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Effect of Different Herbicides in Weed Management in Transplanted Rice

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ABSTRACT

Weed is one of the major yield-limiting factors in rice cultivation. It causes yield losses of around 40-90%, depending on the situation. Manual weeding is the dominant weed management method in rice and limited farmers use herbicides in Nepal. Selecting effective herbicides for different weed species is a crucial task for farmers. So, an experiment with 9 treatments consisting of 5 herbicides was conducted in RCB Design with 3 replications during 2020 and 2021 to find effective herbicides. The recommended agronomic practices were followed. Rice variety Khumal 11 was transplanted in a 4m x 3m plot with a spacing of 20 cm between rows and 15 cm between plants. Pooled data of two years showed the lowest weed density (14.2 m^{-2}) and highest (73.2 m^{-2}) in the treatment pretilachlor @ 0.5 kg ha^{-1} (pre) as sand mix and in the weedy check. Similarly, the lowest weed dry biomass (7.4 g m^{-2}) and the highest (42.4 g^{-2}) were recorded in the same treatments. The grain yield was the highest (7253 kg ha^{-1}) in pretilachlor applied at 0.5 kg a.i ha^{-1} as pre-emergence spray and the lowest (4339 kg ha^{-1}) in the control. The treatment pretilachlor @ 0.5 kg a.i ha^{-1} (pre) applied as spray was superior in managing weed and resulting in the highest grain yield, so it is recommended for mid-hill ecologies under transplanted rice.

Keywords: Pretilachlor, management, rice, weed, yield

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INTRODUCTION

Rice (*Oryza sativa* L.) is a major cereal crop cultivated in at least 95 countries (FAO 2017). It is a major crop in Nepal, cultivated on 1.4 million hectares with a production of 5.1 million tons and productivity of 3.5 tons per hectare (MoALD 2020/21), contributing to approximately 16% of the Agricultural Gross Domestic Product (AGDP). Rice is cultivated in three different agroecological zones, viz., in the terai (68%), in mid-hills (28%) and 4% in the high hills (Gauchan et al 2014). The majority of the rice area is under rainfed conditions and the open-pollinated varieties are primarily used. Hybrid rice is recently in use in some parts of the country. The typical methods of establishing rice are through transplanting methods and direct seeded rice is also practiced in some areas of terai regions and as upland rice in the hills. There are many constraints in rice production viz., availability of quality seeds, irrigation, availability of fertilizers and other agrochemicals in time, weeds, diseases, and insects. The shortage and the high labor costs are also major challenging issues in the sustainability of rice production. The uneven with less rainfall and escalating temperature due to the impact of climate change also hinder rice cultivation. For 1°C increase in average summer temperature results in a 4183 kg reduction in rice production (Rayamajhee et al 2021). The labor-intensive practices for transplanting and weeding are further causing difficulties in rice cultivation.

Weeds, the most severe pests in agriculture compete with the crop for nutrients through rapid growth and development. Weeds are the main biological constraints in attaining the potential rice yield. They also significantly reduce quality and profitability (Ahmed et al 2014 and Kumar et al 2013). Weeds take available nutrients and compete with rice plants for water, light and space (Khaliq et al 2014). During adverse conditions, weeds negatively affect plant growth and development, tillering ability, yield and yield attributes of rice (Ashraf et al 2014). It is estimated that the yield losses in Asia due to weeds in lowland rice range from 10% to 20% (Savary et al 2012). The dependence on manual weeding in rice can be reduced through different herbicides. However, the technical knowledge of herbicides is lacking among farmers in Nepal. The weed density is high with different weed flora (grasses, sedges, and broad-leaved weeds) in rice. The diverse weed flora under transplanted situations can reduce yield to 76% (Singh et al 2004). There are several herbicides recommended for different weed species.

In most Asian countries manual weeding by hand-pulling has traditionally been the most common practice of weed control in rice (Ahmed et al 2015, Islam et al 2017). Weeding operations usually require more labour than other production practices in rice, which increase production costs and achieve weeding in a longer time. The application of herbicides provides effective control of weeds during labour scarcity. The proper dose of herbicide use depends on several factors such as soil type, cultural practices and environmental conditions. A sequential spray of pendimethalin @1 kg ha^{-1} followed by bispyribac sodium @ 30 g ha^{-1} at 15 days after sowing resulted in the effective management of weeds in DSR (Mahajan et al 2009). However,due to the intensive use of herbicides, there is a risk of herbicide resistance and environmental contamination, so, there is a need to integrate herbicides with other approaches of weed management (Mahajan and Chauhan 2013a).

MATERIALS AND METHODS

An experiment with nine treatments of five herbicides was conducted in the Agronomy Research Field at Khumaltar, Lalitpur in 2020 and 2021. The trial was set up in RCB design with 3 replications.The details of treatments is given in Table 1. The recommended agronomic practices were followed. Rice variety Khumal 11 was transplanted in a plot of 4m x 3m (12 m^2) size with a spacing of 20 cm between rows and 15 cm between plants. Recommended fertilizers dose of 100:40:30 N: P_2O_5:K_2O kg ha^{-1} was applied. Total nitrogen was applied in three splits with 1/3 each at basal, tillering, and panicle initiation stages. A knapsack sprayer with a flat fan nozzle was used to sprayed with 500 liters of water per hectare. In time, other agronomic practices such as irrigation, top dressing, and hand weeding in the required treatment were carried out. Data on growth and yield attributes were taken from 10 sample plants from each plot. The weed data were recorded from the area of 1m^2. Grain and straw yield were recorded from a 9.6 m^2 net plot area. The economy of the different treatments was calculated using the costs incurred for the treatments and the market value of paddy price at Rs 38 per kg for the benefits. Data of two years were pooled and analyzed using software Excel 2013 and Genstat 18 edition.

Table 1. Details of the treatment used in the experiment

SN	Treatment details	Notation
1	Pretilachlor @ 0.5 kg a.i. ha^{-1} (pre) as spray	Preti (Spry)
2	Pretilachlor @ 0.5kg a.i. ha^{-1} (pre) as sand mix	Preti (SM)
3	Pretilachlor @ 0.5kg a.i. ha^{-1} as spray Fb 1 Hand weeding (HW)	Preti (Spry) HW
4	Pendimethalin as spray @ 1.0 kg a.i. ha^{-1} (pre) Fb 1 HW	Pendi (Spry) HW
5	Butachlor (pre) as broadcast @ 25 kg ha^{-1} fb 1 HW	Buta fb HW
6	Bispyribac as post @ 25 g a.i. ha^{-1}	Bispy
7	Metsulfuron (almix) as post @ 4 g a.i. ha^{-1}	Mets
8	Farmers' practice (2 Hand Weeding)	FP(2HW)
9	Weedy check (control)	Control

Weather conditions

The weather parameters during the crop growing period is given in Table 2. The maximum and minimum temperature during the crop periods (May to November 2020) ranged from 23.3 to 28.8 °C and 7.5 to 20.1°C, respectively, and total rainfall received was 1212.5 mm. During the second crop (May to November 2021), the maximum and minimum temperatures ranged from 22.2-27.8°C and 11.2-20.8 °C respectively and the total rainfall was 1107.9 mm. The rainfall was higher during July in both years.

Table 2: Weather parameters during the crops season

Months	2020				2021			
	Max. Temp °C	**Min. Temp °C**	**Total rainfall (mm)**	**Rainy Days**	**Max. Temp °C**	**Min. Temp°C**	**Total rainfall (mm)**	**Rainy Days**
May	26.6	16.3	151.2	15	25.6	16.4	127.6	16
June	27.1	19.8	268.6	22	27.8	20.0	204	24
July	27.5	20.8	388	22	27.4	20.8	397.7	29
August	28.8	21.3	181.2	22	27.4	20.6	215.9	26
Sept.	28.1	20.1	223.5	16	27.6	19.5	131.5	21
October	28.4	15.7	0	0	26.8	16.6	31.2	8
November	23.3	7.5	0	0	22.2	11.2	0	0
Total			**1212.5**	**97**			**1107.9**	124

Soil characteristics

The soil texture of the experimental site was silty clay loam (Sand 17.3%, Silt 57.1% and Clay 25.6%). The soil was acidic (5.98 pH), low in organic matter (2.01%), medium in total nitrogen (0.14%), high in P_2O_5 (478.8 kg ha^{-1}) and medium in K_2O (160.5 kg ha^{-1}).

RESULTS AND DISCUSSION

Effect of different treatments on weed dynamics and weed biomass

The major weeds observed in the experimental plots were *Ammania sp, Alternanthera philoxeroides, Caesulia axillaris, Cyperus iria, Cyperus difformis, Commelina sp, Echinochloa colona, Echinochloa crusgalli, Eleusine indica, Fimbristylis littoralis, Lindernia cardifolia and Rotalla rotundifolia.* The number of grassy weeds (GW) ranged from 0.8 to 5.4 per meter square (m^{-2}) with the lowest and highest grassy weed number found in treatment pendimethalin applied as spray followed (fb) by 1 hand weeding (HW) and control (no weeding) respectively. The treatment mean of the pooled data showed significant differences in the grassy weed numbers among the treatments. The reduced number of grassy weeds observed in the pendimethalin sprayed treatment compared to other treatments suggests that pendimethalin is effective in controlling grassy weeds. Similar results were reported by Bhurer et al (2013) and Shah et al (2021). Pendimethalin (Group 3) provides about 1 month of residual control of many summer annual grasses and some annual broadleaf weeds as they germinate (Dwight 2020).

The effect of different treatments on weed dynamics and weed biomass is given in Table 3. The number of sedge weeds (Sedg) among the different treatments ranged from 2.3 to 12.0, with the lowest and highest sedge weeds recorded in the treatment pretilachlor applied as sand mixed and in control, respectively. The number of sedge weeds is controlled due to the pretilachlor treatment applied as a spray or sand mixed in compared to the control and other treatments. Pretilachlor showed an effect in controlling the sedges in rice. Butachlor fb 1 HW also showed effectiveness in managing the population of sedges (Table 3).

The number of broadleaf weeds (BR) recorded in the range 8 to 66 with the lowest value in treatment pretilachlor applied as spray followed by one-hand weeding and the highest value in the control. The mean difference for the broadleaf leaf was statistically significant. The number of broadleaf weeds was controlled by applying treatment pretilachlor spray fb 1 HW. The weed number also reduced due to the application of treatments pretilachlor as sand mixed and butachlor fb 1 HW. However, treatment of pendimethalin spray fb 1 HW was ineffective in controlling the broadleaf weeds (Table 3).

The weed density (WD) per meter square ranged from 14.2 to 52.9 with the lowest value in pretilachlor applied as a spray and the highest value in control, respectively. The lower value was also recorded in the treatment viz., pretilachlor applied as sand mixed (14.6) and butachlor fb 1 HW (17.4). The number of broadleaf weeds was controlled by applying treatment pretilachlor spray fb 1 HW. The weed number also reduced due to the application of treatments pretilachlor as sand mixed and butachlor fb 1 HW. However, treatment of pendimethalin spray fb 1 HW was ineffective in controlling the broadleaf weeds (Table 3).

The value of weed dry biomass (WDBM) ranged from 7.4 to 42.4 grams per square meter. The mean value differed significantly among the treatments, with the lowest in pretilachlor applied as sand mixed and the lowest in the control. The weed dry biomass was found to be lowest in the treatment pretilachlor applied as sand mixed, proving the best herbicides in reducing the weed biomass (Table 3).

Table 3. Effect of different herbicides in weed density and weed biomass in transplanted rice

Treatment	GW	Sedg	BR	WD	WDBM (g)
Preti (Spry)	2.1(4.3)	1.7(2.3)	3.7(26)	3.4 (31.2)	4.3 (14.9)
Preti (SM)	1.7(2.1)	1.7(2.3)	2.5(11)	2.4(14.6)	3.1 (7.4)
Preti (Spry) HW	2.0(3.6)	2.0(4.9)	2.7(8)	3.7(14.2)	3.6 (17.3)
Pendi (Spry) HW	1.3(0.8)	1.9(3.4)	4.7(47)	3.1(50.6)	5.2(15.4)
Buta fb HW	1.6 (2)	1.7(3.0)	3.0(11)	3.9(17.4)	3.7 (16.4)
Bispy	1.7(2.1)	2.1(5.1)	4.4(32)	4.1(39.5)	5.0 (23.9)
Mets	2.1(4.3)	2.4(6.0)	4.2 (28)	3.5 (41.1)	5.3(14.7)
FP(2HW)	1.5(1.6)	2.1(5.9)	5.0 (46)	3.4 (52.9)	5.5(14.6)
Control	2.1(5.4)	2.8(12.1)	5.8 (66)	5.4	6.6(42.4)
G. mean	**1.8**	**2.0**	**4.0**	**37.2**	**4.7**
LSD (0.05)	0.4	0.6	**1.2**	49.99	ns
CV (%)	22.5	30.2	26	29.2	64

Data subjected to square root transformation and data in the parenthesis are the original values. GW = number of grassy weeds per meter square, Sedg number of sedge weeds per meter square, BR=Number of broadleaf weeds per meter square, WD=Total weed density per meter square, WDBM =weed dry biomass per meter square in gram

Effect of different treatments on growth and yield attributes

The effect of different treatments on growth and yield attributes is given in Table 4. The plant height (Pl.ht.) ranged from 88 to 107 cm among the different treatments with the lowest and the highest value found in the treatment control and metsulfuron respectively. Plant height increased due to the applications of all the herbicides and hand weeding in the treatments compared to the no weeding as control. The competition of plants with weeds in control retarded the plant's height. The number of tillers per plant also exhibited differences in the mean value among the treatments with the lowest (289) in control and the highest (336) in pretilachlor spray treatment (Table 4). A large number of tillers were produced due to the application of pretilachlor as a spray which might be due to this treatment's effective weed management.

Table 4. Effect of different herbicides in growth and yield attributes in transplanted rice

Treatment	Pl.ht. (cm)	Tillers	P length (cm)	FG	UFG	Total Grains	TGW
Preti (Spry)	104	336	23	145	13.3	158	27.1
Preti (SM)	105	300	23	131	20.5	152	27.4
Preti (Spry) HW	106	301	23	147	18.8	166	27.3
Pendi (Spry) HW	102	270	23	143	15.4	158	27.3
Buta fb HW	106	307	23	134	18.0	152	27.2
Bispy	105	322	21	139	23.0	162	27.0
Mets	107	372	23	146	14.2	160	27.0
FP(2HW)	106	312	23	145	15.7	161	27.0
Control	88	289	22	109	25.8	134	25.5
G. mean	**103**	**312**	**23**	**138**	**18.3**	**156**	**27.0**
LSD (0.05)	4.41	61.9	1.04	21.97	8.76	15	0.89
CV (%)	4.3	19.8	4.6	15.9	47.7	14	3.3

FG =Number of filled grains per panicle, P length =panicle length, pl.ht= plant height

The panicle length (P length) showed significant variation among the treatments with the lowest value in bispyribac spray and the highest value in the different 7 treatments. The panicle length was shortest in treatment bispyribac, which exhibited a negative effect compared to others. The mean value ranged from 109 to 147 in the filled grains per panicle, with the lowest value in control and the highest in treatment pretilachlor spray fb 1 HW. The number of unfilled grains among the different treatments varied significantly. Pretilachlor sprayed treatment showed the lowest value (13.3) whereas control showed the highest value (25.8). The total grains per panicle ranged from 134 to 166 showing significant differences among the treatments with the lowest value in the control and the highest value in the treatment pretilachlor spray fb 1 HW (Table 4).

The number of filled grains increased due to the application of pretilachlor fb 1 HW compared to the control. The number of filled grains also increased in the other treatments compared to the control. The less weeds or weed-free environment allowed the developing grains to get sufficient photosynthates to achieve more filled grains per panicle. The smaller number of unfilled grains in pretilachlor spray treatment was due to less competition inflicted by weeds and sufficient inputs for grain development than control. The value of thousand grains weight (TGW) ranged from 25.5 to 27.4 g and the lowest and highest value was found in control and pretilachlor spray fb 1 HW treatments. The thousand grains weight also shows a similar trend with grains per panicle (Table 4).

Effect of different treatments on yield and economy

The effect of different herbicides on grain yield, straw yield and economy is given in Table 5. The grain yield (GY) among the different treatments ranged from 4339 kg to 7253 kg ha^{-1} with the lowest yield obtained in control and the highest yield in pretilachlor sprayed treatments respectively. The mean grain yield difference is found to be significant. Grain yield increased due to the application of pretilachlor as spray which might be due to the timely and effective control of weeds. The crops develop without the shortage of inputs in a less stressful environment compared to control. The straw yield (SY) among the treatments ranged from 7178 to 7880 kg ha^{-1} with the lowest value in the control and the highest value in the treatment butachlor fb 1 H. The straw yield was highest in butachlor fb 1 HW treatment compared to others (Table 5).

The total costs of different treatments ranged from Rs 50000 to Rs 90000 per hectare. The lowest total cost was incurred in the control and the highest was in the farmers' practice (2 HW). The benefit obtained from the different treatments ranged from Rs 114882 to Rs 220614 with the lowest value in the control and highest in pretilachlor spray. The benefit-cost ratio (B:C) among the different treatments ranged from 1.97 to 4.01 with the lowest in farmers' practice treatment and highest in pretilachlor spray. The total cost was highest in the treatment farmers' practice (2 HW) involving two-hand weeding due to the high labor cost incurred. The benefit obtained from the treatment was highest in the pretilachlor as spray due to the highest grain yield resulting from better weed management by the treatment applied. The highest benefit-cost ratio was also from the same treatment pretilachlor as spray due to the highest yield and reasonable total costs (Table 5).

Table 5. Effect of different herbicides in yield and economy in transplanted rice

Treatment	Grain Yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total cost (RS)	Gross Returns (RS)	Benefit (RS)	B:C
Preti (Spry)	7253	7736	55000	275614	220614	4.01
Preti (SM)	6982	7198	55000	265316	210316	3.82
Preti (Spry) HW	7054	7423	75000	268052	193052	2.57
Pendi (Spry) HW	7229	7536	74000	274702	200702	2.71
Buta fb HW	7183	7880	75000	272954	197954	2.64
Bispy	7068	7518	57500	268584	211084	3.67
Mets	7020	7633	56000	266760	210760	3.76
FP(2HW)	7033	7571	90000	267254	177254	1.97
Control	4339	7178	50000	164882	114882	2.30
G. mean	**6796**	**7519**				
LSD (0.05)	689.4	ns				
CV (%)	10.1	18.6				

CONCLUSION

The analysis of two-year pooled data showed pretilachlor applied at 0.5 kg a.i.ha^{-1} as pre-emergence herbicide as spray exhibited effective weed control and resulted in the highest grain yield (7253 kg ha^{-1}).This treatment also resulted in the highest benefit (Rs 220614) and benefit-cost ratio (4.01) compared to all the treatments. The treatment pretilachlor @ 0.5 kg a.i. ha^{-1} (pre) as the sand mix was also found to be an effective alternative in managing weed and producing the highest yield, benefit and benefit-cost ratio. So, applying pretilachlor herbicide at 0.5 kg a.i. ha^{-1} as pre-emergence spray for weed management is recommended for mid-hill ecologies in the transplanted rice.

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AUTHORS' CONTRIBUTION

RK Bhattarai conceptualized, conducted and prepared the manuscript as a lead author while other authors assisted in field work and write-up.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

REFERENCES

Ahmed S and BS Chauhan. 2014. Performance of different herbicides in dry-seeded rice in Bangladesh. Scientific World J. DOI: https://doi.org/10.1155/2014/ 729418

Ahmed S, TH Awan, M Salim and BS Chauhan.2015. Economics of nitrogen and integrated weed management in dry seeded rice. J Anim Plant Sci. **25**:1675–1684

Ashraf U, SA Anjum, KI Ehsanullah and M Tanveer. 2014. Planting geometry induced alteration in weed infestation, growth and yield of puddled rice. Pakistan Journal of Weed Science Research. **20**(1):77-89

Bhurer KP, DN Yadav, JK Ladha, RB Thapa and KR Pandey. 2013. Influence of integrated weed management practices on dynamics and weed control efficiency in dry direct seeded rice. Nepal Journal of Science and Technology. **14**(2):33-42

Dwight Lingenfelter .2020.Hay, Grassy Weeds, and Prowl. https://extension.psu.edu/hay-grassy-weeds-and-prowl

FAO. 2017. FAOSTAT Database. Food and Agriculture Organization of the United Nations, Rome, Italy.

Khaliq A, A Matloob and BS Chauhan. 2014. Weed management in dry-seeded fine rice under varying row spacing in rice wheat system of Punjab, Pakistan. Plant Production Science. **17**(4):321-332

Kumar V, S Singh, RS Chhokar, RK Malik, DC Brainard and JK Ladha. 2013. Weed management strategies to reduce herbicide use in zero-till rice–wheat cropping systems of the Indo-Gangetic Plains. Weed Technol. **27**:241–254

MoALD. 2022. Statistical information of Nepalese Agriculture 2077/78 (2020/21). Ministry of Agriculture and Livestock Development 2022.

Mahajan G, BS Chauhan and DE Johnson. 2009. Weed management in aerobic rice in north western Indo-Gangetic Plains. Journal of Crop Improvement. **23**: 366-382.

Mahajan G and BS Chauhan. 2013a. Herbicide options for weed control in dry-seeded aromatic rice in India. Weed Technology. **27**: 682-689.

Singh VP and M Singh. 2004. Effect of Bispyribac sodium on transplanted rice and associated weeds. Indian J. Weed Sci. **36**:190-192.

Shah P, SK Sah, KB Basnet and MN Paudel. 2021. Effect of seedbed preparation methods and herbicide application on yield and economics of dry direct-seeded rice at Parwanipur, Nepal. Agronomy Journal of Nepal (Agron JN). **5**: 32-38.

Savary S, A Ficke, J Aubertot and C Hollier .2012. Crop losses due to diseases and their implications for global food production losses and food security. Food Security. **4**:519–537. DOI: https://doi.org/10.1007/s12571-012-0200-5

Rayamajhee V, W Guo and AK Bohara. 2021.The Impact of Climate Change on Rice Production in Nepal. EconDisCliCha. **5**: 111–134. DOI:https://doi.org/10.1007/s41885-020-00079-8.