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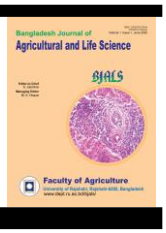

Weed management enhances yield of transplanted aman rice

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ABSTRACT

An experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from June to December'2013with a view to finding out the weed control efficiency of different weeding regime effects on yield and yield components of transplanted aman rice. Four transplant aman rice varieties viz. BR11, BRRI dhan39, BRRI dhan56 and BINA dhan7 were used as a testing plant. Four different weeding regime treatments namely no weeding, hand weeding at 20 DAT and 35 DAT, Herbicide manage and Herbicide + one hand weeding at 35 DAT were evaluated. Weed population were significantly ($P \geq 0.05$) affected by varieties and weeding regimes. *Paspalum scrobiculatum*, *Echinochloa crusgalli*, *Leersia hexandra*, *Oxalis europaea*, *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Cyperus difformis*, *Scirpus juncoides* and *Fimbristylis diphylla* were the major weeds found in the experimental plots. The effect of weeding treatments on weed density was significant. Among the weeding treatments hand weeding at 20 and 35 DAT produced the best performance of all the crop characters including yield (3.90 t ha^{-1}), the next best was herbicide manage and no weeding treatments had the worst effect on yield (2.25 t ha^{-1}). This study concluded that hand weeding at 20 and 35 DAT practices enhanced growth response and yield of transplanted aman rice.

Introduction

As one of the most important food sources for humans, rice (*Oryza sativa*) plays a vital role for society and economics worldwide. In Bangladesh, agriculture is characterized by rice based cropping systems. Rice is extensively grown here in aus, aman and boro seasons. More specially, rice production in aus, aman and boro seasons are 2.16, 12.89 and 18.78 million tons, respectively (BBS, 2013).

Variety itself is a genetic factor, which contributes a lot in producing yield components and yield of a particular crop. Yield components are directly related to variety and the neighboring environments in which it grows. BRRI (1991) reported that modern transplant *aman* rice varieties produced grain yield up to 6.5 t ha^{-1}. Therefore, varietal performance is an important factor for improving crop production.

Weeds are present on every cropland in the world. Therefore, it is often mentioned,

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"Agriculture is a fight against weed" (Mukhopadhyay and Ghose, 1981).The infestation of weed is one of the important constrains in the cultivation of crops (Mamun, 1988). The prevailing climatic and edaphic factors are favorable for luxuriant growth of numerous species of weeds, which offer a keen competition with rice crop in Bangladesh (Mamun, 1988).

Many investigations have reported great losses in the yield of rice due to weed infestation in different parts of the world (Singhet el., 1999). In Bangladesh, weed infestation reduces the grain yield by 70-80% in aus rice (early summer), 30-40% for transplanted aman rice (autumn) and 22-36% for modern boro rice cultivars (winter rice) (Mamun, 1990; BRRI, 2008). This study aims to evaluate weed control efficiency of different weeding regime and to see their effects on yield and yield components of transplanted aman rice. It was hypothesized that hand weed management will be improved growth response and yield of transplanted aman rice.

Materials and Methods

Experimental Site

The experimental site was located at 24°75' N latitude and 90°50' E longitude at an elevation of 18 m above the mean sea level. The experimental area is characterized by non-calcareous dark grey floodplain soil belonging to the Sonatola Soil Series under the Old Brahmaputra Floodplain. The experimental was fall under Agro-Ecological Zone 9 (UNDP and FAO, 1988).

Experimental Treatment

The experimental treatments were as follows:

Factor A: Variety

i. BR11=V_1
ii. BRRI dhan 39= V_2
iii. BRRI dhan 56= V_3
iv. BINA dhan7= V_4

Factor B: Weeding regimes

i. No Weeding= W_0
ii. Hand Weeding at 20 & 35 DAT= W_1
iii. Herbicide manage = W_2
iv. Herbicide + One Hand Weeding at 35 DAT= W_3

Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Total numbers of unit plots were 4×4×3=48 and each plot size was 3.0 m × 2.0 m. The distance maintained between the individual unit plots was 0.5m and that between the replications 1.0 m.

Description of varius rice cultivars or varieties used in this study

A brief description of the rice variety used in the experiment is given below:

BR11

BR11, a high yielding rice variety was developed by Bangladesh Rice Research Institute (BRRI) in 1980 from crossing between IR5 (IR5-144-3-1)5-47-2 and IR20 (IR532-E576).It is characterized with weakly photoperiod sensitivity suitable for late transplanting among modern varieties in transplanted *aman* season (BRRI,1995). It is a non-lodging type of rice variety and it takes about 140-145 days to complete its life cycle after transplanting with an average yield of 4-5 t ha^{-1}.

BRRI dhan39

BRRI dhan39 is a high yielding variety of aman rice released by the Bangladesh Rice Research Institute (BRRI) in 1999. It was developed from the cross between BR2558-7-3-2-2, BR1185-2B-5b-2-1-1 and BR1674-28-3-1-1.It is recommended for aman season in Bangladesh. Plant height ranges from 95-115 cm. The stem and leaves are green and erect. The variety requires 120-125 days after transplanting(DAT) to complete its life cycle with an average yield of 4.6 to 5.0 t ha^{-1} (BRRI, 2004). The variety is resistant to lodging.

BRRI dhan56

BRRI dhan56 is a short-duration rice variety, which is cultivated during aman season. It is a drought-tolerant and can be harvested earlier than other varieties. It takes 110 days to complete its life cycle with an average yield of about 5.5 t ha^{-1}.

BINA dhan7

BINA dhan7 is a short duration and high yielding transplant aman rice variety with good quality of rice released in 2007 by BINA. It is non-lodging taking 110-120 days to complete its life cycle and can be successfully grown in aman season. The yield ranges between 5.5 to 6.0 t ha^{-1} (BRRI, 2011). Plant height ranges from 95-115 cm. The stem and leaves are green and erect. The variety is resistant to lodging.

Description of the weeding regime

No Weeding (W_0)

Weeds were allowed to grow up to harvesting of the crop.

Hand weeding at 15 and 35 days after transplanting (DAT) (W_1)

In this treatment, weeds were allowed to grow with the crop for the first 19 DAT. At 20 days one hand weeding was done and thereafter no weeding was done till harvesting. Weeds were allowed to grow with the crop till 34 DAT and at 35 DAT, another hand weeding was given and afterwards no weeding was done till harvesting.

Herbicide manage (W_2)

In this treatment, Pre-chlor 500EC @ 1 liter ha^{-1} was applied at 6 DAT in 4-5 cm standing water by hand sprayer in the plots and thereafter no weeding was done till harvesting.

Herbicide manage + One Hand Weeding at 35 DAT (W_3)

In this treatment, Pre-chlor 500EC @ 1 liter ha^{-1} was applied at 6 DAT in 4-5 cm standing water by hand in the plots. Weeds were allowed to grow with the crop for the first 34 DAT. At 35 days one hand weeding was done and afterwards no weeding was done till harvesting.

Raising of crops

Preparation of seedling nursery bed and seed sowing

A piece of land was selected for raising seedlings. The land was puddle well with country plough followed by leveling with a ladder. The sprouted seeds were sown in the nursery bed. Proper care was taken to raise the healthy seedlings in the nursery bed. Weeds were removed and irrigation was done in the nursery bed as and when necessary.

Preparation of experimental land for transplanting

The experimental field was opened with a power tiller and subsequently ploughed four times with country plough followed by laddering. The layout of the field was made after final land preparation. Weeds and stubbles were removed and cleaned from individual plots.

Fertilizer application

The experimental area was fertilized with 180-100-70-60-10 kg ha^{-1} and 90-50-35-30-5 kg ha^{-1} urea, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. The entire amounts of TSP, MP, gypsum and zinc sulphate were broadcast and incorporated with the soil at the time of final land preparation. Urea was applied in three installments at 15, 30 and 45 days after transplanting (DAT).

Uprooting seedlings

The nursery bed was made wet by application of water on the previous day before uprooting the seedlings. The seedlings were uprooted without causing much mechanical injury to the roots and they were immediately transferred to the main field. After uprooting the seedlings were graded. Healthy and similar sized seedlings were selected for transplanting.

Transplanting of seedlings

Seedlings were transplanted in the main field as per experimental treatments at the rate of three seedlings $hill^{-1}$, maintained row and hill distance of 25cm and 15cm, respectively.

Weeding

Weeding was done as per as the experimental treatments.

Irrigation and drainage

Due to frequent rains during crop growth period, no irrigation was needed. The excess rain water was drained out as and when necessary.

Plant protection measures

Plants were slightly infested with leaf-hoppers which were successfully controlled by spraying Dimecron 100EC @ 1.5 l ha^{-1} twice at 20 and 50 DAT. Crop damage by diseases like blast and brown spot was negligible. So, no control measure was taken against diseases.

General observations

Observations were regularly made and the field looked nice with normal green plants. The flowering was uniform. All the grains matured at the same time.

Sampling, Harvesting and Processing

The crops were harvested at full maturity. Maturity of crops was determined when 90% of the grains became golden yellow in color. Then the harvested crops of each plot was bundled separately, tagged properly and brought them to the threshing floor. The crops were then threshed. The fresh weights of grain and straw were recorded plot-wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

Data collection

Weed parameters

i) Weed species
ii) Weed density

Crop characters at harvest

i) Plant height (cm)
ii) Number of total tillers $hill^{-1}$
iii) Number of effective tillers $hill^{-1}$
iv) Panicle length (cm)
v) Number of grains $panicle^{-1}$
vi) Number of sterile spikelets $panicle^{-1}$
vii) 1000-grain weight (g)
viii) Grain yield (t ha^{-1})
ix) Straw yield (t ha^{-1})
x) Biological yield (t ha^{-1})
xi) Harvest index (%)

Procedure of Recording Data

Weed species

Data on number of weed species were collected from each plot at 20 DAT, 35 DAT & 50 DAT of the rice plants by using 0.5m × 0.5m quadrate as per method described by Cruz *et. al.,* (1986). The quadrate was placed in three spots at random. The weeds within the quadrate were counted and converted to number m^{-2} multiplying by four.

Crop characters

From each of the unit plots five hills were selected at random and uprooted carefully and tagged before harvesting for recording data. Data were collected on the following characters:

Plant height (cm)

Plant height was measured from the base of the plant (ground level) to the tip of the longest panicle.

Number of total tillers $hill^{-1}$

Tillers which had at least one visible leaf were counted including both panicle bearing and non-bearing tillers.

Number of effective tillers $hill^{-1}$

The tiller which had at least one visible grain in the panicle was considered as effective tiller.

Panicle length (cm)

Measurement was taken from basal node of the rachis to the apex of last grains of each panicle.

Number of grains panicle^{-1}

Presence of any food material in the spikelet was considered as grain and such spikelet present on each panicle were counted.

Number of sterile spikelets panicle^{-1}

The spikelet that lacked any food material inside was considered as sterile spikelet and such spikelet present on each panicle were counted.

Harvest index (%)

It indicates the ratio of economic yield (grain yield) to biological yield (grain yield + straw yield) and was calculated by the following formula:

Harvest index (%)

$$= \frac{\text{Grain yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100$$

Table 1. Infesting species of weed In the experimental field of transplanted *aman* rice Weed density

Sl. No.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Angta	*Paspalum scrobiculatum*	Gramineae	Grass	Perennial
2	Shama	*Echinochloa crusgalli*	Gramineae	Grass	Annual
3	Arail	*Leersia hexandra*	Gramineae	Grass	Perennial
4	Amrul shak	*Oxalis europaea*	Oxaledaceae	Broadleaved	Annual
5	Panikachu	*Monochoria vaginalis*	Pontederiaceae	Broadleaved	Perennial
6	Panilong	*Ludwigia hyssopifolia*	Onagraceae	Broadleaved	Annual
7	Sabuj Nakphul	*Cyperus difformis*	Cyperaceae	Sedge	Annual
8	Chechra	*Scirpus juncoides*	Cyperaceae	Sedge	Perennial
9	Joina	*Fimbristylis diphylla*	Cyperaceae	Sedge	Perennial

1000-grain weight (g)

One thousand clean dried grains were counted from the seed stock obtained from five sample hills of each plot and weighed by using an electric balance. The weight was adjusted at a seed moisture content of 14%.

Grain yield (t ha^{-1})

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1m^2 areas were added to the respective unit plot yield to record the final grain yield plot^{-1} and finally converted to t ha^{-1}.

Straw yield (t ha^{-1})

Straw obtained from each unit plot including the straw of central 1m^2 areas of respective unit plot was dried in the sun and weighed to record the straw yield plot^{-1} and finally converted to t ha^{-1}.

Biological yield (%)

Grain yield together with straw yield was regarded as biological yield and calculated with the following formula:

Biological yield=Grain yield + Straw yield

Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package, MSTAT. Duncan's Multiple Range Test (Gomez and Gomez, 1984) adjudged the mean differences among the treatments. All the statistical testing was performed based on $P \leq 0.05$ as the critical level for the significance of Tukey test.

Results and Discussion

Weed parameters

Conditions favourable for growing transplant *aman* rice also favourable for the exuberant growth of a number of weed species that compete with crop plants. Weeds found in transplant *aman* rice field are aquatic, semi aquatic, broad leaved, grasses and a few sedges which can withstand water logging usually enough to depress crop yield very significantly if not timely controlled (Miah and Gaffer, 1960). The findings on weed infestation in this study are presented as below:

The experimental plots were infested with nine weed species belonging to five families (Table 1). Three weed species were of the family

Cyperaceae, three of the family Gramineae and one each of the family Oxaledaceae, Pontederiaceae and Onagraceae. The infesting species of weeds were *Paspalum scrobiculatum* L., *Echinochloa crusgalli* (L.) P. Beauv, *Leersia hexandra* Swartz, *Oxalis europaea* L., *Monochoria vaginalis* (Burm. F.) C. Presl, *Ludwigia hyssopifolia* (G. Don) Exell, *Cyperus difformis* L., *Scirpus juncoides* Roxb. and *Fimbristylis diphylla*. Weed densities m-2 at 20, 35 and 50 DAT were significantly (P ≥ 0.05) influenced by weeding (Table 2). The highest weed density 40.17 at 20 DAT, 49.92 at 35 DAT and 22.33 at 50 DAT were found at no weeding (W0) treatment and the lowest weed density were found 20.50 at 20 DAT, 11.83 at 35 DAT and 4.25 at 50 DAT in hand weeding at 20 and 35 DAT treatment (W1) (Table 3).

Number of Effective tillers hill^{-1}

Number of effective tillers hill^{-1}was not significantly influenced by different weeding regimes (Table 4).The highest number of effective tillers hill^{-1}(7.60) was produced by W_1 (hand weeding at 20 and 35 DAT) treatment, while the lowest number of effective tillers hill^{-1}(5.99) was produced by W_0 (No weeding) treatment.

Panicle length

Panicle length was significantly influenced by weeding regime**.** The longest panicle length (24.30 cm) was observed in W_1 (hand weeding at 20 and 35 DAT) treatment and the shortest (20.89 cm) was observed in W_0 (no weeding) treatment (Table 4).

Table 2. Analysis of variance (mean square value) of weed density in Transplanted aman rice as influenced by variety and weeding.

Source of variation (SV)	Degrees of freedom(df)	Mean square value		
		Weed density		
		20	35	50
Replication	2	1156.75	980.02	126.58
Variety (A)	3	381.74NS	169.41NS	72.02NS
Weeding (B)	3	1016.52**	4037.25**	850.69**
A x B	9	331.74NS	169.84NS	45.45NS
Error	30	193.12	151.11	35.38

In a column figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letters differ significantly (as per DMRT); *= Significant at 5% level of probability; **= Significant at 1% level of probability; NS= Not significant.

Effect on crop characters

Plant height

Plant height was significantly influenced by weeding (Table 4). The highest plant height (106.9) was found in W_1 (hand weeding at 20 and 35 DAT)) among the weeding treatments. The lowest (100.9) plant height was obtained in W_0 (no weeding) condition. Chowdhury *et. al,.* (1994) reported that the height plant height was produced due to weed free condition and the lowest plant height was in no weeding plot.

Number of Total tillers hill^{-1}

The number of total tillers hill^{-1} was not significantly affected by weeding regime**.** The highest number of total tillers hill^{-1} was produced by W1 (10.00) treatment and the lowest one (8.517) was found in W0 (No weeding) treatment (Table 4).

Number of grains panicle^{-1}

Number of grains panicle^{-1} was significantly influenced by different weeding regimes (Table 4).The highest number of grains panicle^{-1}(128.2) was produced by W_1 (hand weeding at 20 and 35 DAT) treatment, while the lowest number of grains panicle^{-1}(95.52) was produced by W_0 (No weeding) treatment. In this study hand weeding at 20 and 35 DA treatment produced the highest number of grains panicle^{-1} which might be attributed due to vigorous growth of rice plant without crop weeded competition in hand weeding treatment.

Number of sterile spikelets panicle^{-1}

Number of sterile spikelets panicle^{-1}was not significantly influenced by different weeding regimes (Table 4). The highest number of sterile spikelets panicle^{-1} (20.42) was produced by W_0 (No weeding) treatment, while the lowest number

of sterile spikelets panicle^{-1} (18.31) was produced byW_3(Hand weeding + Herbicide manage at 35 DAT) treatment.

Table 3. Effect of weeding regime on the number of weed species at 20, 35 and 50 DAT of transplant aman rice.

Weeding	Number of weeding species at days after transplanting		
	20	35	50
W_0	40.17a	49.92a	22.33a
W_1	20.50b	11.83b	4.250b
W_2	22.67b	13.42b	6.000b
W_3	22.42b	14.67b	6.583b
$S\overline{x}$	4.01	3.54	1.71
CV%	52.57	54.74	60.75
Level of sig.	**	**	**

In a column figures with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT; * = Significant at 5% level of probability; ** = Significant at 1% level of probability; NS = Non-significant; W_0 = No weeding; W_1 = Hand weeding at 20, 35 and 50 DAT; W_2 = Herbicide manage; W_3 = Hand weeding + Herbicide manage at 35 DAT.

1000-grain weight

The weight of 1000-grain was significantly affected by weeding regime(Table 4).The highest weight of 1000 grains (24.68 g) was recorded in W_1 (hand weeding at 20 and 35 DAT) treatment and the weight of 1000-grain was lowest (23.00 g) in W_0 (no weeding) condition.

Grain yield

Grain yield was significantly influenced by different weeding regimes**.** The highest grain yield (3.90t ha^{-1}) was produced by W_1 (hand weeding at 20 and 35 DAT) treatment while the lowest grain yield (2.25t ha^{-1}) was produced byW_0 (no weeding) treatment (Table 4). The weeds compete with the crop for nutrient, water, air, sunlight and space. The increased yield was contributed in weed free treatment by higher number of effective tiller hill^{-1}, higher number of grains panicle^{-1} over no weeding treatment. These might be due to the fact that the weeding kept the rice field weed free and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth.

Straw yield

Straw yield was significantly influenced by different weeding regime (Table 4). The highest straw yield (0.7642t ha^{-1}) was observed in W_1 (hand weeding at 20 and 35 DAT) treatment and the lowest straw yield (0.5700t ha^{-1}) was observed in W_0 (No weeding) treatment.

Biological yield

Biological yield was significantly influenced by weeding regime. The highest biological yield (8.48 t ha^{-1}) was found in W_1 (hand weeding at 20 and 35 DAT) treatment and lower biological yield (5.67

Table 4. Effect of weeding regime on the yield and yield components of transplant *aman* rice

Weeding	Plant height (cm)	Total tillers/hill	Effective tillers/hill	Panicle Length (cm)	Grains/ panicle	Sterile spikelet/ panicle	1000-grain weight (g)	Grain yield (t/ha)	Straw Yield (t/ha)	Biological Yield (t/ha)	Harvest Index (%)
W_0	100.9c	8.517	5.99	20.89c	95.52b	20.42	23.00c	2.25c	3.42b	5.67c	38.59b
W_1	106.9a	10.00	7.60	24.30a	128.2a	19.85	24.68a	3.90a	4.58a	8.48a	46.46a
W_2	103.3b	8.750	6.88	23.16b	122.4a	18.53	23.86b	3.42b	3.79b	7.21b	47.00a
W_3	106.1a	9.458	7.10	23.87ab	123.0a	18.31	23.95b	3.31b	4.00ab	7.31b	45.51a
$S\overline{x}$	0.765	0.514	0.399	0.314	2.80	1.12	0.138	0.156	0.222	0.304	1.62
CV%	2.54	19.44	20.09	4.74	8.27	20.17	2.01	16.77	19.51	14.72	12.61
Level of significance	**	NS	NS	**	**	NS	**	**	**	**	**

In a column figures with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT; ** = Significant at 1% level of probability; NS = Non significant; W_0 = No weeding, W_1 = Hand weeding at 20 and 35 DAT, W_2 = Herbicide manage, W3 = Hand weeding + Herbicide manage at 35 DAT.

t ha^{-1}) was found in W_0 (no weeding) treatment (Table 4).

Harvest index (%)

The results showed that there were significant differences in harvest indices due to different weeding regime. The highest harvest index (47.00 %) was observed in W_2(Herbicide manage) treatment and the lowest harvest index (38.59 %) was observed in W_0 (No weeding) treatment (Table 4).

Summary and Conclusion

The density of infesting weed species was recorded at 20, 35 and 50 DAT with the help of a plant counter measuring 1m × 1m from plot. The crops were severely infested by weeds. In total, nine weed species belonging to five families were found in the experimental fields which were Paspalum scrobiculatum L., Echinochloa crusgalli (L.) P. Beauv, Leersia hexandra Swartz, Oxalis europaea L., Monochoria vaginalis (Burm. F.) C. Presl, Ludwigia hyssopifolia (G. Don) Exell, Cyperus difformis L., Scirpus juncoides Roxb. In addition, Fimbristylis diphylla. Weed density was significantly affected by weeding treatments include in the study. The highest weed density was observed in no weeding treatment and the lowest weed density was noticed in hand weeding at 20 and 35 DAT treatment. Except number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$ and number of sterile spikelet $panicle^{-1}$, various characters of transplant *aman* rice were significantly affected by weeding regime. In general, all weeding treatments showed their superiority over no weeding in the production of grain and straw yields. Among the weeding treatments hand weeding at 20 and 35 DAT produced the best performance of all the crop characters including yield, and no weeding treatments had the worst effect.

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