IMPACTS OF INTEGRATED WEED MANAGEMENT IN TRANSPLANT AMAN RICE

T. AHMED[1], A.K.M.M.B.CHOWDHURY[2], S.M.SAYEM[3] AND M.M.KARIM[4]

[1]Scientific Officer, Bangladesh Tea Research Institute, [2]Assistant Professor, Dept.of Crop Botany, [3]Assistant Professor, Department of Soil Science, Hajee Mohammad Danesh Science and Technology University(HSTU), Dinajpur-5200, [4]Professor, Dept. of Agronomy, Bangladesh Agricultural University, Mymensigh-2202, Bangladesh

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ABSTRACT

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Transplant aman rice suffers from weed infestation which contributes to lower yield of this crop. A field experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July to December 2002 to find out the best approach of weed management and an effective and economical weed control treatment through integrated approach on transplant aman rice cv. BRRI dhan37. The experiment was laid out in a randomized complete block design with four replications. There were fifteen treatments namely, No weeding, One hand weeding, Two hand weeding, Ronstar @ 2.0 1 ha^{-1}, Argold @ 0.75 1 ha^{-1}, M-chlor @ 13 kg ha^{-1}, Ronstar @ 2.0 1 ha^{-1}+ 1 hand weeding, Argold @ 0.75 1 ha^{-1}+ 1 hand weeding, M-chlor @ 13 kg ha^{-1} + 1 hand weeding, Ronstar @ 2.0 1 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 l ha^{-1} + 1 weeding with Japanese rice weeder, M-chlor @ 13 kg ha^{-1} + 1 weeding with Japanese rice weeder, 1 hand weeding + 1 weeding with Japanese rice weeder, 2 hand weeding + 1 weeding with Japanese rice weeder, and Weed free. The effect of weed control treatments on the weed density, and weed dry weight was significant. Weed control treatments had significant effect on all the studied crop characters except 1000grain weight. The highest grain and straw yields were produced in the weed free treatment which was followed by Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding, 2 hand weeding + 1 weeding with Japanese rice weeder and Argold @ 0.75 l ha^{-1} + 1 hand weeding. The lowest grain and straw yields were produced in the No weeding treatment which was followed by others. However the cost benefit analysis showed a bit different trend than that of grain and straw yields where the maximum profit was noticed in Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder which was followed by Argold @ 0.75 1 ha^{-1}+ 1 hand weeding. M-chlor @ 13 kg ha^{-1} + 1 weeding with Japanese rice weeder and Ronstar @ 2.0 1 ha^{-1}+ 1 hand weeding weed control treatments.

Keywords: Weed, integrated management, yield and economic performance of aman rice

INTRODUCTION

Rice (Oryza sativa L.) is the staple food of Bangladesh. Almost all the people depend on rice and have tremendous influence on agrarian economy of Bangladesh. Rice alone constitutes 95% of the food grain production in Bangladesh (Julfiquar et al., 1998). Among the three types of rice transplant aman rice covers about 53.28% of total rice area and it contributes to 44.68% of the total rice production in the country (BBS, 2002).

Bangladesh ranks fourth in area and production of rice (FAO, 1994) and 39 th in yield of rice in the world (IRRI, 1995). The average yield of rice in Bangladesh is around 2.15 t ha^{-1} (BBS, 2002) which is frustratingly below the highest ranking country (12.9 t ha^{-1}) demonstrated like China (IRRI, 2001). Poor weed control is one of the major factors for yield reduction of rice (Amarjit *et al*., 1994). According to Thomas *et al*., (1997) yield losses of rice from uncontrolled weeds can be as high as 74%. Mamun (1990) reported that weed growth reduced the grain yield by 45% in transplant aman rice. This loss is, therefore, a serious threat for the food deficit countries like Bangladesh.

In transplant aman rice high weed infestation is a major constraint. The humid climate of Bangladesh, especially in aman season favours weed growth and the edaphic and climatic conditions are suitable for the growth of numerous species of obnoxious weeds in arable lands. For the competitive abilities of weeds exert a serious negative effect on crop production and are responsible for marked losses in crop yield (Mamun *et al*., 1993). Among the factors responsible for low grain yield of rice, weeds are well recognized as a great factor. So, proper weed management is essential for successful rice production.

Weeds are controlled in Bangladesh generally by hand pulling or by using simple tools like niranees, sickles, Japanese rice weeder and so on. Japanese rice weeder controls weeds in between the rows of rice hills efficiently, but the weeds closer to the rice hills seldom come under the action of Japanese rice weeder.Usually two or three hand weeding are done in a transplant rice field depending upon the nature of weeds and their intensity of infestation. Though hand weeding is the most common and effective method of weed control in rice but it is difficult and uneconomical day-by-day due to high wage and non-availability of labours at the peak period of farm operations. Under that situation the use of herbicides may be an alternative in controlling weeds more easy and economic. In a transplant aman rice field weed flora are variable and may not be controlled by herbicide alone as flashes of weeds come up at different stages. On the other hand the continuous uses of single weed control method eg. herbicide alone will lead to build up of weed species of more tolerant to weed control methods (De Datta, 1977). From the above concept integrated weed management (IWM) is introduced. In developed countries IWM is extensively used to control weeds but in Bangladesh it is rather a new approach.

The principle of IWM is that no single weed control method is effective in all circumstances. The best weed control is achieved through the integration of several methods simultaneously (Moody and De Datta, 1982). Integration of different weed control methods can effectively control weeds in transplant aman rice and it may even reduce weeding cost. Weed competition at early growth stage can be eliminated through pre-emergence herbicides. Pre-emergence herbicides in combination with another weed control method like Japanese rice weeder or hand pulling; more efficient weed control may be achieved. Herbicides like Ronstar 25EC (Oxadiazon), Argold l0EC (Cinmethylin) and Emchlor SG (Butachlor) are good selective pre-emergence herbicide having against mono and dicotyledonous weeds in rice field and these can be used in Bangladesh. Replacernent of traditional weeding in transplant aman rice by herbicides and implements or herbicides in combination with hand weeding would help to obtain higher crop yield with less efforts and cost.

The present study was therefore, undertaken to find out an effective and economic weed control technology through integrated approaches and comparing their cost and benefits with conventional method of two hand weeding in transplant aman rice cv. BRRI dhan37.

MATERIALS AND METHODS

The experiment was conducted with transplant aman rice cv. BRRI dhan37 at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period from July to December 2002.Geographically the field is located at 24^0 $25^/$ N latitude and $90^0 50^/$ E longitude at an elevation of average 18 m above the sea level belonging to non- calcareous dark grey flood plain soil under the sonatola series of old Brahmaputra flood plain (AEZ-9) (BARC, 1997;

The morphological, physical and chemical characteristics of soil (0-15 cm) of the experimental plot are given below:

A. Morphological characters

i) Soil tract	: Old Brahmmaputra Alluvial
ii) Soil series	: Sonatola series
iii) Parent materials	: Old Brahmmaputra River borne deposite

B. Physical characters of soil

Constituent	Per cent
i) Sand (2.00-0. 5 mm dia)	25.2
ii) Silt (0.5-0.002 mm dia)	72.0
iii) Clay (below0.002 mm dia)	2.8
Texture	Silty loam

C. Chemical characters of soil

i) pH	6.8
ii) Organic matter (%)	0.93
iii) Total nitrogen (%)	0.11
iv) Available Phosphorus (ppm)	16.3
v) Available sulphur (ppm)	13.9
vi) Exchangeable potassium (%)	0.27

The experiment consisted of fifteen weed control treatments with four replication namely, No weeding (Wo),One hand weeding (W_1),Two hand weeding (W_2), Ronstar @ 2.01 ha^{-1} (W_3) ,Argold @ 0.751 ha^{-1} (W_4),M-chlor @ 13 kg ha^{-1}, (W_5)Ronstar @ 2.01 ha^{-1}+ 1 hand weeding (W_6), Argold @ 0.75 1 ha^{-1} + 1 hand weeding (W_7),M-chlor @ 13 kg ha^{-1}+ 1 hand weeding (W_8),Ronstar @ 2.01 ha^{-1} 1 + 1 weeding with Japanese rice weeder (W_9), Argold @ 0.75 1 ha^{-1}+ 1 weeding with Japanese rice weeder (W_{10}),M-chlor @ 13 kg ha^{-1}+ 1 weeding with Japanese rice weeder (W_{11}),1 hand weeding + 1 weeding with Japanese rice weeder (W_{l2}),2 hand weeding + 1 weeding with Japanese rice weeder (W_{13}),Weed free (W_{14}).

The size of the individual plot was 4.0 m X 2.5 m and total number of plots was 60 having spacing between the unit plots and the replications were 0.75 m and 1.0 m, respectively. The field was fertilized with urea, TSP, MP, gypsum and zinc sulphate at the rate of 150, 100, 70, 60 and 10 kg ha^{-1}respectively following the guideline of BRRI (2000). Thirty five days old seedlings were transplanted in the unit plots on 30 July 2002 at the rate of three seedlings per hill, maintaining row and hill spacing of 25 cm x 15 cm respectively. Weeding was done as per the experimental treatments. Other intercultural operations were done as and when necessary.

Data on weed density were collected from each plot at flowering stage of the rice plants by using 0.5 m X 0.5 m quadrants as per method described by Curz et al., (1986).After counting the weed density, the weeds were dried first in the sun then in an electrical oven for 72 hours at a temperature of 80^0C.The dry weight of each weed sample was taken an electrical balance and expressed in g m^{-2} .

The crop was harvested plot-wise at full maturity on 14 December 2002. The harvested crop was threshed with pedal thresher and cleaned thoroughly and sun dried. Data on yield and yield characters were taken namely, Plant height, Total number of tillers $hill^{-1}$,Number of bearing tillers $hill^{-1}$,Number of non-bearing tillers $hill^{-1}$,Panicle length, Number of grains $panicle^{-1}$,Number of sterile spikelets $panicle^{-1}$, 1000-grain weight, Grain yield, Biological yield and Harvest index.

The data were statistically analyzed with the help of computer package programme MSTAT and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

The cost of individual expenditure head was recorded and partial budget analysis was done. Relative profitability or loss of different methods of weed control was calculated in comparison with Two hand weeding which is the conventional method of weeding.

RESULTS AND DISCUSSION

Weed density

Weed density was significantly influenced by different weed control treatments. The highest weed density (298.41 no. m^{-2}) was observed in the no weeding treatment followed by One hand weeding and hand weeding + 1 weeding with Japanese rice weeder, respectively (Table 1). No weed was observed in the Weed free treatment and the lowest weed density (5.31 no. m^{-2}) was observed in Ronstar @ 2.0 1 ha^{-1} + 1 hand reeding treatment which was followed by Ronstar @ 2.01 ha^{-1} + 1 weeding vith Japanese rice weeder (7.38 no. m^{-2}),Argold @ 0.75 1 ha^{-1}+ 1 hand weeding (10.43 no. m^{-2}) and M-chlor @ 13 kg ha^{-1}+ 1 hand weeding 2.08 no. m^{-2}), respectively. Trivedi *et al*., (1986) also observed effective control of weeds by 0.75 Oxadiazon ha^{-1} with manual weeding among the14 different weed control treatments in rice. Among the weed control treatments percent reduction of weed density was observed the highest in Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding (98.22) and the lowest was observed in the One hand weeding treatment (49.26) compared with the No weeding treatment. Similar findings was also reported by Rekha *et al*., (2002) that weed density was lower in all treatments compared to the unweeded control plot.

Weed dry weight

The weed dry weight was significantly influenced by weed control treatments. The highest weed dry weight (113.69 g m^{-2}) was recorded from the No weeding plot (Table 1) which was significantly followed by One hand weeding (79.23 g m^{-2}), 1 hand weeding + 1 weeding with Japanese rice weeder and so on. Singh and Kumar (1999) also reported that the maximum weed dry weight was recorded in the unweeded control which was significantly higher compared to other weed control treatments. The least weed dry weight (1.18 g m^{-2}) was recorded in Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding treatment which was identical with Ronstar @ 2.01 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.751 ha^{-1} + 1 weeding with Japanese rice weeder, M-chlor @ 13 kg ha^{-1} + 1 weeding with Japanese rice weeder and 2 hand weeding + 1 weeding with Japanese rice weeder. Without the Weed free treatment highest weed control efficiency (98.96%) was recorded from the weed control treatment of Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding which was followed by Ronstar @ 2.01 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 hand weeding , M-chlor 13 kg ha^{-1}+ 1 hand weeding, Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder, M-chlor 13 kg ha^{-1} + 1 weeding with Japanese rice weeder, 2 hand weeding + 1 weeding with Japanese rice weeder, respectively. Among the weed control treatments the least weed control efficiency (30.31 %) was recorded from the One hand weeding treatment. Jena et al., (2002) also reported that Oxadiazon had better weed control efficiency than thiobencarb and the per-emergence application of Oxadiazon supplemented with One hand weeding at 45 DAT in rice field recorded the highest weed control efficiency.

Plant height

Plant height was significantly influenced by weed control treatments. There was no significant difference among the treatments W_3 to W_{14} and also among W_1 to W_5 and W_7 to W_{13} (Table 2). The lowest plant height produced in No weeding treatment (W_O) was significantly inferior to rest of the weed control treatments. The tallest plant (127.24 cm) was observed in Weed free treatment (W_{14}) which was statistically identical with rest of the treatments except Wo, W_1 and W_2. Again the difference in plant height among the treatments W_1, to W_3; and W_7 to W_{13} were not significant. Results indicated that heavy weed infestation in the No weeding treatment might have hampered the normal growth and development of rice plants and ultimately plants became shorter. Similar results were also reported by Patil et al., (1986) that plant height significantly reduced by heavy weed infestation.

Total tillers $hill^{-1}$

Total number of tillers $hill^{-1}$ was significantly affected by weed control treatments. The highest number of tillers $hill^{-1}$ (13.46) was observed in the Weed free treatment (Table 2). The next highest total number of tillers $hill^{-1}$ (12.22) observed in Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding was identical with 2 hand weeding + 1 weeding with Japanese rice weeder, Ronstar @ 2.0 1 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + l weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 hand weeding and Ronstar @ 2.01 ha^{-1} respectively. On the other hand, the lowest number of total tillers $hill^{-1}$ (9.00) was observed in No weeding treatment which was identical with one hand weeding. Results of this study showed that weed free condition was best for tiller production. No weeding or only one hand weeding treatment failed to produce more tillers due to severe weed infestation in the experimental plots. Similar results were also reported by Attalla and Kholosy (2002).

Bearing tillers hill^{-1}

The weed control treatment exhibited almost the same trend of effect on bearing tillers $hill^{-1}$ as shown on the total tillers $hill^{-1}$. The highest number of bearing tillers $hill^{-1}$ (11. 18) was observed in the Weed free treatment (Table 2) and it was followed by Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding, 2 hand weeding + 1 weeding with Japanese rice weeder and Ronstar @ 2.0 1 ha^{-1} + l weeding with Japanese rice weeder without significant difference. On the other hand the lowest number of bearing tillers $hill^{-1}$ (4.58) was observed in the No weeding treatment. This might be due to the fact that the higher competition of weeds did not allow the rice plant to produce more number of bearing tillers $hill^{-1}$ in the No weeding treatment. Similar findings were also reported by Sanjoy et al., (1999) that panicle number m^{-2} increased by 18% due to weed control over its lower level.

Non-bearing tillers hill^{-1}

The number of non-bearing tillers $hill^{-1}$ was significantly influenced by weed control treatments. The highest number of nonbearing tillers $hill^{-1}$ (3.53) was observed in No weeding treatment (W_O) which was statistically identical with all other weed control treatments except Weed free (W_{14}), Ronstar @ 2.0 1 ha-1 + 1 hand weeding (W_6) and 2 hand weeding + 1 weeding with Japanese rice weeder (W_{13}) (Table 2). The lowest number of non-bearing tillers $hill^{-1}$ (2.28) was observed in the Weed free treatment (W_{14}) which was identical with W_6, W_{13}, W_9, W_{1o}, W_7 ,W_8, W_{11} and W_I, respectively. The reason of producing higher number of nonbearing tillers $hill^{-1}$ might be due to hard competition from the weeds with the crop plants for nutrient, air, space, light, water and other growth and development requirements of grain formation in the tillers.

Panicle length

The panicle length was significantly influenced by weed control treatments. The highest length of panicle (23.50 cm) observed in the Weed free treatment was significantly higher than those of rest of them (Table 2). The highest panicle length was followed by the treatment of Ronstar @ 2.01 ha^{-1} + 1 hand weeding which was identical with Argold @ 0.75 1 ha^{-1} + 1 hand weeding and Ronstar @ 2.01 ha^{-1} + 1 weeding with Japanese rice weeder. The lowest length of panicle (I9.17 cm) was observed in the treatment of No weeding. The lowest length of panicle might have resulted due to higher competition of weeds with the crop plants failed to produce the normal growth of panicles. Similar observation was also reported by Attalla and Kholosy (2002) where weed control treatments significantly enhanced the crop characters like panicle length, number of grain $panicle^{-1}$, 1000-grain weight and harvest index.

Total spikelets panicle-1

The weed control treatments significantly affected the total number of spikelets $panicle^{-1}$. The total number of spikelets $panicle^{-1}$ was the highest (127.85) in the Weed free treatment which was identical with Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding (Table 2). The total number of spikelets panicle $^{-1}$ was the lowest (102.44) in the One hand weeding which was identical with No weeding, 1 hand weeding + 1 weeding with Japanese rice weeder and Two hand weeding, respectively. In the treatments where weeds were controlled effectively there total number of spikelets $panicle^{-1}$ recorded higher because weeds did not compete with the rice plant for the nutrients, water, light etc. Similar results were reported by Attalla and Kholosy (2002).

Grains panicle^{-1}

The influence of different weed control treatments was significant on the number of grains $panicle^{-1}$. The highest number of grains $panicle^{-1}$ (107.28) obtained from the Weed free plots was significantly higher than those of rest of the weed control treatments (Table 2). Ronstar @ 2.01 ha^{-1} + 1 hand weeding was identical with 2 hand weeding + 1 weeding with Japanese rice weeder but both of them were significantly better than the other weed control treatments with herbicides alone or in combination with other implements. The lowest number of grains $panicle^{-1}$ (69.41) was observed in the No weeding treatment which was inferior to others. This might be due to higher crop-weed competition in the No weeding treatment and the treatments where weeding was not done effectively, because weeds shared with the crop for its nutrients, water, light or other necessary growth factors and consequently reduced grains $panicle^{-1}$. Similar findings were also reported by Polthanee et al., (1996) and Sanjoy et al., (1999) where the number of filled grains $panicle^{-1}$ were increased due to weed control over no weeding. Weeds were controlled effectively there total number of spikelets panicle^{-1} recorded higher because weeds did not compete with the rice plant for the nutrients, water, light etc. Similar results were reported by Attalla and Kholosy (2002).

Sterile spikelets panicle^{-1}

The number of sterile spikelets panicle^{-1} varied significantly due to the effect of weed control treatments. The highest number of sterile spikelets panicle^{-1} (34.06) was observed in the No weeding treatment which was significantly higher than those of other treatments (Table 2) and was followed by One hand weeding, 1 hand weeding + 1 weeding Japanese rice weeder, Two hand weeding, M-chlor @ 13 kg ha^{-1} and Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder. The lowest number of sterile spikelets panicle^{-1} (21.82) was observed in the Weed free treatment. The second lowest number (24.20) produced in Ronstar @ 2.01 ha^{-1} + 1 weeding with Japanese rice weeder was identical with Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding, Ronstar @ 2.0 1 ha^{-1} and Argold @ 0.75 1 ha^{-1} treatment. Weed infestation perhaps, the main reason for such variation of the number of sterile spikelets panicle^{-1} in different treatments. In No weeding treatment or the treatments where weeding was inadequate there number of sterile spikelets panicle^{-1} was high because weed shared with the rice plant for nutrients, water and other growth factors and consequently had adverse effect on the grain formation and caused the high percentage of sterile spikelets panicle^{-1} .

1000-grain weight

Thousand grain weights were not significantly influenced by weed control treatments although they numerically differed among themselves. Similar findings were also reported by Polthanee et al., (1996) where the weed control treatments did not affect the 1000-grain weight but significantly increased the grain yield (Table 2).

Grain yield

Significant variation was observed in grain yield due to the effect of different weed control treatments (Table 2). The highest grain yield (3.45 t ha^{-1}) was observed in the Weed free treatment and the next highest yield (3.33 t ha^{-1}) in the treatment Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding which was statistically identical with 2 hand weeding + 1 weeding with Japanese rice weeder, Ronstar @ 2.0 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder (Table 2). On the other hand the lowest grain yield (1.82 t ha^{-1}) was observed in the No weeding treatment which was significantly inferior to rest of the treatments. It is seen that the effect of one hand weeding or individual herbicide was less effective in controlling weeds than those of integrated weed control treatments like Herbicide + 1 hand weeding or Herbicide + 1 weeding with Japanese rice weeder and also 1 or 2 hand weeding + l weeding with Japanese rice weeder. The lowest grain yield in the No weeding treatment might be due to resultant effects of the poor performance of yield contributing characters. This happened due to severe weed infestation with various species of weeds and competition for moisture, space, air, light and nutrient between weeds and rice plant, which had adverse effect on all the yield components and finally on grain yield. In the treatments where weeding were done properly the nutrients, moisture and other growth requirements were used by the rice plants more efficiently and finally increased the grain yield. Similar findings were also reported by Polthanee et al., (1996), Thomas et al., (1997), Sanjoy et al., (1999), Gogoi et al., (2000), Attalla and Kholosy (2002) where different weed control practices significantly increased the rice yield over the unweeded control. Sing and Kumar (1999) also observed the maximum grain yield in Weed free treatment and the lowest grain yield in the unweeded control.

Straw yield

Straw yield of rice significantly influenced by different weed control treatments. The highest straw yield (5.65 t ha^{-1}) was recorded in the Weed free treatment (Table 1). The next highest straw yield (5.33 t ha^{-1}) was observed in the treatments Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding and Ronstar @ 2.0 1 ha^{-1} + 1 weeding with Japanese rice weeder which were identical with 2 hand weeding + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder. On the other hand, the lowest straw yield (3.97 t ha^{-1}) was observed in the No weeding treatment because of severe weed infestation that hampered the normal growth and development of rice plant and also its tillering capacity and finally reduced the straw yield. Islam (1995) also reported the highest grain and straw yields ha^{-1} from the Weed free plots and the lowest from the No weeding plots.

Biological yield

Biological yield was significantly influenced by different weed control treatments. The highest biological yield (9.10 t ha^{-1}) was observed in the Weed free treatment (Table 2) and the next highest biological yield (8.66 t ha^{-1}) was observed in the weed control treatment of Ronstar @ 2.01 ha^{-1} + 1 hand weeding which was statistically identical with 2 hand weeding + 1 weeding with Japanese rice weeder, Ronstar @ 2.01 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 hand weeding, Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder and

M-chlor @ 13 kg ha^{-1} + 1 hand weeding treatments. The lowest biological yield (5.79 t ha^{-1}) was observed in the No weeding treatment which was statistically inferior to other weed control treatments. It is evident from Table 1 that use of one of the herbicides + 1 hand weeding or 1 weeding with Japanese rice weeder were more effective in controlling weeds and for getting desired yield of grains than the weed control treatments with only one herbicides or One hand weeding. Variation of biological yield among the treatments was dependent upon the severity of weed infestation. Higher weed infestation not only reduced the grain yield but also hampered the plant growth and tillering capacity and ultimately reduced straw yield and also biological yield.

Harvest index

Harvest index was significantly affected by the different weed control treatments (Table 2). The highest harvest index (38.45) was observed in the weed free treatment (Table 2) which was statistically identical with Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding, 2 hand weeding + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder, Argold @ 0.75 1 ha^{-1} + 1 hand weeding, M-chlor @ 13 kg ha^{-1} + 1 hand weeding, Ronstar @ 2.0 1 ha^{-1} + 1 weeding with Japanese rice weeder, M-chlor @ 13 kg ha $^{-1}$ + 1 weeding with Japanese rice weeder treatment, respectively. On the contrary the lowest harvest index (31.39) was found from the No weeding treatment which was statistically inferior to rest of the treatments. Heavy weed infestation in the No weeding treatment reduced the grain yield which ultimately affected the harvest index. Similar observation also reported by Attalla and Kholosy (2002) that all weed control treatments significantly enhanced grain and straw yields and yield components eg. Harvest index.

Relative profitability of weed control treatments

Relative profitability of weed control treatments in BRRI dhan37 rice have been presented in Table 3. In Bangladesh conventionally Two hand weeding is practised for weed control in transplanted rice field. For this reason relative profitability of different weed control treatments of this experiment was calculated in comparison with Two hand weeding. It was found that all integrated weed management treatments except 1 hand weeding + 1 weeding with Japanese rice weeder were profitable compared to the conventional method. Among them each of the per-emergence herbicides combined with one hand weeding or weeding with Japanese rice weeder resulted higher profit than conventional method. Application of preemergence herbicide at the initial stage of weed germination resulted less weed infestation to the rice field at a certain stage and after that another weeding through hand or Japanese rice weeder gave favourable condition for rice growth and finally produced higher grain and straw yield than that of Two hand weeding. The highest profit compared to the conventional method was obtained from the integrated weed control treatment Argold @ 0.75 1 ha^{-1} + 1 weeding with Japanese rice weeder (Table 3) and followed by Argold @ 0.75 1 ha^{-1} + 1 hand weeding, M-chlor @ 13 kg ha^{-1} + 1 weeding with Japanese rice weeder, Ronstar @ 2.0 1 ha^{-1} + 1 hand weeding, Ronstar @ 2.0 1 ha^{-1} + 1 weeding with Japanese rice weeder, M-chlor @ 13 kg ha^{-1} + l hand weeding and 2 hand weeding + 1 weeding with Japanese rice weeder integrated weed control treatments, respectively. All the integrated weed control treatments mentioned above were more profitable than the Weed free or any other individual method of weed control treatment.

Table: 1. Effect of weed control treatments on Weed density and dry weight of weed.

Treatment	Weed density (no.m^{-2})	Weed dry weight (g m^{-2})
W_0	298.41a	113.69a
W_1	1151.39b	79.23b
W_2	77.29d	18.53cd
W_3	50.75f	23.10cd
W_4	74.28e	28.73cd
W_5	79.10d	31.07cd
W_6	5.31k	1.18ef
W_7	10.43i	3.08def
W_8	12.08hi	4.21def
W_9	7.38j	2.01ef
W_{10}	13.1gh9	4.52c-f
W_{11}	15.06g	5.08c-f
W_{12}	103.07c	32.50c
W_{13}	13.77gh	5.09def
W_{14}	0.00n	0.00f
Level of significance	0.01	0.01
CV (%)	6.67	5.41

In column, means having common letter (s) do not differ significantly

Table: 2. Effect of weed control treatments on the crop characters of transplant aman rice cv. BRRI dhan37

Treatment	Plant height (cm)	Tillers hill^{-1}			Panicle length (cm)	Total spikelets panicle^{-1}
		total	bearing	non-bearing		
W_0	113.36c	9.00e	5.48g	3.53a	19.17j	103.47e
W_1	119.94b	9.67de	6.65f	3.03abcd	19.98i	102.44e
W_2	120.36b	10.68cd	7.25ef	3.40ab	21.52fgh	105.65e
W_3	124.19ab	11.30bc	8.06cde	3.24ab	22.26cd	115.52cd
W_4	123.73ab	10.87cd	7.55def	3.32ab	21.76d-h	113.06c
W_5	123.04ab	10.69cd	7.19ef	3.50ab	21.40gh	112.95c
W_6	126.27a	12.22b	9.78b	2.44cd	22.82b	124.03ab
W_7	122.47ab	11.30bc	8.38cde	2.92abcd	22.43bc	120.59bc
W_8	124.28a	10.75cd	7.82cdef	2.94abcd	22.22cde	119.49bc
W_9	123.68ab	11.48bc	8.76bc	2.75abcd	22.35bc	116.91 cd
W_{10}	123.05ab	11.37bc	8.55cd	2.82abcd	21.96c-h	120.81 bc
W_{11}	122.60ab	10.87cd	7.86cde	3.00abcd	21.69e-h	118.31bcd
W_{12}	122.55ab	10.45cd	7.28ef	3.17abc	21.24h	104.43e
W_{13}	125.09ab	11.60bc	8.88bc	2.72bcd	22.00c-f	121.64bc
W_{14}	127.24a	13.46a	11.18a	2.28d	23.50a	127.85a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	4.25	5.15	6.86	8.83	5.24	7.64

In column, means having common letter (s) do not differ significantly

Table: 2. contd.

Treatment	Grains panicle^{-1} (no)	Sterile spikelets panicle^{-1} (no)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0	69.41j	34.06a	14.76	1.82h	3.97h	5.79h	31.39f
W_1	73.99i	28.45b	14.92	2.26g	4.38g	6.63g	33.99e
W_2	78.72h	26.94bcd	15.05	2.80e	4.91ef	7.55ef	37.13bc
W_3	90.18ef	25.34de	14.96	2.94d	5.09d	8.03c	36.63c
W_4	87.24fg	25.83cde	14.91	2.88de	4.96e	7.84cd	36.72c
W_5	86.01g	26.94bcd	14.95	2.85de	4.92ef	7.76de	36.67c
W_6	99.44b	24.59e	15.22	3.33b	5.33b	8.66b	38.40a
W_7	94.85cd	25.75de	15.09	3.27bc	5.28bc	8.56b	38.24a
W_8	93.76d	25.74de	15.02	3.21c	5.20c	8.42b	387.15ab
W_9	95.21cd	24.20e	15.15	3.28bc	5.33b	8.61b	38.10ab
W_{10}	974.00d	26.81bcd	15.04	3.26bc	5.25bc	8.51b	38.32a
W_{11}	92.70de	25.60de	14.98	3.20c	5.22c	8.42b	38.00ab
W_{12}	76.60hi	27.83bc	15.05	2.62f	4.86f	7.47f	34.99d
W_{13}	97.31bc	24.33e	14.87	3.30bc	5.31b	8.61b	38.33a
W_{14}	107.28a	21.82f	15.11	3.45a	5.65a	9.10a	38.45a
Level of significance	0.01	0.01	NS	0.01	0.01	0.01	0.01
CV (%)	5.74	11.69	4.17	5.94	4.05	6.63	5.36

In column, means having common letter (s) do not differ significantly
NS= Not significant

W_0= No weeding, $W_{1=}$ One hand weeding, W_2 = Two hand weeding, W_3= Ronstar@2.0 l ha^{-1}, W_4= Argold@ 0.75 l ha^{-1}, W_5= M-chlor@ 13 kg ha^{-1}, W_6= Ronstar@2.0 l ha^{-1} + One hand weeding, W_7= Argold@ 0.75 l ha^{-1}+One hand weeding, W_8= M-chlor@ 13 kg ha^{-1} + One hand weeding, W_9= Ronstar@2.0 l ha^{-1} + 1 weeding with Japanese rice weeder, W_{10}= Argold@ 0.75 l ha^{-1}+1 weeding with Japanese rice weeder, W_{11}= M-chlor@ 13 kg ha^{-1} + 1 weeding with Japanese rice weeder, W_{12}= One hand weeding +1 weeding with Japanese rice weeder, W_{13}= Two hand weeding +1 weeding with Japanese rice weeder, W_{14}= Weed free

Table: 3. Economic performance of transplant aman rice cv. BRRI dhan37

Treatment	Total cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Benefit cost ratio (BCR)
W_0	13335.00	21376.00	8041.00	1.60
W_1	14955.00	22600.00	11149.00	1.75
W_2	16275.00	31928	15653.00	1.96
W_3	15455.00	33472.00	18017.00	2.17
W_4	13915.00	32768.00	18853.00	2.35
W_5	14535.00	32436.00	17901.00	2.23
W_6	16235.00	37564.00	21329.00	2.31
W_7	14695.00	36924.00	22229.00	2.51
W_8	15315.00	36260.00	20945.00	2.37
W_9	15935.00	37064.00	21129.00	2.33
W_{10}	14395.00	36800.00	22405.00	2.55
W_{11}	15015.00	36676.00	21661.00	2.44
W_{12}	15795.00	30088.00	14293.00	1.90
W_{13}	16995.00	37248.00	20253.00	2.19
W_{14}	19695.00	39020.00	19325.00	1.98

From the above result and discussion it may be concluded that application of pre-emergence herbicide followed by one hand weeding or mechanical weeding was a good combination of integrated weed management approach.

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