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Research Article

Yield and Yield Attributing Characters of Promising Rice Genotypes under Dry Direct Seeded Conditions as Affected by Varieties and Weed Control Methods

Dev Kumar Saphi[1*], Dil Raj Yadav[1], Rajib Kumar Yadav[1], Rajendra Yadav[2]

[1]National Rice Research Program, Hardinath, Dhanusha, Nepal
[2]Department of Agriculture, Ministry of Agriculture, Land Management and Cooperatives, Nepal

Abstract

Dry direct seeded rice (DSR) is an alternative to the farmers in the context of climate change and inputs scarcity especially labor. However, weeds are the major problem in dry direct seeded conditions competing with different resources provided to the crop. Hence, field experiments were conducted for two consecutive years 2015 and 2016 at the experimental field of Rice Research Program, Hardinath, Dhanusha to identify the appropriate herbicides for DSR. The experiment was laid out in a split plot design and treatments were replicated thrice. Three varieties of rice namely Ciherang Sub-1, IET 16775 and Sukhkhadhan-3 were treated as main plot factors while five levels of weed control methods (oxadiargyl@ 100 g a.i./ha as pre-emergence followed by fenoxaprop@ 90 g a.i./ha with safener, pendimethalin @ 1000 g a.i./ha as pre-emergence followed by bispyribac sodium @ 25 g a.i/ha at three weeks after seeding, pendimethalin @ 1000 g a.i./ha as pre-emergence followed by pyrazosulfuron ethyl @ 25 g a.i./ha + bispyribac sodium @ 25 g a.i./ha at three weeks after seeding, hand weeding and weedy check) were treated as sub-plot factors. The statistical analysis showed that the effect of weed control methods on yield and yield attributing parameters of the tested rice varieties was significant. Out of all the treatments, hand weeding yielded significantly higher grain yield (5.4 t/ha) followed by herbicides pendimithalin fb pyrazosulfuron ethyl + bispyribac sodium; which reduced the weed density and was comparable with hand weeding for grain yield. The interaction effect of weed control methods and varieties was found non-significant. Pendimithalin fb pyrazosulfuron ethyl + bispyribac sodium was found to control broad spectrum of weeds and also reduced the human labour drudgery and increasing the rice yield than the other herbicides in direct seeded rice.

Keywords: Dry direct seeded; herbicides; weed biomass

Introduction

Rice is a major cereal crop of Nepal and contributes about 22% in agricultural gross domestic product (AGDP) of the country. It is grown in about 1.34 million hectares with an average productivity of 3.35 t/ha (MoAD, 2016). In Nepal, rice is predominantly grown by transplanting seedlings into puddled soil and kept flooded for most part of the growing season. The puddled soil ensures good crop establishment, weed control with standing water, and reduces water losses through deep percolation (Sharma *et al.*, 2003). However,

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[1]***Corresponding author**
Dev Kumar Saphi,
National Rice Research Program, Hardinath, Dhanusha, Nepal
Email: dknarc130@gmail.com

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the conventional method of rice cultivation requires a huge amount of water, labour, and energy, which are gradually becoming scarce and more expensive. Direct seeding is a good alternative of conventional transplanting and yield potential of direct seeded rice is comparable to the transplanted rice under good water management and weed control conditions (Awan *et al.*, 1989). Weeds are the major threat to the direct seeded rice by competing for nutrients, light, space and moisture throughout the crop growth period (WARDA, 1996). The risk of yield loss from weeds in direct-seeded rice is greater than the conventional transplanted rice (Rao *et al.*, 2007). It has been reported that yield reduction up to 48, 53 and 74% in transplanted, direct seeded flooded and direct seeded aerobic rice, respectively (Ramzan, 2003). Usually, dry direct seeded rice is much more affected with a broader weed spectrum than flooded transplanted rice (Balasubramanian and Hill, 2002). Therefore, an effective and economical weed control strategy needs to be implemented to meet the demand of staple food for increasing population in Nepal. Thus, this experiment was carried out to explore the most suitable economical methods of weed management in dry direct seeded rice.

Materials and Methods

Experimental Site

Field experiments were carried out at the research block of National Rice Research Program, Dhanusha, Nepal in 2015 and 2016 rainy seasons. The experimental site is located at the latitude of 26°49' E and longitude of 86°01' N with an altitude of 93 m from mean sea level. Agro-ecologically, the area falls under sub-tropical region. The climate is warm and moist having hot and humid summer and mild winter. The maximum temperature in summer is 44°C and minimum temperature in winter is 4.8°C. The average annual rainfall is 1281 mm and maximum rainfall occurs in July and 80% of the total annual rainfall comes between June and September.

Experimental Design and Treatments

The experiment was laid out in a split design with three replications. A total of three rice varieties (two recently released rice varieties-Sukhkhadhan-3 and Ciherang Sub1 and one promising rice genotype-IET 16775) and five weed control methods were included as treatments. Rice varieties were treated as main plot factors and weed control methods were as sub plot factors. The details of treatments included in the experiment are given in Table 1.

Experimental Details

Seeds of each three cultivars were treated with carbendazim @ 0.5 g ai/kg rice seed and sown in the first week of June in both years. Seeds were direct seeded at a rate of 30 kg/ha at a soil depth of 2-3 cm. The herbicides were applied using a battery operated back-pack knapsack sprayer fitted with a flat-fan nozzle and calibrated to deliver 500 lit/ha for pre-spray and 375 lit/ha for post spray. The crop was managed following the standard recommended practices for rice in Nepal. Fertilizers were applied @ 90:30:30 N:P_2O_5:K_2O kg/ha. Half dose of the N, full dose of P_2O_5 and K_2O was applied as a basal application. Remaining N was splitted into two equal parts and applied at 40 and 60 DAS as a top dress.

Weed species were counted from two quadrates of 0.5 m^2 size each per plot was taken at 30, 60 and 90 DAS from weedy check plots. Weeds were categorized into grass, sedge and broadleaf weeds. Weed biomass was determined at 20 and 45 DAS from a randomly selected 0.5 m^2 quadrate in each plot. Weed samples were oven dried before weighing at 70°C till the constant weight was achieved. At harvesting, five rice plant clusters were randomly selected from each treatment to collect data for plant height (cm), panicle length, number of grains/panicle. Effective tillers were recorded from 1 m^2 area for each treatment at harvesting. The crop was harvested leaving the border area of 22.5 cm from each side of the plot. Crop from net area was harvested, sun dried and threshed manually. Grain and straw thus separated were kept separately, dried and finally weighed.

Table 1: Details of treatments included in the experiment

Treatments	Details	Dose (g a.i./ha)	Time of application (Days after sowing)
Main plot factor-Variety (3 levels)			
V1	Ciherang Sub1	-	-
V2	IET16775	-	-
V3	Sukhkhadhan-3	-	-
Weed control method (5 levels)			
W1	Oxadiargyl fb fenoxaprop	100 fb 90	3 fb 21
W2	Pendimethalin fb bispyribac sodium	1000 fb 25	3 fb 21
W3	Pendimethalin fb pyrazosulfon ethyl + bispyribac sodium	1000 fb 25 + 25	3 fb 21
W4	Weed-free	-	-
W5	Weedy check	-	-

Abbreviation: fb = followed by.

Statistical Analysis

Data were subjected to analysis of variance using CropStat V.07 (IRRI, 2007). The interaction effect of varieties with weed control methods was non-significant; therefore, combined analysis was done. Weed density data were subject analysis square root transformation before analysis. Means were separated using Least Significant Difference (LSD) test at $P \leq 0.05$.

Results

Weed Flora

The experimental site was infested with mixed weeds and the major weed flora recorded in the experimental plots (weedy check) is presented in Table 2. The general ground coverage by weeds at 45 DAS was 83% (45% grassy weeds, 28% broad leaf weeds and 10% sedges.

Yield Parameters

Most of the yield parameters were significantly affected by weed control methods in both years; while effects of varieties were significant only for days to heading and days to maturity. The varietal effects were non-significant for other growth and yield attributing traits. Similarly, the interaction effects of varieties, weed control methods and years were also non-significant (Table 3 and 4). Sukhkhadhan-3 headed (94 and 95 days), and matured (124 and 125 days) earlier than the other two varieties in 2015 and 216, respectively. The effect of weed control methods was significant for plant height (cm), number of effective tillers/m^2 and panicle length (cm) and significantly higher values of all these yield attributing characters were recorded in weed control treatments as compared to weedy check (control). The highest values of plant height (102.5 and 94.6 cm), number of effective tillers/m^2 (242 and 442) and panicle length (23.9 and 23.6 cm) were recorded in weed free treatment in 2015 and 2016, respectively. However, they were at par with herbicidal treatments (Table 3 and 4).

Table 2: Composition of weed species at experimental site (weedy check plots)

Grassy weeds (45%)	**Broad leaf** (28%)	**Sedges** (10%)
Echinocloacruss-galli	*Digera arvensis*	*Cyperus difformis*
Dactyloctenium aegyptium	*Ageratum conyzoides*	*Cyprus iria*
Leptochloa chinensis	*Cleome viscosa*	*Cyperus rotundus*
Cynodon dactylon	*Eclipta prostrata*	
Paspalum distichum	*Ludwigia parviflora*	
	Eurphorbia hirta	
	Phyllanthus niruri	
	Eclipta alba	

Table 3: Growth and yield attributing characters of rice as influenced by varieties and weed control methods in 2015 at NRRP, Dhanusha, Nepal

Treatments	**Growth and yield attributing characters**					
	Days to heading	**Days to maturity**	**Plant height (cm)**	**Effective tillers/m^2**	**Panicle length (cm)**	**1000-grains weight (g)**
Varieties						
V_1	100	128	99.6	215	23.2	23.7
V_2	98	127	99.5	222	23.0	25.8
V_3	94	124	98.2	216	23.3	23.5
SEM (±)	0.76	0.48	0.76	5.6	0.33	1.7
F-test(5%)	**	**	ns	ns	ns	ns
LSD (5%)	5.3	1.34	-	-	-	-
Weed Control methods						
W_1	94	124	101.1	223	23.8	25.4
W_2	92	123	99.8	220	23.6	24.0
W_3	95	125	100.8	230	23.3	25.6
W_4	93	124	102.5	242	23.9	25.8
W_5	94	124	91.3	174	21.2	23.9
Grand Mean	93	123	99.1	218	23.2	24.3
SEM (±)	1.26	1.09	1.249	12.3	0.38	2.4
F-test (5%)	ns	ns	**	**	**	ns
LSD (5%)	2.6	2.25	2.57	25.4	0.8	4.96
CV%	3.1	2.1	2.7	12	3.5	21

* and ** = Significant at 1 and 5%, respectively, CV = Coefficient of variation

Table 4: Growth and yield attributing characters of rice as influenced by varieties and weed control methods in 2016 at NRRP, Dhanusha, Nepal

Treatments	Growth and yield attributing characters					
	Days to heading	**Days to maturity**	**Plant height (cm)**	**Effective tillers /m^2**	**Panicle length (cm)**	**1000-grains weight**
Varieties						
V_1	101	121	94.2	364	23.1	22.9
V_2	99	129	84.2	402	22.5	22.5
V_3	95	132	97.6	364	22.6	24.3
SEM (±)	0.76	0.48	0.755	17.2	0.72	1.05
F-test (5%)	**	**	ns	-	ns	ns
LSD (5%)	2.11	2.45	-	47.76	-	-
Weed control methods						
W_1	97	127	93.6	424	23.1	23.4
W_2	98	128	94.5	418	23.2	22.8
W_3	98	128	92.7	444	23.6	23.6
W_4	99	129	94.6	442	23.0	23.2
W_5	98	127	84.4	155	20.9	23.0
Grand Mean	98	127	92.0	377	22.8	24.3
SEM (±)	1.26	1.09	1.249	28.56	0.67	0.54
F-test (5%)	*	ns	**	**	**	ns
LSD (5%)	2.6	0.88	4.81	58.94	1.3	1.13
CV%	1.8	1.9	5.4	16.1	6.3	5.0

* and ** = Significant at 1 and 5%, respectively, CV = Coefficient of variation

Table 5: Effect of weed control methods on weed dry biomass, straw and grain yields of rice varieties during 2015-16 at NRRP, Dhanusha, Nepal

Treatments	Weed dry biomass (g/m2) 45 DAS			Reduction in dry weed biomass over control (%)	Straw yield (t/ha)			Grain yield (t/ha)		
	2015	2016	Average		2015	2016	Average	2015	2016	Average
Variety										
V_1	45.3	44.5	44.9	-	3.5	6.5	5.0	4.4	4.0	4.2
V_2	39.2	39.9	39.6	-	3.7	7.3	5.5	4.6	5.0	4.8
V_3	37.5	35.4	36.5	-	3.5	6.7	5.1	5.3	5.6	5.5
SEM (±)	0.02	0.07	0.04	-	0.10	0.90	0.203	0.10	0.20	0.15
F-test (5%)	ns	ns	ns	-	ns	ns	ns	*	*	*
LSD (5%)	-	-	-	-	-	-	-	0.56	0.62	0.65
Weed control methods										
W_1	35.3	33.0	34.2	81.2	6.4	6.1	6.3	4.3	4.1	4.2
W_2	29.7	28.7	29.2	83.9	6.8	6.4	6.6	4.7	4.3	4.5
W_3	15.6	15.0	15.3	91.6	6.9	6.8	6.9	4.9	5.7	5.3
W_4	0.0	0.0	0.0	100.0	7.2	7.1	7.1	5.4	5.7	5.6
W_5	187.8	175.4	181.6	-	2.33	4.03	3.18	2.9	1.2	2.1
Grand Mean	53.7	50.4	52.1	-	5.9	6.1	6.0	4.4	4.2	4.3
SEM (±)	0.09	0.07	0.08	-	0.14	0.43	0.29	0.17	0.08	0.09
F-test (5%)	**	**	**	-	**	**	**	**	**	**
LSD (5%)	12.3	14.6	17.8	-	0.78	0.88	0.81	0.58	0.62	0.71
CV%	21.7	23.1	19.5	-	10.3	13.4	15.2	11.7	9.2	11.4

* and ** = Significant at 1 and 5%, respectively, CV = Coefficient of variation

Weeds Control

Data on effects of varieties and weeds controls methods on dry weeds biomass (g/m^2) and reduction in dry weeds biomass (%) over control are presented in Table 5. Weeds biomass (dry weight basis) was identical in all the three varieties in both years, with mean values in the range of 35.4-44.9 g/m^2. The lowest weeds dry biomass was recorded in Sukhkhadhan-3. Application of herbicide has a significant effect on weeds dry biomass production at 45 DAS in both years. Significantly lower biomass productions/m^2 were recorded in all the herbicidal treatments compared to weedy check (control), with values in the range of 15.6-35.3 g and 15.0-33.0 g in 2015 and 2016, respectively. Among the herbicides, the lowest biomass/m^2 (15.3 g) was recorded in plots treated with pendimethalin fb pyrazosulfuron + bispyribac sodium; with about 92% reduction in weeds biomass over control. This reduction was comparable with weeds free treatment.

Grain and Straw Yield

Varietal effect on straw yield (t/ha) was non-significant in both years. However, it was significant for grain yield (t/ha) in both years and the highest grain yield of 5.5 t/ha was recorded in Sukhkhadhan-3. All the herbicide applications resulted in significantly higher straw and grain yields compared to weedy check (control). Among herbicides, the highest mean grain and straw yields of (5.3 and 6.9 t/ha) was recorded with the application of pendimethalin fb pyrazosulfuron + bispyribac sodium and it was comparable with the grain and straw yields (5.6 and 7.1 t/ha) obtained in weeds-free plots.

Discussion

Different type of weeds belonging to grass, broad leaf and sedges were observed in the experimental site and the dominant weed species belonged to grass followed by broad leaf weeds. Singh *et al.* (2016), Kumar and Ladha (2011) and Hussain *et al.* (2008) also reported broad spectrum of weed species especially grass and broad leaf in upland rice ecosystem under direct seeded condition. The weed biomass recorded at 45 DAS was reduced by 92% over control with the pre-emergence application of pendimethalin fb pyrazosulfuron + bispyribac sodium and it was comparable with the weed-free plots. The effectiveness of pendimethalin as pre-emergence fb by bispyribac sodium as post-emergence in reducing the weed density and weed biomass has been reported by several authors (Valverde and Gressel, 2005; Walia *et al.*, 2008; Singh *et al.*, 2016). The results of the current study are in conformity with previous reports of effective weed control in DSR with pre-emergence application of pendimethalin fb bispyribac sodium as post-emergence (Ganie *et al.*, 2013). The combination of azimsulfuron with bispyribac sodium for post-emergence application broadens the spectrum of weed control because azimsulfuron effectively controls sedges and broad leaf weeds (Singh *et al.*, 2010; Walia *et al.*, 2008).

Khaliq *et al.* (2012) reported that higher rice grain and economic returns with post-emergence application of bispyribac sodium. Similarly, application of pendimethalin @ 0.75 kg/ha as pre-emergence fb bispyribac sodium @ 25 g/ha as post-emergence resulted in 372% increase in rice grain yield compared to weedy check. Our results are in accordance with the findings of several authors (Khaliq *et al.*, 2012; Mahajan and Chauhan, 2015; Chauhan *et al.*, 2015).

In dry direct seeded rice, the applications of herbicides were found effective to control broad spectrum weeds. Our study suggests that pre-emergence application of pendimethalin fb pyrazosulfuron + bispyribac sodium could be effective to do rice cultivation by dry direct seeding method. However, it would be advisable to give more emphasis on economic returns along with evaluating other alternative herbicide options.

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