modernization Project (PMAMP) super zone at Baniyani, Jhapa. The experiment was laid out in randomized complete block design (RCBD) with seven weed management related treatments and three replications. The treatments consisted of pre-emergence application of Pretilachlor, pre-emergence application of Pendimethalin, pre-emergence application of Pretilachlor fb post-emergence butachlor pre-emergence application of Pendimethalin fb post-emergence Bispyribac Na, *Sesbania* co-culture along with pre-emergence application of Pendimethalin along with two control treatments (weedy free and weedy check). The rice variety Hardinath-1 was used in the experiment. Data regarding the weed flora, weed density, weed dry weight, growth, yield attributes and yield were recorded and analyzed. The highest number of effective tillers per m^2 (371.51) and number of grains per panicle (145.43) were obtained in Pendimethalin treated plot and were statistically as par with *Sesbania* co-culture + Pendimethalin (363.44 m^{-2} and 140.54 respectively). Higher and statistically similar grain yield was observed in *Sesbania* co- culture + Pendimethalin (4870kg ha^{-1}) and Pendimethalin treated plots (4780 kg ha^{-1}). The experiment concluded that there was reduction in yield by 66.78 percent due to presence of weed as compared to weed free. Pre-emergence application of Pendimethalin was most beneficial in terms of gross returns, net returns and B:C ratio compared to other weed management practices and hence was most economical.

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INTRODUCTION

Rice is the world's most important food and source of calories, protein for more than half of the world's especially in developing countries. In world rice is cultivated in an area of 167 million ha and production of 782 million tons with productivity of 4.67 t ha^{-1} (FAOSTAT, 2018). In context of Nepal, rice is ranked first in terms of area of 0.14 million ha and production 0.56 million tons with productivity of 3.76 t ha^{-1} (MOALD, 2019). Transplanting of rice in puddled soil is most popular and convectional method of rice cultivation in Nepal. However, puddled soil becomes hard after drying, leading to the development of cracks and hard pan. Puddling also results in poor soil physical conditions for post rice crop (Kalita *et al.*, 2020). Although transplanting has been a major traditional method of rice establishment in Nepal but economic factors and development in rice production technology have increased the desirability of direct- seeding methods (Subbaiah, 2008). Different research has shown that Direct seeded rice (DSR) is a cost-effective rice establishment method and helps to save irrigation water by 12-35% and labour up to 60% as result higher return with almost similar or slightly low yield can be obtained (Kumar and Ladha, 2011). Despite of

many advantages of dry DSR, weeds remain major problem in it. Weeds are the major biological constraint in DSR due to the concurrent emergence of competitive weeds, absence of water to suppress weeds at the time of seedling emergence (Raj and Syriac, 2017). Weed can cause rice yield losses of up to 50% and the risk of yield loss is greater than transplanted rice and as high as 50-91% (Hossain *et al.*, 2016).

Hand weeding is extensively practiced in Nepal as well as in different countries of Asia. Although hand weeding is very easy and environment-friendly, but with the increase in labour cost and lack of labour farmers are parting away from manual weeding. Manual weeding becomes tedious, time consuming, expensive and slow process. Increase in labor cost and labor scarcity has been major drivers for farmers to seek alternatives of manual weeding. Effective weed management practices are an important prerequisite in DSR culture, with herbicide application seemingly indispensable (Azmi *et al.*, 2005). Thus, weeds are the most severe constraints in dry seeded rice and timely weed management is crucial for increasing the productivity of dry seeded rice (Shekhawat *et al.*, 2020). Moreover, a very few experiments have been carried out with a view to evaluate the efficacy of herbicides under field conditions. Therefore, the present experiment was conducted to find out effective herbicide for weed control in direct seeded rice. This study is also conducted to work out economics of different weed management and compare yield of dry direct seeded rice under different weed management practices.

MATERIALS AND METHODS

Experimental design

A field experiment was conducted at farmer's field under Prime Minister Agriculture Modernization Project, Super zone, Jhapa, Nepal. The experiment was carried out from 28th Magh, 2076 B.S. (11th February, 2020) to 10th Asar, 2077 B.S. (25th June 2020). The experimental field was 61 meter above the mean sea level and located geographically at 27° 36.22'N latitude and 84° 19.073'E longitude. The soil texture of the research plot was clay loam with pH acidic (5.2) in nature. Table 1 describes the physico-chemical traits of experimental. The total rainfall received during the crop season was 1038.95 mm. In the experiment a total of seven treatments were used to see their performance in RCBD design in three replications. The individual plot size was 4.0 m × 3.2 m (12.8 m^2) and the variety used was Hardinath-1, a moderately fine grain most popular variety in the eastern terai of Nepal.

Cultivation practices and data collection

Seed with seed rate was 70 kg/ha (90 grams per plot) was manually sown in the field and sowing was carried out on 16th Falgun, 2076 (28th February, 2020). Sesbania used as the co-culture treatment was seeded at 48 kg/ha (60 grams mixed with 90 gram of rice seed per plot) soaked in water for 24 hours. The row spacing was 20 cm. The chemical fertilizer was applied at the rate of 100: 40: 30 kg /ha of N: P_2O_5: K_2O. The whole dose of phosphorus and potash and half dose of nitrogen was applied as basal during the sowing time and remaining half dose was top dressed as split application at tillering and panicle initiation (PI) stage. The crop was given five irrigations, two during early crop establishment, two at tillering stage and rest one at PI stage. Soil surface application of all the chemical herbicides were carried out using flat fan nozzle by a Knap sack sprayer. Pre-emergence herbicide application was made at third day of sowing while post -emergence herbicides application was done at 15 days of sowing. The weed data were taken from a fixed quadrate of size 50 × 40 cm^2 at 30, 45days after sowing (DAS) and at harvest. After they were classified into broadleaf, grasses and sedges. Observations were taken on weed density, weed index, weed control efficiency and weed control index. All other yield and yield attributing data were recorded as per the Standard evaluation system of rice developed by the IRRI. The straw and the grains yield were taken from the net plot area (6 m^2).

Statistical analysis

The data were subjected to ANOVA technique by applying R-studio software and Fisher's protected LSD test was used to separate the means.

Table 1. Treatments details used in the study.

Treatment No.	Treatment practice
T_1	*Sesbania* fb Pendimethalin(pre) 30 % EC @1 kg a.i. ha^{-1} fb 2,4-D ethyl Easter (post) 38% EC @1 kg a.i. ha^{-1}
T_2	Pretilachlor (pre) 50%EC @0.75 kg a.i. ha^{-1}
T_3	Pendimethalin (pre) 30 %EC @1 kg a.i. ha^{-1}
T_4	Pretilachlor (pre) 50 %EC @0.75kg a.i. ha^{-1} followed by butachlor (post) 50% EC @0.75 kg a.i. ha^{-1}
T_5	Weedy check
T_6	Weedy free
T_7	Pendimethalin (pre) 30% EC @1 kg a.i. ha^{-1} followed by Bispyribac Na (post) 10% SC @25 g a.i. ha^{-1}

RESULTS AND DISCUSSION

Plant height

The study revealed that the plant height was significantly influenced by weed management practices. The average plant height varied from 10.77cm (30 DAS) to 93.06 cm (at harvest) and increasing up to harvest. Plant height in each date of observations was significantly influenced by weed management practices up to harvest (Table 2). At 30 DAS and harvest statistically longest plant height was observed with *Sesbania* co- culture + Pendimethalin treated plot along with Pendimethalin treated plots while at 45, 60 and 90 DAS statistically longest plant height was recorded from *Sesbania* co- culture + Pendimethalin treated plot which was found to be statistically at par with Pendimethalin treated. The results were also supported from the earlier researches who reported treatment including *Sesbania* produced the crop with tallest plant height (142cm),15.49% taller than weedy check; which may be due to competition between *Sesbania* and rice for resources (Bhattarai *et al.*, 2016). Statistically shortest plant height was recorded in weedy check plot at all the dates of observation.

Number of tillers per unit area

Number of tillers per square meter at all the dates of observation was found to be significantly affected by various weed management practices. Weedy control plots had statistically lowest number of tillers per square meter at all the crop growth phase's i.e. at 30, 45,60,75 DAS and harvest (Table 3). Remaining treatments were statistically at par with each other at all the dates of observations. It was observed that number of tillers progressively increased up to 45 DAS then declined afterwards. Maximum tillering was observed at 45 DAS. At the 45 DAS, numerically highest number of tillers per square meter was recorded in Pendimethalin treated plots (800 m^{-2}) and lowest value was recorded from weedy check plots (445.56 m^{-2}), also statistically lowest. Availability of nutrients, water and light along with decreased weed competition at critical crop growth stages results in increased in effective tillers per square meter (Bhurer *et al.*, 2013).

Table 2. Plant height (cm) of rice as influenced by the different weed management practices at Baniyani, Jhapa, 2020.

Treatments	Plant height (cm)					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
Sesbania culture fb Pendimethalin	11.98^{a}	18.50^{a}	28.19^{a}	53.08^{ab}	74.41^{a}	97.57^{a}
Pretilachlor	9.74^{bc}	14.85^{c}	23.99^{b}	50.33^{c}	71.34^{c}	93.62^{c}
Pendimethalin	11.82^{a}	17.85^{ab}	27.10^{ab}	54.12^{a}	74.31^{ab}	96.72^{a}
Pretilachlor fb Butachlor	10.59^{abc}	15.62^{bc}	24.35^{b}	51.32^{bc}	71.51^{bc}	93.29^{c}
Weedy check	8.82^{c}	10.71^{d}	18.83^{c}	39.39^{d}	59.28^{d}	79.60^{d}
Weed free	11.48^{ab}	17.31^{abc}	26.65^{ab}	53.97^{ab}	73.88^{abc}	96.05^{ab}
Pendimethalin fb Bispyribac Na	10.92^{ab}	16.98^{abc}	25.83^{ab}	53.46^{ab}	72.98^{abc}	94.54^{bc}
SEm (±)	0.29	0.59	0.71	1.09	1.12	1.26
^{a}F- test	*	***	**	***	***	***
LSD (=0.05)	1.83	2.60	3.46	2.66	2.81	2.16
CV, %	9.53	9.14	7.77	2.94	2.22	1.30
Grand mean	10.77	15.97	24.99	50.81	71.10	93.06

Note: fb means followed by , *, **,*** and NS indicate significant at 0.05, 0.01, 0.001 and insignificant respectively.

Table 3. Number of tillers per square meter of rice as influenced by the different weed management practices at Baniyani, Jhapa, 2020.

Treatments	Number of tillers per square meter				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Sesbania culture + Pendimethalin	394.44^{a}	832.22^{a}	645.56^{a}	370.00^{a}	368.28^{a}
Pretilachlor	353.33^{a}	763.33^{a}	564.44^{a}	354.44^{a}	353.23^{a}
Pendimethalin	395.55^{a}	840.00^{a}	644.44^{a}	378.89^{a}	375.27^{a}
Pretilachlor fb Butachlor	370.00^{a}	770.00^{a}	567.78^{a}	364.47^{a}	359.14^{a}
Weedy check	266.67^{b}	445.56^{b}	241.11^{b}	227.78^{b}	223.12^{b}
Weed free	382.22^{a}	804.44^{a}	602.22^{a}	367.78^{a}	365.59^{a}
Pendimethalin fb Bispyribac Na	366.67^{a}	776.67^{a}	577.78^{a}	355.55^{a}	353.23^{a}
SEm (±)	10.21	29.45	30.33	11.31	11.37
^{a}F-test	***	***	***	***	***
LSD (=0.05)	47.17	102.06	109.45	31.47	29.18
CV, %	7.34	7.68	11.21	5.12	4.79
Grand mean	361.27	747.46	549.05	345.56	342.55

Note: fb means followed by,a *, **,*** and NS indicate significant at P<0.5, p<0.05 and insignificant.

Table 4. Yield attributes as influenced by the different weed management practices at Baniyani, Jhapa, 2020.

Treatments	Yield attributes				
	Effective tillers per square meter	Panicle length	Florets per panicle	Sterility (%)	1000grain Weight (g)
Sesbania culture + pendimethalin	363.44^{ab}	23.10^{a}	140.54^{ab}	20.21	22.61
Pretilachlor	347.85^{bc}	22.68^{ab}	134.87^{ab}	25.71	22.62
Pendimethalin	371.51^{a}	22.43^{ab}	145.43^{a}	22.91	21.34
Pretilachlor fb butachlor	328.50^{c}	21.86^{b}	130.38^{ab}	26.73	22.09
Weedy check	211.29^{d}	20.10^{c}	83.28^{c}	19.55	23.28
Weed free	364.52^{ab}	22.13^{ab}	141.67^{ab}	24.86	21.98
Pendimethalin fb Bispyribac Na	351.61^{b}	21.53^{b}	122.83^{b}	21.56	22.15
SEm (±)	11.73	0.23	4.78	0.96	0.32
^{a}F- test	***	**	***	-	-
LSD (=0.05)	19.63	1.19	21.25	NS	NS
CV, %	3.30	3.04	9.30	18.77	7.59
Grand mean	334.10	21.98	128.43	23.08	22.30

Note: fb means followed by, *, **, *** and NS indicate significant at 0.05, 0.01, 0.001 and insignificant respectively.

Table 5. Grain yield of rice (kg ha^{-1}), Straw yield (kg ha^{-1}) and harvest index (%) of rice as influenced by the different weed management practices at Baniyani, Jhapa, 2020.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)
Sesbania co-culture + Pendimethalin	4.870^{a}	4352^{a}	52.79^{a}
Pretilachlor	4069^{ab}	3873^{ab}	51.22^{a}
Pendimethalin	4780^{a}	4318^{a}	52.55^{a}
Pretilachlor fb butachlor	3780^{b}	3705^{b}	50.11^{a}
Weedy check	1529^{c}	2189^{c}	40.99^{b}
Weed free	4603^{ab}	4231^{a}	52.08^{a}
Pendimethalin fb Bispyribac Na	4516^{ab}	4083^{ab}	52.50^{a}
SEm (±)	250.13	161.46	0.91
^{a}F-test	***	***	***
LSD (=0.05)	898.51	505.52	3.42
CV, %	12.56	7.44	3.82
Grand mean	4021	3822	50.32

Note: fb means followed by, *, **, *** and NS indicate significant at 0.05, 0.01, 0.001 and insignificant respectively.

Yield attributes

Effective tillers per square meter was statistically highest with Pendimethalin applied field (371.51 m^{-2}) and found to be statistically at par with *Sesbania* co-culture +Pendimethalin treated and weed free plots (Table 4). Bhurer *et al.* (2013) reported similar results with the use of Pendimethalin in dry direct seeded rice. Statistically longest panicle length was obtained in *Sesbania* co-culture + Pendimethalin treated plots and statistically similar with Pretilachlor, Pendimethalin treated plots and weed free plots. The effect of Pendimethalin played significant role in producing maximum florets per panicle and was statistically at par with remaining treatments except Pendimethalin fb Bispyribac Na treated plots. The average sterility percentage during the experiment was observed to be 23.08%, weedy check treatment had lowest record on sterility percentage (19.55%). The mean 1000-grain weight in the experiment was 22.30 g .Grain weight was not influenced significantly due to different treatments because it is a stable varietal character and the grain size is rigidly controlled by the hull (Yadana *et al.*, 2018).

Grain yield, straw yield and harvest index

The effect of different weed management practices was highly significant for all attributes as grain yield, straw yield and harvest index. The mean grain yield of the experiment was found to be 4021kg ha^{-1}, *Sesbania* co-culture + Pendimethalin (4870 kg ha^{-1}) and Pendimethalin (4780 kg ha^{-1}) treated plots produced significantly higher and statistically similar grain yield and Statistically at par with other plots except Pretilachlor fb Butachlor treated plots and weedy check treatments (Table 5). Similar result was obtained from (Marasini *et al.*, 2020) while studying weed dynamic and productivity in dry seeded rice. Statistically lower grain yield was obtained from weedy check plots (1529 kg ha^{-1}) which might be due to inferior performance in terms of some yield attributing characters. The highest straw yield was recorded with *Sesbania* co-culture + Pendimethalin (4352 kg ha^{-1}) and Pendimethalin (4352 kg ha^{-1}) treated plots. The weedy check plots produced statistically lowest straw yield 2189 kg ha^{-1}. The result behind this outcome might be lower number of tillers per square meter due heavy weed infestation in weedy check plots where crop growth and yield were controlled by weeds. Harvest index was found statistically similar in all the treatments except Weedy check plots under which harvest index was statistically lowest (40.99%). Numerically highest value for harvest index (%) was obtained from sesbania co-culture + pendimethalin applied plot (52.79%). The efficacy of pendimethalin alone is high as reported by several authors (Moody, 1991), (Valverde and Gressel, 2005).

Table 6. Weed density (no. m^{-2}) at 30DAS as influenced by the different weed management practices in DDSR at Baniyani, Jhapa, 2020.

Treatments	Weed density (no. of weeds m^{-2}) at 30 DAS			
	Sedges	Grasses	BLW	Total
Sesbania co-culture + Pendimethalin	0.71^{b} (0.00)	1.95^{b} (4.17)	2.17^{a} (4.22)	2.92^{b} (8.34)
Pretilachlor	0.71^{b}(0.00)	1.95^{bc} (4.17)	2.16^{a} (4.19)	2.91^{b} (8.35)
Pendimethalin	0.71^{b}(0.00)	1.68^{bc} (2.77)	1.18^{b} (1.33)	2.15^{b} (4.11)
Pretilachlor fb butachlor	0.71^{b}(0.00)	2.64^{b} (6.95)	0.71^{b} (0.00)	2.64^{b} (6.94)
Weedy check	2.43^{a}(5.56)	6.04^{a}(36.11)	0.71^{b} (0.00)	6.47^{a} (41.67)
Weed free	0.71^{b}(0.00)	2.16^{b} (4.17)	0.71^{b} (0.00)	2.16^{b} (4.17)
Pendimethalin fb Bispyribac Na	0.71^{b}(0.00)	0.71^{c} (0.00)	0.71^{b} (0.00)	0.71^{c} (0.00)
SEm (±)	0.135358	0.368823	0.149674	0.370332
^{a}F- test	***	***	***	***
LSD (=0.05)	0.31	1.24	0.55	0.88
CV, %	18.58	28.46	25.90	17.42
Grand mean	0.78	8.33	1.39	10.52

Note: fb means followed by *, **,*** and NS indicate significant at P<0.5, p<0.05 and insignificant respectively. The figures in the parenthesis represent the original value and outside the parenthesis the square root transformation value (√(x+0.5).

Table 7. Weed density (no. m^{-2}) at 60 DAS as influenced by the different weed management practices in DDSR at Baniyani, Jhapa, 2020.

Treatments	Weed density (no. of weeds m^{-2}) at 60 DAS			
	Sedges	Grasses	BLW	Total
Sesbania co-culture + Pendimethalin	2.70^{b} (6.94)	1.46^{c} (2.78)	0.71 (0.00)	3.09^{b} (9.64)
Pretilachlor	1.95^{b} (4.17)	3.18^{b} (9.72)	2.43 (5.55)	4.30^{b} (18.06)
Pendimethalin	2.70^{b} (6.94)	1.19^{c} (1.39)	2.16 (4.17)	3.60^{b} (12.50)
Pretilachlor fb butachlor	0.71^{b} (0.00)	2.43^{bc} (5.56)	1.46 (2.78)	2.91^{b} (8.16)
Weedy check	9.90^{a} (101.39)	9.12^{a} (83.33)	1.68 (2.78)	13.65^{a} (187.50)
Weed free	1.19^{b} (1.39)	2.16^{bc} (5.56)	1.46 (2.78)	3.18^{b} (9.83)
Pendimethalin fb Bispyribac Na	1.68^{b} (2.78)	1.19^{c} (1.39)	2.16 (4.17)	3.12^{b} (9.72)
SEm (±)	0.665837	0.593504	0.183496	0.804552
LSD (=0.05)	2.01	1.67	NS	1.47
CV, %	38.05	31.74	48.27	17.07
Grand mean	17.66	15.67	3.17	36.49

Note: fb means followed by, a *, **,*** and NS indicate significant at P<0.5, p<0.05 and insignificant respectively. The figures in the parenthesis represent the original value and outside the parenthesis the square root transformation value (√(x+0.5).

Weed density (no. m^{-2})

The result suggested that herbicide treatment significantly (*P<0.05*) affected the weed density at the all dates of observations i.e. at 30, 60 DAS and harvest presented in Table 6,7,8. The total weed density was recorded statistically higher in Weedy check plots at all the dates of observations. At 30 DAS remaining treatments were statistically similar excluding Pendimethalin fb Bispyribac Na which recorded significantly lowest value for the total weed density. The total weed density was recorded statistically similar at 60 DAS. At harvest, weedy check along with pendimethalin treated plot was statistically similar with rest plots excluding weed free plot and pendimethalin fb Bispyribac Na treated plots which were statistically lowest. From all three observations lowest weed density was incurred with the application of pendimethalin fb Bispyribac Na. The results are in conformity with (Ali *et al.*, 2014) ,who reported that Nominee 20%SC and Clover 20%SC herbicides containing Bispyribac sodium as gamma isomer gave the best weed control over all types of weeds which was 98.1 % and 94.8%, respectively. Grand mean of weed density at 30 DAS showed the higher grasses density (10.52 m^{-2}), 60 DAS showed dominant sedges density (17.66 m^{-2}) and broad leaf weed density (14.88 m^{-2}) was found to be prominent at harvest.

Weed index (WI %)

Weed index of DDSR as influenced by different weed management practices is presented in Figure 1. Grand mean weed index for the experiment was 14.75% and ranges from -5.80% to 66.78%. Weed index was significantly influenced by various weed management practices. Among the weed management practices, there was 66.78%yield reduction in weedy check plot which was significantly higher than other weed management practices. (Sharma, 2013) also found similar report of 65% yield reduction due to weed in direct seeded rice in Chitwan condition. Weed index of the plot treated with *Sesbania* co-culture (-5.80%) and Pendimethalin treated plot (-3.86%) were significantly lowest and were statistically at par Pretilachlor (11.60%) and Pendimethalin fb Bispyribac (1.90%). Weed index of Pretilachlor fb Butachlor treated plot (17.88%) was intermediate and statistically par with Pretilachlor (11.60%) and Pendimethalin fb Bispyribac (1.90%). The negative weed index in the plot treated with herbicides indicates higher yield than that of weedy free plot.

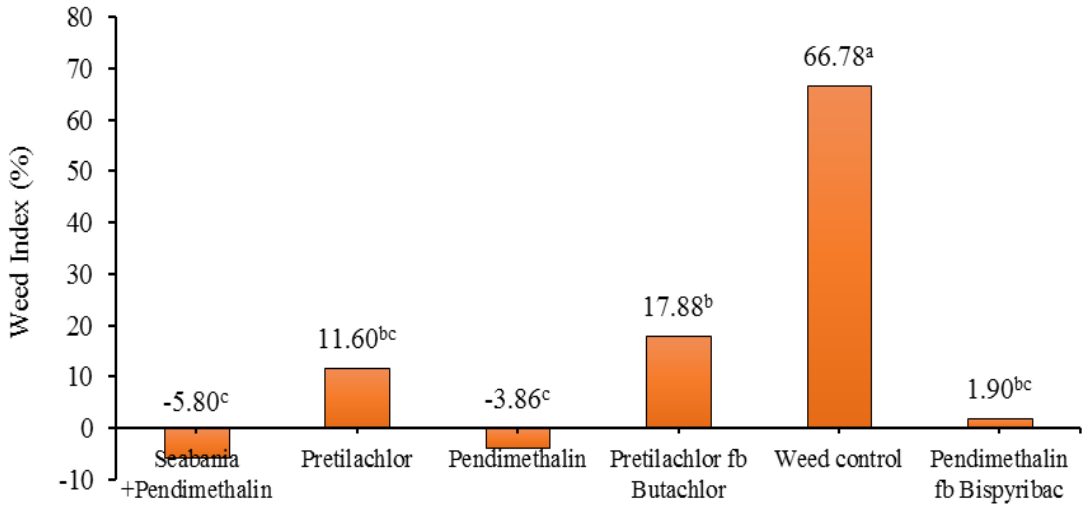

Figure 1. *Weed index (%) as influenced by different weed management practices DDSR at Baniyani, Jhapa, 2020.*

Table 7. Weed density (no. m^{-2}) at harvest as influenced by the different weed management practices in DDSR at Baniyani, Jhapa, 2020.

Treatments	Weed density (no. of weeds m^{-2}) at harvest			
	Sedges	Grasses	BLW	Total
Sesbania co-culture + Pendimethalin	1.19^{bc} (1.39)	2.16^{b} (4.17)	3.73^{ab} (13.89)	4.45^{bc} (19.44)
Pretilachlor	0.71^{c} (0.00)	1.19^{b} (1.39)	4.70^{a} (22.22)	4.83^{bc} (23.61)
Pendimethalin	1.95^{b} (4.17)	1.68^{b} (2.78)	4.70^{a} (22.22)	5.26^{b} (27.78)
Pretilachlor fb butachlor	0.71^{c} (0.00)	1.19^{b} (1.39)	4.12^{a} (16.67)	4.27^{bc} (18.06)
Weedy check	4.56^{a} (20.83)	6.07^{a} (37.50)	4.57^{a} (22.22)	8.95^{a} (80.56)
Weed free	0.71^{c} (0.00)	2.16^{b} (4.17)	1.46^{c} (2.78)	3.30^{c} (11.11)
Pendimethalin fb Bispyribac Na	0.71^{c} (0.00)	2.43^{b} (5.55)	1.67^{bc} (4.17)	3.46^{c} (12.50)
SEm (±)	0.309361	0.366307	0.356372	0.423134
^{a}F- test	***	***	*	***
LSD (=0.05)	1.05	1.37	2.17	1.64
CV, %	39.38	31.97	34.26	18.65
Grand mean	3.77	8.13	14.88	27.58

Note: fb means followed by, a *, **,*** and NS indicate significant at P<0.5, p<0.05 and insignificant respectively. The figures in the parenthesis represent the original value and outside the parenthesis the square root transformation value (√(x+0.5).

Table 8. Weed control efficiency (WCE %) and Weed control index (WCI%) as influenced by the different weed management practices in DDSR at Baniyani, Jhapa, 2020.

Treatment No.	Treatments	Weed control efficiency (WCE%)			Weed control index (WCI%)		
		30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T_1	*Sesbania* co-culture + Pendimethalin	79.88^{b}	94.86	75.86	90.36	99.44^{b}	98.57
T_2	Pretilachlor	79.95^{b}	90.37	70.69	99.01	99.08^{c}	97.93
T_3	Pendimethalin	90.13^{ab}	93.33	65.52	99.20	99.64^{ab}	96.89
T_4	Pretilachlor fb Butachlor	83.33^{b}	95.65	77.59	98.35	99.66^{ab}	99.10
T_5	Weed control	-	-	-	-	-	-
T_6	Weed free	89.99^{ab}	94.76	84.48	99.61	99.69^{ab}	99.01
T_7	*Pendimethalin* fb *Bispyribac Na*	100.00^{a}	94.82	86.21	100.00	99.86^{a}	97.74
SEm (±)		2.03	0.38	2.33	7.73	7.66	7.52
^{a}F- test		*	-	-	-	**	-
LSD (=0.05)		11.25	NS	NS	NS	0.29	NS
CV, %		7.10	2.27	10.44	5.84	0.16	1.14
Grand mean		87.22	93.97	76.72	97.75	99.56	98.20

Note: fb means followed by , *, **,*** and NS indicate significant at 0.05, 0.01, 0.001 and insignificant respectively.

Table 10. Total cost of production, Gross Return, Net return and B: C ratio as influenced by different weed management practices at Baniyani, Jhapa, 2020.

Treatment No.	Treatments	Total cost of cultivation NRs.ha^{-1}('000)	Gross return NRs.ha^{-1}('000)	Net return NRs.ha^{-1}('000)	B:C ratio
T_1	*Sesbania* co-culture + Pendimethalin	83.63	161.77^{a}	78.14^{ab}	1.93^{ab}
T_2	Pretilachlor	73.49	136.27^{ab}	62.78^{ab}	1.85^{ab}
T_3	Pendimethalin	74.29	159.01^{a}	84.72^{a}	2.14^{a}
T_4	Pretilachlor fb butachlor	77.19	127.08^{b}	49.89^{b}	1.65^{b}
T_5	Weedy check	69.79	57.18^{c}	-12.61^{c}	0.82^{c}
T_6	Weed free	141.79	153.45^{ab}	11.66^{c}	1.08^{c}
T_7	Pendimethalin fb Bispyribac Na	80.79	150.23^{ab}	69.44^{ab}	1.86^{ab}
SEm (±)		-	7.83	7.81	0.10
^{a}F- test		-	***	***	***
LSD (=0.05)		-	28.31	28.31	0.34
CV, %		-	11.79	32.38	11.91
Grand mean			135.50	49.15	1.62

Note: fb means followed by, *, **,*** and NS indicate significant at 0.05, 0.01, 0.001 and insignificant respectively.

Weed control efficiency (WCE %)

Weedy control efficiency was significantly influenced by various weed management practices at 30 DAS while non- significant impact was observed at 60DAS and harvest presented in Table 9. At 30 DAS, WCE was found statistically highest in Pendimethalin fb Bispyribac Na treated plots (100.00%), and was statistically at par with Pendimethalin (90.13%) and weed free plots (89.99%). Remaining treatments occupied statistically similar position. WCE at 60 DAS and harvest as influenced by various weed management practices was found to be non- significant. At 60 DAS, numerically lowest value was found in Pretilachlor applied field (90.37%) field and highest value of WCE was found in Pretilachlor fb Butachlor treated plots (95.65%).At harvest, WCE was noted numerically highest in Pendimethalin fb Bispyribac Na treated plots (86.21%) and Pendimethalin treated plot had numerically lowest value of WCE (65.52%).There was 100% reduction in weed population with application of Pendimethalin @ 1 kg a.i. ha$^{-1\,fb}$ Bispyribac Na @25g a.i. ha^{-1} over weedy check at 30 DAS.

Weed control index (WCI %)

At 60 DAS, significant effect of various weed management practices was observed on WCI whereas effect was non-significant at 30 DAS and harvest (Table 9). At 30, numerically highest value of WCI was recorded for Pendimethalin fb Bispyribac Na treated plots, 100.00%. This result signified that there was 100% reduction in weed dry weight with application of Pendimethalin @ 1 kg a.i. ha$^{-1\,fb}$ Bispyribac Na @25g a.i. ha^{-1} over weedy check at 30 DAS. WCI was found to be significantly highest in Pendimethalin fb Bispyribac Na treated plot (99.86%) at 60 DAS and was statistically at par with remaining treatments except *Sesbania* co-culture + Pendimethalin and Pretilachlor treated plots. Treatment Pretilachlor occupied statistically lowest position (99.08%). At harvest, numerically highest value of WCI was recorded for Pretilachlor fb Butachlor treated plots, 99.10%. This result signified that there was 99.10% reduction in weed dry weight with application of Pretilachlor @ 0.75 kg a.i. ha$^{-1\,fb}$ Butachlor @0.75 kg a.i. ha^{-1} over weedy check at harvest.

Economic analysis

Significant effect of weed management practices were observed on the net return, gross return per hectare and Benefit: Cost ratio as presented in Table 10. Weedy check plots had statistically lowest value for gross return (NRs. 57.18 thousand ha^{-1}), net return (NRs. -12.61 thousand ha^{-1}) and B:C ratio (0.82). Highest value of gross return was found in *Sesbania* co-culture+ Pendimethalin treated plot (NRs. 161.77 thousand ha $^{-1}$), which was statistically at par with the Pendimethalin treated plot (NRs.159.01 thousand ha^{-1}) whereas the highest net return (NRs. 84.72 thousand) was observed in the Pendimethalin treated plot which was statistically at par with remaining treatments except for weed free treatment. Application of Pendimethalin @ 1kg a.i. ha^{-1} had the significantly highest B: C ratio (2.14) while the lowest B: C ratio was observed in weedy check (0.82) and weed free (1.08) treatments.

Conclusion

Weed are major problems in dry direct seeded rice and its management can prevent severe yield loss. All the weed management practices significantly improved grain yield of dry seeded rice and was found to be significantly highest in Sesbania co-culture + Pendimethalin (4869.99 kg ha^{-1}) and Pendimethalin (4780.45 kg ha $^{-1}$) treated plots. There was reduction in yield by 66.78% due to presence of weed as compared to weed free. Weed density and Weed dry weight were reduced by weed management practices in dry direct seeded rice. Total weed density at 30 DAS, 60 DAS and harvest were found to be significantly lowest in Pendimethalin fb Bispyribac Na treated plot except total weed dry weight at harvest where Pretilachlor fb Butachlor had lower value and statistically lowest. Though due to lower cost production (NRs 74.29 thousand ha^{-1}) and superior performance in many parameters including grain yield per hectare, gross return (NRs.159.01 thousand ha^{-1}), net return (NRs. 84.72 thousand ha^{-1}) and B:C ratio (2.14); treatment Pendimethalin is proved to be best weed management practices for direct seeded rice at Baniyani, Jhapa.

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