EFFECT OF DIFFERENT WEED CONTROL METHODS

ON

THE YIELD OF TRANSPLANTED AMAN RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF DIFFERENT WEED CONTROL METHODS ON THE YIELD OF TRANSPLANTED AMAN RICE VARIETIES"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by **TANIA SHARMIN**, Registration No. **08-2984** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged .

Dated: December, 2014
Place: Dhaka, Bangladesh

……………………………………

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DEDICATED TO

MY

BELOVED PARENTS

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EFFECT OF DIFFERENT WEED CONTROL METHODS
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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August to December, 2013 in T. aman season with a view to find out the performance of two transplanted aman rice varieties BRRI dhan56 and BRRI dhan57 under different weed control methods viz. chemical herbicide Rifit 50EC (Pretilachor 500 g L^{-1}) @ 1 L/ha (W_1), polythene paper (W_2), stale seedbed (W_3), one hand weeding at 20 DAT (W_4), two hand weeding at 20 and 40 DAT (W_5) and no weeding (control) (W_6) using split plot design. Eighteen different weed species infested the field among which *Cyperus michelianus* (36.73%), *Cyperus esculentus* (17.31%) at 30 DAT; *Cyperus esculentus* (25.13%) *Alternanthera sessilis* (21.53%) and *Cyperus difformis* (15.79%) at 60 DAT, *Fimbristylis miliaceae* (19.50%) at 90 DAT were dominant. Two hand weeding at 20 and 40 DAT (W_5) showed highest weed control efficiency 89.90% at 30 DAT, 59.74% at 60 DAT and 78.85% 90 DAT. The results showed that BRRI dhan56 produced the highest (3.70 t ha^{-1}) grain yield when two times weeding were performed at 20 and 40 DAT. BRRI dhan56 produced longest panicle length (23.39 cm), 1000-grain weight (23.12 g), grain yield (3.14 t ha^{1}), straw yield (5.16 t ha^{-1}), biological yield (8.90 t ha^{-1}), harvest index (35.08%) better than the BRRI dhan57. Economic analysis of the weed control parameters shows that, the highest (1.92) BCR was recorded from the chemical herbicide Rifit 500EC weed control. While the two hand weeding, stale seed bed and one hand weeding produces 1.79, 1.69 and 1.48 BCR respectively.

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LIST OF ACRONYMS

AEZ	= Agro Ecological Zone
BCR	= Benefit Cost Ratio
BARC	= Bangladesh Agricultural Research Council
BBS	= Bangladesh Bureau of Statistics
BINA	= Bangladesh Institute of Nuclear Agriculture
BARI	= Bangladesh Agricultural Research Institute
BRRI	= Bangladesh Rice Research Institute
Cm	= Centi meter
cv.	= Cultivar
DAT	= Days After Transplanting
DF	= Degrees of Freedom
EC	= Emulsifiable Concentrate
et al.	= and others
etc.	= Etcetera
FAO	= Food and Agricultural Organization
g	= Gram
HI	= Harvest Index
HYV	= High Yielding Variety
IRRI	= International Rice research Institute
Kg	= Kilogram
LSD	= Least Significant Difference
m	= Meter
m^2	= meter square
mm	= Millimeter
viz.	= namely
%	= Percent
CV %	= Percentage of Coefficient of Variance
SAU	= Sher-e-Bangla Agricultural University
T. aman	= Transplanted aman
t ha^{-1}	= Tons per hectare

INTRODUCTION

Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds ofmillions of people in Africa and Latin America (IRRI,2006). The people in Bangladesh depend on rice asstaple food and have tremendous influence on rice. In Bangladesh, majority of food grains come from rice *(Oryza sativa* L.).The population of Bangladesh became almost double over last three decade from 72 million in 1972 to 140 million in 2005 with an average increase by over 2 million per year and to feed the increased population in 2020, about 32800 thousand metric tons of rice will be needed to produce in the country (MoA, 2007). About 80% of cropped area of this country is used for rice production, with annual production of 25.18 million tons from 10.29 million ha of land (IRRI, 2006). Transplant aman covers the largest area of 5713 thousand hectare with a production of 11249thousand metric ton and average yield was about 1.951 ton ha^{-1} (BBS, 2001). The average yield of rice in Bangladesh is 2.45 t ha^{-1}(BRRI, 2007). This average yield is almost less than 50% of the world average rice grain yield.

Weeds grow in the crop fields throughout the world. It is often said, "Crop production is a fight against weeds" (Mukhopadhyay and Ghosh, 1981). The prevailing climatic and edaphic conditions are highly favorable for luxuriant growth of numerous species of weeds which offer a keen competition with rice crop. Since weeds and crops largely use the same resources for their growth, they will compete when these resources are limited (Zimdahl, 1980).Weeds in tropical zones cause yield loss on rice of about 35% (Oerke and Dehne, 2004). Most of the weeds derive their nourishment through rapid development and manifested by quick root and shoot development. Uncontrolled weeds cause grain yield reduction up to 76% under transplanted conditions in India (Singh et al., 2004). Weeds are the most competitors in their early growth stages than the later and hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). Studying competition between weeds and crops can help many societies reach their goals of increased food production (Ehteshami and Esfehani, 2005).Infestation of weed is one of the most important causes for low yield of rice. In Bangladesh, weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for Transplanted (T) Aman rice (late summer) and 22-36% for modern Boro rice cultivars (summer rice) (BRRI, 2006; Mamun, 1990). Production cost of rice increased due to increases in weed control cost. The prevailing climatic and edaphic conditions are highly favorable for luxuriant growth of numerous species of weeds that strongly compete with rice crop. The present weed management system which is done manually, is laborious, time consuming expensive and can't be done on time due to various reason (Ahmed *et al.,* 2005). Mechanical weeding and herbicides are the alternative to hand weeding. Mechanical weeders are in use in some areas of the country. But due to some disadvantages to its use, it has not gained widespread popularity actions are available in the market. Different types of chemical herbicides are also used.

In Bangladesh, few studies have attempted to establish the most suitable and economic weed management system in *T. aman* rice.

Thus the objectives of this study were

i. To observe the yield performances of two *T. aman* rice varieties.

ii. To find out the effective weed control method in *T. aman* rice and

iii. Assessment of economic performances of different weed control methods.

REVIEW OF LITERATURE

Weed is one of the limiting factors for successful rice production. Among various cultural practices, plant spacing play a vital role in the production and yield of rice through controlling the weeds as well as make the environment favourable for rice production. To justify the present study attempts have been made to incorporate some of the important findings of renowned scientists and research workers in this country and elsewhere of the world.

2.1 Weed vegetation in transplanted aman rice

Weed vegetation in crops is the result of cropping, cropping season, topography of land and management practices like time and degree of land preparation, plant spacing, time of planting date, fertilizer management, weeding method and intensities.

Venkataraman and Goplan (1995) observed that the most important weed species in transplanted low land rice in Tamil Nadu, India, were *Echinochloa crus-galli, Cyperus difformis, Echinochloa Colonum, Cyperus iria, Fimbristylis miliacea, Scirpus spp, Eclipta alba, Ludwigia parviflora, Marsilea quadrifolia* and *Monochoria vaginaliz.*

Bari *et al.* (1995) observed 53 weed species to grow in transplanted rice field. In respect of abundance value the three most important weeds were *Fimbristylis miliacea, Paspalum scrobiculaturm* and *Cyperus rotundus*.

Mamun *et al.* (1993) from the same location identified 60 weed species in T. aman rice of which *Fimbristylis miliacea, Lindernia antipoda* and *Eriocaulen cinereesm* were the most important weed species.

Elliot *et al.* (1984) reported that in transplanted rice *Monochoria vaginalis* was the important weed and other weed species were *Ischaemum rogusum, Scirpus supinus, Cyperus difformis, Ipomoea aquatica* and *Marsilea minuta*.

In the irrigated and rainfed area, Carbonell and Moody (1983) observed various weed species in transplanted rice in Nueva Ecija, Philippines.The most important weeds in the rainfed area were *Ischaemum rogusum, Fimbristylis miliacea, Echinochloa crus-galli* and *Monochoria vaginalis*.

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2.2 Weed control efficiency

Weed control efficiency is one of the important measurements of weed control in crop field. High weed control efficiency throughout the growing period by a weed control treatment ensures proper crop growth and profitable weed control. Weed control efficiency varies with weed control technology.

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and observed that *Paspalum distichum* was the dominating weed species in the experimental site.

Biswas *et al.* (2011) conducted a field experiment at Agronomy field of Sher-e-Bangla Agricultural University, Bangladesh during December 2010 to May 2011 including 16 popular inbred and hybrid rice varieties. They concluded that at 30 DAT, the significantly highest weed population of 119.00 and 117.00 m-2 was found in BRRI dhan29 and BRRI dhan45 respectively whereas BR3 and BRRI dhan50 resulted the lowest weed population of 31.00 and 38.00 m-2 respectively. Similar lowest weed population i.e. 35.33 and 36.00 m-2 was also found in BRRI dhan50 and BRRI hybrid dhan1 respectively at 60 DAT.

Bhuiyan *et al.* (2010) conducted an experiment during *boro* 2006 at Gazipur and Comilla location for the control of mixed weed flora in transplanted rice (*Oryza sativa L.*) and reported that *Cynodon dactylon*,*Scirpus maritimus*, *Monochoria vaginalis*,*Cyperus difformis*, *Fimbristylis miliacea*, *Cyperus iria*, *Marsilea quadrifolia* and *Alternanthera philoxeroides* were the major weeds in the experimental plots.

Reza *et al.* (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period 9mfrom January to April 2008 and found eight weed species to infest the crop were *Echinochloa crusgalli, Scirpus mucronatus, Cyperus difformis, Panicum repens, Digitaria ischaemum, Monochoria vaginalis, Leersia hexandra* and *Marsilia quadrifolia.* Among the weed species, *E. crusgalli* was the dominant one. They reported that the higher weed dry matter accumulation per unit area (7.98 g m-2) was obtained from shorter variety, BRRI dhan28 and the lower weed dry weight (5.51 g m-2) from the taller variety, Pajam.

Mian *et al.* (2007) observed eight weed species in transplanted *aman* rice field, namely *Paspalum scrobiculatum* L., *Echinochloa colonum* L., *Fimbristylis littralis* (L.) Vahl.*Cyperus iria* L., *Alisma plantago* L., *Jussieua decurrens* (Walt.) DC., *Polygonum orientale* L. and *Sphenocelea zeylanica* Gaertn. Among them, *Paspalum scrobiculatum* L. was the most dominating species in respect of summed dominance ratio (SDR of 41.71) and relative dry weight (RDW of 60.18%). All weed species except *A. plantago* and *J. decurrens* were found dominant in semi-dwarf modern cultivars (BR11 and BR22) than in traditional tall cultivars (Nizersail and Biroi).

Mitra *et al.* (2005) conducted an experiment and found *Fimbristylis miliacea, Scirpus murconatus* and *Monochoria vaginalis* as dominant weed species in transplanted *aman* rice field.

Sharma and Bhunia (1999) reported that Pendimethalin @ 1.5 kg/ ha plus one
hand weeding resulted in highest weed control efficiency than any other treatments.

Ahmed *et al.* (1997) reported that higher wed control efficiency (90.35%) was observed in herbicides with one hand weeding treatment than sole herbicides or conventional weed control methods.

Alam *et al.*, (1996) reported that weed control efficiency was higher in two hand weeding (90.67%) than dose of Oxadiazon and Cinosulfuron treatments .

In another experiment Singh and Bhan (1992) found that two hand weeding resulted better weed control efficiency (72.3%) than Butachlor @ 1.5 kg ha^{-1}(54.4%) in transplanted rice under medium land condition.

Burhan *et al.* (1989) reported that Cinosulfuron @ 20 g ha^{-1}resulted in 85% control of *Monochoria vaginalis, Marsilea crenata, Cyperus spp Fimbristylis miliacea* and *Scirpus juncoides* but only 50-60% control of *Echinochloa crus-galli* in transplanted rice.

2.3 Effect of hand weeding

Khan and Tarique (2011) carried out an experiment during June to December 2006 and observed that highest total tillers plant-1 was observed in completely weed free condition throughout the crop growth period. On the other hand, total tillers plant-1 that appeared next to the highest was found in two hand weeding treatment. However, shorter plant was found in no weeding treatment.

Ashraf *et al.* (2006) made an experiment in Lahore, Pakistan, during 2004 and 2005 kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000). In the second year the maximum control of weeds was 94.67% in the case of hand weeding. Regarding the number of tillers plant^{-1} , hand weeding resulted in 20.8 compared to 16.6 for the control in second year, whereas the highest number of grains per panicle was 135.50 during the second year. In terms of paddy yield, hand weeding gave the highest grain yield but remained statistically at par with certain herbicides

Gogoi (1998) observed that Anilofos at 0.4 kg ha^{-1}gave significantly higher yield and the yield was not significantly different from the hand weeding at 20 days after transplanting.

Nandal *et al.* (1998) evaluated the herbicide in direct seeded puddled rice during Kharif season. They observed that Pretilachlor (1.0 kg ha^{-1}) + hand weeding reduced weed population and weed dry weight significantly than other treatments. They also found that the highest grain yield and gross margin was obtained from the Pretilachlor (1.0 kg ha^{-1}) + hand weeding.

Angiras and Rana (1998) observed that greatest yield and desired weed control was achieved form the Pretilachlor (0.8 kg ha^{-1}) + hand weeding.

BRRI (1997) reported that two hand weeding performed best than chemical treatments but two hand weeding gave the higher weeding cost than herbicidal treatments.

Shivamdiah *et al.* (1987) investigated that Oxadiazon 0.75 kg ha^{-1}+ one hand weeding gave significantly greater yields than herbicides alone. They also found that combination of herbicidal treatment and one hand weeding gave higher straw yield.

Navarez *et al.* (1982) showed in rainfed condition that the lack of weed control in tall rice cultivars resulted in the yield reduction by 41% but one hand weeding at 40 days after transplanting reduced the grain yield by 31%.

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Baloch *et al.* (2006) made an experiment in NWFP, Pakistan to evaluate the effect of weed control practices on the productivity of transplanted rice. Among weed management tools, the maximum paddy yield was obtained in hand weeding, closely followed by Butachlor (Machete 60EC) during both cropping seasons.

Manish *et al.* (2006) said that *Alternanthera triandra, Echinochloa colona, Fimbristylis miliacea* and *Xanthium strumarium* were the dominant weeds associated with the transplanted rice crop. Results revealed that hand weeding at 15 and 30 DAT (days after transplanting) gave the highest grain yield, straw yield and harvest index. Maximum weed density and dry matter were recorded in the unweeded control, while the minimum values were obtained with hand weeding at 15 and 30 DAT.

Other than weed free condition, the highest grain yield (5.9 t ha^{-1}) was produced by BR 11 under two hand weeding. It was further identified to reduce the weed seed bank status in rice soils and rice grains to the lowest extent in both farmer's field as well as experimental field (Bijon, 2004).

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. The treatments were two hand weeding, Butachlor 2.0 kg ha^{-1}and Oxadiazon 0.8 kg ha^{-1}. They found that two hand weeding produced the highest ear length (23.49cm), number of grains panicle^{-1}, grain yield (33.65 g ha^{-1}), straw yield (65.35 g ha^{-1}) and harvest index (33.97%).

Bhowmick (2002) said two hand weeding at 20 and 40 days after transplanting (DAT) in transplanted rice showed the highest control of weeds.

Bhowmick *et al.* (2002) revealed that *Echinochloa crus-galli, Cyperus iria, Cyperus rotundus* were the dominant weeds in transplanted rice. He observed that two hand weeding at 20 and 40 days after transplanting were able to control almost all categories of weeds.

Chandra and Pandey (2001) showed that hand weeding was the most effective in mitigating the weed dry matter accumulation and also reported that higher grain and straw yield were obtained with hand weeding.

Hossain (2000) observed experiment oriented impact of different weeding approaches on rice like one hand weeding, two hand weeding, three hand weeding, Oxadiazon, Oxadiazon in combination with one hand weeding and observed that yield and yield contributing traits in rice production had upgraded by degrees with the higher frequency of hand weeding.

Balaswamy (1999) found that hand weeding twice at 20 and 40 days after transplanting resulted in low weed numbers, followed by herbicides. Gogoi (1998) observed that Anilofos at 0.4 kg ha^{-1} gave significantly higher yield and the yield was not significantly different from the hand weeding at 20 days after transplanting.

Nandal *et al.* (1998) evaluated the herbicide in direct seeded puddled rice during Kharif season. They observed that Pretilachlor (1.0 kg ha^{-1}) + hand weeding reduced weed population and weed dry weight significantly than other treatments. They also found that the highest grain yield and gross margin was obtained from the Pretilachlor (1.0 kg ha^{-1}) + hand weeding.

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2.4 Effect of herbicides :

Hasanuzzaman *et al.* (2008) stated that Ronstar 25EC @ 1.25 L ha^{-1}+ IR5878 50 WP @ 120 g ha-1 was most efficient that influenced plant height according to the effectiveness of the treatments.

Samar *et al.* (2007) conducted an experiment to evaluate the effects of herbicides for managing weeds and optimizing the yield of wet seeded rice. It was concluded that application of Pendimethalin(1000 g a.i. ha^{-1}) or Pretilachlor with Safener (500 g a.i.ha^{-1}) as pre-emergence applications followed by one hand-weeding were effective in controlling weeds, increasing grain yield of rice, and resulting in higher net returns than the weed-free treatment.

Raju et al. (2003) observed the effect of pre emergence application of Pretilachlor plus Safener 0.3 kg ha^{-1}, Butachlor 1 kg ha^{-1} and post emergence herbicide like Butanil 3.0 kg ha^{-1} on 4, 8 and 15 days after sowing. They found that Pretilachlor plus Safener 0.3 kg ha^{-1} gave the highest yield attributes (productive tillers m^{-2}, number of grains $panicle^{-1}$ and 1000 grain weight) and grain yield.

Mahajan et al. (2003) observed that application of Pretilachlor alone or in combination with Safener and hand weeding resulted in the lowest total weed density and dry matter and grain yield and number of panicles.

Kalhirvelan and Vaiyapuri (2003) observed the effect of weed management pratices on transplanted rice. The application of Pretilachlor at 187, 250 or 375 g ha^{-1}, Pretilachlor and 2, 4 D at 180 + 180, 240+ 240 and 300+ 300 g ha^{-1} with twice hand weeding. They found that hand weeding recorded the lowest weed population (2.78 m^{-2}) and weed dry weight (155.7 kg ha^{-1}). Pretilachlor and 2, 4-D at 300 + 300 g ha^{-1} caused the lowest weed density and weed dry weight. Hand weeding recorded the highest grain and straw yields (5.81 and 7. 26 t ha^{-1}, respectively) than Pretilachlor and 2, 4-D (5. 55 and 6.89 t ha^{-1}).

Moorthy et al. (2002) investigated the efficacy of pre and post emergence herbicides in controlling weeds in rainfed upland direct sown rice. The application of Pretilachlor 625 g ha^{-1}, and Butachlor 1600 g ha^{-1} days after sowing and the treatments gave effective weed control and produced highest grain yield compared with twice hand weeding on 20 and 40 DAT.

Tamilselvan and Budhar (2001) studied the effects of pre emergence herbicides Pretilachlor 0.4 kg ha^{-1}, Pretilachlor 0.4 kg a.i. ha^{-1} on rice cv. ADT 43. The herbicides were applied 8 days after sowing . The density and dry weight of weeds at 40 DAS were lower in herbicide treated plots than in unweeded and hand weeded plots. The highest number of productive tillers hill^{-1} was obtained with Pretilachlor 0,40 kg a.i. ha^{-1} (14.2). The number of filled grain panicle^{-1} was the highest with Pretilachlor 0.40 kg a.i. ha^{-1} (126.3). The weed control treatment had effect in increasing grain yield .

Selvam et al. (2001) observed the effect of time of sowing along with weed management practices in semidry rice. The treatments included sowing practices and herbicide, Pendimethalin 1.24 kg ha^{-1} 8 days after rainfall, Pretilachlor 1.00 kg ha^{-1} at 4 DAS and 8 DAS, Pretilachlor + Safener 4 DAS and 8 DAS, hand weeding twice and unweeded control. All herbicides receiving plots were suppplemented with one hand weeding at 25 DAS. Among the herbicides, Pendimethalin recorded the highest grain yield (3773 kg ha^{-1} and was at par with Pretilachlor at 8 DAS.

Islam et al. (2001) investigated the application of few doses of Pretilachlor (312.50-562.50 g a.i. ha^{-1} and one hand weeding in transplanted rice. They found that Pretilachlor (312.50-562.50 a.i. ha^{-1}) and hand weeding reduced weed population and dry matter weight.

Moorthy et al. (1999) observed the performance of the pre emergence herbicides Pretilachlor + safener, Butachlor+ safener, Butachlor, Anilofos + ethoxysulfuron, Thiobencarb and Anilofos for their efficiency to control weeds in direct sown rice under puddled soil condition. They observed that Pretilachlor + safener (0.4 kg ha^{-1} and 0.6 kg ha^{-1}, Butachlor + safener (1.5 kg ha^{-1})and Anilofos+ ethoxysulfuron (0.37+0.04 kg ha^{-1}) controlled the most dominant weeds (Cyperus difformis and Fimbristylis miliacea) and produced yields comparable to those of the hand weeded control.

Rajendran and Kempuchetty (1998) observed the application of Thiobencarb 1.51.5 kg and hand weeding at 25 days after sowing, Pretilachlor 0.3 kg and hand weeding at 25 days after sowing as well as two hand weeding (25 and 45 days after sowing) in dry seeded low land rice cv. ADT 38. They found that the highest grain yield (5.5 t ha^{-1}) was achieved with Pretilachlor 0.3 kg + hand weeding treatment compared with Thiobencarb+ hand weeding (4.7 t ha^{-1}, 74.9% respectively).

Mandal et al. (1995) reported the efficacy Pretilachlor as herbicide in comparison to hand weeding in BR 11 variety . The major weeds in the rice field were Cyperus iria, Scirpus muronatus, Monochoria hastata and Eleusine indica. The lower doses of Pretilachlor at 1 l ha^{-1}

failed to kill the weeds properly. The grain yield reduction due to weed infestation was 20.3 percent.

Janardhan et al. (1993) evaluated pre emergence Pretilachlor 0.5-1 kg ha^{-1} on weed control in transplanted rice . They found that herbicidal treatment decrease weed dry weight and increased grain yield.

2.5Effect of Polythene paper :

Hochmuth et al. (2008) explained that Florida leads the country in the use of synthetic (polyethylene) mulch with about 100,000 acres of mulched vegetables.

Dittmar & McRae (2012) said that black polyethylene mulch is used most widely because it effectively decreases or eliminates most weed growth by inhibiting photosynthesis.

Dittmar & McRae, (2012) the use of black polyethylene mulch increases yield and earliness of vegetables in the spring, and works well to suppress most weeds except nutsedge.

Gilreath et al. (2004) said that paper mulch has been shown to be more effective
than polyethylene plastics at suppressing purple nutsedge, a weed that can be a limiting factor in tomato and other vegetable production.

Schonbeck (1993) said that paper mulches could provide comparable benefits similar to polyethylene mulches in terms of weed control and soil environment and may be particularly adapted to cool-season crop. In addition, paper mulches have the ability to decompose at the end of the season, reducing both the environment and economic costs of plastic mulch disposal.

Hochmuth (1992) Black plastic is used typically in early spring and white or
white-on-black plastic mulch is used to control weeds in fall crops that are established under hot summer conditions. Plastics of different colors and paper mulches are both useful for maintaining the weed-free period in production systems. Plastic mulch is durable enough to provide weed control extended periods.

Hochmuth(1992) paper may only provide weed control for about 40 to 60 days before the environmental elements begin to cause degradation. Synthetic mulches can be highly effective at eliminating the weeds that compete with crops and serve as a host to pests.Ghosh et al (2006) said that the pod yield of groundnut under black polythene was higher than under transparent polythene. The polythene mulch increased soil temperature by 4–5 °C throughout the crop growth (germination to maturity), which increased seeding emergence but was detrimental to pod setting and pod development (soil temperature exceeded 40 °C). Thus, the benefit of polythene was only observed when it was retained up to podding stage, but not up to harvest.

Plastic mulch increased baby corn yield by 18.9% and 77.5% over rice straw and unmulched treatment respectively stated by Mahajan et al in 2007.

2.6 Effect of stale bed :

soil physical properties and environmental pollution .

Rice in the Indo Gangetic plains is raised by two principal rice methods of establishment, *viz.* transplanting and direct seeding.

Sindhu *et al.* (2010) reported the emergence of weeds are killed either by a non selective herbicide or by shallow tillage prior to the sowing of rice. Stale seedbed can also be implemented by submergence of rice field after 7 and 14 days of weed emergence.

Singh *et al.* (2009) reported 53% lower weed density in dry– DSR after stale seedbed than without this practice.

Rao *et al.* (2007)reported that stale or false seedbed technique is preventive method of weed management.This technique involves the soil preparation of a seedbed to promote germination of weeds, a number of days or weeks before the actual sowing or planting of the crop, thus depleting the seed bank in the surface layer of soil and reducing subsequent emergence of weeds .

Riemens et al (2007) reported that depending on location and year, stale seedbed preparations followed by weed control prior to planting reduced the amount of weeds during crop growth by 43–83%.

Mazid *et al*. (2002) said emphasis is now being given on direct-seeded-rice cultivation which provides opportunities for system intensification and diversification .

Paradkar *et al.*(1997) reported that a major impediment in the successful cultivation of directseeded rice (DSR) in tropical countries is heavy infestation of weeds which often range from 50-91% due to simultaneous emergence of weeds and crop and less availability of efficient selective herbicides for control of weeds during initial stages of crop weed competition. Further, nature of weed flora infesting direct-seeded rice also changes over years and it increased infestation of weedy rice in DSR of South Asian countries.

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Jhonson et al (1995) stated that shallow tillage on stale seedbed s can reduce weed populations prior to planting and increase peanut yields.

Bhuiyan *et al*. (1995) reported that certain constraints associated with transplanted rice like water and labour shortage, deterioration of

2.7 Effect of no weeding

Khan and Tarique (2011) observed that the effects of weeding regimes were significant in respect of yield and most of the characters. The longest panicle and heavier 1000 grain weight were observed in completely weed free condition throughout the crop growth period. On the other hand, values that appeared next to the highest were found in two hand weeding treatment. However, panicle length and heavier 1000 grain weight were lowest in no weeding treatment.

Hassan *et al.* (2010) recorded the highest value of 1000 grain weight from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

Gogoi *et al.* (2000) from Assam reported that different weed control practices significantly reduced the dry matter accumulation of weed and increased the rice yield over the unweeded control in transplanted rice.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest grain yield was observed in the unweeded control in the scented rice variety Pusa Basmati-1.

Singh *et al.* (1999) studied the effect of various weed management practices on the weed growth and yield and nitrogen uptake in transplanted rice and weeds and reported that weedy control until maturity removed significantly higher amount of nitrogen through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT.

Sanjoy *et al.* (1999) observed that control of weeds played a key role in improving the yield of rice because of panicle m^{-2}increased 18% due to weed control over its lower level, number of filled grains $panicle^{-1}$increased 32% due to weed control over its lower level and significant yield increase was observed (43%) with weed control.

Thomas *et al.* (1997) reported that rice weed competition for moisture was heavy during initial stages and yield losses from uncontrolled weeds might be as high as 74%.

Kamalam and Bridgit (1993) reported that the average reduction in grain yield due to weed competition it was 56 percent .

Sing et al (2008) reported both weed density and dry weight were negatively correlated with rice grain yield.

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to
conduct the experiment during the period from August to December 2013. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings:

3.1 Experimental site

The study was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.2 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris*et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.3 Treatment of the experiment

There were two factors in the experiment as follows:

Factor-A: Two varieties of Rice (main factor)

V_1= BRRI dhan56
V_2= BRRI dhan57

Factor-B: Six weeding methods (sub factor)

T_1= Rifit 50EC
T_2= polythene paper
T_3= stale bed
T_4= one hand weeding (at 30 DAT)
T_5 = two hand weeding (at 30 DAT and 60 DAT)
T_6 = Control (no weeding)

3.4 Planting material

The rice varieties collected from Bangladesh Rice Research Institute (BRRI) BRRI dhan56 and BRRI dhan57 were used as planting materials.

3.5 Design of the experiment

The two factorial experiments were laid out in a Split plot Design with three replications.

3.6 Management of the Crop

The crop in each treatment was raised under same level of management practices. The management practices followed in this experiment are described below:

3.6.1 Collection of seeds

The seeds of BRRI dhan56 and BRRI dhan57 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur , Gazipur.

3.6.2 Seed sprouting

The collected seeds were healthy. The seeds were immersed in a bucket filled with water for 24 hours. Then the seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.6.3 Preparation of seedling nursery and sowing of seeds

For raising rice seedlings a piece of high land was selected at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka. The land was puddled with mouldboard plough and levelled with ladder. Then the sprouted seeds were sown in the nursery beds on 17 July 2013. Weeds were removed and irrigation was given in the seedling nursery as and when necessary.

3.6.4 Preparation of experimental land

Tillage was given in the experimental land with a power tiller. Then the land was puddled thoroughly by repeated ploughing and cross ploughing with a moldboard plough and subsequently leveled by laddering. Immediately after final land preparation the layout of experimental plot was made on 12 August 2013 according to experimental design. Weeds and stubbles were cleared off from individual plots and finally were levelled so properly by wooden plank that no water remained in the puddle field.

3.6.5 Fertilizer application

A fertilizer dose of 100-70-60-5 kg ha^{-1} of triple superphosphate, muriate of potash, gypsum and zinc sulphate, respectively were applied at the time of final land preparation. Granular urea was applied as a source of nitrogen .

3.6.6 Uprooting of seedlings

The seedlings were uprooted without causing any mechanical injury to the roots. Then the uprooted seedlings were transplanted in the main field.

3.6.7 Transplanting of seedlings

The seedlings were transplanted on 23 August 2013. Two to three seedlings were transplanted in each hill maintaining the spacings of 25 cm x 20 cm.

3.7 Intercultural operations

3.7.1 Gap filling

Seedling in some hills died off and these were replaced by gap filling after one week of transplanting with seedlings from the same source.

3.7.2 Collection of weeds

Two weed collection were done in order to keep the crop weed free at 20 and 40 days after transplanting.

3.7.3 Water management

Water was supplied at 5-7 cm depth to all the plots throughout the growing period to fulfill the water requirement of the rice plant.

3.7.4 Crop protection measures

No major disease incidence was observed. But, the crop was mildly attacked by green leaf hopper, brown plant hopper and stem borer at the vegetative growth stage. Diazinon (60 EC) was applied at the rate of 1.5 litre per hectare to control the insect pests.

3.8 Harvesting and processing

Five hills were selected randomly from each plot prior to harvesting. The plants were uprooted carefully for data collection. The crop of each experimental plot was harvested separately at full maturity on 14 December 2013. From the central 1 m^2 area of each plot, the crop plants were harvested for collecting data on grain and straw yields. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The bundles were dried in sunshine, threshed and then grains were cleaned. After proper sun drying, the grain and straw weights taken plot wise.

3.9 Collection of data at harvest

Experimental data on yield and yield contributing characters were recorded on the following parameters

3.9.1 Plant height (cm)

Plant height was measured from the base of the plants to the tip of the panicle.

3.9.2 Total tillers hill^{-1}

Five hills plot^{-1} were selected and numbers of tillers were counted.

3.9.3 Effective tillers hill^{-1}

At least one grain containing panicles were considered as number of bearing tillers.

3.9.4 Non-effective tillers hill^{-1}

The panicles that contain no grain or the tiller without panicle were considered as number of non-bearing tillers.

3.9.5 Panicle length (cm)

Length of panicle was measured from the first node to the tip of the panicles and then the averages were expressed in cm.

3.9.6 Total grains panicle^{-1}

From each samples five panicles were randomly selected. Then total grains were counted and averages of 5 samples were taken.

3.9.7 Number of unfilled grains panicle^{-1}

Spikelets having partial food material inside were considered as unfilled grains and the numbers of such spikelets present on each panicle were counted.

3.9.8 Number of filled grains panicle^{-1}

Spikelets having food material inside were considered as filled grains and the numbers of such spikelets present on each panicle were counted.

3.9.9 Weight of 1000-grain (g)

Thousand grains were randomly selected from each plot and then it was dried in an oven. Weight was taken in an electric balance.

3.9.10 Grain yield (t ha^{-1})

Grains obtained from the central 1 m^2 area of each plot were sun dried and weighed. Then dry weight of grains of each plot was converted to grain yield ton hectare^{-1}.

3.9.11 Straw yield (t ha^{-1})

Straw yield obtained from the central 1 m^2 area of each plot was sun dried and weighed separately. Then the weight was converted to straw yield ton hectare^{-1}.

3.9.12 Biological yield (t ha^{-1})

Grain yield and straw yield were altogether considered as biological yield.Biological yield was calculated with the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + straw yield (t ha^{-1})

3.9.13 Harvest index (%)

The ratio of grain yield to biological yield and was calculated with the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.10 Collection of weed data

3.10.1 Weed density

The data on weed infestation as well as density were collected from each unit plot at 15 days interval up to 75 DAT. A plant quadrate of 1.0 m^2 was placed at three different spots of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

3.10.2 Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then 42 kept in an electrical oven for 72 hours maintaining a constant temperature of 800C. After drying, weight of each species was taken and expressed to g m^{-2}.

3.10.3 Weed control efficiency

Weed control efficiency was calculated with the following formula developed by Sawant and Jadav (1985):

$$\text{Weed control efficiency (WCE)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

3.10.4 Relative weed density (%)

Relative weed density was calculated by using the following formula:

$$\text{RWD} = \frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100$$

3.11 Statistical analysis

All the collected data were analyzed by following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a computer operated programme named MSTAT-C.

RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from the study.

4.1 Infested weed species in the experiment field:

The experimental rice field was infested by a total of eighteen weed species and the types of weeds were grass, sedge, aquatic, broadleaf and fern (Table 1). The total eighteen weed species were comprised of six grass, five sedge, three aquatic, three broadleaf, one fern type weeds. The most important weed species were *Cyperus michelianus*, *Cyperus esculentus*, *Alternanthera sessilis*, *Eleusine indica*, *Echinochloa crussgalli and Echinochloa colonum.* Similar kind of weed species in the transplanted aman rice field were also reported by Bhuiyan *et al.* (2010), Reza *et al.* (2010), Salam *et al.* (2010), Venkataraman and Goplan (1995)

Table 1. Weed species found in the experimental plots of *T. aman* rice

SL No.	Local name	Common name	Scientific name	Family	Types
1	Durba	Bermuda grass	*Cynodon dactylon*	Gramineae	Grass
2	Chanci	Sessile joy weed	*Alternanthera sessilis*	Amaranthaceae	Aquatic
3	Malancha	Alligatorweed	*Alternanthera philoxeroides*	Amaranthaceae	Aquatic
4	Boro Shama	Barnyard Grass	*Echinochloa crussgalli*	Gramineae	Grass
5	Chandmala	Duck weed	*Sagittaria guyanensis*	Alismataceae	Aquatic
6	Sushni	European water clover	*Marsilea quadrifolia*	Marsileaceae	Fern
7	Nakful	Nutsedge	*Cyperus michelianus*	Cyperaceae	Sedge
8	Joyna	Fringerush	*Fimbristylis miliaceae*	Cyperaceae	Sedge
9	Mutha	Nutgrass	*Cyperus rotundus*	Cyperaceae	Sedge
10	Jhilmorich	Gooseweed	*Sphenoclea zeylanica*	Sphenocleaceae	Broadleaf
11	Panilong	Willow primrose	*Ludwigia octovalvis*	Onagraceae	Broadleaf
12	Arail	Rice grass	*Leersia hexandra*	Gramineae	Grass
13	Behua	Small flower umbrella	*Cyperus difformis*	Cyperaceae	Sedge
14	Holde mutha	Yellow nutsedge	*Cyperus esculentus*	Cyperaceae	Sedge
15	Keshuti	Eclipta	*Eclipta alba*	Asteraceae	Broadleaf
16	Moyurleja	Red sprangletop	*Leptochloa panicea*	Gramineae	Grass
17	Chapra	Indian goosegrass	*Eleusine indica*	Gramineae	Grass

4.2 Relative weed density:

Among the total 18 weed species found in the relative weed density was highest in sedge type of weeds. At 30 DAT, the sedge type weed *Cyperus michelianus* recorded the highest (36.73%) relative weed density and *Cyperus esculentus* recorded the second highest (17.31%). At 60 DAT, *Cyperus esculentus* recorded the highest (25.13%) relative weed density. Aquatic weed *Alternanthera sessilis* recorded the second highest (21.53%) and *Cyperus difformis,* a sedge type weed, recorded third highest (15.79%) At 90 DAT, *Fimbristylis miliaceae,* a sedge type weed, recorded the highest (19.50%) relative weed density and *Cyperus esculentus* recorded the second highest (15.32%) relative weed density.

Table 2.Relative weed density (%) of different weed species infested the experimental area

SL No.	Scientific name	Types	30 DAT	60 DAT	90 DAT
1	*Cynodon dactylon*	Grass	1.84	0.43	0.70
2	*Alternanthera sessilis*	Aquatic	5.25	21.54	3.06
3	*Alternanthera philoxeroides*	Aquatic	0.47	0.57	0.84
4	*Echinochloa crussgalli*	Grass	4.20	6.46	12.53
5	*Sagittaria guyanensis*	Aquatic	2.36	0.79	0.70
6	*Marsilea quadrifolia*	Fern	4.20	0.43	0.84
7	*Cyperus michelianus*	Sedge	36.73	1.58	0.70
8	*Fimbristylis miliaceae*	Sedge	1.31	8.61	19.50
9	*Cyperus rotundus*	Sedge	6.82	0.57	1.11
10	*Sphenoclea zeylanica*	Broadleaf	2.20	2.15	0.70
11	*Ludwigia octovalvis*	Broadleaf	3.67	3.59	9.19
12	*Leersia hexandra*	Grass	0.79	0.36	0.84
13	*Cyperus difformis*	Sedge	4.72	15.79	3.06
14	*Cyperus esculentus*	Sedge	17.31	25.13	15.32
15	*Eclipta alba*	Broadleaf	4.72	0.36	0.84
16	*Leptochloa panicea*	Grass	0.10	3.59	9.75
17	*Eleusine indica*	Grass	2.31	4.74	12.26
18	*Echinochloa colonum*	Grass	0.31	2.73	6.13

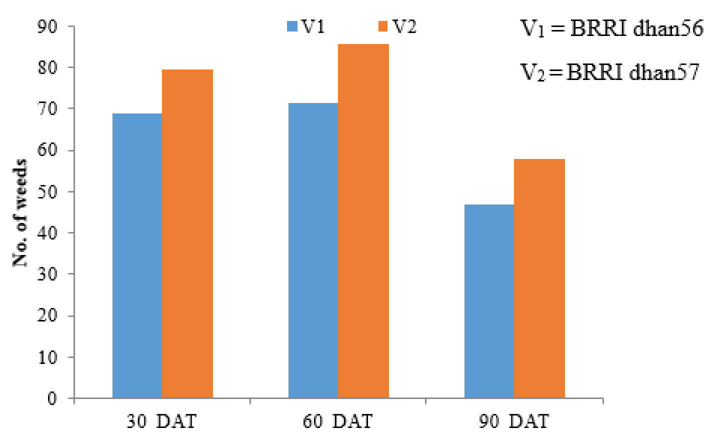
4.3 Total no. of weed

4.3.1 Effect of variety:

The total number of weeds varied significantly due to varietal treatments (Figure 1). It was observed that the total number of weeds were higher in V_2 at 30, 60 and 90 DAT. However, the total number of weeds were lower in V_1 at 30, 60 and 90 DAT.

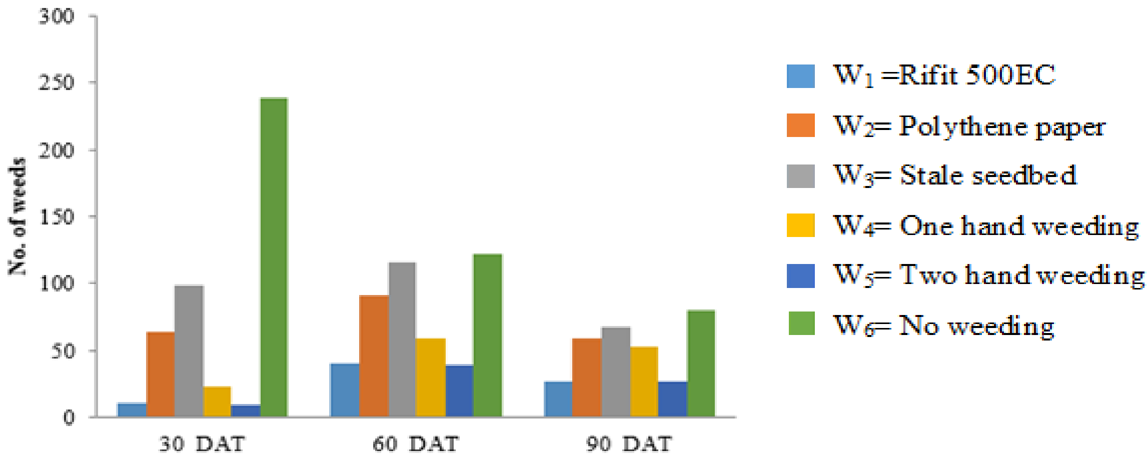
4.3.2 Effect of weed control methods:

The total number of weeds varied significantly due to various weed control treatments (Figure 2). It was observed that the control (W_6) plots showed highest number of weeds at 30, 60 and 90 DAT. At 30 DAT, the highest number of weeds (239.40) were recorded in W_6 and the lowest number of weeds (10.06) which were statistically similar with W_1 and W_4. At 60 DAT, W_6 recorded the highest number of weeds was statistically similar with W_3; However, W5 recorded the lowest (39.48) number of weeds which was statistically similar with W_1. At 90 DAT, W6 recorded the highest and W_5 recorded the lowest (26.55) number of weeds which was statistically similar with W_1. Total number of weeds was higher in unweeded treatments and the lowest in weed population was recorded in hand weeding treatments. Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).



Days after transplanting

Figure 1. Effect of variety on the number of weeds in *T. aman* rice field (SE = 2.12, 1.50, 1.25 at 30, 60 and 90 DAT respectively)



Days after transplanting

Figure 2. Effect of weed control on the number of weeds in *T. aman* rice field (SE = 10.49, 2.97 and 2.59 at 30, 60 and 90 DAT respectively)

4.3.3 Interaction effect of variety and weed control methods:

The interaction effect of variety and weed control treatments had significant effect on the total number of weeds in *T. aman* rice field (Table 3). At 30 DAT, it was observed that the treatment combination of V_2W_6 resulted with the highest total number of weeds (251.10) which was statistically similar with V_1W_6. However, the combination of V_1W_5 showed the lowest (8.67) total number of weeds which was statistically similar with V_1W_1, V_1W_2, V_1W_4, V_2W_1, V_2W_4 and V_2W_5. At 60 DAT, the V_2W_6 again appeared with the highest (135.30) total number of weeds. But, the combination of V_1W_5 was recorded with the lowest (30.96) number of weeds which was statistically similar with V_1W_1. At 90 DAT, V_2W_6 again recorded the highest (85.00) total number of weeds and V_1W_5 wasrecorded the denoted with the lowest (20.78) number of weeds which was statistically similar with V_1W_1.

Table 3. Interaction effect of variety and weed control methods on the number of weeds in *T. aman* rice field

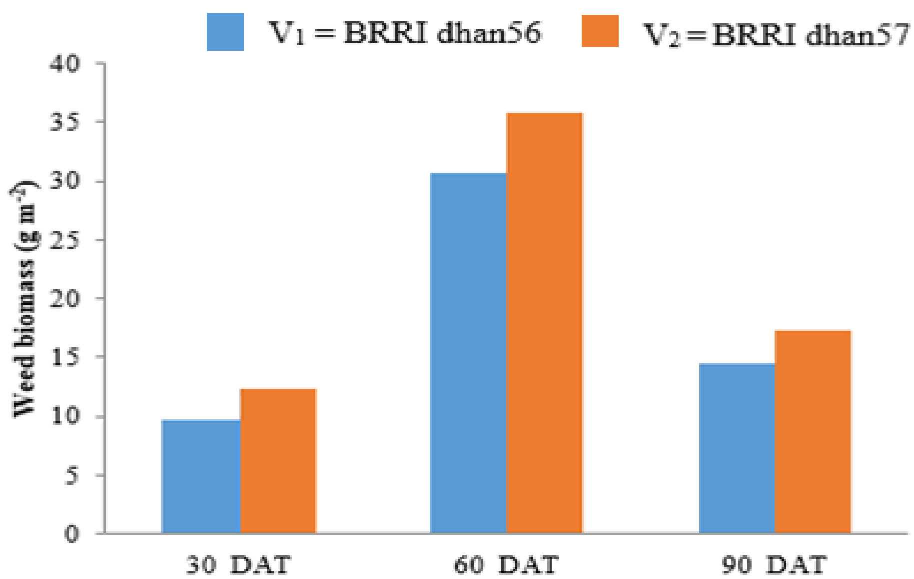
Treatments	Total no of weeds		
	30 DAT	60 DAT	90 DAT
V_1W_1	9.000 e	33.00 f	21.78 fg
V_1W_2	57.89 c-e	86.78 c	56.67 d
V_1W_3	88.31 bc	113.0 b	64.00 b-d
V_1W_4	21.66 e	54.00 de	43.66 e
V_1W_5	8.67 e	30.96 f	20.78 g
V_1W_6	227.8 a	110.6 b	74.33 ab
V_2W_1	11.67 e	48.66 e	33.00 ef
V_2W_2	69.89 b-d	97.00 c	62.00 cd
V_2W_3	108.7 b	120.3 b	72.33 bc
V_2W_4	25.00 de	65.00 d	62.00 cd
V_2W_5	11.44 e	48.00 e	32.33 ef
V_2W_6	251.1 a	135.3 a	85.00 a
SE	14.84	4.21	3.68
CV%	34.52	9.27	12.17

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.4Weed biomass (g m^{-2}):

4.4.1 Effect of variety:

Varietal treatments had significant influence on the weed biomass of transplanted aman rice field (Figure 3). It was observed that at 30 DAT, V_2 recorded the highest (12.29 g m^{-2}) weed biomass and V_1 recorded the lowest (9.65 g m^{-2}) weed biomass. At 60 DAT, V_2 recorded the highest (35.77 g m^{-2}) weed biomass and V_1 recorded the lowest (30.77 g m^{-2}) weed biomass. At 90 DAT, V_2 again recorded the highest (17.24 g m^{-2}) weed biomass and V_1 recorded the lowest (14.57 g m^{-2}) weed biomass.



Days after transplanting

Figure 3. Influence of variety on the weed biomass on *T. aman* rice field (SE= 0.55, 0.96 and 0.54 at 30, 60 and 90 DAT respectively)

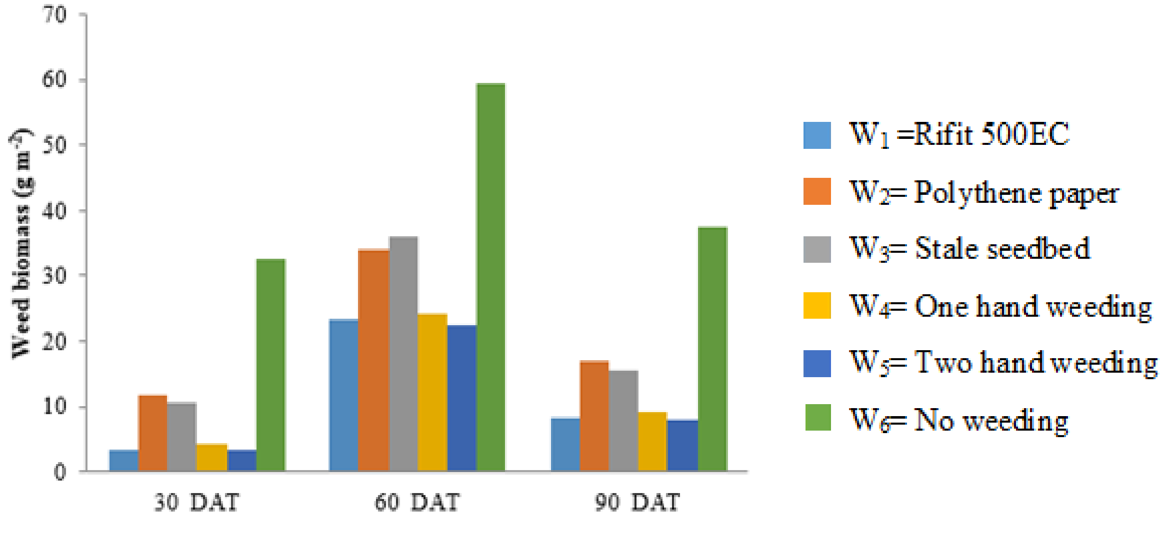


Figure 4. Effect of weed control on the weed biomass in *T. aman* rice field (SE=0.47, 2.64 and 0.48 at 30, 60 and 90 DAT respectively)

4.4.2 Effect of weed control methods:

Weed control treatments had significant influence on the weed biomass (Figure 4). At 30 DAT, W_6 showed the highest (32.40 g m^{-2}) weed biomass and W_5 recorded the lowest (3.33 g m^{-2}) weed biomass which was statistically similar with W_1 and W_4. At 60 DAT, W_6 appeared with the highest weed biomass (59.50 g m^{-2}) and the lowest (22.33 g m^{-2}) weed biomass was recorded from W_5 which was statistically similar with W_1 and W_4. At 90 DAT, the highest (37.50 g m^{-2}) weed biomass and the lowest (7.94 g m^{-2}) weed biomass in W_6 and W_5 respectively which was again statistically similar with W_1 and W_4. Islam *et al.* (2001) and Singh and Kumar (1999) also reported similar results.

4.4.3 Interaction effect of variety and weed control methods:

The treatment combination of variety and weed control methods had significant effect on the weed biomass of the experiential field (Table 4). At 30 DAT, the combination of V_2W_6 showed the highest (33.00 g m^{-2}) weed biomass which was statistically similar with V_1W_6 and the lowest (2.15 g m^{-2}) weed biomass was recorded in V_1W_5 which was statistically similar with V_1W_1. At 60 DAT, V_2W_6 produced the highest (63.89 g m^{-2}) weed biomass which was statistically similar with V_1W_6 and the lowest (20.44) weed biomass was recorded from V_1W_5 which was statistically similar with V_1W_1, V_1W_2, V_1W_3, V_1W_4, V_1W_5, V_2W_1, V_2W_4 and V_2W_5. At 90 DAT, the highest (38.00 g m^{-2}) weed biomass was recorded from V2W6 which was statistically similar with V_1W_6 and the lowest (6.67 g m^{-2}) weed biomass was recorded from V_1W_5 which was statistically similar with V_1W_1 and V_1W_4.

Table 4. Interaction effect of variety and weed control on the weed biomass in *T. aman* rice field

Treatments	Weed biomass (g m^{-2})		
	30 DAT	**60 DAT**	**90 DAT**
V_1W_1	2.217 f	21.88 d	7.217 fg
V_1W_2	10.89 c	32.22 b-d	15.89 c
V_1W_3	7.330 d	31.65 b-d	12.33 d
V_1W_4	3.330 ef	23.33 d	8.330 e-g
V_1W_5	2.147 f	20.44 d	6.67 g
V_1W_6	32.00 a	55.11 a	37.00 a
V_2W_1	4.553 e	24.55 cd	9.553 e
V_2W_2	12.78 bc	35.89 bc	17.78 bc
V_2W_3	13.66 b	40.66 b	18.66 b
V_2W_4	5.260 e	25.26 cd	10.26 e
V_2W_5	4.513 e	24.22 cd	9.220 ef
V_2W_6	33.00 a	63.89 a	38.00 a
SE	0.67	3.74	0.69
CV%	10.59	19.50	7.52

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.5 Weed control efficiency:

4.5.1 Effect of variety:

The weed control efficiency varied significantly due to varietal treatments (Figure 5). It was observed that the weed control efficiency was highest in V_1 than V_2 at 30, 60 and 90 DAT.

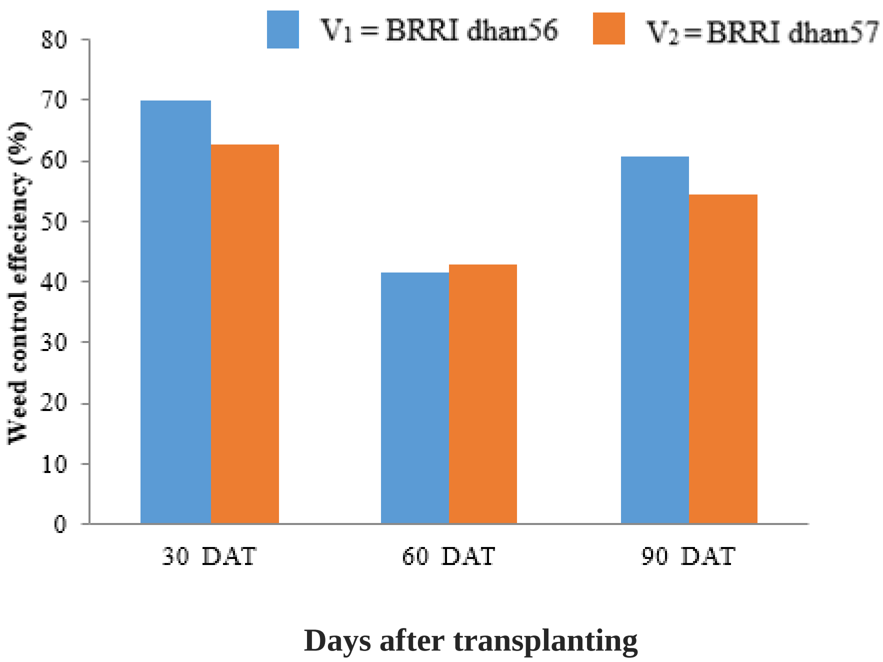
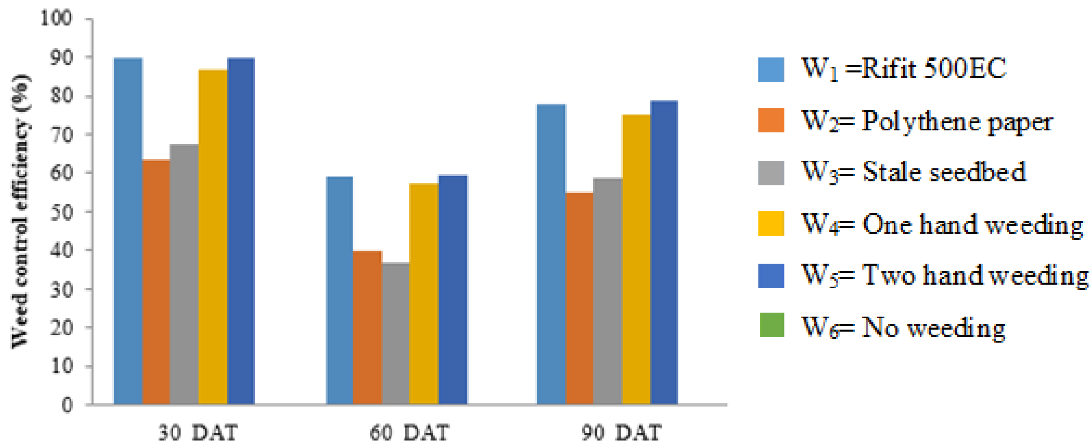


Figure 5. Effect of variety on the weed control efficiency on *T. aman* rice field (SE = 1.78, 3.30 and 1.50 at 30, 60 and 90 DAT respectively)

4.5.2 Effect of weed control methods:

Weed control efficiency varied significantly due to various weed control treatments (Figure 6). At 30 DAT, the highest (89.80%) weed control efficiency was recorded from W_5 which was statistically similar with W_1 and W_4. However the lowest (63.63%) was recorded from W_2. At 60 DAT, W_5 recorded the highest (59.74%) weed control efficiency which was statistically similar with W_1 and W_4; and the lowest (36.63%) was recorded from W_3 which was statistically similar with W_2. At 90 DAT, W_5 again recorded the highest (78.85%) weed control efficiency which was statistically similar with W_1 and W_4 and the lowest (55.13%) was recorded from W_2. Two hand weeding treatment (W_5) produced highest weed control efficiency among the weed control treatments as hand weeding is an efficient method of weed control. Bhowmick (2002), Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that two hand weeding weed control performed better than herbicidal treatments.



Days after transplanting

Figure 6.Effect of weed control methods on the weed control efficiency on *T. aman* rice field (SE= 1.33, 2.73 and 1.20 at 30, 60 and 90 DAT respectively)

4.5.3 Interaction effect of variety and weed control methods:

Weed control efficiency varied significantly due to various treatment combinations of variety and weed control methods (Table 5). At 30 DAT, the highest (93.35%) weed control efficiency was recorded from V_1W_5 which was statistically similar with V_1W_1 and V_1W_4. At 60 DAT, the highest (60.77%) weed control efficiency was recorded from V_2W_5 which was statistically similar with V_1W_1, V_1W_4, V_1W_5, V_2W_1 and V_2W_4. At 90 DAT, the highest (82.02%) weed control efficiency was recorded from V_1W_5 which was statistically similar with V_1W_1 and V_1W_4.

Table 5. Interaction effect of variety and weed control on the weed control efficiency in *T. aman* rice field

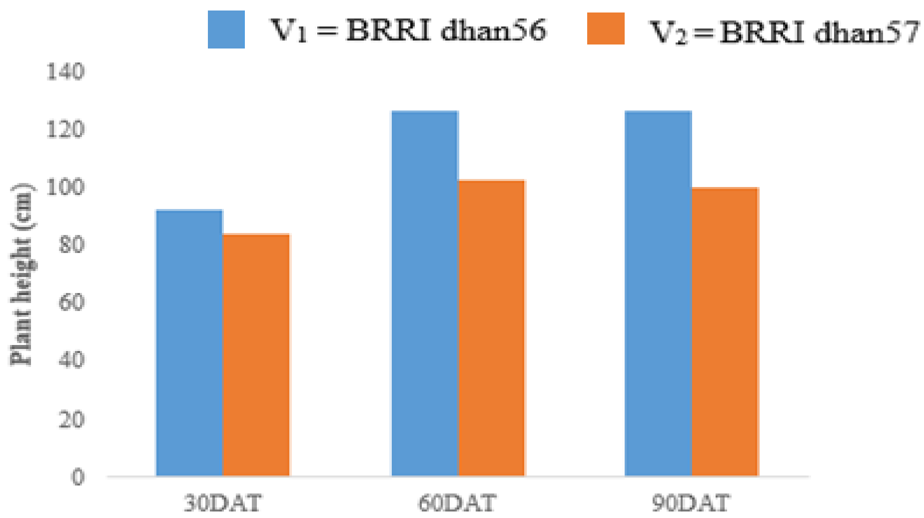
Treatments	Weed Control Efficiency (%)		
	30 DAT	**60 DAT**	**90 DAT**
V_1W_1	93.13 a	57.62 a	80.53 ab
V_1W_2	66.04 d	38.50 b	57.10 e
V_1W_3	76.98 c	38.90 b	66.59 d
V_1W_4	89.55 ab	54.92 a	77.45 a-c
V_1W_5	93.35 a	58.71 a	82.02 a
V_1W_6	0 f	0 c	0 g
V_2W_1	86.13 b	60.63 a	74.80 c
V_2W_2	61.22 de	41.63 b	53.17 ef
V_2W_3	58.51 e	34.36 b	50.81 f
V_2W_4	83.99 b	59.30 a	72.94 c
V_2W_5	86.25 b	60.77 a	75.68 bc
V_2W_6	0 f	0 c	0 g
SE	1.89	3.87	1.70
CV%	4.94	15.90	5.11

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.6 Plant height

4.6.1 Effect of Variety:

The plant height of the crop was significantly varied due to varietal treatments (Figure 7). At 30 DAT, the highest plant height was observed in V_1(92.28 cm) and the lowest plantheight was observed in V_2 (84.23 cm). At 60 DAT, the highest plant height was observed in V_1 (126.59 cm) and the lowest plant height was observed in V2 (102.80 cm). At 90 DAT, the highest plant height was observed in V1 (126.22 cm) and the lowest plant height was observed in V_2 (99.77 cm). Plant height varies between varieties as this is a genetical character and several other scientists had reported in their earlier works (Bisne *et al.*,2006 and Om *et al.,* 1998).

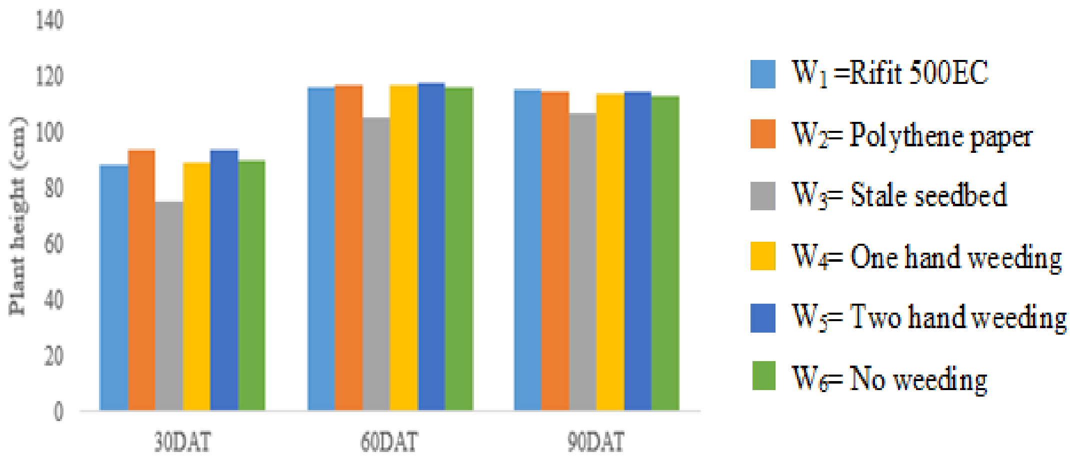


Days after transplanting

Figure 7. Effect of variety on the plant height of *T. aman* rice at 30, 60 and 90 DAT (SE= 1.33, 0.65 and 1.50 at 30, 60 and 90 DAT respectively)

4.6.2 Effect of weed control methods :

The plant height was also significantly influenced by different weed control methods during the periods from 30 DAT to 90 DAT (Figure 8). It was observed that W_5 treatment produced the tallest plant in all dates of sampling and attained to its highest value (117.6 cm) at 60 DAT. The lowest plant height was observed at every sampling period in stale bed treatment (W_3). Weed free conditions give plants better opportunity to obtain necessary nutrients, use light and space to grow. Similar kinds of results were also reported by Khan and Tarique (2011) and Hassan *et al.* (2010).



Days after transplanting

Figure 8. Effect of weed control treatments on the plant height of *T. aman* rice at 30, 60 and 90 DAT (SE = 2.43, 2.13 and 1.37 at 30, 60 and 90 DAT respectively)

4.6.3 Interaction effect of variety and weed control:

The interaction between weed control treatment and variety had significant Influence on plant height (Table 6). Weed control treatments showed significant difference in plant height. At 30 DAT, the highest plant height was observed in V_1W_2 (99.33 cm) which was significantly similar to V_1W_1, V_1W_4, V_1W_5, V_1W_6, V_2W_2, and V2W5.

Table 6: Interaction effect of variety and weed control treatments on plant height (cm) of *T. aman* rice

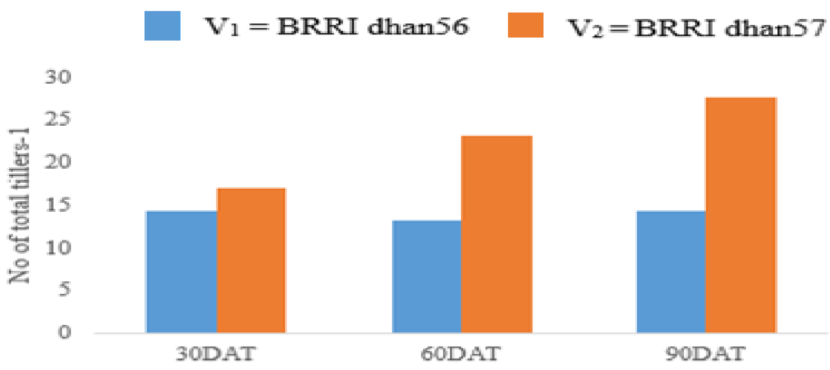
Treatments	Plant Height (cm)		
	30DAT	60DAT	90DAT
V_1W_1	92.13 a-c	129.3 ab	129.1a
V_1W_2	99.33 a	126.1 ab	127.7ab
V_1W_3	79.80 de	119.5 b	122.1b
V_1W_4	92.33 a-c	128.0 ab	123.7ab
V_1W_5	93.60 a-c	126.9 ab	129.1a
V_1W_6	96.47 ab	129.8 a	125.5ab
V_2W_1	84.73 cd	102.6 c	101.5 c
V_2W_2	88.67a-d	107.3 c	101.3 c
V_2W_3	70.40 e	91.07 d	90.67d
V_2W_4	85.33 b-d	105.2 c	104.3 c
V_2W_5	93.27 a-c	108.3 c	100.4 c
V_2W_6	83.00 cd	102.3 c	100.5 c
SE	3.44	3.02	1.94
CV%	6.75	4.56	2.97

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.7 No. of tillers hill^{-1}

4.7.1 Effect of Variety:

The number of tillers hill^{-1} was significantly influenced by the varietal treatment (Figure 9). At 30 DAT, the no. of tillers hill^{-1} was same. At 60 DAT, the highest no. of tillers hill^{-1} was observed in V2 (23.06) and the lowest no. of tillers hill^{-1} was observed in V_2 (13.22). At 90 DAT, the highest no. of tillers hill^{-1} was observed in V_2 (27.61) and the lowest no. of tillers hill^{-1} was observed in V_1 (14.28). Bisne *et al.* (2006) and Jones *et al.* (1996) also found similar results.

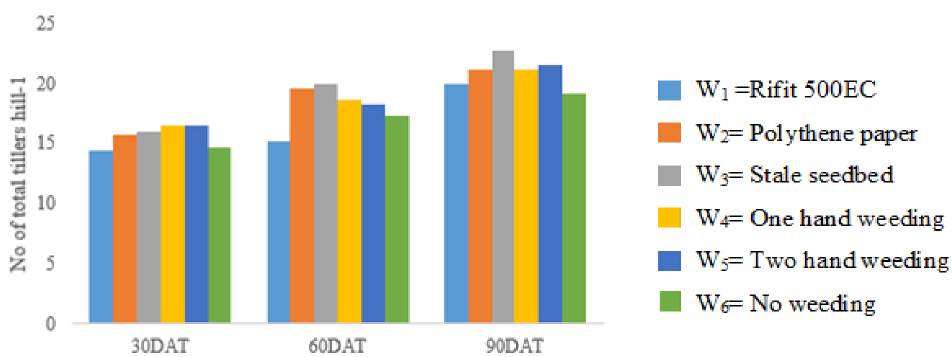


Days after transplanting

Figure 9. Effect of variety on the no of tillers hill^{-1} of *T. aman* rice at 30, 60 and 90 DAT

4.7.2 Effect of weed control methods :

Total number of tillers hill^{-1} was significantly affected by different weed control treatments (Figure 10). Among the different weed managements, the highest number of total tillers hill^{-1} (22.50) was observed by W_3 (stale bed).The W_6 (unweeded) treatment gave the lowest number of total tillers hill^{-1} (19.33). Unweeded treatment failed to produce more tillers due to severe weed infestation in the experimental plots. Khan and Tarique (2011) and Ashraf *et al.* (2006) also reported significant influence of weed control treatments on the number of tillers of rice.



Days after transplanting

Figure 10. Effect of variety on the no of tillers hill^{-1} of *T. aman* rice at 30, 60 and 90 DAT (SE = 1.49, 1.36 and 0.96 at 30, 60 and 90 DAT respectively)

4.7.3 Interaction effect of variety and weed control:

The interaction of variety and weed control had a significant Influence on no. of tiller hill^{-1} (Table 7). At 30 DAT, the highest no. of tillers hill^{-1}was observed in V_2W_2 (19.00) and which was statistically significant to all other treatment combinations and the lowest no. tillers hill^{-1}was observed in V_1W_2 (12.33). At 60 DAT, the highest no. of tillers hill^{-1} was observed in V_2W_2 (26.00) which was statistically similar to V_2W_3, V_2W_4, V_2W_5 and V_2W_6 and the lowest no. of tillers hill^{-1} was observed in V_1W_1 (11.67) which was statistically similar to other treatment combinations V_1W_2, V_1W_4,V_1W_5 and V_1W_6. At 90 DAT, the highest no. of tillers hill^{-1} was observed in V_2W_2 (28.33) which was statistically similar to other treatment combinations and the lowest no. of tillers hill^{-1}was observed in V_1W_6 (12.33) which was statistically significant to other treatment combinations.

Table 7. Interaction Influence of variety and weed control treatments on total tillers hill^{-1} of *T. aman* rice

Treatments	**No of tiller hill^{-1}**		
	30DAT	**60DAT**	**90DAT**
V_1W_1	13.67	11.67d	13.67b
V_1W_2	12.33	13.00 cd	14.00b
V_1W_3	15.00	16.00 bc	17.00b
V_1W_4	14.00	13.00 cd	14.00b
V_1W_5	15.67	13.33 cd	14.67b
V_1W_6	14.67	12.33 cd	12.33b
V_2W_1	15.00	18.67b	26.33a
V_2W_2	19.00	26.00a	28.33a
V_2W_3	17.00	24.00a	28.33a
V_2W_4	19.00	24.33a	28.33a
V_2W_5	17.33	23.00a	28.33a
V_2W_6	14.67	22.33a	26.00a
SE	NS	1.22	1.47
CV%	23.47	11.64	12.16

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper,

W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

Yield contributing characters

4.8 Effective tillers $hill^{-1}$

4.8.1 Effect of Variety:

The no. of effective tillers $hill^{-1}$was significantly influenced by the varietal treatment (Table 7). The highest no. of Effective tiller $hill^{-1}$ was recorded in V_2 (25.06) and the lowest no. of effective tillers $hill^{-1}$ was recorded in V_1 (13.94). Jones *et al.* (1996) also found significant variation of effective tiller $hill^{-1}$ among different varieties.

4.8.2 Effect of weed control methods:

Weed control treatments caused no considerable variations in the number of effective tillers $hill^{-1}$(Table 7). However, numerically the highest (20.50) number of effective tillers $hill^{-1}$was obtained in W_3 (stale bed) treatment and W_1 (herbicides) treatment produced the lowest (18.50) number of effective tillers $hill^{-1}$. Effective tillers were higher in the weed free plots than the unweeded plots as weed negatively influence the growth of plant (Hassan *et al.*,2010)

4.8.3 Interaction effect of variety and weed control:

The interaction of variety and weed control had a significant Influence on no. effective tillers $hill^{-1}$ (Table 7). The highest no. of Effective tillers $hill^{-1}$ was recorded in V_2W_2 (26.33) which was statistically similar to other treatment combinations and the lowest no. of Effective tiller $hill^{-1}$ was recorded in V_1W_6 (12.67) which was statistically similar to other combinations.

4.9 No. non-effective tillers $hill^{-1}$

4.9.1 Effect of Variety:

The no. of non-effective tillers $hill^{-1}$ was significantly influenced by varietal treatment (Table 7). The highest no. of non-Effective tillers $hill^{-1}$ was observed in V_2 (2.50) and the lowest no. of non-Effective tiller was observed in V_1 (0.39).

4.9.2 Effect of weed control methods:

The number of non-effective tillers hill^{-1} was significantly influenced by weed control treatments (Table 7). Numerically the highest number of non-effective tillers (2.00) was obtained by the W_3 stale bed treatment which was statistically similar to W_2 (polythene paper) 1.33 and the lowest number of non-effective tillers (0.67) was obtained from the unweeded W_6 treatment.

4.9.3 Interaction **effect of variety and weed control methods:**

The interaction of variety and weed control had a significant on no. of non-Effective tillers hill^{-1} (Table 8). The highest no. of non-effective tillers hill^{-1} was observed in V_2W_3 (3.33) which was statistically similar to V_2W_1, V_2W_4 and V_2W_5. The lowest no. of non-effective tillers hill^{-1} was observed in V_1W_6 (0.00).

4.10 Panicle length

4.10.1 Effect of Variety:

The length of panicle was significantly influenced by the varietal treatment (Table 7). The highest panicle length was observed in V_1 (23.39 cm) and the lowest panicle length was observed in V_2 (22.86 cm). Wang *et al.* (2006) also found significant variation of panicle length in different rice varieties.

4.10.2 Effect of weed control methods :

Weed control treatments had significant influence on the panicle length of transplanted aman rice (Table 7). Panicle length was highest (24.18 cm) in W_1 treatment which was statistically similar to W_2, W_3, W_4 and W_5 and the panicle length was lowest (22.32 cm) in unweeded treatment W_6. Khan and Tarique (2011) also found longest panicle length in the weed free plots.

4.10.3 Interaction effect of variety and weed control methods :

The interaction of variety and weed control treatments had a significant on panicle length (Table 7). The highest panicle length was observed in V_1W_1 (24.19) which was statistically similar to other treatment combinations. The lowest panicle length was observed in V_2W_5 (21.64 cm) which was significantly to other treatment combinations.

4.11 Filled grains panicle^{-1}

4.11.1 Effect of variety:

The no. of filled grains panicle^{-1} was significantly influenced by the varietal treatment (Table 7). The highest no. of filled grains panicle^{-1} was observed in V_2 (121.33) and the lowest no. of filled grains panicle^{-1} was observed in V_1 (106.83). Guilani *et al.* (2003) also found significant variation of grain filling different among different varieties.

4.11.2 Effect of weed control methods :

The influence of different weed control treatments was not significant on the number of filled grains panicle^{-1} (Table 7). However, numerically the highest (124.0) number of filled grains panicle^{-1} was obtained from W_2 treatment and the lowest (106.3) number of grains panicle^{-1} was observed in the W_3 treatment. Ashraf *et al.* (2006) also found highest filled grains panicle^{-1} in the weed free treatments.

4.11.3 Interaction effect of variety and weed control methods :

The interaction of variety and weed control treatment had a significant Influence on filled grains panicle^{-1} (Table 7). The highest no. of filled grains panicle^{-1} was observed in V_2W_2 (136.3) which was statistically similar to other treatment combinations. The lowest no. of filled grains panicle^{-1} was observed in V_1W_3 (99.67) which was statistically similar to other treatment combinations.

4.12 Unfilled grain panicle^{-1}

4.12.1 Effect of variety:

The no. of unfilled grains panicle^{-1} was significantly influenced by the varietal treatment (Table 7). The highest no. of unfilled grains panicle^{-1}was observed in V_2 (33.06). The lowest no. unfilled grains panicle^{-1} was observed in V_1 (22.50).

4.12.2 Effect of weed control methods:

The influence of different weed control treatments was significant on the number of unfilled grains panicle^{-1} (Table 7). The highest number of unfilled grains panicle^{-1} (37.83) was obtained from W_4 treatment which was similar to W_1 and W_3 treatment. The lowest (18.83) number of unfilled grains panicle^{-1} was observed in the W_6 (unweeded) treatment which was statistically similar to W_3 and W_5 treatment. Weeds has significant influence on the grain filling of rice. Similar kind of results were also reported by Ashraf *et al.* (2006).

4.12.3 Interaction effect of variety and weed control methods:

The interaction of variety and weed control treatment had a significant Influence on no. of unfilled grains panicle^{-1}(Table 7). The highest no. of unfilled grains panicle^{-1} was observed in V_2W_1 (45.33) which was statistically similar to V_2W_4. The lowest no. of unfilled grains panicle^{-1} was observed in V_1W_5 (14.67) which was statistically significant to V_1W_1, V_1W_2, V_1W_6, V_2W_2 and V_2W_6.

4.13 Rachis panicle^{-1}

4.13.1 Effect of variety:

The no. of rachis panicle^{-1} was significantly affected by the varietal treatment (Table 7). The highest no. of rachis panicle^{-1} was observed in V_2 (10.72) and the lowest no. of rachis panicle^{-1} was observed in V_1 (10.33).

4.13.2 Effect of weed control methods :

The number of rachis panicle^{-1} of transplanted aman rice was significantly affected by the weed control treatments (Table 7). The highest (11.33) number of rachis panicle^{-1}was observed in W_3 which was statistically similar with W_2 and W_4. The lowest (10.17) number of rachis panicle^{-1} was observed in W_1 which was statistically identical with W_6.

4.13.3 Interaction effect of variety and weed control methods :

The interaction of variety and weed control treatments had a significant influence on no. of rachis panicle^{-1} (Table 7). The highest no. of rachis panicle^{-1} was observed in V_2W_2 (160.3) which was statistically significant to other treatment combinations. The lowest no. of rachis panicle^{-1} was observed in V_1W_5 (9.333) which was statistically similar to other treatment combinations.

4.14 Weight of 1000 grain

4.14.1 Effect of variety:

The weight of 1000 grain was significantly influenced by the varietal treatment (Table 7). The highest weight of 1000 grain was observed in V_1 (23.12 gm) and the lowest weight of 1000 grain was observed in V_2 (21.02). Hossain *et al.* (2007) also found similar kind of results.

4.14.2 Effect of weed control methods :

1000-grain weight was significantly influenced by weed control treatments (Table 7). The 1000-grain weight was highest (22.05 g) in W_1 treatment and lowest (22.13 g) in the W_3 treatment. 1000-grain weight is negatively related to weed density (Karim and Ferdous, 2010). Khan and Tarique (2011) and Nahar *et al.* (2010) also reported heavier grain weights of weed free plots.

4.14.3 Interaction effect of variety and weed control methods:

The interaction of variety and weed control treatments had a significant Influence on weight of 1000 grain (Table 7). The highest weight of 1000 grain was observed in V_1W_4 (23.47 gm) which was statistically similar to other treatment combinations. The lowest weight of 1000 grain was observed in V_2W_4 (20.70 gm) which was statistically similar to other treatment combinations.

Table 8. Effect of variety, weed control methods and their interaction on the panicle length, no of Effective tillers hill^{-1}, no of non-Effective tillers hill^{-1}, filled grains panicle^{-1}, rachis panicle^{-1} and 1000-grain weight of *T. aman* rice

Treatments	Panicle length (cm)	No of effective tillers hill^{-1}	No of non-effective tillers hill^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Rachis panicle^{-1}	1000-grain weight (g)
Influence of variety							
V_1	23.39 a	13.94 b	0.39 b	106.83 b	22.50 b	10.33 b	23.12 b
V_2	22.86 b	25.06 a	2.50 a	121.33 a	33.06 a	10.72 a	21.02 a
SE	0.39	0.71	0.26	1.24	0.28	0.26	0.09
CV%	7.18	15.40	75.55	4.58	4.36	10.37	1.65

Influence of weed control treatments							
W_1	24.18 a	18.50a	1.500a	113.2a	32.00a	10.17b	22.05a
W_2	23.82 ab	19.83a	1.333ab	124.0a	23.50bc	10.67ab	22.23a
W_3	22.61 ab	20.50a	2.000a	106.3a	30.33ab	11.33a	21.99a
W_4	23.09 ab	19.67a	1.500a	115.7a	37.83a	10.50ab	22.08a
W_5	22.73 ab	19.83a	1.667a	114.2a	24.17bc	10.33b	22.13a
W_6	22.32 b	18.67a	0.6667b	111.2a	18.83 c	10.17b	21.93a
SE	0.49	1.15	0.25	6.89	2.44	0.28	0.39
Influence of treatment combination							
V_1W_1	24.19 a	13.33b	0.33 de	114.7ab	18.67d	10.00b-d	23.30a
V_1W_2	23.65 ab	13.33b	0.67 de	111.7ab	23.00 cd	10.67a-d	23.13ab
V_1W_3	23.18 ab	16.33b	0.67 de	99.67b	30.33 c	11.67a	23.00a-c
V_1W_4	23.01 ab	13.67b	0.33 de	113.7 ab	33.67bc	10.67a-d	23.47a
V_1W_5	23.83 ab	14.33b	0.33 de	104.7 ab	14.67d	9.333d	23.37a
V_1W_6	22.46 ab	12.67b	0.0 e	96.67 b	14.67d	9.667 cd	22.43a-d
V_2W_1	24.18 a	23.67a	2.67 ab	111.7 ab	45.33a	10.33a-d	20.80d
V_2W_2	23.99 ab	26.33a	2.00 bc	136.3 a	24.00 cd	10.67a-d	21.32 cd
V_2W_3	22.05 ab	24.67a	3.33 a	113.0 ab	30.33 c	11.00a-c	20.97d
V_2W_4	23.16 ab	25.67a	2.67 ab	117.7 ab	42.00ab	10.33a-d	20.70d
V_2W_5	21.64 b	25.33a	3.00 ab	123.7 ab	33.67bc	11.33ab	20.90d
V_2W_6	22.17 ab	24.67a	1.33 cd	125.7 ab	23.00 cd	10.67a-d	21.43b-d
SE	0.69	1.62	0.36	9.74	3.45	0.40	0.55
CV%	5.17	14.40	42.55	14.79	21.53	6.57	4.34

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Chemical herbicide, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.15 Grain weight

4.15.1 Effect of variety:

The grain weight was significantly influenced by the varietal treatment (Table 9). The highest (3.14 t ha^{-1}) grain weight was observed in V_1 and the lowest (3.02 t ha^{-1}) grain weight was observed in V_2.

Table 9. Effect of variety and weed control treatments on the grain yield, straw yield, biological yield and harvest index of *T. aman* rice

Treatments	**Grain weight (t ha^{-1})**	**Straw weight (t ha^{-1})**	**Biological yield (t ha^{-1})**	**Harvest index (%)**
V1	3.14 a	5.76 b	8.90 b	35.08 a
V2	3.02 b	5.59 a	8.61 a	34.72 b
SE	0.21	0.06	0.27	1.30
CV%	29.13	12.40	13.06	15.75
W1	3.617a	6.315a	9.932a	36.29ab
W2	2.933b	5.643b	8.577b	34.31a-c
W3	2.877b	5.117 c	7.993bc	35.68a-c
W4	2.958b	5.720b	8.678b	33.63bc
W5	3.717a	6.247a	9.963a	37.29a
W6	2.385 c	5.005 c	7.390 c	32.19 c
SE	0.16	0.16	0.26	1.12
CV%	12.16	7.07	7.32	7.85

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.15.2 Effect of weed control methods:

Crop management practices are among the factors responsible to get higher yield of rice (Table 9). Proper weed management in transplanted aman rice field ensures higher yield. Grain yield was considerably affected by weed control treatments. The highest (3.72 t ha^{-1}) grain yield was obtained from W_5 treatment which was statistically similar with W_1. The lowest (2.39 t ha^{-1}) grain yield was obtained from W_6 treatment. Singh *et al*. (2004) reported that weed management is one of the major factors, which affect rice yield. Uncontrolled weeds cause grain yield reduction up to 76% under transplanted conditions. This happened due to severe weed infestation with various species of weeds and competition for moisture, space, air, light and nutrients between weeds and transplanted aman rice plants which had adverse Influence on all the yield components and finally on grain yield (Bhuiyan *et al.*, 2011, Khaliq *et al.*, 2011).

4.15.3 Interaction effect of variety and weed control methods:

The interaction of variety and weed control treatment had a significant Influence on grain yield of transplanted aman (Table 10). The highest grain weight was observed in V_1W_5 (3.70 t ha^{-1}) which was statistically similar with the treatment combinations of V_1W_1, V_1W_2, V_1W_3, V_1W_4, V_1W_5, V_2W_1, V_2W_2, V_2W_3, V_2W_4 and V_2W_5. The lowest grain weight was observed in V_1W_6 (2.40 t ha^{-1}) which was statistically similar to other treatment combinations. Ali *et al.* (2010), Hassan *et al.* (2010) and Islam *et al.* (2010) also found similar results.

4.16 Straw weight

4.16.1 Effect of variety:

The straw weight was significantly influenced by the varietal treatment (Table 9). The highest (5.76 t ha^{-1}) straw weight was observed in V_1 and the lowest (5.59 ta ha^{-1}) straw weight was observed in V_2.

4.16.2 Effect of weed control methods:

Straw weight of transplanted aman rice was significantly influenced by different weed control treatments (Table 9). The highest (6.32 t ha^{-1}) straw yield was obtained from the treatment W_1

which was statistically similar with the treatment W_5. Significantly the lowest (5.01 t ha^{-1}) straw yield was obtained from the unweeded treatment W6 which was statistically similar with W3. Straw yield increases with weed free conditions as weed free conditions increased plant growth. Similar kind of results were also reported by Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011), Bhuiyan *et al.* (2011), Khan and Tarique (2011) and Mamun *et al.* (2011),

4.16.3 Interaction effect of variety and weed control methods:

The interaction of variety and weed control treatments had a significant Influence on straw weight (Table 10). The highest (6.42 t ha^{-1}) straw weight was observed in V_1W_1 which was statistically similar with the treatment combinations of V_1W_1, V_1W_2, V_1W_4, V_2W_1, V_2W_4 and V_2W_5. The lowest straw weight was observed in V_2W_6 (4.94 t ha^{-1}) which was statistically similar to the treatment combinations of V_1W_3, V_1W_4, V_1W_6, V_2W_2 and V_2W_3. This result was in agreement with the findings of Khan and Tarique (2011) and Salam *et al.* (2010) who revealed that weeding had significant variation on straw yield of rice.

4.17 Biological yield

4.17.1 Effect of variety:

The biological yield was significantly influenced by the varietal treatments (Table 9). The highest (8.90 t ha^{-1}) biological yield was observed in V_1 and the lowest (8.61 t ha^{-1}) yield was observed in V_2.

4.17.2 Effect of weed control methods :

Biological yield was significantly influenced by different weed control treatments (Table 9). The highest (9.96 t ha^{-1}) biological yield was observed in the W_5 treatment which was statistically similar with the treatment W_5 which was statistically similar with W_1. However, the unweeded plot (W_6) produced the lowest (7.39 t ha^{-1}) biological yield which was statistically similar with W_3.

4.17.3 Interaction effect of variety and weed control methods :

The interaction of variety and weed control treatments had a significant Influence on biological yield (Table 10). The highest (10.09 t ha^{-1}) biological yield was observed in V_1W_5 which was statistically similar with V_1W_1, V_1W_2, V_2W_1 and V_2W_5 and the lowest (7.437 t ha^{-1}) biological yield was observed in V_1W_6 which was statistically similar with V_1W_3, V_1W_4, V_1W_6, V_2W_3 and V_2W_6.

4.18 Harvest index

4.18.1 Effect of variety:

The harvest index was significantly influenced by the varietal treatment (Table 9). The highest (35.08%) harvest index was observed in V_1 and the lowest (34.72%) harvest index was observed in V_2.

4.18.2 Effect of weed control methods:

Harvest index was significantly affected by the different weed control treatments (Table 9).The highest (37.29%) harvest index was observed in the W_5 treatment which was statistically similar to W_1, W_2 and W_3treatments. The lowest (32.19%) harvest index was observed in the treatment W_6 (unweeded) which was statistically similar with W_2, W_3 and W_4. Similar findings were observed by Manish *et al.* (2006) who stated that weeding had significant variation on harvest index.

4.18.3 Interaction effect of variety and weed control methods:

The interaction of variety and weed control treatments had a significant Influence on harvest index (Table 10). The highest (38.98%) harvest index was observed in V_1W_3 which was statistically similar to the treatment combinations of V_1W_1, V_1W_2, V_1W_5, V_2W_1, V_2W_2, V_2W_4, V_2W_5 and the lowest harvest index was observed in V_1W_6 (31.80%) which was statistically similar to the treatment combinations of V1W1, V_1W_2, V_1W_4, V_1W_5, V_2W_1, V_2W_2, V_2W_3 and V_2W_6

Table 10. Interaction effect of variety and weed control treatments on the grain yield, straw yield, biological yield and harvest index of transplanted aman rice

Treatments	Grain weight ($t\ ha^{-1}$)	Straw weight ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
V_1W_1	3.607ab	6.420a	10.03ab	35.89a-c
V_1W_2	3.053ab	5.943ab	8.997a-c	34.22a-c
V_1W_3	3.277ab	5.100 cd	8.377 cd	38.98a
V_1W_4	2.830ab	5.663a-d	8.493 cd	32.94bc
V_1W_5	3.70a	6.387a	10.09a	36.65a-c
V_1W_6	2.37b	5.067 cd	7.437d	31.80 c
V_2W_1	3.627ab	6.210a	9.837ab	36.70a-c
V_2W_2	2.813ab	5.343b-d	8.157 cd	34.41a-c
V_2W_3	2.477ab	5.133 cd	7.610d	32.38 c
V_2W_4	3.087ab	5.777a-c	8.863bc	34.32a-c
V_2W_5	3.733a	6.107a	9.840ab	37.92ab
V_2W_6	2.40b	4.943d	7.343d	32.59bc
SE	0.37	0.23	0.37	1.58
CV%	12.16	7.07	7.32	7.85

V_1= BRRIdhan-56, V_2= BRRIdhan-57, W_1= Rifit 500 EC, W_2= Polythene paper, W_3= Stale bed, W_4= One hand weeding, W_5= Two hand weeding, W_6= Control

4.19 Economic analysis of weed control methods

Economic analysis of the weed control parameters shows that, the benefit cost ration (BCR) of different weed control methods varies significantly (Table 11). The highest (1.92) BCR was recorded from the chemical herbicide Rifit 500EC (W_1) weed control. While the two hand weeding (W_5) recorded the second highest (1.79) ahead of stale seed bed (W3), one hand weeding (W_4), despite the fact the two hand weeding involves larger labour cost. This may be because two hand weeding reduces weed competition and increases the rice yield thus increases the net income. The lowest (1.36) BCR was recorded from no weeding (W_6).

Table 11: Total cost, net income and BCR of the weed control treatments

Treatments	Running capital (Tk)	Overhead cost (Tk)	Total Cost (Tk)	Net income (Tk)	BCR
W_1 (Rifit 500EC)	27,616	13438.92	1220	93,237.6	1.92
W_2 (Polythene Paper)	27,616	13438.92	5600	79,493.8	1.52
W_3 (Stale Seedbed)	27,616	13438.92	3300	83,959.32	1.69
W_4 (One hand weeding)	27,616	13438.92	3300	65,763.88	1.48
W_5 (Two hand weeding)	27,616	13438.92	6600	85,693.2	1.79
W_6 (No weeding)	27,616	13438.92	0	55,863.32	1.36

Summary and Conclusion

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August to December, 2013 in *aman* season with a view to find out the performance of two transplanted aman rice varieties under different weed control methods.

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 3.0 m x 2.0 m and total numbers of plots were 36. There were 12treatment combinations. Variety was placed along the main plot and weed control methods were placed along the sub plot.

The experiment was carried out with two transplanted aman rice varieties *i.e*. BRRI dhan56(V_1) and BRRI dhan57(V_2) and six weed control methods viz. herbicide Rifit 50 EC (W_1), polythene paper (W_2), stale seedbed (W_3), one hand weeding at 20 DAT (W_4), two hand weeding at 20 and 40 DAT (W_5) and no weeding (control) (W_6) in the sub plot in split plot design.

The data on weed parameters were collected from 30 DAT to 90 DAT. Weed parameters such as total weed population (no. m^{-2}); relative weed density (RWD %), weed biomass (g m^{-2}) and weed control efficiency (%) were examined. The data on growth parameters viz. plant height, total tillers $hill^{-1}$; were recorded during the period from 30 to 90 DAT. At harvest, characters like plant height, total tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, total grains $panicle^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panile^{-1}$, 1000 grain weight, grain yield, straw yield, biological yield and harvest index were recorded.

Eighteen different weed species infested the field among which *Cyperus michelianus* (36.73%), *Cyperus esculentus* (17.31%) at 30 DAT; *Cyperus esculentus* (25.13%) *Alternanthera sessilis* (21.53%) and *Cyperus difformis* (15.79%) at 60 DAT, *Fimbristylismiliaceae* (19.50%) at 90 DAT were dominant. Two hand weeding at 20 and 40 DAT (W_5) showed highest weed control efficiency 89.90% at 30 DAT, 59.74% at 60 DAT and 78.85% 90 DAT.

The results showed that BRRI dhan56 (V_1) produced the highest (3.70 t ha^{-1}) grain yield when two times weeding were performed at 20 and 40 DAT (W5). BRRI dhan56 (V_1) produced longest panicle length (23.39 cm), 1000-grain weight (23.12 g), grain yield (3.14 t ha^{-1}), straw yield (5.16 t ha^{-1}), biological yield (8.90 t ha^{-1}), harvest index (35.08%) better than the BRRI dhan57 (V_2).

Economic analysis of the weed control parameters shows that, the highest (1.92) BCR was recorded from the chemical herbicide Rifit 50EC (W_1) weed control. While the two hand weeding (W_5) recorded the second highest (1.79) and stale seed bed (W3) produces the third highest (1.69). One hand weeding (W_4) produces the fourth highest (1.48) BCR.

Based on this experiment the following conclusion can be drawn:

1. Sedge weeds dominated the crop field throughout the growing period with the highest relative weed density in the study area.
2. Weed control played an important role for the growth and yield of transplanted aman rice.
3. BRRI dhan56 (V_1) produced highest grain yield (3.14 t ha^{-1}), straw yield (5.16 t ha^{-1}), biological yield (8.90 t ha^{-1}), harvest index (35.08%) with better weed control efficiency.
4. Among the weed control treatments two hand weeding at 20 and 40 DAT (W_5) showed highest weed control efficiency 89.90% at 30 DAT, 59.74% at 60 DAT and 78.85% 90 DAT.
5. Because using chemical herbicides involves environmental pollutions and two hand weeding involves higher labor costs, stale seed bed and one hand weeding could be very economical weed control practices for cultivating *T. aman* rice.

REFERENCES

Ahmed, G. J. U., Mamun, A. A., Hossain, S. M. A., Siddique, S. B. and Mirdha, A. J. (1997). Effect of Bosagran and raking combined with hand weeding to control weeds in aus rice .*Bangladesh Agron. J.* **7** (1&2): 31-32.

Ahmed, G. J. U., Mridha, A. J., Bhuiyan, M. K. A., Riches, C. R. and Mortimer, M. (2003). Effect of different weed management systems on weed control, plant growth and grain yield of lowland rice. In: Proceedings of Nineteenth Asian Pacific Weed Sci. Soc. Conf. 17-21 March, 2003. Philippines. No.1: 84-92.

Ahmed, G. J.U., Hossain, S. T., Rahman M. B. and Kabir M. S. (1999). Chemical weed control in wet seeded rice. Brighton Crop Protec. Conf. Weeds Proc. Intl. Conf. Brighton, UK. pp. 243-248.

Ahmed, N. U. (1981). Effect of time of nitrogen application on weed growth and yield of dry seeded rice. *Intl. Rice. Res. Newl.* 6(2): 12-13.

Akobundu, I. O. and Ahissou, A. (1985). Effect of inter row spacing and weeding frequency on the performance of selected rice cultuvars on hydromorphic soils of West Africa. *Crop Protec.* 4(1): 71-76.

Alam, M. S., Islam, M. N., Zaman, A. K. M., Biswas, B. K. and Saha, M. K. (1996). Relative efficiency and economics of different cultural methods and herbicides for weed control in transplanted aus rice. *Bangladesh J. Agril. Sci.* 23(1): 67-73.

Al-Mamun, M.A., Shultana, R., Bhuiyan, M.K.A., Mridha, A.J. and Mazid, A. (2011). Economic weed management options in winter rice. *Pak. J. Weed sci. Res.* 17(4):323-331.

Angiras, N. N. and Rana, S. S. (1998). Integrated weed management in direct seeded puddled sprouted rice. *Indian J. Agron.* 43(4): 644-649.

Ashraf, M. M., Awan, T. H., Manzoor, Z., Ahmad, M. and Safdar, M. E. (2006). Screening of herbicides for weed management in transplanted rice. *J. Animal Plant Sci.* 16(3/4): 89-92.96

Ashraf, M. M., Awan, T. H., Manzoor, Z., Ahmad, M. and Safdar, M. E. (2006).Screening of herbicides for weed management in transplanted rice.*J. Animal Plant Sci.*16(3/4):89-92.

Attalla, S. I. and Kholosy, A. S. (2002). Effect of weed control treatment on transplanted rice. Bull. Fac. Agric., Cairo Univ. 53 (4): 525-530.

Azad, A. K., Gaffer, M. A., Samanta, S. C., Kashem, M. A. and Islam, M. T. (1995). Response of BR 10 rice variety to different levels of nitrogen and spacing. *Bangladesh J. Sci. Ind. Res.* 30(1): 31-38.

Aziz, M. B. and Hasan, R. (2000). Evaluation of System of Rice Intensification (SRI) in Bangladesh. Locally Intensified Farming Enterprised Project, CARE, Dhaka, Bangladesh. pp. 4-9.

Balasubramanian V and Hill JE. 2002. Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century, pp. 15–39.

Balasubramiyan, P. (1983). Effect of planting system, herbicide application and nitrogen on weed growth and yield of rice. *Madras Agric. J.* 70(20): 125-127.

Balaswamy, K. (1999). Effect of urea and herbicides on weed composition and density in transplanted rice. *J. Res. ANGRAU.* 27(3): 5-11.

Bali, A. S. (2006). Response of scented rice 'mushk budgi' to various planting geometry and fertility levels under temperate agro-climatic conditions of Jammu and Kashmir. *Environ. Ecology.* 24(Special 3): 638-64.

Baloch, M. S., Awan, I. U., Gul H. and Khakwani, A. A. (2006). Effect of establishment methods and weed management practices on some growth attributes of rice. *Rice Sci.*13(2): 131-140

Bari, M. N., Mamun, A. A. and Anwar, S. M. S. (1995). Weed infestation in transplanted aman rice as affected by land topography and time of transplanting. *Bangladesh J. Agril. Sci.* 22(2): 227-235.

BBS (Bangladesh Bureau of Statistics). (2001). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Min. Plan., Govt. of the People's Repub. Bangladesh. p.36.

BBS (Bangladesh Bureau of Statistics). (2003). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Stat. Div., Min. Plan. Govt. of the People's Repub. of Bangladesh. p.123.

Bhuiyan SI, Sattar MA and Tabbal DF.(1995). Wet-seeded rice: wateruse efficiency and productivity constraints in wider adoption,pp. 143–145. In: *Constraints, Opportunities and Innovationsfor Wet Seeded Rice.* (Ed. Moody K). IRRI, Los Banos Philippines.

Bhuiyan, M. K. A., Ahmed,G. J. U., Mridha,A. J., Ali,M. G., Begum, J. A. and Hossain, S. T. (2010). Performance of Oxadiargyl 400SC for weed control in transplanted rice.*Bangladesh J. Weed Sci.*1(1):55-61.

Biswas, P. K., Touhiduzzaman and Roy, T. S. (2011). Allelopathic effects of rice varieties transplanted in SRI (System of rice Intensification) to control weeds. The 6th World Congress on Allelopathy, December 15-19, Guangzhou, Chaina. p.17.

Bisne, R., Motiramani, N. K. and Sarawgi, A. K. (2006).Identification of high yielding hybrids in rice. *Bangladesh J. Agril. Res*. 31(1):171-174.

Carbonell, P. U. and Moody, K. (1983). Weed control practices in irrigated and rainfed rice farms in Nueva, Ecija, Philippines. Philippines Agric. 66: 458-469.

Chandra, S. and Pandey, J. (2001). Effect of rice culture, nitrogen and weed control on nitrogen competition between scented rice and weeds .*Indian J. Agron.* 46(1): 68-74.

Chavan, S. A., Kanade, V. M. and Khanvilkar, S. A. (1989). Effect of graded N and spacing on performance on Mashuri variety of rice. *J. Maharashtra Agril. Univ.* 14(2): 196-197.

Dittmar, P.J. & MacRae, A.W. (2012). The Florida Vegetable Handbook. *Weed Management: Chaper 5.* University of Florida IFAS Extension [Online:

http://nfrec.ifas.ufl.edu/Vegetable_Production/2012_VPG_main5.pdf] Last accessed: October 14, 2013

Gautam, A. K., Mishra, B. N., Sarkar, N. C. and Mishra, P. K. (2005). Effect of graded levels of nitrogen and plant spacing on grain yield and quality of aromatic rice. *Annals Agril. Res.* 26(3): 402-405.

Ghosh, P. K., Dayal, D., Bandyopadhyay, K. K., & Mohanty, M. (2006). Evaluation of straw and polythene mulch for enhancing productivity of irrigated summer groundnut. Field Crops Research, 99(2), 76-86.

Guilani, A. A., Siadat, S. A. and Fathi, G. (2003). Effect of plant density and seedling age on yield and yield components in 3 rice cultivars in Khusestan growth conditions. *Iranian J. Agric. Sci.* 34(2):427-438

Hassan, M. N., Ahmed, S., Uddin, M. J. and Hasan, M. M. (2010). Effect of weeding regime and planting density on morphology and yield attributes of transplant *aman* rice cv. BRRI dhan41. *Pak. J. Weed Sci. Res.* 16(4):363-377.

Hochmuth, G. J., Hochmuth, R.C., & Olson, S.M. (2008). Polyethylene Mulching for Early Vegetable Production in North Florida. University of Florida IFAS Extension. Publication No. Cir805.[Online: http://edis.ifas.ufl.edu/cv213]

Hossain, M. F., Bhuiya, M.S.U. and Ahmed, M. (2007).Chemical and physical properties of aromatic rice varieties as influenced by transplanting date in transplant *aman* season. *J. Nation. Sci. Found. Sri Lanka.*35(2):127-132.

Islam, S.S., Amin, M.H.A., Parvin, S., Amanullah, A.S.M. and Ahsanullah, A.S.M. (2010). Effect of pre and post-emergence herbicides on the yield of transplant *aman* rice. *Bangladesh res.Public.J.*3(4):1242-1252.

Islam, T., Bhowmick, M. K., Ghosh, R. K. and Sounda, G. (2001).Effect of Pretilachlor on weed control and yield of transplanted rice. *Environ. Ecol.*19(2):265-268.

Johnson III, W. Carroll, and Benjamin G. Mullinix Jr. "Weed management in peanut using stale seedbed techniques." Weed Science (1995): 293-297.

Jones, M. P., Johnson,D., Fofana, B. S. and Koupeur, T. (1996).Selection of weed competitiveness in upland rice. *Int*l*. Rice Res. Notes.*21(1):32-33.

Kamalam, J. and Bridgit, T. K. (1993). Effect of chemical and integrated weed management in upland rice. J. Tropic. Agric. 31: 77-80. Karim, M., Rahman, M., Aziz, M. and Gonsalves, C. (2002). Effect of spacing and

Karim, S. M. R. and Ferdous, M. N.(2010). Density effects of grass weeds on the plant characters and grain yields of transplanted *aus* rice.*Bangladesh J. Weed Sci.*1(1):49-54.

Khaliq, A., Riaz, M. Y. and Matloob, A. (2011). Bio-economic assessment of chemical and non-chemical weed management strategies in dry seeded fine rice (*Oryza sativa* L.). *J. Plant Breed.and Crop Sci*.3(12):302-310.

Khan, T.A. and Tarique, M. H. (2011). Effects of weeding regime on the yield and yield contributing characters of transplant *aman* rice.*Int*l*. J. Sci. and Advan. Technol.*11:11-14.

Mamun, M. A. A., Shultana, R., Islam, S. A., Badshah,M. A., Bhuiyan, M. K. A. and Mridha, A. J. (2011).Bio-efficacy of bensulfuron methyl + pretilachlor 6.6% GR against weed suppression in transplanted rice.*Bangladesh J. Weed Sci.* 1(1):8-11.

Mahajan, G., Sharda, R., Kumar, A., & Singh, K. G. (2007). Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. African Journal of Agricultural Research, 2(1), 19-26.

Manish C., Khajanji, S. N., Savu, R.M. and Dewangan, Y. K. (2006).Effect of halosulfuron-methyl on weed control in direct seeded drilled rice under puddled condition of Chhattisgarh plains.*Plant Archives.*6(2):685-687.

Mazid MA, Bhuiyan SI, Mannan MA and Wade LJ. 2002. Dry seeded rice for enhancing productivity of rainfed drought-pronelands: lessons from Bangladesh and the Philippines, pp. 185–200. In: *Direct Seeding: Research Strategies and Opportunities.*

Mian, M. A. K., Matin, M. A. and Hossain, M. A. (2007). Occurrence of weed species in transplanted *aman* rice field as affected by cultivar. *Bangladesh J. Bot.* 36(1):89-92.

Mitra, B. K., Karim, A. J. M. S., Haque, M. M., Ahmed, G. J. U. and Bari, M. N. (2005). Effect of weed management practices on transplanted *aman* rice. *J. Agron.* 4(3):238-241.

Mohler CL. 2001. Mechanical management of weeds, pp. 139–209.In: *Ecological Management of Agricultural Weeds*. (Eds.Liebman M, Mohler CL and Staver CP). Cambridge UniversityPress, Cambridge.

Mukhopadhyay, S. K. and Ghosh, D. C. (1981). Weed problem in oil seed crops and its control. Pesticide Info., 7:44.

Nahar, S., Islam, M. A. and Sarkar, M. A. R. (2010). Effect of spacing and weed regime on the performance of transplant *aman* rice. *Bangladesh J. Weed Sci*.1(1):89-93.

Om, H., Dhiman, S. D., Nandal, D. P. and Verma, S. L. (1998).Effect of method nursery raising and nitrogen on growth and yield of hybrid rice (*Oryza sativa*). *Indian J. Agron*.43(1):68-70.

Reza. M. S. U. A., Karim, S. M. R.and Begum, M. (2010). Effect of nitrogen doses on the weed infestation and yield of *boro* rice. *Bangladesh J. Weed Sci.* 1(1):7-13.

Riemens. M. M., Van Der Weide, R. Y., Bleeker, P. O., & Lotz, L. A. P. (2007). Effect of stale seedbed preparations and subsequent weed control in lettuce (cv. Iceboll) on weed densities. Weed Research, 47(2), 149-156.

Salam, M. A., Islam, M. M., Islam, M. S. and Rahman, M. H. (2010). Effects of herbicides on weed control and yield performance of Binadhan-5 grown in *boro* season. *Bangladesh J. Weed Sci*.1(1):15-22.

Schonbeck, M.W. (1993). Evaluation of recycled paper film mulch and organic mulches asalternatives to black plastic mulch on vegetable horticulture. Annual report for SARE/ACEproject. U.S.A. 11 pp.

Singh, S. P. and Kumar, R. M. (1999).Efficacy of single and sequential application of herbicides on weed control in transplanted rice. *Indian J. Weed Sci.*31(3-4):222-224

Singh, V. P., Govindra, S. and Mahendra, S. (2004). Effect of fenoxaprop-p-ethyl on transplanted rice and associated weeds. *Indian J. Weed Sci.* 36(1/2):190-192.

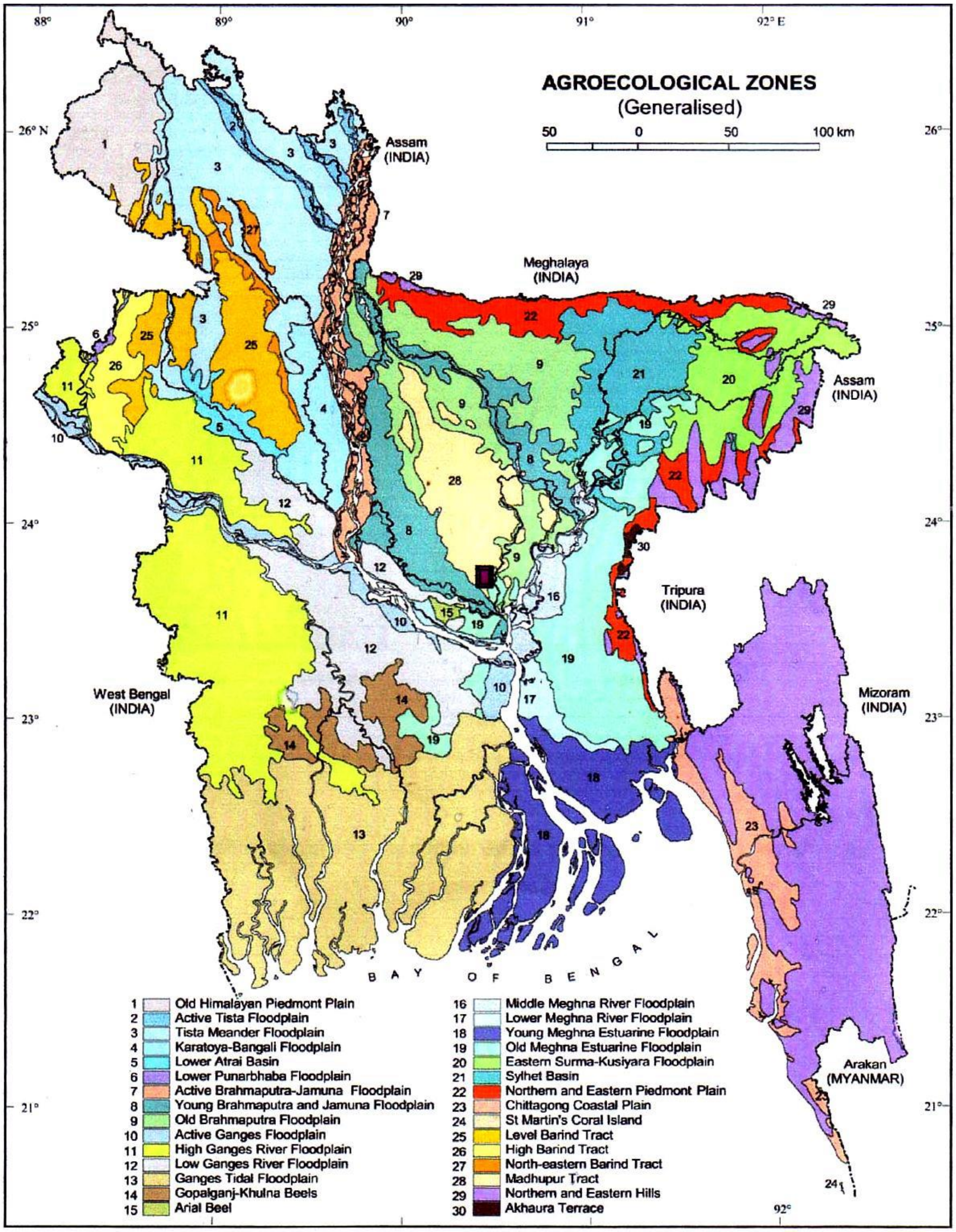
Singh, S., Ladha, J. K., Gupta, R. K., Bhushan, L., & Rao, A. N. (2008). Weed management in aerobic rice systems under varying establishment methods.Crop Protection, 27(3), 660-671.

Venkataraman, N. S. and Gopalan, M. (1995).Current status of weed problems in rice production in Tamil Nadu, India.In. Papusas, H. R. and Heong, K. L. (ed.) Weed Management in Rice Production. Intl. Rice. Res. Inst., Los. Banos. Laguna, Philippines. pp. 113-126.

Wang, J. L., Xu, Z. J. and Yi, X. Z. (2006).Effects of seedling quantity and row spacing on the yields and yield components of hybrid and conventional rice in northern China. *Chinese J. Rice Sci.*20(6):631-637.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from August to December 2013

Month	Average RH(%)	Average Temperature (ºC)		Total Rainfall (mm)	Average Sunshine hours
		Min.	Max.		
August	80	26.7	33.5	514	4.7
September	79	24.4	31	183	3.6
October	78	22.8	31.3	341	4.9
November	73	18.9	28.6	107	5.8
December	69	16.6	23.2	0	5.6

Source : Bangladesh Meteorological Department (Climatic Divission), Agargaon, Dhaka-1207

Appendix III. Means square values for weed density m^{-2} of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30	60	90
Replication	2	1831.893	89.927	21.572
Variety (V)	1	1038.558*	1852.011*	1070.599*
Error	2	81.322	40.573	28.257
Weed control (W)	5	46535.149*	8293.652*	2800.795*
V X W	5	130.757*	58.400*	28.024*
Error (B)	20	660.924	53.044	40.546
CV (%)		34.62	9.27	12.17

*Significant at 5 % level
ns- Non-significant

Appendix IV. Means square values for weed biomass m^{-2} of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30	60	90
Replication	2	2.695	51.486	3.703
Variety (V)	1	62.858*	222.507*	64.401*
Error	2	5.560	16.726	5.398
Weed control (W)	5	749.958*	1197.781*	757.264*
V X W	5	5.269*	14.538*	5.246*
Error (B)	20	1.351	42.045	1.431
CV (%)		10.59	19.50	7.52

*Significant at 5 % level
ns- Non-significant

Appendix V. Means square values for weed control efficiency (%) of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30	60	90
Replication	2	47.642	1050.121	52.050
Variety (V)	1	461.605*	16.120*	329.181*
Error	2	57.154	196.204	40.905
Weed control (W)	5	7104.549*	3159.424*	5386.787*
V X W	5	56.203*	15.656*	41.454*
Error (B)	20	10.717	44.818	8.650
CV (%)		4.94	15.90	5.11

*Significant at 5 % level
ns- Non-significant

Appendix VI. Means square values for plant height (cm) of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30	60	90
Replication	2	41.884	106.126	4.708
Variety (V)	1	582.418*	5094.152*	6299.068*
Error	2	31.858	7.827	40.534
Weed control (W)	5	282.511*	130.327*	66.206*
V X W	5	29.724*	29.019*	24.953*
Error (B)	20	35.476	27.374	11.274
CV (%)		6.75	4.56	2.97

*Significant at 5 % level
ns- Non-significant

Appendix VII. Means square values for tillers hill^{-1} of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30	60	90
Replication	2	8.528	137.861	48.028
Variety (V)	1	69.444^{ns}	870.250*	1600.000*
Error	2	44.194	33.583	16.750
Weed control (W)	5	5.111^{ns}	18.094*	8.911*
V X W	5	9.511^{ns}	7.117*	2.000*
Error (B)	20	13.428	4.456	6.489
CV (%)		23.47	11.64	12.16

*Significant at 5 % level
ns- Non-significant

Appendix VIII. Means square values for panicle length (cm), effective tiller hill^{-1}, non-effective tiller hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, rachis panicle^{-1} and 1000 grain weight (g) of *T. aman* rice at different days after transplanting

Sources of variation	**DF**	**Means square values at different days after transplanting**						
		Panicle length	**Effective tiller**	**Non-effective tiller**	**Filled grains**	**Unfilled grains**	**Rachis panicle**	**1000-grain weight**
Replication	2	1.30	45.08	0.028	341.58	187.44	0.36	0.32
Variety (V)	1	2.44*	1111.11*	40.11*	1892.25*	1002.78*	1.36*	39.50*
Error	2	2.76	9.03	1.19	27.75	1.44	1.19	0.13
Weed control (W)	5	3.20*	3.53*	1.18*	204.32*	284.18*	1.16*	0.07*
V X W	5	1.40*	4.04*	0.58*	225.52*	163.04*	1.43*	0.61*
Error (B)	20	1.43	7.89	0.38	284.83	35.778	0.48	0.92
CV (%)		5.17	14.40	42.55	14.79	21.53	6.57	4.34

*Significant at 5 % level
ns- Non-significant

Appendix IX. Means square values for grain weight (t ha^{-1}) , straw weight (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) of *T. aman* rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting			
		Grain weight	Straw weight	Biological yield	Harvest index
Replication	2	0.649	0.045	0.748	45.577
Variety (V)	1	0.122*	0.284*	0.780*	1.170*
Error	2	0.806	0.070	1.309	30.229
Weed control (W)	5	1.505*	1.800*	6.391*	21.015*
V X W	5	0.205*	0.097*	0.305*	14.294*
Error (B)	20	0.140	0.161	0.411	7.507
CV (%)		12.16	7.07	7.32	7.85

*Significant at 5 % level
ns- Non-significant

Appendix X : Operation wise break up of labour required per hectare of T. aman rice

Sl. No.	Item of work	Tractor driven	Rate (tk)		Labor No.	Rate (tk)		Total (tk)
			Per tractor day	Total (tk)		Per tractor day	Total (tk)	
01	Seed soaking and treatment				1	220	220	220
02	Ploughing, laddering and seedbed preparation				4	220	880	880
03	Carrying manure,fertilizer and spreading				4	220	880	880
04	Sowing seeds and other operations				2	220	440	440
05	Uprooting of seedlings				2	220	440	440
06	Preparation of main field by ploughing and laddering	2	220	440	20	220	4400	4840
07	Trimming, spading of corners and removing stubbles				2	220	440	440
08	Transplanting in the main field				15	220	3300	3300
09	Gap filling				2	220	440	440
10	Irrigation (2 times)				2	220	440	440
11	Fertilizer top dressing and applying pesticide				4	220	880	880
12	Harvesting, binding and carrying etc				8	220	1760	1760
13	Threshing and winnowing				6	220	1320	1320
14	Drying and heaping				4	220	880	880
15	Storing				4	220	880	880
Grand Total = 18,040								

Appendix XI :Cost of production per hectare of *T. aman* rice excluding weeding cost

A. Material cost

Sl. No.	Items	quantity	Rate	Cost (tk)
01	Cost of seed	20 kg/ha	100 tk/kg	2000
02	Cost of manure and fertilizers			
	a) Cowdung	5 ton/ha	250 tk/ton	1250
	b) Urea	58 kg/ha	12 tk/kg	696
	c) TSP	100 kg/ha	13 tk/kg	1430
	d) MOP	70 kg/ha	10 tk/kg	700
	e) Gypsum	60 kg/ha	5 tk/ha	300
	f) Zinc sulphate	5 kg/ha	40 tk/kg	200
03	Cost of irrigation (2 times)			2000
04	Cost of pesticides			1000
			Grand total =	9576

Total input cost (running capital) = (18040+9576) Tk = 27,616 Tk

B. Overhead cost

Sl. No.	Items	Cost (tk)
01	Tax of land for 6 month	125
02	Interest of running capital @7% for 6 month	1933.12
03	Interest on fixed capital taking the value of land as Tk. 1 Lakh for 6 months or Leasing value of 1 ha for 6 month	10000
04	Miscellaneous (approximately 5% of the running capital)	1380.8
	Total =	13438.92

Total cost of production (excluding weeding cost)

= Running capital+Overhead cost

= 27,616+13438.92 = 41,562.12 Tk

Appendix XII : Weeding cost of different weed control treatments for one hectare of land of *T. aman* rice

Treatments	No. of labour	Labour cost	Herbicide cost	Polythene paper cost	Total weeding cost
W_1 (Rifit 500EC)	2	440	2000	-	2440
W_2 (Polythene Paper)	20	4400	-	1200	5600
W_3 (Stale Seedbed)	15	3300	-	-	3300
W_4 (One hand weeding)	15	3300	-	-	3300
W_5 (Two hand weeding)	30	6600	-	-	6600
W_6 (No weeding)	0	0	-	-	0

Appendix XIII : Economic performance of different weed control treatments

In case of all weeding methods , same cost was = 41,054.92 Tk

1 Mon = 37.32 kg

1 Mon grain = 800 Tk i.e., 1 ton grain price = 800/37.32 X 1000

= 21,436.22 Tk

1 Ton Straw = 1000 Tk

W_1 = herbicides	
Input cost	Output cost
Labor cost = 2440 Tk Total cost = 41,054.92+2440 = 43,494.92 Tk	Grain yield =3.60 t ha^{-1} = 3.60 X 21,436 = 77,169.6 Tk Straw yield = 6.42 t ha^{-1} = 6.42 X1000 = 6420 Tk Total income = (77,169.6 + 6420) Tk = 93237.6 Tk
BCR = 1.92 Tk return per Tk invested	
W_2 = polythene paper	
Input cost	Output cost
Labor cost = 5600 Tk Total cost = 41,054.92+5600 = 46,654.92 Tk	Grain yield = 3.05 t ha^{-1} = 3.05 X 21436 = 65,379.8 Tk Straw yield = 5.94 t ha^{-1} = 5.94 X 1000 = 5940 Tk Total income = (65,379.8 + 5940) Tk = 79,493.8 Tk
BCR = 1.52 Tk return per Tk invested	

W_3 = stale bed	
Input cost	Output cost
Labor cost = 3300 Tk Total cost = 41,054.92 + 3300 = 44,354.92 Tk	Grain yield = 3.27 t ha^{-1} = 3.27 X 21436 = 70,095.72 Tk Straw yield = 5.1 X 1000 = 5100 Tk Total income = (70,095.72 + 5100)Tk

	= 83,959.32 Tk
BCR = 1.69 Tk return per Tk invested	
W_4 = one hand weeding	
Input cost	Output cost
Labor cost = 3300 Tk Total cost = 41,054.92 + 3300 = 44354.92 Tk	Grain yield = 2.83 t ha^{-1} = 2.83 X 21436 = 60,663.88 Tk Straw yield = 5.1 t ha^{-1} = 5.1 X 1000 = 5100 Tk Total income = (60,663.88 + 5100)Tk = 65,763.88 Tk
BCR = 1.48 Tk return per Tk invested	
W_5 = two hand weeding	
Input cost	Output cost
Labor cost = 6600 Tk Total cost = 41,054.92 + 6600 = 47,654.92 Tk	Grain yield = 3.70 t ha^{-1} = 3.70 X 21436 = 79,313.2 Tk Straw yield = 6.38 t ha^{-1} = 6.38 X 1000 Tk = 6380 Tk Total income = (79,313.2 + 6380) Tk = 85,693.2 Tk
BCR = 1.79 Tk return per Tk invested	
W_6 = control	

Input cost	Output cost
Labor cost = 0 Tk Total cost = 41,054.92 Tk	Grain yield = 2.37 t ha^{-1} = 2.37 X 21436 = 50,803.32 Tk Straw yield = 5.06 t ha^{-1} = 5.06 X 1000 = 5060 Tk Total income = (50,803.32 + 5060)Tk =55,863.32 Tk
BCR = 1.36 Tk return per Tk invested	