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Practice of Sustainable Rice Production by Weed Management

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Abstract: Wet direct-seeded rice (*Oryza sativa* L.) is an attractive alternative to transplanted rice, as it saves the drudgery of raising seedlings and transplanting, reducing labor and cost of cultivation. As direct-seeded rice stays in the field for a longer duration than transplanted rice so weed control remains one of the major challenges for its success. A field experiment was conducted at Bangladesh Rice Research Institute, Bangladesh during Boro season of 2013-14, to evaluate effectiveness of different weed management practices; weedy, hand weeding and other practices with pre and post-emergence herbicides; Bensulfuran methyl + Acetachlor and Pyrazosulfuran ethyl on the performance of direct-seeded rice. Results showed that 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 direct-seeded rice was obtained. Irrespective of weed management options, hand weeding (5.21 t ha^{-1}), pre with post emergence herbicide (5.15 t ha^{-1}), post emergence herbicide with one supplement hand weeding (5.02 t ha^{-1}) and pre emergence herbicide with one supplement hand weeding (4.95 t ha^{-1}) produced significantly higher yield, while lowest yield was recorded in control plots (3.54 t ha^{-1}).

Keywords: Direct seeding, weed management, hand weeding, weed density, rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world's population, especially in Bangladesh. It is great source to nutritional calories, providing 35-80% of total calorie uptake [1]. Rice production needs to be increased by 50% or more above the current production level to meet the rising food demand [2]. Because the present nutritional situation of developing countries like Bangladesh is a matter of great concern since the most of the people are suffering from malnutrition [3, 4, 5]. In Bangladesh, rice is commonly grown by transplanting seedling into puddle soil. But repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers and forming hard pans at shallow depth, all of which can negatively affect the following non- rice crop in rotation. Higher water requirements and increasing labor costs are the major problems of the traditional rice production system. Direct seeded rice culture, growing rice without standing water, can be an attractive alternate. Direct wet seeding of rice may involve sowing pre-germinated seed onto a puddled soil surface. The risk of crop yield loss due to competition from weeds by direct seeding methods is higher than for transplanted rice because of the absence of the size differential between the crop and weeds and the suppressive effect of standing water on weed growth at crop establishment [6]. Weeds compete for nutrient, space, sunlight and consume the available moisture with crop plant resulting in crop yield reduction [2, 7]. Weed management in rice production is a major constraint and is expensive [8]. The common practice of weed control in rice field is hand pulling which makes the practice to be labor intensive and many a times not satisfactorily executed. As a result, yields in farmers' fields are lower than the well managed researchers' fields. However, weed-crop competition is abundant, natural and undesirable in agricultural plant communities [9]. Weed control is as old practice as agriculture itself. It is the method of limiting weed infestation so that crops can be grown profitably. Therefore, the degree of weed control depends on costs or benefits and the resources available. So weed management are component technologies essential to the control of weeds in direct wet seeding of rice. Herbicides are one of the most important tools for managing weeds in direct seeded rice systems. Herbicides in particular are an important tool of weed management, but hand weeding is either partially or extensively practiced in country. Timely weed control is of vital importance to increase rice productivity [10]. Several pre and post emergence herbicides have been reported to provide a fair degree of weed control in direct seeded rice [11, 12]. Thus, it is crucial to upgrade the direct seeded rice technology along with effective weed management and make it more cost effective, environment and farmer's friendly. Therefore, the present study was undertaken to determine effective weed control management system in wet direct seeded rice cultivation for sustainable crop production.

MATERIALS AND METHODS

Field experiment was conducted at Bangladesh Rice Research Institute (BRRI), Gazipur, field laboratory during Boro season of 2013-14 to find out an appropriate method of weed management with its impacts on yield of rice. The soil of the experimental site was non-calcareous dark grey flood plain [13] with pH around 6.2 and low in organic matter (1.2%). In direct seeding method, sprouted seeds of BRRI dhan28 were sown in line on 20th January, 2014. The experiment was carried out with five treatments viz. i) Pre-emergence herbicide with one hand weeding, ii) Post-emergence herbicide with one hand weeding, iii) Pre-emergence herbicide with Post-emergence herbicide, iv) Hand weeding at 15, 30 and 45 days after sowing (DAS), and compared with v) Control (no weeding). The pre-emergence herbicide: Bensulfuran methyl+ Acetachlor @ 750 g ha^{-1} applied at 5 days after sowing (DAS) and post-emergence herbicide: Pyrazosulfuran ethyl @ 150 g ha^{-1} applied at 10 DAS with the help of a knapsack sprayer. In herbicide treated plot one hand weeding was done at 25 DAS. The treatments were distributed following RCB design with three replications. The fertilizers were applied following BRRI recommended dose. Irrigation water, insect and pest control were done as and when necessary.

Data on weed density and dry weight were taken from each plot on 20 DAS and 40 DAS. The weeds were identified species-wise. Dry weights of weeds were taken by drying them in electric oven at 60^0 C for 72 hours followed by weighing by digital balance. Relative weed density (RWD), relative weed biomass (RWB) and weed control efficiency (WCE) of different weed control treatments were calculated. Data on panicle no. m^{-2}, grains $panicle^{-1}$ and grain yield were collected. Rice yield was recorded at the time of crop maturity. Graphical representation of the data was carried out using MS Excel programme. The data was subjected to statistical analyses following Gomez and Gomez [14] using Crop-Stat 7.2 [15] statistical programme.

RESULTS AND DISCUSSION

Weed infestation

Weed infestation at 20 DAS

In this study the rice field was infested with different types of weeds. The relative density of these weed species was also different (Table 1). Different weed species were observed in control (no weeding) plot where most dominating weeds were sedge and gress. Among the weed species maximum relative weed density (RWD) was observed for *Cyperus difformis* (33.70%), *Scripus maritimus* (32.83) and *Echinochloa crus-galli* (30.46), respectively. Higher weed biomass (RWB) value was observed for *Echinochloa crusgalli* (35.45%), *Cyperus difformis* (31.63) and *Scripus maritimus* (28.91), respectively.

Table 1: Weed composition, Relative density (RWD), Biomass (RWB) and Summed dominance ratio (SDR) in the untreated control plots

Name of Weed Species	Family	Class	RWD (%)	RWB (%)
20 DAS				
Echinochloa crus-galli	Poaceae	Grass	30.46	35.45
Cynodon dactylon	Poaceae	Grass	10.19	8.73
Cyperus difformis	Cyperaceae	Sedge	33.70	31.63
Scripus maritimus	Cyperaceae	Sedge	32.83	28.91
Monochoria vaginalis	Pontederiaceae	Broad leaf	16.47	15.73
Ludwigia octovalvis	Onagraceae	Broad leaf	1.47	0.78
40 DAS				
Echinochloa crus-galli	Poaceae	Grass	33.90	34.73
Cynodon dactylon	Poaceae	Grass	11.24	8.62
Cyperus difformis	Cyperaceae	Sedge	26.30	29.23
Scripus maritimus	Cyperaceae	Sedge	34.79	36.03
Monochoria vaginalis	Pontederiaceae	Broad leaf	21.67	19.59
Ludwigia octovalvis	Onagraceae	Broad leaf	3.34	1.06
Sphenoclea zeylanica	Sphenocleaceae	Broad leaf	2.83	1.23

Weed infestation at 40 DAS

Among the weed species maximum relative weed density (RWD) was observed for *Scripus maritimus* (34.79%), *Echinochloa crus-galli* (33.90) and *Cyperus difformis* (26.30), respectively. Higher weed biomass (RWB) value was observed for *Scripus maritimus* (36.03%), *Echinochloa crus-galli* (34.73) and *Cyperus difformis* (29.23), respectively (Table 1).

So Cyperaceae and Poaceae weeds are dominant in low land eco system rice cultivation which is similar to the findings of [6]. In this study it was also observed that broad leaf were less dominating weed species. Similar result was found by [16] in their experiment.

Weed ranking

The summed dominance ratio (SDR) is an important indicator of showing ranking of weeds. Here SDR of infesting weeds are showing in Figure 1. The three most dominant weeds in 20 DAS were *Echinochloa crus-galli* (32.95%), *Cyperus difformis* (32.66%) *and Scirpus maritimus* (30.87%). Higher rank of dominant weed was *Scirpus maritimus* (35.40%) followed by *Echinochloa crus-galli* (34.31%) and *Cyperus difformis* (27.76%) at 40 DAS. So broad leaf weeds were less dominant than other weeds. Shultana *et al.* [17] also found that broad leaf weeds were not dominating weed species in low land ecosystem.

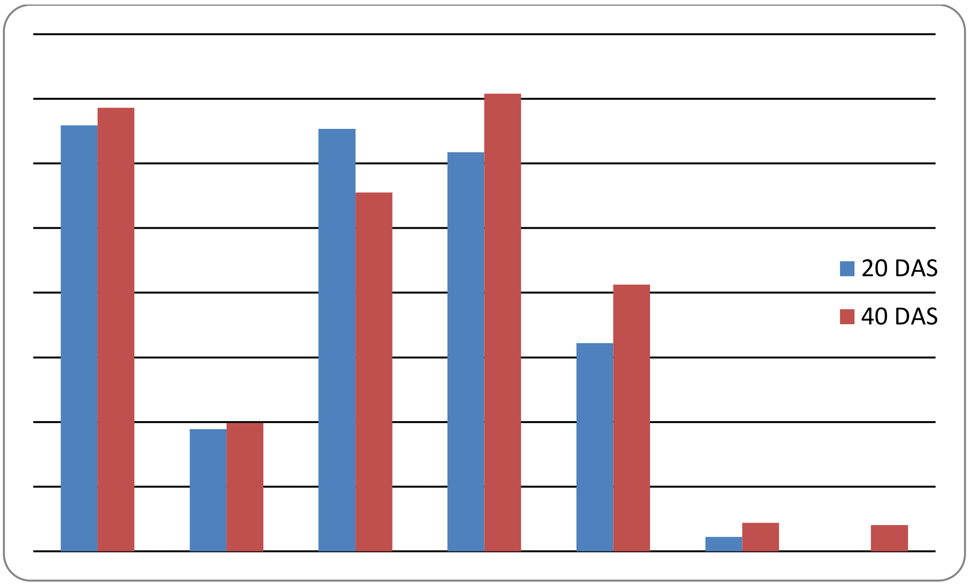

Fig-1: Summed dominance ratio (SDR) of infesting weeds

[ECCR= *Echinochloa crus-galli,* CYDA= *Cynodon dactylon,* CYDI=*Cyperus difformis,* SCMA=*Scirpus maritimus,* MOVA=*Monochoria vaginalis, LUOC=Ludwigia octovalvis,* SPZE= *Sphenoclea zeylanica*]

Weed control efficiency (WCE)

In Boro, 2013-2014, at 20 DAS, treatment W_1 controls all the weeds less than 80% where as W_2 and W_3 control *Cyperus difformis* 80.7 and 81.64, respectively and W_4 (hand weeding) control *Echinochloa crus-galli*, *Cyperus difformis* and *Scripus maritimus* more than 80%. At 40 DAS, treatment W_1 and W_2 controls *Echinochloa crus-galli* and *Scripus maritimus* more than 80%. Treatment W_3 controls *Echinochloa crus-galli, Scripus maritimus* and *Scripus maritimus* more than 80% except *Cynodon dactylon* and W_4 controls *Echinochloa crus-galli, Scripus maritimus, Scripus maritimus* and *Monochoria vaginalis* more than 80% (Table 2). However, the highest weed control was given by hand weeding. These findings are in agreement with [18].

Yield and yield contributing characters

Considering yield and yield contributing characters (Table 3) no significant effect observed in panicle production in different herbicide treated plot except hand weeding. Results indicated that the highest panicle number m^{-2} was observed in hand weeding treatment. Significantly higher grains panicle^{-1} was produced in hand weeding treatment irrespective of control treatment followed by pre-emergence herbicide with one hand weeding, post-emergence herbicide with one hand weeding and pre-emergence with post-emergence herbicide treatment. The minimum number of panicles m^{-2} in the control plot was the result of higher competition for nutrient, air space, light and water between crop plants and weeds. Hasanuzzaman *et al.* [19] reported similar results. In this study, the number of panicle m^{-2}, number of grains panicle^{-1} were severely reduced by weed competition, similar result finding by [2, 20]. Competition with weed may reduce the panicle length which indirectly reduced the number of grains panicle^{-1}. The variation of grain yield among the treatments was statistically significant, where 46% higher grain yield was found in hand weeding treatment over control (no weeding) treatment. Weeds caused severe reductions to yields which was similar to the finding by [20, 21].

Table 2: Effect of weed control efficiency in direct wet seeded rice

Name of weeds	W_1	W_2	W_3	W_4
	20 DAS			
Echinochloa crus-galli	73.78	71.54	75.29	81.63
Cynodon dactylon	34.57	38.65	42.21	58.17
Cyperus difformis	79.56	80.7	81.64	82.8
Scripus maritimus	74.87	77.3	79.67	80.7
Monochoria vaginalis	42.12	45.71	50.75	82.08
	40 DAS			
Echinochloa crus-galli	76.7	77.78	80.6	81.78
Cynodon dactylon	33.87	36.94	33.25	51.70
Cyperus difformis	81.59	80.94	82.52	83.53
Scripus maritimus	80.62	82.69	84.49	89.74
Monochoria vaginalis	74.34	78.73	77.91	80.17
Ludwigia octovalvis	67.87	71.34	70.56	76.45
Sphenoclea zeylanica	70.41	69.58	71.51	73.47

W_1= Pre-emergence herbicide with one hand weeding, W_2= Post-emergence herbicide with one hand weeding, W_3= Pre-emergence herbicide with post-emergence herbicide and W_4= Hand weeding

Table 3: Performance of the integrated weed control option for increasing yield of rice

Treatments	Panicle m^{-2}	Grains panicle^{-1}	Grain yield (t ha^{-1})
Pre-emergence herbicide with one hand weeding	281	71	4.95
Post-emergence herbicide with one hand weeding	284	72	5.02
Pre-emergence herbicide with post-emergence herbicide	288	72	5.15
Hand weeding (3 times)	291	74	5.21
Control (no weeding)	207	58	3.54
LSD $_{(0.05)}$	7.13	4.45	0.25
CV (%)	1.4	3.4	1.7

CONCLUSION

Based on the results, yield, yield attributing parameters and weed dynamics were greatly influenced by different weed management practice in higher yield and lower weed dynamics in different growing stage of direct-seeded rice. It can be concluded from these studies that in direct seeded rice an effective control of weeds (i.e. grasses and sedges) and ultimately a higher paddy yield could be achieved with application of herbicide along with single hand weeding treatment.

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