GROWTH AND YIELD OF BORO RICE AS AFFECTED BY WEED MANAGEMENT

HITANGSHU CHAKRABORTY

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA 1207

JUNE, 2010

GROWTH AND YIELD OF BORO RICE AS AFFECTED BY WEED MANAGEMENT

BY

HITANGSHU CHAKRABORTY

REG. NO. : 04-01296

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JANUARY-JUNE, 2010

APPROVED BY:

Prof. Dr. Parimal Kanti Biswas	**Prof. Md. Sadrul Anam Sardar**
Supervisor	Co-Supervisor

Prof. Dr. Md. Fazlul Karim
Chairman
Examination Committee

DEDICATED

TO

MY BELOVED PARENTS

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled "**Growth and Yield of Boro Rice as Affected by Weed Management**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Hitangshu Chakraborty**, Registration number: **04-1296** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Dr. Parimal Kanti Biswas
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

ACKNOWLEDGEMENT

All praises to Almightly and Kindfull trust on to "Omnipotent Creator" for His never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor Dr. Parimal Kanti Biswas, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period, gratuitous labor in conducting and successfully completing the research work, and in the preparation of the manuscript.

The author also grateful to his respected Co-Supervisor, Md. Sadrul Anam Sardar, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. Md. Fazlul Karim, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

GROWTH AND YIELD OF BORO RICE AS AFFECTED BY WEED MANAGEMENT

ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from January to May, 2009 to study the growth and yield of *Boro* rice as affected by weed management. The experiment comprised two factors. Factor A: Variety: 2 levels; BRRI dhan29 – V_1; Hira 1 – V_2; Factor B: Weed management: 5 levels; No weeding – M_0; 2 hand weedings – M_1; Application of herbiside – M_2; Application of water hyacinth – M_3 and Application of rice straw – M_4. The experiment was laid out in split plot design with three replications. Significant variation was recorded for data on weed population, different yield contributing characters and yield At 25 and 65 DAT, it was found that the maximum number of weeds (17.24 m^{-2} and 21.79 m^{-2}) were found in the Hira 1 cultivated plot whereas the minimum number (16.48 m^{-2} and 20.92 m^{-2}) was recorded in BRRI dhan29. At 30, 50, 70, 90 DAT and harvest the taller plant (22.83 cm, 29.37 cm, 43.13 cm, 58.16 cm and 82.92 cm, respectively) was recorded from V_2, whereas the shorter plant (21.68 cm, 28.14 cm, 41.80 cm, 55.82 cm and 81.79 cm respectively) from V_1. The higher grain yield (6.62 t/ha) was recorded from V_2, whereas the lower yield (6.04 t/ha) from V_1. At 25 and 65 DAT, the lowest dry weight of weed biomass (1.51 g and 1.29 g respectively) was recorded in M_3 and the highest weed biomass (1.59 g and 1.72 g) was found in the M_0 plot. At 30, 50, 70, 90 DAT and at harvest, the tallest plant (25.06 cm, 32.08 cm, 45.53 cm, 63.18 cm and 89.65 cm, respectively) was observed from M_1, while the shortest plant (19.90 cm, 25.53 cm, 39.12 cm, 50.37 cm and 74.58 cm, respectively) was recorded from M_0. The highest grain yield (7.56 t/ha) was observed from M_1, while the lowest grain yield (3.84 t/ha) was recorded from M_0. The highest straw yield (7.78 t/ha) was observed from M_1, while the lowest straw yield (4.53 t/ha) was recorded from M_0. At 25 DAT, the maximum (21.54 m^{-2}) weed population was observed in V_2M_1 and the lowest (6.70 m^{-2}) population observed in V_1M_2. At 65 DAT, the maximum (31.79 m^{-2}) weed population was observed in V_2M_0. At 30, 50, 70, 90 DAT and at harvest the tallest plant (25.31 cm, 32.40 cm, 46.03 cm, 65.20 cm and 89.80 cm, respectively) was observed from V_2M_1, while the shortest (18.67 cm, 24.80 cm, 38.35 cm, 49.60 cm and 74.53 cm, respectively) from V_1M_0. The highest grain yield (7.71 t/ha) was observed from V_2M_1, while the lowest yield (3.56 t/ha) from V_1M_0.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) belonging to the family Gramineae; is the staple food for at least 62.8% of planet inhabitants and it contributes on an average 20% of apparent caloric intake of the world population and 30% of population in Asia. This contribution varies from 29.5% for China to 72.0% for Bangladesh (Begum *et al.*, 2001). Ninety per cent of this crop is grown and consumed in South and Southeast Asia, the major centers of the world's population.

Rice is the most important food for majority of people around the world. It is the staple food for more than two billion people in Asia. In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield (2.34 t ha^{-1}) is very low compared to that of other rice growing countries. For instance, the average rice yield in China is about 6.30 t ha^{-1}, Japan is 6.60 t ha^{-1} and Korea is 6.30 t ha^{-1} (FAO, 2008). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country.

In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties

(BBS, 2008). Consumer demand for the fine rice varieties is high due to its good nutritional quality, palatability and due to special flavor and taste. Very recently various new rice varieties were developed and available as BRRI dhan. The BRRI dhan29 and Hira 1 is exceptionally high yielding, slender and has mild aroma of cooked rice. This variety however, needs further test under weed management to interact with different environmental conditions of the season. According to Begum *et al*. (2001) and Islam *et al*. (1989) 62.8% and 27-100% respectively is occupied by high yielding rice varieties.

Weed is one of the most important factors responsible for low yield of crops (Islam *et al.*, 1989). Rice is very competitive against weed and therefore weed control is essential for rice production. Yield losses due to uncontrolled weed growth in rice ranges from 27 to 100%. The rate of dry matter production in many crops is proportional to the intercepted radiation coupled with uptake of soil nutrients and moisture. The growth of crop is, therefore, often analyzed in term of intercepted radiation and the efficiency of conversion of solar radiation to dry weight (Gallagher and Biscoe, 1978). However, such relationship may be changed for a crop which is in competition with weed for solar radiation, nutrients and moisture. The leaf area of rice may be reduced due to competition of weeds these radiation interception is markedly lower for dry matter production. Several authors reported that management of weeds coupled with higher yielding varieties of high yielding rice could be one of the solution to the back drop of rice cultivation. The judicial management of weed in rice cultivation is an important factor that greatly affects the growth, development and yield of high yielding rice varieties.

The BRRI dhan29 and Hira 1 has higher yield potential as compared to existing other modern varieties.

Under this circumstance the present research work has been taken with the following objectives:

a. To observe the growth and yield performance of BRRI dhan29 and Hira 1,
b. To study the influence of weed management on the growth and yield performance of rice . and
c. To find the interaction effects of variety and weed management on growth and yield performance of rice.

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depends on manipulation of basic ingredients of agriculture. The basic ingredients include variety, environment and agronomic practices (planting density, fertilizer, irrigation, weed management etc.). Among the above factors variety and weed management are more responsible for the growth and yield of rice. High yielding varieties (HYV) are generally more sensitive to weeds, they produce higher yield with weed free condition. The available relevant reviews related to variety and weed management in the recent past with rice and other crops have been presented and discussed under the following headings:

2.1 Performance of rice cultivars

Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) was compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill^{-1}, equal row spacing and 3 seedlings hill^{-1}, wide-narrow row spacing and one seedling hill^{-1}, and wide-narrow row spacing and 3 seedlings hill^{-1}) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelets per panicle and adaptability.

Patel (2000) studied that the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively. Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains $panicle^{-1}$ and greater seed weight.

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains per plant, number of spikes per plant and grain weight per plant, but heterosis for spike fertility was low.

Julfiquar *et al*. (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *boro* season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. They also reported that thirteen rice hybrids were evaluated in three locations of BADC farm during the boro season of 1995-96. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}. Rajendra *et al.* (1998) carried out an experiment with hybrid rice cv. Pusa 834 and Pusa HR3 and observed that mean grain yields of Pusa 834 and Pusa HR3 were 3.3 t ha^{-1} and 5.6 t ha^{-1}, respectively.

Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line. Roy *et al*. (1995) observed that the plants, which needed more days for 50% flowering generally, gave more yield.

Son *et al.* (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, were evaluated at plant densities of 10 to 300 plants m^{-2} and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo regardless of plant density.

Devaraju *et al.* (1998) in a study with two rice hybrids such as Karnataka Rice Hybrid 1 (KRH1) and Karnataka Rice Hybrid-2(KRI42) using HYV IR20 as the check variety and found that KRH2 out yielded than IR20. In IR20, the tiller number was higher than that of KRH2.

Mishra and Pandey (1998) evaluated standard heterosis for seed yield in the range of 44.7 to 230.9% and 42.4 to 81.4%, respectively. Plant height, panicle per plant, grain per panicle and 1000 grain weight increase the yield in modern varieties.

Associations of various yield components in rice (Padmavathi *et al.*, 1996; Sharaan and Ghallab, 1997) indicate that the plants with large panicles tend to have a high number of fertile grains. Similarly, a positive correlation was observed between number of panicle/plant and panicle length.

Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

BRRI (1994) studied the performance of BR14, BR5, Pajam, and Tulsimala and reported that Tulsimala produced the highest number of filled grains panicle^{-1} and BR14 produced the lowest number of filled grains penicle^{-1}. BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19. They found that varieties differed significantly on panicle length and sterile spikelets panicle^{-1}. It was also reported that varieties BINA13 and BINA19 each had better morphological characters like more grains panicle^{-1} compared to their better parents which contributed to yield improvement in these hybrid lines of rice.

Hossain and Alam (1991) also found that the growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in *boro* season. Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Rice tillering is a major determinant for panicle production (Miller *et al*., 1991) and as a consequence affects total yield (Gallagher and Biscoe, 1978). The high tillering capacity is considered as a desirable trait in rice production, since number of tillers per plant is closely related to number of panicles per plant. To some extent, yield potential of a rice variety may be characterized by tillering capacity. On the other hand, it was reported that the plants with more tillers showed a greater inconsistency in mobilizing assimilates and nutrients among tillers. Moreover, grain quality could be also affected by tillering ability due to different grain development characteristics. It has been well documented that either excessive or insufficient tillering is unfavorable for high yield. Ghose and Ghatge (1960) stated that tiller number, panicle length contributed to yield. Ghosh and Hossain (1988) reported that effective tillers/plant, number of grains/panicle and grain weight as the major contributory characters for grain yield it had positive correlations with number of productive tillers/plant.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mut. NSI and Mut. NSS were planted and found that plant height were greater in Mut. NSI than Nizersail.

Patnaik *et al*. (1990) reported that in hybrids, yield was primarily influenced by effective tillers per plant and fertile grains per panicle, whereas in parents it was panicle length, maturity and effective tillers per plant. Number of effective tillers per plant and fertile grains per panicle remained constant and common in explaining heterosis for yield of most of the hybrids. The heterosis for grain yield was mainly due to the significant heterosis for the number of spikelets/panicle, test weight and total dry matter accumulation.

Saha *et al*. (1989) studied the characteristics of CMS lines V20A, 279A, V41A and P203A with their corresponding maintainer (B) lines and two restorer (R) lines IR50 and IR54. In maintainer lines tiller number were recorded highest in V20B.

Shamsuddin *et al*. (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among varieties. Sawant *et al.* (1986) conducted an experiment with the new rice lines R-73-1-1, R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest.

Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984). Prasad *et al*. (2001) observed that days to flowering are negatively correlated with plant height. Grain yield is negatively correlated with plant height (Amirthadevarathinam, 1983). Patnaik *et al*. (1990) found that hybrids with intermediate to tall plant height having non-lodging habit could be developed gave more than 20% grain yield than the standard checks.

Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems. However, grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al*., 1979). In addition, grain yield also related with other characters such as plant type, growth duration, and yield components (Yoshida, 1981). Rice yield is a product of number of panicles per unit area, number of spikelets per panicle, percentage of filled grains and weight of 1000 grains (Yoshida, 1981; De Datta, 1981). Improving rice (*Oryza sativa* L.) grain yield per unit land area is the only way to achieve increased rice production because of the reduction in area devoted to rice production (Cassman, 1999).

2.2 Effect of weed management

Norsworthy *et al.* (2007) conducted experiments to compare growth characteristics, biomass production and glucosinolate content of seven autumn-planted glucosinolate-producing cover crops that were terminated the following spring. *D. sanguinalis* control by cover crops ranged from 38% to 79%, and *A. palmeri* control was 23% to 48% at 4 weeks after transplanting (WATP) bell pepper in 2004. *D. sanguinalis* control was positively correlated with total glucosinolate production, but *A. palmeri* control was not. *D. sanguinalis* control in 2005 ranged from 0% to 38% at 2 WATP. In the absence of weeds, cover crops did not negatively affect fruit yields which were often higher than in the absence of a cover crop.

Gomes *et al.* (2007) reported that intercropping combined with competitive maize cultivars can reduce the use of herbicides to control weeds. The cowpea was inefficient in controlling weed, reducing the maize yields and not producing any grain. The maize cultivars 'BA 8512' and 'BA 9012 showed the highest mean green ear yield, and the highest grain yield in hand-weeded, no-weeded and intercropped split-plots. On the other hand, the maize cultivar 'EX 6004' showed such high means only in no-weeded and intercropped split-plots. 'EX 4001 presented the worst means in these variables for hand-weeded, no-weeded ant intercropped split-plots.

Meschede (2007) evaluated seven treatments consisting of the following soil crop covers: Millet ADR 500 (*Penisetum americanum* L.), Millet ADR300, Sorghum (*Sorghum bicolor* L.), Maize (*Zea mays* L.), Crotalaria (*Crotalaria juncea* L.), Castorbean plant (*Ricinus communis* L.) and spontaneous vegetation. Sorghum yielded the highest dry matter weight (11.890 kg ha^{-1}); sorghum, millet and crotalaria showed a better ability to suppress weeds. The spontaneous vegetation presented the lowest biomass values. Maize and Castorbean presented a lower crop cover potential. Biomass accumulation by the covers was inversely proportional to weed biomass.

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 weeding 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.

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 60EQ during both cropping seasons.

Manish *et al*. (2006) said that Alternanthera triandra, Echinochloa colorer, Fimhristylis 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 0 DAT.

Javaid *et al.* (2006) evaluated herbicidal effects of aqueous root and shoot extracts of three allelopathic crops, viz. sunflower (*Helianthus annuus* L.), sorghum (*Sorghum bicolor* L.) and rice (*Oryza sativa* L.) against germination and growth of the noxious alien weed *Parthenium hysterophorus* L. The study indicated insignificant effects on shoot length and seedling biomass while germination and root length were significantly reduced by extracts of all the test crops. In a foliar spray bioassay, aqueous shoot extracts of 50 and 100% w/v (on a fresh weight basis) of sunflower and sorghum were applied to 10 day old *Parthenium* plants.

The root biomass of *Parthenium* plants was significantly suppressed by 50 and 100% extracts of both the test allelopathic extracts. Both concentrations of sorghum extracts significantly reduced shoot biomass, but sunflower extract was effective only at the lower concentration.

Singh (2005) conducted an experiment at Bihar, India, during the wet season to assess the effectiveness of Beushening (a kind of mechanical weed control) in controlling weeds under rainfed lowland conditions as well as to make a comparison between Beushening and chemical weed control (i.e. 2,4-D and Butachlor). It was found that common practice of Beushening alone was not effective in controlling weeds of rainfed lowland rice but standard practice of Beushening along with one hand weeding 40 days after sowing, (DAS) was better in controlling weeds than other chemical treatments with or without one hand weeding 40 DAS and both (common and standard) practices of Beushening as effective as two hand weedings (25 and 40 DAS) in terms of grain yield, net return and benefit cost ratio.

Gawronska *et al.* (2004) studied that wheat germination, even at highest concentration, were almost not, and while of mustard were strongly affected by sunflower allelochemicals. Allelochemicals contained in extracts had negative impact on seedling vigour of both species but mustard growth was almost fully inhibited while wheat, although less vigorously, continues to grow. Moreover, along with increased extract concentration number of roots per wheat seedling increased. At autotrophic growth stage, differences between these two species became less evident but still wheat appears to be more tolerant to allelopathy stress especially in processes related to plant water status.

Mansoor *et al.* (2004) designed an experiment to investigate the efficacy of various weed management strategies in mungbean. Water extracts of sorghum, Eucalyptus and Acacia were used in comparison with hand weeding and pre-emergence herbicide. All the treatments significantly affected Number of branches plant^{-1}, Number of pods plant^{-1}, 1000 grain weight and grain yield. Application of water extract of Acacia ranked at the top in yield and almost all the yield components followed by two hand weeding + Pre-emergence herbicide treatments.

Ahmed *et al*. (2003) said that Cinosulfuron, Pretilachlor and the BRRI push weeder performed better than farmer existing weed control practices of hand weeding with reduced weeding cost.

Cheema *et al.* (2003) tested response of wheat and its weeds to foliar application of sorghum (*Sorghum bicolor*), sunflower (*Helianthus annuus*) and eucalyptus (*Eucalyptus camaldulensis*) water extracts individually and in combinations with each other at different doses under field conditions. Concentrated sunflower water extract @ 12 L ha^{-1} sprayed at 30 and 40 days after sowing gave consistently better weed control and increased wheat yield by 5.5% over control. A combination of water extracts of sorghum, sunflower and eucalyptus each @ 12 L ha^{-1} and 8 L ha^{-1} were also economical. However, conventional methods like hand weeding and herbicides, though effective in weed control, were uneconomical due to higher costs.

Penfold (2003) investigated the capacity for a range of cover crops to compete with weeds, and a variety of mulching materials to inhibit weed germination and growth in the undervine area. Wheat straw was the most effective inhibitor of weeds. Compost based mulches inhibited the growth of most weeds, but if seed rain from the mid-row occurred, they also presented a very desirable growing medium for weeds.

Tawaha and Turk (2003) stated that growth of wild barley, as indicated by plant height and weight, was significantly reduced when grown in soil previously cropped to black mustard compared with that cropped to wild barley. Soil incorporation of fresh black mustard roots and both roots and shoots reduced wild barley germination, plant height and weight when compared with a no-residue control. In bioassays, black mustard extracts reduced wild barley hypocotyl length, hypocotyl weight, radicle weight, seed germination, and radicle length by as much as 44, 55, 57, 63 and 75 %, respectively, when compared with a water control.

Fujii (2001) stated that leguminous cover crops such as hairy vetch (*Vicia villosa*) and velvetbean (*Mucuna pruriens*), graminaceous cover crops, such as oat (*Avena sativa*) and rye (*Secale cereale*), certain cultivars of wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) were promising. Fall-sown cover crops such as hairy vetch, rye, heat, oat, grass pea, and mustard are more effective when compared to spring-sown cover crops. Hairy vetch was most promising for the weed control in abandoned fields because of its ability to die off during summer season to make thick straw-like mulch.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest a grain yield was observed in the unweeded control in the scented rice variety Pusa Basmati-1. Sharma and Bhunia (1999) reported that Pendimethalin @ 1.5 ka/ ha plus one hand weeding resulted in highest weed control efficiency than any other treatments.

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 weed 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.

Sanioy *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.

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

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

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%.

Chandra Babu and Kandasamy (1997) researched allelopathic potential of *Eucalyptus globulus* Labill. (gum tree) fresh and dried leaf leachates was studied using two perennial weeds, viz. purple nutsedge (*Cyperus rotundus* L.) and bermuda grass (*Cynodon dactylon* L. Pers) as test weeds. Aqueous leachate of fresh leaves of eucalyptus significantly suppressed the establishment of vegetative propagules and early seedling growth of the weeds. Leachate of fresh leaf cuttings had growth inhibitory effect on Bermuda grass but showed growth promotion effect on purple nutsedge. Similarly the leachate of dried leaves of eucalyptus had differential influence on the growth of the two weeds. There is a possibility to harness the allelochemicals of eucalyptus leaves as herbicides for the management of these perennial weeds.

Madhu *et al*. (1996) at Bangalore, to evaluate the effectiveness of four herbicides, pendimethylin, Anilofos, Butachlor and oxyfluorfen at 2 application rates during dry and wet seasons in paddled seeded rice field and the results showed that grain and straw yields were higher in the plots treated with Butachlor @ 1.5 kg, ha^{-1}.

Bhattacharya *et al*. (1996) reported that although the hand weeding treatment gave the highest grain yield, the results indicated that this was laborious, time consuming and costly and hand weeding, could be replaced by application of Butachlor at 1 kg a.i. ha^{-1}.

Creamer *et al.* (1996) demonstrated that allelochemicals could be leached from rye shoot residue and used as a control to separate the physical effects of weed suppression of surface rye mulch from other types of interference. Leached rye inhibited emergence of eastern black nightshade (*Solanum ptycanthum* Dun.) by 98%.

Masiunas *et al.* (1995) reported that weed suppression by rye residue comes from the considerable biomass rye accumulates early in the growing season, which provides a physical barrier as well as a chemical barrier against weed germination and growth. This suppression extends from 4 to 10 weeks.

Moorthy and Das (1992) stated that the paddy wheel hoe use twice resulted in the greatest weed control (80%), higher grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80%), highest grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80.7%) and grain yield (2.81 t ha^{-1}) but the paddy wheel hoe used gave twice higher straw yield (4.68 t ha^{-1}). 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} (54.40%) in transplanted rice under medium land condition.

Biswas *et al*. (1991) evaluated that Oxadiazon 1.0 and 0.5 kc, a.i. ha^{-1} applied at 30 days after sowing with or without one supplemental hand weeding was compared with normal hand weeding and the results indicated that the use of

Oxadiazon at 0.5 kg a.i. ha^{-1} was more economic than hand weeding for effective weed management.

Leather (1987) conducted field studies to determine if season long weed control could be achieved by combining the use of an herbicide with the natural allelochemicals produced by cultivated sunflower (*Helianthus annuus* L.). The weed biomass was reduced equally in plots planted with sunflowers, whether or not the herbicide was applied in each of 4 years. Weed control diminished the second year in all plots that received the same treatments as had been applied the previous year. This diminished efficacy was attributed to reduced emergence of sunflower (13.5 to 45.2 percent) in second-year plots, as a result of autotoxicity from sunflower crop residues remaining after the first-year harvest.

Putnam and DeFrank (1983) showed reductions in germination and growth of several problem agronomic weeds including barnyardgrass (*Echinochloa crusgalli* L.), common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), green foxtail [*Setaria viridis* (L.) Beauv.], and redroot pigweed (*Amaranthus retroflexus* L.)

Considering above review of literature it can be mentioned that limited researches have been done before and many other such type of researches can be held in respect of the present study. Different locations can be selected at home and abroad with different management of weed control in respect of different rice varieties.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from January to May, 2009 to study the growth and yield of *Boro* rice as affected by weed management. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level.

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix I.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to

February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was presented in Appendix II.

3.2 Test crop and its characteristics

BRRI dhan29 and Hira 1 was used as the test crop in this experiment. This two varieties are recommended for boro season. Average plant height of the BRRI dhan29 variety is 100 cm at the ripening stage. The grains are medium fine and white. It requires about 155-160 days completing its life cycle with an average grain yield of 6.5 t ha^{-1} (BRRI, 2010).

Hira 1 variety is grown in boro season. This variety is recommended for cultivation in medium high land and medium low land. The cultivar mature at 140-145 days of planting. It attains a plant height 125-130 cm.The cultivar gives an average yield of 10-12 per hecter.

3.3 Experimental details

3.3.1 Treatments

The experiment comprised as two factors.

Factor A: Variety

i. BRRI dhan29 – V_1

ii. Hira 1 – V_2

Factor B: Weed management

i. No weeding – M_0
ii. 2 hand weedings – M_1
iii. Application of herbicide – M_2
iv. Application of water hyacinth – M_3
v. Application of rice straw – M_4

As such there were 10 (2 × 5) treatment combinations viz. V_1M_0, V_1M_1, V_1M_2, V_1M_3, V_1M_4, V_2M_0, V_2M_1, V_2M_2, V_2M_3 and V_2M_4.

3.3.2 Experimental design and layout

The experiment was laid out in Split-plot design with three replications. The layout of the experiment was prepared for distributing the combination of variety and weed management. There were 10 plots of size 4 m × 3 m in each of 3 replications. The treatments of the experiment was assigned at random into each replication following the experimental design where variety was in main plot and weed management in sub-plot.

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seeds of the test crop i.e. BRRI dhan29 and Hira 1 was collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur and Hira from Local market**.**

3.4.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.4.1.3 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on December 05, 2008 in order to transplant the seedlings in the main field.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of January 2009 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

The fertilizers N, P, K, S and B in the form of urea, TSP, MoP, Gypsum and borax, respectively were applied. The entire amount of TSP, MoP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in three equal installments at post recovery, tillerings and before panicle initiation stage. The dose and method of application are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (kg/ha)	Application (%)			
		Basal	1st installment	2nd installment	3rd installment
Urea	150	0	33.33	33.33	33.33
TSP	100	100	--	--	
MoP	100	100	--	--	
Gypsum	60	100	--	--	
Borax	10	100	--	--	

Source: Adunik Dhaner Chash (BRRI, 2010), Joydebpur, Gazipur

3.4.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on January 14, 2009 without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on January 15, 2009 and the rice seedlings were transplanted in lines each having a line to line distance of 25 cm and plant to plant distance 15 cm in the well prepared plot.

3.4.6 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

3.4.6.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.4.6.2 Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.4.6.3 Weeding

Weed samples are collected from 1 m^2 area of each plot at 25 and 65 DAT from where weed population and dry weights were measured.

3.4.6.4 Top dressing

The urea fertilizer was top-dressed in 3 equal installments at 10 days after transplanting at tillering stage and before panicle initiation stage.

3.5 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The BRRI dhan29 was harvested on 13th May, 2009 and Hira 1 on 2nd May, 2009. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data recording

The following data were collected during the study period:

3.6.1 Data regarding weed

1. Weed population
2. Dry weight of weed biomass
3. Weed control efficiency

3.6.2 Data regarding yield contributing characters and yield of rice

1. Plant height
2. Number of tillers hill^{-1}
3. Dry matter hill^{-1}
4. Effective tillers hill^{-1}
5. Non-effective tillers hill^{-1}
6. Total tillers hill^{-1}
7. Length of panicle
8. Filled grain panicle^{-1}
9. Unfilled grains panicle^{-1}
10. Total grains panicle^{-1}
11. Weight of 1000 grains
12. Grain yield
13. Straw yield

14. Biological yield

15. Harvest index

3.6.1.1 Weed population

From the $1m^2$ area of every plot, the total weeds were uprooted and counted.

3.6.1.2 Dry weight of weed biomass

The fresh weight of weeds from $1m^2$ area of each plot was weighed and oven dried at 80^0C. The sample was then transferred into desiccators and allowed to cool down to the room temperature and then final weight of the sample was taken.

3.6.1.3 Weed control efficiency

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

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

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

3.6.2 Yield contributing characters and yield of rice

3.6.2.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90 DAT (days after transplanting) and at harvest. Data were recorded as the average of same 5 plants pre selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.6.2.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 30, 50,70 and 90 DAT by counting total tillers as the average of same 5 hills pre selected at random from the inner rows of each plot.

3.6.2.3 Dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 30, 50, 70, 90 DAT and at harvest by drying plant sample. Data were recorded as the average of 3 sample hill plot^{-1} selected at random from the outer rows of each plot leaving the boarder line and expressed in gram.

3.6.2.4 Effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing hill plant^{-1}. Data on effective tillers hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.2.5 Non-effective tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of non panicle bearing tillers plant^{-1}. Data on non effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.2.6 Total tillers hill^{-1}

The total tillers hill^{-1} was calculated by adding effective and non-effective tillers hill^{-1} and average value was recorded.

3.6.2.7 Length of panicle

The length of panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.6.2.8 Filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains panicle^{-1} was recorded.

3.6.2.9 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot and then average number of unfilled grains panicle^{-1} was recorded.

3.6.2.10 Total grains panicle^{-1}

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.6.2.11 Weight of 1000 grains

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.6.2.12 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The central 6 lines from each plot were harvested, threshed, dried, weighed and finally converted to t ha^{-1} basis.

3.6.2.13 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 6 lines were harvested, threshed, dried and weighed and finally converted to t ha^{-1} basis.

3.6.2.14 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6.2.15 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

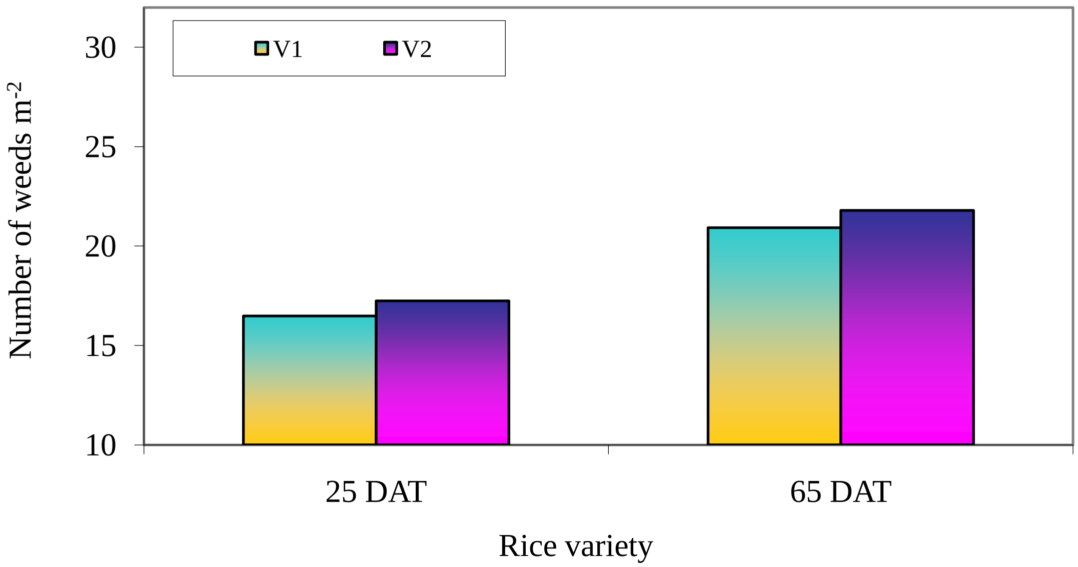
The experiment was conducted to study the growth and yield of *Boro* rice as affected by weed management. Data on weed population, dry weight of weed, different yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-IX. The results have been presented with the help of Tables and Graphs and possible interpretations given under the following headings:

4.1 Weed control

4.1.1 Weed Population

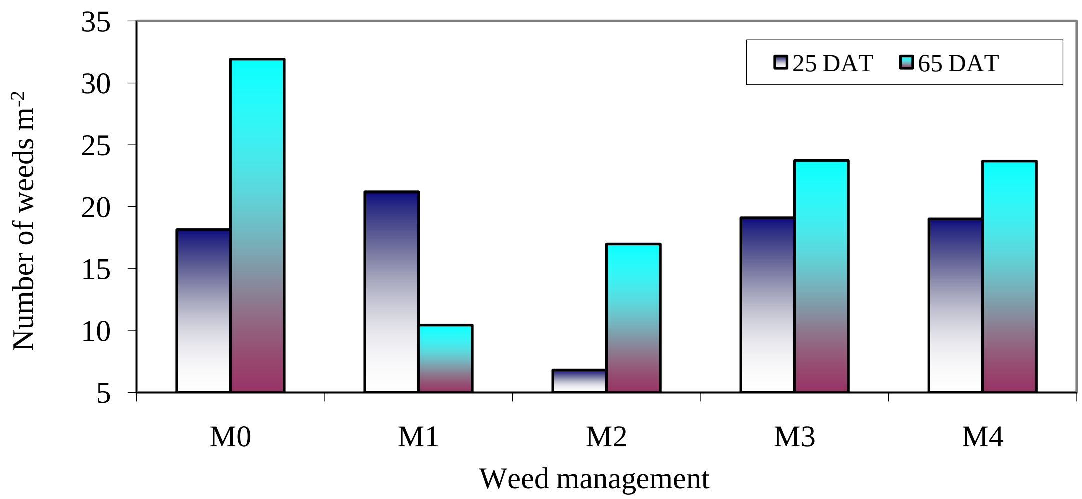
Weed population varied considerably due to BRRI dhan29 and Hira 1 (Appendix III). At 25 DAT, it was found that the higher numbers of weeds (17.24 m^{-2}) were found in the Hira 1 cultivated plot (Figure 1) whereas the lower number (16.48 m^{-2}) was recorded in BRRI dhan29. At 65 DAT, it was found that the maximum numbers of weeds (21.79 m^{-2}) were found in the Hira 1 cultivated plot (Figure 1), while the lower number (20.92 m^{-2}) was recorded in BRRI dhan29. Ashraf *et al*. (2006) reported that maximum control of weeds was 94.67% in the case of hand weeding.

Weed population also varied significantly due to different weed management (Appendix III). At 25 DAT, the lowest weed population (6.81 m^{-2}) was recorded in M_2 (application of herbicide). The highest weed population (21.21 m^{-2}) was found in the M_1 (2 hand weedings) plot which was closely followed



V_1: BRRI dhan29 V_2: Hira 1

Figure 1. Effect of different r ice variety on weed population Boro rice (SE = 0.326 and 0.512 for 25 and 65 DAT respectively)



M_0: No weeding M_1: 2 hand weedings
M_2: Application of herbicide M_3: Application of water hyacinth
M_4: Application of rice straw

Figure 2. Effect of weed management on weed population Boro rice (SE = 1.428 and 0.992 for 25 and 65 DAT respectively)

(19.11 m^{-2}, 19.02 m^{-2} and 18.15 m^{-2}) by M_3 (application of water hyacinth), M_4 (application of rice straw) and M_0 (no weeding). At 65 DAT, the lowest weed population (10.44 m^{-2}) was recorded in M_1 (2 hand weedings), while the highest weed population (31.93 m^{-2}) was found in the M_0 (no weeding) plot (Figure 2).

There was significant effect on weed population by the interaction effect of variety and weed management (Appendix III). At 25 DAT, the highest (21.54 m^{-2}) weed population (21.54 m^{-2}) was observed in V_2M_1 (Hira 1 with 2 hand weedings which was 21.57% higher than the lowest (6.70 m^{-2}) population observed in V_1M_2 (BRRI dhan29 with herbicide application) (Table 2). There was no significant variation of weed population observed between V_2M_1 and V_1M_1 as well as V_1M_2 and V_2M_2. At 65 DAT, the maximum weed population (31.79 m^{-2}) was observed in V_2M_0 (Hira 1 with no weeding) that similar to V_1M_0 (BRRI dhan29 with no weeding) and the lowest weed population (15.85 m^{-2}) was in V_1M_2 (BRRI dhan29 with herbicide application).

4.1.2 Dry weight of weed biomass

Dry weight of weed biomass varied considerably due to varieties (BRRI dhan29 and Hira 1) (Appendix III). At 25 DAT, it was found that the higher weight of weed biomass (1.60 g m^{-2}) were found in the Hira 1 cultivated plot (Figure 3) whereas the lower weight (1.37 g m^{-2}) was recorded in BRRI dhan29. At 65 DAT, it was found that the highest weed biomass (1.56 g m^{-2}) were found in the Hira 1 cultivated plot (Figure 3), while the lowest weight (1.47 g m^{-2}) was recorded in BRRI dhan29.

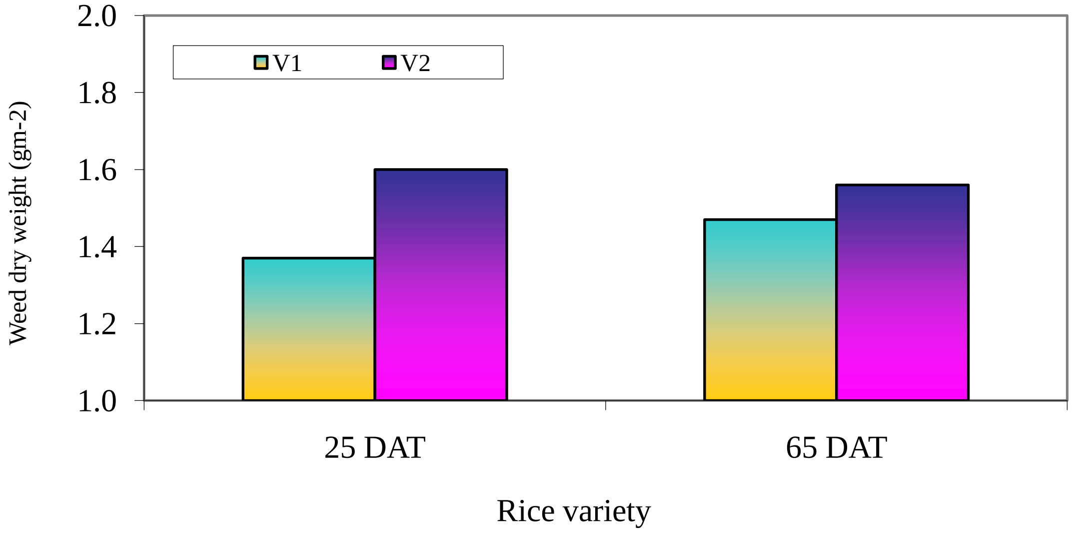
Table 2. Interaction effect of variety and weed management on weed population, dry weight of weed biomass and weed control efficiency of *Boro* rice

Treatments	Weed Population/m^2 at		Dry weight of weed biomass (g m^{-2}) at		Weed control efficiency (%) at	
	25 DAT	65 DAT	25 DAT	65 DAT	25 DAT	65 DAT
V_1M_0	17.87 e	32.08 a	1.53 bc	1.69 ab	0.00	0.00
V_1M_1	20.88 a	9.95 g	1.20 f	1.22 f	21.57	27.81
V_1M_2	6.70 f	15.85 e	1.39 de	1.54 cd	9.15	8.88
V_1M_3	18.20 de	23.46 c	1.41 cde	1.48 cd	7.84	12.43
V_1M_4	18.77 cd	23.29 c	1.33 e	1.44 de	13.07	14.79
V_2M_0	18.43 de	31.79 a	1.61 b	1.76 a	-5.23	-4.14
V_2M_1	21.54 a	10.94 f	1.78 a	1.36 e	-16.34	19.53
V_2M_2	6.92 f	18.13 d	1.52 bc	1.59 bc	0.65	5.92
V_2M_3	20.02 b	24.00 b	1.62 b	1.56 cd	-5.88	7.69
V_2M_4	19.28 c	24.08 b	1.45 cd	1.54 cd	5.23	8.88
SE	0.235	0.172	0.038	0.035	--	--
CV(%)	6.42	9.39	8.47	7.99	--	--

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

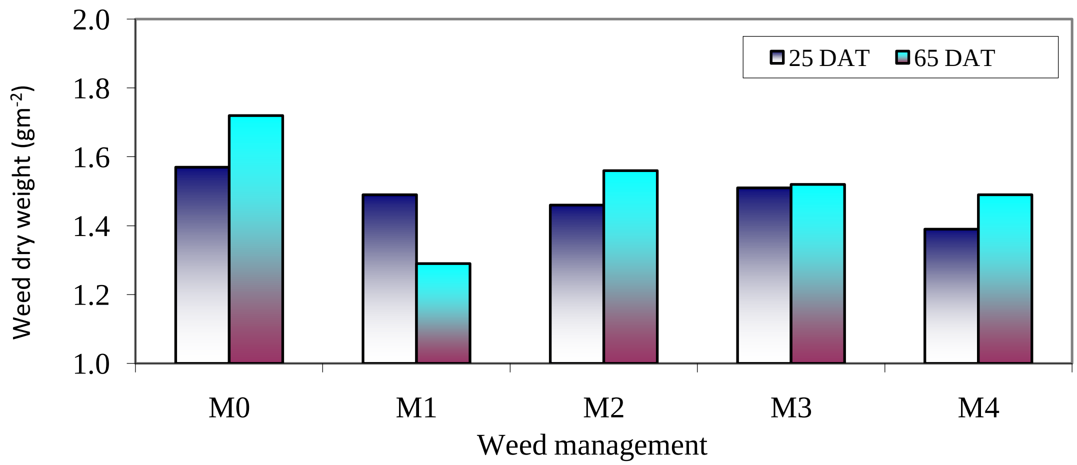
V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw



V_1: BRRI dhan29 V_2: Hira 1

Figure 3. Effect of different rice variety on weed dry weight Boro rice (SE =0.451 and 1.291 for 25 and 65 DAT respectively)



M_0: No weeding M_1: 2 hand weedings
M_2: Application of herbicide M_3: Application of water hyacinth

Figure 4. Effect of weed management on weed dry weight in Boro rice (SE = 1.917 and 1.981 for 25 and 65 DAT respectively)

Dry weight of weed biomass also varied significantly due to different weed management (Appendix III). At 25 DAT, the lowest dry weight of weed biomass (1.51 g m^{-2}) was recorded in M_4 (application of rice straw) and the highest weed biomass (1.57 g m^{-2}) in M_0 (no weeding) plot. At 65 DAT, the lowest weight of weed biomass (1.29 g m^{-2}) was recorded in M_1 (2 hand weedings), while the highest weight (1.72 g m^{-2}) in M_0 (no weeding) plot (Figure 4). Manish *et al*. (2006) recorded maximum dry matter were recorded in the unweeded control, while the minimum values were obtained with hand weeding at 15 and 30 0 DAT.

There was significant effect on weed biomass by the interaction effect of variety and weed management (Appendix III). At 25 DAT, the highest (1.78 g m^{-2}) weed biomass was observed in V_2M_1 (Hira 1 with 2 hand weedings and lowest weight (1.20 g m^{-2}) observed in V_1M_1 (BRRI dhan29 with 2 hand weedings. At 65 DAT, the highest weed biomass (1.76 g m^{-2}) was observed in V_2M_0 (Hira 1 with no weeding) that similar to V_1M_0 (Table 2), while the lowest weed dry weight (1.22 g m^{-2}) in V_1M_1 (BRRI dhan29 with 2 hand weedings) plots.

4.1.3 Weed control efficiency

The weed control efficiency indicates the percentage of weed in comparison to control. Table 2 indicates that at 25 DAT, the highest (21.57%) weed control efficiency in V_1M_1 (BARI dhan 29 with 2 hand weedings), while the lowest with negative (16.34%) efficiency recorded in V_2M_1 (Hira 1 with 2 hand weedings). At 65 DAT, the highest (27.81%) weed control efficiency was recorded in V_1M_1, while the lowest with negative (-4.14%) was recorded in V_2M_0).

4.2 Yield contributing characters and yield of rice

4.2.1 Plant height

Plant height varied significantly at 30, 50, 70, 90 DAT and at harvest of BRRI dhan29 and Hira 1 under the present trial (Appendix IV). At 30, 50, 70, 90 DAT and at harvest the taller plant (22.83 cm, 29.37 cm, 43.13 cm, 58.16 cm and 82.92 cm, respectively) was recorded from V_2 (Hira 1), whereas the shorter plant (21.68 cm, 28.14 cm, 41.80 cm, 55.82 cm and 81.79 cm) from V_1 (BRRI dhan29) (Figure 5). Different varieties produced longest or smallest plant on the basis of their varietal characters.

Different weed management showed significant variation on plant height at 30, 50, 70, 90 DAT and at harvest (Appendix IV). At 30, 50, 70, 90 DAT and at harvest, the tallest plant (25.06 cm, 32.08 cm, 45.53 cm, 63.18 cm and 89.65 cm, respectively) was observed from M_1 (2 hand weedings), which was closely followed (23.71 cm, 30.90 cm, 44.12 cm, 61.30 cm and 87.78 cm) by M_2 (application of herbicide), while the shortest plant (19.90 cm, 25.53 cm, 39.12 cm, 50.37 cm and 74.58 cm, respectively) from M_0 (no weeding) (Figure 6).

Interaction effect of variety and weed management showed significant differences on plant height at 30, 50, 70, 90 DAT and at harvest (Appendix IV). At 30, 50, 70, 90 DAT and at harvest the tallest plant (25.31 cm, 32.40 cm, 46.03 cm, 65.20 cm and 89.80 cm, respectively) was observed from V_2M_1 (Hira 1 + 2 hand weedings), while the shortest (18.67 cm, 24.80 cm, 38.35 cm, 49.60 cm and 74.53 cm, respectively) from V_1M_0 (BRRI dhan29 + no weeding) (Table 3).

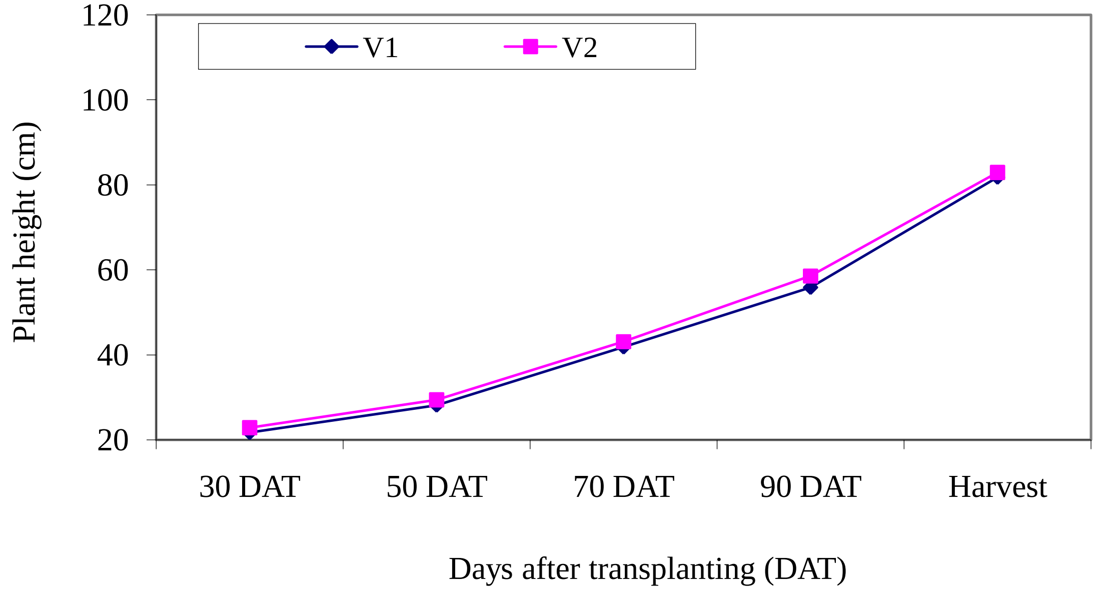
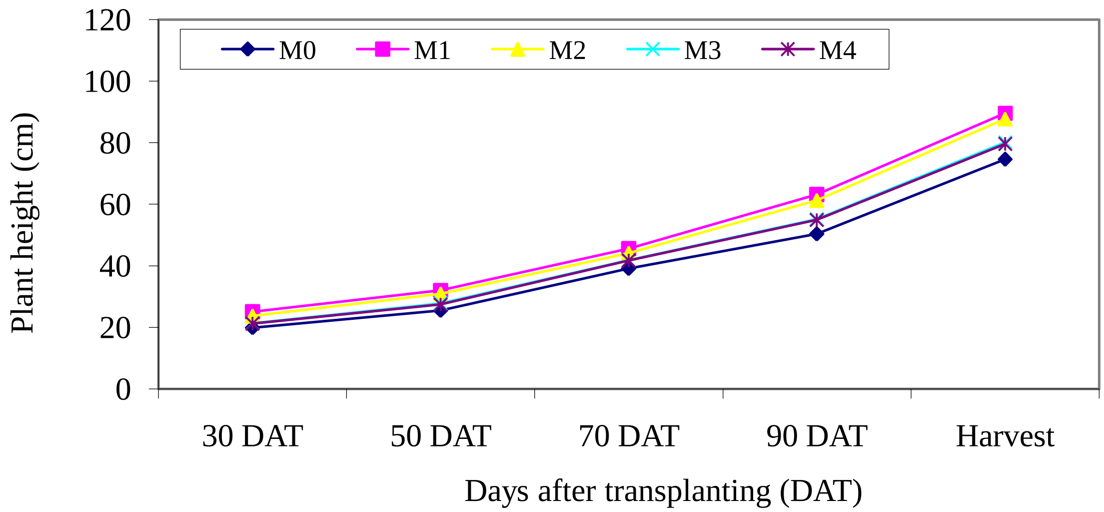


Figure 5. Effect of different rice variety on plant height in Boro rice (SE = 0.160,0.186,0.145,0.295 and 0.119 for 30,50,70,90 and harvest respectively)



M_0: No weeding M_1: 2 hand weedings
M_2: Application of herbicide M_3: Application of water hyacinth
M_4: Application of rice straw

Figure 6. Effect of different weed management on plant height in Boro rice (SE = 0.198,0.234,0.268,0.316 and 0.335 for 30,50,70,90 and harvest respectively)

Table 3. Interaction effect of variety and weed management on plant height of *Boro* rice

Treatments	Plant height (cm) at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
V_1M_0	18.67 e	24.80 g	38.35 g	49.60 f	74.53 e
V_1M_1	24.82 a	31.76 ab	45.03 ab	61.16 b	89.50 a
V_1M_2	23.47 b	30.50 c	44.00 bc	60.77 b	86.77 b
V_1M_3	20.80 d	26.40 f	40.33 ef	54.10 d	78.67 d
V_1M_4	20.63 d	27.23 ef	41.28 de	53.49 d	79.17 d
V_2M_0	21.13 cd	26.27 f	39.89 f	51.13 e	74.63 e
V_2M_1	25.31 a	32.40 a	46.03 a	65.20 a	89.80 a
V_2M_2	23.96 b	31.29 bc	44.23 bc	61.84 b	88.80 a
V_2M_3	21.93 c	29.13 d	43.33 c	56.15 c	81.70 c
V_2M_4	21.83 c	27.77 e	42.15 d	56.50 c	79.97 d
SE	0.281	0.330	0.379	0.447	0.474
CV)%)	6.18	7.99	5.55	9.36	6.00

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

4.2.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} varied significantly at 30, 50, 70 and 90 DAT of BRRI dhan29 and Hira 1 under the present trial (Appendix V). At 30, 50, 70 and 90 DAT the higher number of tillers hill^{-1} (5.78, 10.92, 20.53 and 16.98, respectively) was recorded from V_2 (Hira 1), whereas the lower number (5.54, 10.11, 19.25 and 15.65, respectively) from V_1 (BRRI dhan29) (Table 4).

Different weed management showed significant differences on number of tillers hill^{-1} at 30, 50, 70 and 90 DAT (Appendix V). At 30, 50, 70 and 90 DAT, the highest number of tillers hill^{-1} (6.27, 12.32, 23.60 and 19.12, respectively) was observed from M_1 (2 hand weedings), which was closely followed (5.84, 11.10, 21.55 and 18.27) by M_2 (application of herbicide), while the lowest number (4.85, 7.60, 14.15 and 11.43, respectively) from M_0 (no weeding) (Table 4). Biswas *et al*. (1991) evaluated that Oxadiazon 1.0 and 0.5 kc, a.i. ha^{-1} applied at 30 days after sowing with or without one supplemental hand weeding was compared with normal hand weeding and the results indicated that the use of Oxadiazon at 0.5 kg a.i. ha^{-1} was more economic than hand weeding for production of tillers.

Interaction effect of variety and weed management showed significant differences on number of tillers hill^{-1} at 30, 50, 70 and 90 DAT (Appendix V). At 30, 50, 70 and 90 DAT the highest number of tillers hill^{-1} (6.46, 12.73, 24.70 and 19.87, respectively) was observed from V_2M_1 (Hira 1 + 2 hand weedings), while the lowest (4.73, 7.20, 13.67 and 10.90, respectively) from V_1M_0 (BRRI dhan29 + no weeding) (Table 5).

Table 4. Effect of variety and weed management on number of tillers hill^{-1} of *Boro* rice

Treatments	Number of tillers hill^{-1} at			
	30 DAT	50 DAT	70 DAT	90 DAT
Variety				
V_1	5.54 b	10.11 b	19.25 b	15.65 b
V_2	5.78 a	10.92 a	20.53 a	16.98 a
SE	0.014	0.090	0.128	0.066
Weed Management				
M_0	4.85 d	7.60 c	14.15 d	11.43 d
M_1	6.27 a	12.32 a	23.60 a	19.12 a
M_2	5.84 b	11.10 b	21.55 b	18.27 b
M_3	5.70 c	10.83 b	20.33 c	16.52 c
M_4	5.65 c	10.73 b	19.83 c	16.23 c
SE	0.032	0.153	0.276	0.115
CV(%)	8.39	7.57	9.40	5.73

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29

V_2: Hira 1

M_0: No weeding

M_1: 2 hand weedings

M_2: Application of herbicide

M_3: Application of water hyacinth

M_4: Application of rice straw

Table 5. Effect of variety and weed management on number of tillers $hill^{-1}$ of *Boro* rice

Treatments	Number of tillers $hill^{-1}$ at			
	30 DAT	50 DAT	70 DAT	90 DAT
V_1M_0	4.73 h	7.20 f	13.67 g	10.90 h
V_1M_1	6.09 b	11.90 b	22.50 b	18.37 b
V_1M_2	5.74 de	10.97 c	21.20 cd	17.73 c
V_1M_3	5.64 ef	9.93 d	19.83 ef	15.90 e
V_1M_4	5.51 f	10.57 cd	19.07 f	15.33 f
V_2M_0	4.97 g	8.00 e	14.63 g	11.97 g
V_2M_1	6.46 a	12.73 a	24.70 a	19.87 a
V_2M_2	5.93 c	11.23 bc	21.90 bc	18.80 b
V_2M_3	5.76 de	11.73 b	20.83 cde	17.13 d
V_2M_4	5.78 d	10.90 c	20.60 de	17.13 d
SE	0.046	0.217	0.391	0.163
CV(%)	8.39	7.57	9.40	5.73

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

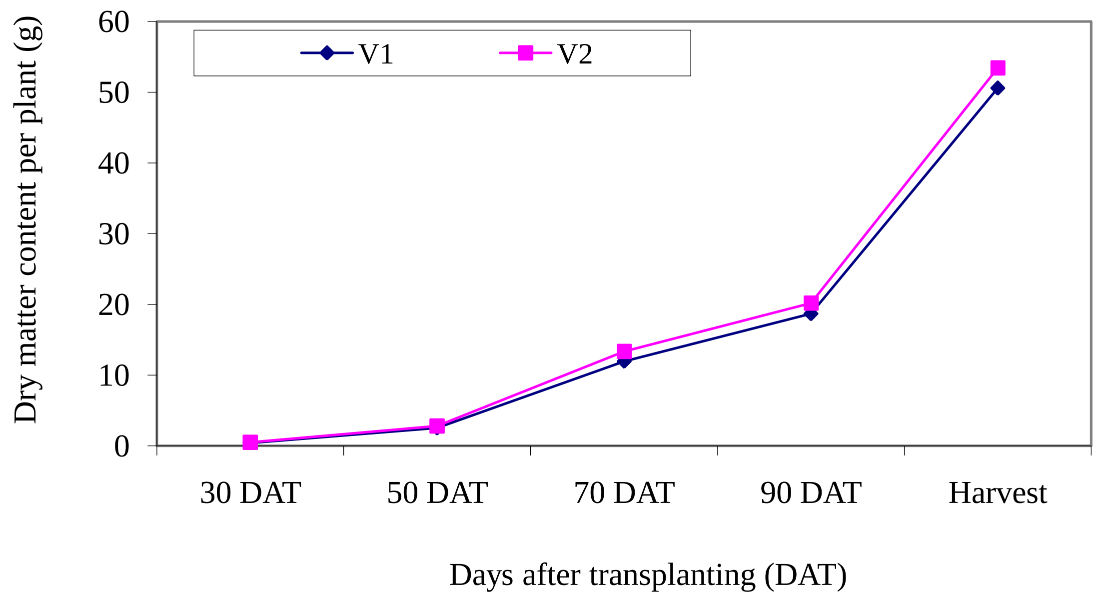
M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

4.2.3 Dry matter content hill^{-1}

Dry matter content hill^{-1} varied significantly at 30, 50, 70, 90 DAT and at harvest of BRRI dhan29 and Hira 1 (Appendix VI). At 30, 50, 70, 90 DAT and harvest the higher dry matter content hill^{-1} (0.498 g, 2.81 g, 13.33 g, 20.16 g and 53.43 g, respectively) was recorded from V_2 (Hira 1), whereas the lower (0.430 g, 2.52 g, 11.96 g, 18.68 g and 50.58 g) from V_1 (BRRI dhan29) (Figure 7). Amin *et al.* (2006) reported the variation of dry matter amoung different rice varieties.

Different weed management showed significant variation on dry matter content hill^{-1} at 30, 50, 70, 90 DAT and at harvest (Appendix VI). At 30, 50, 70, 90 DAT and at harvest, the highest dry matter content hill^{-1} (0.550 g, 3.55 g, 15.62 g, 22.79 g and 57.50 g, respectively) was observed from M_1 (2 hand weedings), which was closely followed (0.495 g, 2.95 g, 13.77 g, 22.59 g and 55.05 g) by M_2 (application of herbicide), while the lowest dry matter content hill^{-1} (0.323 g, 1.51 g, 9.09 g, 14.51 g and 41.99 g, respectively) was recorded from M_0 (no weeding) (Figure 8).

Interaction effect of variety and weed management showed significant differences on dry matter content hill^{-1} at 30, 50, 70, 90 DAT and at harvest (Appendix VI). At 30, 50, 70, 90 DAT and at harvest the highest dry matter content hill^{-1} (0.585 g, 3.92 g, 16.65 g, 23.78 g and 58.62 g, respectively) was observed from V_2M_1 (Hira 1 + 2 hand weedings), while the lowest (0.286 g, 1.43 g, 8.33 g, 14.04 g and 40.81 g, respectively) from V_1M_0 (BRRI dhan29 + no weeding) (Table 6).



V_1: BRRI dhan29 V_2: Hira 1

Figure 7. Effect of different rice variety on dry matter content per plant in Boro rice (SE = 0.008,0.051,0.610,0.139 and 0.415 for 30,50,70,90 DAT and harvest respectively)

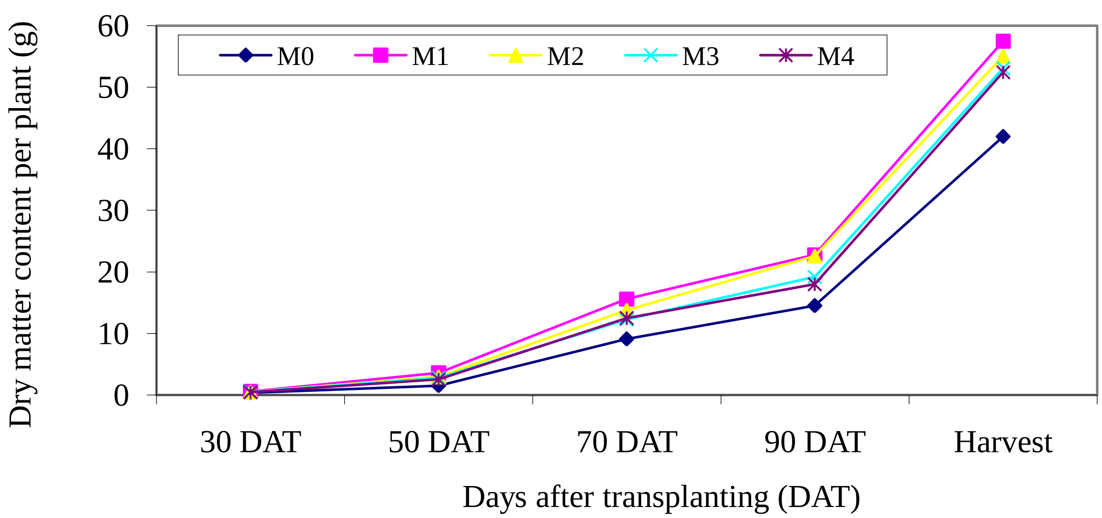


Figure 8. Effect of different weed management on dry matter content per plant in Boro rice (SE = 0.004,0.047,0.129,0.285 and 0.455 for 30,50,70,90 DAT and harvest respectively)

Table 6. Effect of variety and weed management on dry matter content hill^{-1} of *Boro* rice

Treatments	Dry matter content hill^{-1} at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
V_1M_0	0.286 f	1.43 e	8.33 g	14.04 e	40.81 e
V_1M_1	0.515 b	3.18 b	14.60 b	21.80 b	56.38 b
V_1M_2	0.468 c	2.83 c	13.29 c	22.26 b	54.31 b
V_1M_3	0.455 c	2.70 c	11.41 e	17.92 d	51.24 c
V_1M_4	0.428 d	2.44 d	12.19 d	17.39 d	50.18 c
V_2M_0	0.360 e	1.59 e	9.85 f	14.97 e	43.17 d
V_2M_1	0.585 a	3.92 a	16.65 a	23.78 a	58.62 a
V_2M_2	0.522 b	3.08 b	14.26 b	22.92 ab	55.78 b
V_2M_3	0.512 b	2.79 c	13.16 c	20.49 c	54.85 b
V_2M_4	0.512 b	2.66 c	12.72 cd	18.63 d	54.75 b
SE	0.007	0.065	0.182	0.403	0.643
CV(%)	7.61	8.24	10.49	6.60	7.14

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29

V_2: Hira 1

M_0: No weeding

M_1: 2 hand weedings

M_2: Application of herbicide

M_3: Application of water hyacinth

M_4: Application of rice straw

4.2.4 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} at harvest varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VII). The higher number of effective tillers hill^{-1} (12.58) was recorded from V_2 (Hira 1), whereas the lower number (11.69) from V_1 (BRRI dhan29) (Table 7).

Different weed management showed significant differences on number of effective tillers hill^{-1} at harvest (Appendix VII). The highest number of effective tillers hill^{-1} (13.72) was observed from M_1 (2 hand weedings), which was closely followed (13.18) by M_2 (application of herbicide), while the lowest number (8.98) was recorded from M_0 (no weeding) which was closely followed (12.15) by M_4 (application of rice straw) (Table 7). Biswas *et al*. (1991) evaluated that Oxadiazon 1.0 and 0.5 kc, a.i. ha^{-1} applied at 30 days after sowing with or without one supplemental hand weeding was compared with normal hand weeding and the results indicated that the use of Oxadiazon at 0.5 kg a.i. ha^{-1} was more economic than hand weeding for the production of effective tillers.

Interaction effect of variety and weed management showed significant differences on number of effective tillers hill^{-1} at harvest (Appendix VII). The highest number of effective tillers hill^{-1} (13.93) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (13.50) and V_2M_2 (13.43), while the lowest (8.40) from V_1M_0 (BRRI dhan29 + no weeding) (Table 8).

Table 7. Effect of variety and weed management on number of effective, non effective, total tillers hill^{-1} and length of panicle of *Boro* rice

Treatments	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Length of panicle (cm)
Variety				
V_1	11.69 b	3.34 b	15.03 b	21.72 b
V_2	12.58 a	3.79 a	16.37 a	22.54 a
SE	0.098	0.056	0.142	0.084
Weed Management				
M_0	8.98 e	4.28 a	13.27 c	18.13 d
M_1	13.72 a	2.80 d	16.52 a	24.56 a
M_2	13.18 b	3.35 c	16.53 a	24.18 a
M_3	12.63 c	3.82 b	16.45 a	22.30 b
M_4	12.15 d	3.57 bc	15.72 b	21.48 c
SE	0.139	0.085	0.184	0.196
CV(%)	8.80	5.81	7.86	9.17

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

Table 8. Interaction effect of variety and weed management on number of effective, non effective, total tillers hill^{-1} and length of panicle of *Boro* rice

Treatments	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Length of panicle (cm)
V_1M_0	8.40 f	4.20 a	12.60 g	17.31 e
V_1M_1	13.50ab	2.23 e	15.73 d	24.43 a
V_1M_2	12.93 b	3.23 d	16.17 bcd	23.86 a
V_1M_3	12.20 c	3.60 cd	15.80 cd	21.72 c
V_1M_4	11.40 d	3.43 cd	14.83 e	21.30 c
V_2M_0	9.57 e	4.37 a	13.93 f	18.95 d
V_2M_1	13.93 a	3.37 cd	17.30 a	24.69 a
V_2M_2	13.43 ab	3.47 cd	16.90 ab	24.50 a
V_2M_3	13.07 b	4.03 ab	17.10 a	22.87 b
V_2M_4	12.90 b	3.70 bc	16.60 abc	21.66 c
SE	0.196	0.120	0.260	0.277
CV(%)	8.80	5.81	7.86	9.17

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29

V_2: Hira 1

M_0: No weeding

M_1: 2 hand weedings

M_2: Application of herbicide

M_3: Application of water hyacinth

M_4: Application of rice straw

4.2.5 Number of non-effective tillers hill^{-1}

Number of non-effective tillers hill^{-1} varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VII). The lower number of non-effective tillers hill^{-1} (3.34) was recorded from V_1 (BRRI dhan29), whereas the higher number (3.79) from V_2 (Hira 1) (Table 7). Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

Different weed management showed significant differences on number of non-effective tillers hill^{-1} (Appendix VII). The lowest number of non-effective tillers hill^{-1} (2.80) was observed from M_1 (2 hand weedings), which was closely followed (3.35) by M_2 (application of herbicide), while the highest number (4.28) was recorded from M_0 (no weeding) which was closely followed (3.82 and 3.57) by M_3 (application of water hyacinth) and M_4 (application of rice straw) (Table 7).

Interaction effect of variety and weed management showed significant differences on number of non-effective tillers hill^{-1} (Appendix VII). The lowest number of non-effective tillers hill^{-1} (2.23) was observed from V_1M_1 (BRRI dhan29 + 2 hand weedings), while the highest number (4.37) from V_2M_0 (Hira 1 + no weeding) that similar to V_1M_0 (4.20) and V_2M_3 (4.03) (Table 8).

4.2.6 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VII). The higher number of total tillers hill^{-1}

(16.37) was recorded from V_2 (Hira 1), whereas the lower number (15.03) from V_1 (BRRI dhan29) (Table 7). Hossain and Alam (1991) also found that the growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in *boro* season.

Different weed management showed significant differences on number of total tillers hill^{-1} (Appendix VII). The highest number of total tillers hill^{-1} (16.52) was observed from M_2 (application of herbicide), which was statistically similar (16.52 and 16.45) with M_1 (2 hand weedings) and M_3 (application of water hyacinth) (16.50 and 16.45 respectively) and closely followed (15.72) by M_4 (application of rice straw), whereas the lowest number (13.27) was recorded from M_0 (no weeding) (Table 7).

Interaction effect of variety and weed management showed significant differences on number of total tillers hill^{-1} (Appendix VII). The highest number of total tillers hill^{-1} (17.30) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to all the weed management except M_0 with Hira 1, while the lowest (12.60) from V_1M_0 (BRRI dhan29 + no weeding) (Table 8).

4.2.7 Length of panicle

Length of panicle varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VII). The longer panicle (22.54 cm.37) was recorded from V_2 (Hira 1), whereas the shorter (21.72 cm) from V_1 (BRRI dhan29) (Table 7). BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19 and found that varieties differed significantly on panicle length.

Different weed management showed significant differences on panicle length (Appendix VII). The longest panicle (24.56 cm) was observed from M_1 (2 hand weedings), which was statistically similar (24.18 cm) with M_2 (application of herbicide) and closely followed (22.30 cm) by M_3 (application of water hyacinth), whereas the shortest (18.13 cm) was recorded from M_0 (no weeding) and closely followed (21.48 cm) by M_4 (application of rice straw) (Table 7).

Interaction effect of variety and weed management showed significant differences on panicle length (Appendix VII). The longest panicle (24.69 cm) was observed from V_2M_1 (Hira 1 + 2 hand weedings), that similar to V_2M_2 (24.50 cm), V_1M_1 (24.43 cm) and V_1M_2 (23.86), while the shortest (17.31 cm) from V_1M_0 (BRRI dhan29 + no weeding) (Table 8).

4.2.8 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VIII). The higher number of filled grains plant^{-1} (83.73) was recorded from V_2 (Hira 1), whereas the lower number (80.93) from V_1 (BRRI dhan29) (Table 9). Ahmed *et al.* (1997) found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Different weed management showed significant differences on number of filled grains panicle^{-1} (Appendix VIII). The highest number of filled grains panicle^{-1}

(93.35) was observed from M_1 (2 hand weedings), which was closely followed (90.67) by M_2 (application of herbicide), while the lowest number (64.98) was recorded from M_0 (no weeding) which was closely followed (76.45) by M_4 (application of rice straw) (Table 9).

Interaction effect of variety and weed management showed significant differences on number of filled grains panicle^{-1} (Appendix VIII). The highest number of filled grains panicle^{-1} (93.73) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (92.97) and V_2M_2 (91.40), while the lowest (64.00) from V_1M_0 (BRRI dhan29 + no weeding) that similar to V_2M_0 (65.97) (Table 10).

4.2.9 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VIII). The lower number of unfilled grains panicle^{-1} (7.33) was recorded from V_2 (Hira 1), whereas the higher number (8.47) from V_1 (BRRI dhan29) (Table 9). BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19 and found that varieties differed significantly on sterile spikelets panicle^{-1}.

Different weed management showed significant differences on number of unfilled grains panicle^{-1} (Appendix VIII). The lowest number of unfilled grains panicle^{-1} (4.72) was observed from M_1 (2 hand weedings), which was closely followed (6.33) by M_2 (application of herbicide), while the highest number (12.27) was recorded from M_0 (no weeding) which was closely followed (8.57) by M_3 (application of water hyacinth) (Table 9).

Table 9. Effect of variety and weed management on number of filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of *Boro* rice

Treatments	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000 grains (g)
Variety				
V_1	80.93 b	8.47 a	89.40 a	21.07 b
V_2	83.73 a	7.33 b	91.06 a	21.33 a
SE	0.228	0.071	0.297	0.043
Weed Management				
M_0	64.98 e	12.27 a	77.25 d	19.45 d
M_1	93.35 a	4.72 e	98.07 a	22.29 a
M_2	90.67 b	6.33 d	97.00 a	21.70 b
M_3	86.22 c	8.57 b	94.78 b	21.32 c
M_4	76.45 d	7.60 c	84.05 c	21.25 c
SE	0.630	0.144	0.635	0.067
CV(%)	5.87	11.48	6.72	5.77

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

Table 10. Interaction effect of variety and weed management on number of filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of *Boro* rice

Treatments	Filled grains panicle^{-1}(No.)	Unfilled grains panicle^{-1}(No.)	Total grains panicle^{-1}(No.)	Weight of 1000 grains (g)
V_1M_0	64.00 f	13.80 a	77.80 e	19.40 d
V_1M_1	92.97 a	4.90 g	97.87 a	22.23 a
V_1M_2	89.93 b	6.57 f	96.50 a	21.60 b
V_1M_3	83.03 c	9.17 c	92.20 b	21.10 c
V_1M_4	74.73 e	7.90 de	82.63 d	21.00 c
V_2M_0	65.97 f	10.73 b	76.70 e	19.50 d
V_2M_1	93.73 a	4.53 g	98.27 a	22.34 a
V_2M_2	91.40 ab	6.10 f	97.50 a	21.80 b
V_2M_3	89.40 b	7.97 d	97.37 a	21.53 b
V_2M_4	78.17 d	7.30 e	85.47 c	21.50 b
SE	0.891	0.204	0.897	0.094
CV(%)	5.87	11.48	6.72	5.77

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

Interaction effect of variety and weed management showed significant differences on number of unfilled grains panicle^{-1} (Appendix VIII). The lowest number of unfilled grains panicle^{-1} (4.53) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (4.90), while the highest number (13.80) from V_1M_0 (BRRI dhan29 + no weeding) (Table 10).

4.2.10 Number of total grains panicle^{-1}

Number of total grains plant^{-1} varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VIII). The higher number of total grains panicle^{-1} (91.06) was recorded from V_2 (Hira 1), whereas the lower number (89.40) from V_1 (BRRI dhan29) (Table 9).

Different weed management showed significant differences on number of total grains panicle^{-1} (Appendix VII). The highest number of total grains panicle^{-1} (98.07) was observed from M_1 (2 hand weedings), which was statistically identical (97.00) by M_2 (application of herbicide) and closely followed (94.78) by M_3 (application of water hyacinth), while the lowest number (77.25) was recorded from M_0 (no weeding) which was closely followed (84.05) by M_4 (application of rice straw) (Table 9).

Interaction effect of variety and weed management showed significant differences on number of total grains panicle^{-1} (Appendix VII). The highest number of total grains panicle^{-1} (98.27) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (97.87), V_2M_2 (97.50), V_1M_2 (96.50), while the lowest (76.70) from V_2M_0 (Hira 1 + no weeding) that similar to V_1M_0 (Table 10).

4.2.11 Weight of 1000 grains

Weight of 1000 grains varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix VIII). The higher weight of 1000 grains (21.33 g) was recorded from V_2 (Hira 1), whereas the lower weight (21.07 g) from V_1 (BRRI dhan29) (Table 9).

Different weed management showed significant differences on weight of 1000 grains (Appendix VII). The highest weight of 1000 grains (22.29 g) was observed from M_1 (2 hand weedings), which was closely followed (21.70 g) by M_2 (application of herbicide), while the lowest weight (19.45 g) was recorded from M_0 (no weeding) which was closely followed (21.32 g and 21.25 g) by M_4 (application of rice straw) and M_3 (application of water hyacinth), respectively and they were statistically similar (Table 9).

Interaction effect of variety and weed management showed significant differences on weight of 1000 grains (Appendix VIII). The highest weight of 1000 seeds (22.34 g) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (22.23 g), while the lowest weight (19.40 g) from V_1M_0 (BRRI dhan29 + no weeding) that similar to V_2M_0 (19.50 g) (Table 10).

4.2.12 Grain yield

Grain yield varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix IX). The higher grain yield (6.62 t/ha) was recorded from V_2 (Hira 1), whereas the lower yield (6.04 t/ha) from V_1 (BRRI dhan29) (Table 11). Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than

IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains $panicle^{-1}$ and greater seed weight.

Different weed management showed significant differences on grain yield (Appendix IX). The highest grain yield (7.56 t/ha) was observed from M_1 (2 hand weedings), which was closely followed (7.07 t/ha) by M_2 (application of herbicide), while the lowest grain yield (3.84 t/ha) was recorded from M_0 (no weeding) which was closely followed (6.49 t/ha) by M_4 (application of rice straw) (Table 11). Ashraf *et al*. (2006) reported that terms of paddy yield, hand weeding gave the highest grain yield but remained statistically at par with certain herbicides. Baloch *et al*. (2006) obtained the maximum paddy yield in hand weeding, closely followed by Butachlor (Machete 60EQ during both cropping seasons. Singh *et al*. (1999) reported that weed 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.

Interaction effect of variety and weed management showed significant differences on grain yield (Appendix IX). The highest grain yield (7.71 t/ha) was observed from V_2M_1 (Hira 1 + 2 hand weedings), while the lowest yield (3.56 t/ha) from V_1M_0 (BRRI dhan29 + no weeding) (Table 12).

Table 11. Effect of variety and weed management on grain, straw and biological yield and harvest index of *Boro* rice

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Variety				
V_1	6.04 b	6.33 b	12.37 b	48.57
V_2	6.62 a	6.76 a	13.39 a	49.26
SE	0.054	0.049	0.026	0.423
Weed Management				
M_0	3.84 e	4.53 e	8.37 e	45.79 d
M_1	7.56 a	7.78 a	15.35 a	49.29 b
M_2	7.07 b	7.53 b	14.60 b	48.41 c
M_3	6.69 c	6.60 c	13.29 c	50.35 a
M_4	6.49 d	6.30 d	12.79 d	50.74 a
SE	0.060	0.068	0.110	0.285
CV(%)	7.31	6.53	9.08	8.42

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29

V_2: Hira 1

M_0: No weeding

M_1: 2 hand weedings

M_2: Application of herbicide

M_3: Application of water hyacinth

M_4: Application of rice straw

Table 12. Effect of variety and weed management on grain, straw and biological yield and harvest index of of *Boro* rice

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
V_1M_0	3.56 h	4.34 h	7.90 h	45.08 g
V_1M_1	7.42 b	7.66 ab	15.08 b	49.19 cde
V_1M_2	6.90 d	7.46 b	14.36 c	48.06 e
V_1M_3	6.29 e	6.25 e	12.54 e	50.16 abc
V_1M_4	6.02 f	5.94 f	11.96 f	50.34 abc
V_2M_0	4.11 g	4.73 g	8.84 g	46.51f
V_2M_1	7.71 a	7.90 a	15.61 a	49.38 bcd
V_2M_2	7.23 bc	7.60 b	14.83 b	48.76 de
V_2M_3	7.09 cd	6.94 c	14.03 cd	50.53 ab
V_2M_4	6.96 d	6.65 d	13.62 d	51.14 a
SE	0.085	0.096	0.155	0.402
CV(%)	7.31	6.53	9.08	8.42

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BRRI dhan29
V_2: Hira 1

M_0: No weeding
M_1: 2 hand weedings
M_2: Application of herbicide
M_3: Application of water hyacinth
M_4: Application of rice straw

4.2.13 Straw yield

Straw yield varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix IX). The higher straw yield (6.76 t/ha) was recorded from V_2 (Hira 1), whereas the lower yield (6.33 t/ha) from V_1 (BRRI dhan29) (Table 11). Xu and Wang (2001) evaluated with ten restorer and ten maintainer lines and observed that the restorer lines showed more straw yield than maintainer lines. Rajendra *et al.* (1998) carried out an experiment with hybrid rice cv. Pusa 834 and Pusa HR3 and observed that mean straw yields of Pusa 834 and Pusa HR3 were 3.9 t ha^{-1} and 6.4 t ha^{-1}, respectively.

Different weed management showed significant differences on straw yield (Appendix IX). The highest straw yield (7.78 t/ha) was observed from M_1 (2 hand weedings), which was closely followed (7.53 t/ha) by M_2 (application of herbicide), while the lowest straw yield (4.53 t/ha) was recorded from M_0 (no weeding) which was closely followed (6.30 t/ha) by M_4 (application of rice straw) (Table 11). Moorthy and Das (1992) stated that the paddy wheel hoe use twice resulted in the greatest straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest straw yields (3.54 t ha^{-1}) but the paddy wheel hoe used gave twice higher straw yield (4.68 t ha^{-1}).

Interaction effect of variety and weed management showed significant differences on straw yield (Appendix IX). The highest straw yield (7.90 t/ha) was observed from V_2M_1 (Hira 1 + 2 hand weedings) that similar to V_1M_1 (7.66 t/ha), while the lowest yield (4.34 t/ha) from V_1M_0 (BRRI dhan29 + no weeding) (Table 12).

4.2.14 Biological yield

Biological yield per hectare varied significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix IX). The higher biological yield (13.39 t/ha) was recorded from V_2 (Hira 1), whereas the lower yield (12.37 t/ha) from V_1 (BRRI dhan29) (Table 11).

Different weed management showed significant differences on biological yield per hectare (Appendix IX). The highest biological yield (15.35 t/ha) was observed from M_1 (2 hand weedings), which was closely followed (14.60 t/ha) by M_2 (application of herbicide), while the lowest biological yield (8.37 t/ha) was recorded from M_0 (no weeding) which was closely followed (12.79 t/ha) by M_4 (application of rice straw) (Table 11).

Interaction effect of variety and weed management showed significant differences on biological yield (Appendix IX). The highest biological yield (15.61 t/ha) was observed from V_2M_1 (Hira 1 + 2 hand weedings), while the lowest yield (7.90 t/ha) from V_1M_0 (BRRI dhan29 + no weeding) (Table 12).

4.2.15 Harvest index

Harvest index varied non-significantly for BRRI dhan29 and Hira 1 under the present trial (Appendix IX). The maximum harvest index (49.26%) was recorded from V_2 (Hira 1), whereas the minimum (48.57%) from V_1 (BRRI dhan29) (Table 11).

Different weed management showed significant differences on harvest index (Appendix IX). The maximum harvest index (50.74%) was observed from M_4 (application of rice straw), which was statistically similar (50.35%) by M_3 (application of water hyacinth), while the minimum harvest index (45.79%) was recorded from M_0 (no weeding) which was closely followed (48.41%) by M_2 (application of herbicide) (Table 11). Singh and Kumar (1999) reported that maximum harvest index in the unweeded control in the scented rice variety Pusa Basmati-1.

Interaction effect of variety and weed management showed significant differences on harvest index (Appendix IX). The maximum harvest index (51.14%) was observed from V_2M_4 (Hira 1 + application of rice straw) that similar to V_2M_3 (50.53%), V_1M_4 (50.34%) and V_1M_3 (50.16%), while the minimum (45.08%) from V_1M_0 (BRRI dhan29 + no weeding) (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December, 2008 to May, 2009 to study the growth and yield of *Boro* rice as affected by weed management. The experiment comprised as two factors. Factor A: Variety: 2 levels; BRRI dhan29 – V_1; Hira 1 – V_2; Factor B: Weed management: 5 levels; No weeding – M_0; 2 hand weedings – M_1; Application of herbiside – M_2; Application of water hyacinth – M_3 and Application of rice straw – M_4. The experiment was laid out in Split plot Design with three replications. Significant variation was recorded for data on weed population, dry weight of weed, different yield contributing characters and yield.

At 25 and 65 DAT, it was found that the higher numbers of weeds (17.24 m^{-2} and 21.79 m^{-2}, respectively) were found in the Hira 1 cultivated plot whereas the lower number (16.48 m^{-2} and 20.92 m^{-2}, respectively) was recorded in BRRI dhan29. The higher the maximum weight of weed biomass (1.60 g and 1.56 g m^{-2}) was found in the Hira 1 cultivated plots at 25 and 65 DAT, respectively, whereas the lowest weight (1.37 g and 1.47 g m^{-2}) was recorded in BRRI dhan29.

At 25 DAT, the lowest dry weight of weed biomass (1.51 g m^{-2}) was recorded in M_3 (application of rice straw) and the highest weed biomass (1.59 g m^{-2}) was found in the M_0 plot. At 65 DAT, the lowest weight of weed biomass (1.29 g m^{-2})

was recorded in M_1, while the highest weight (1.72 g m^{-2}) was found in the M_0 plot. At 25 DAT, the lowest weed population (6.81 m^{-2}) was recorded in M_2. The highest weed population (21.21 m^{-2}) was found in the M_1 plot. At 65 DAT, the lowest weed population (10.44 m^{-2}) was recorded in M_1, while the highest weed population (31.93 m^{-2}) was found in the M_0.

At 25 DAT, the maximum (21.54 m^{-2}) weed population was observed in V_2M_1 and the lowest (6.70 m^{-2}) population observed in V_1M_2. At 65 DAT, the maximum (31.79 m^{-2}) weed population was observed in V_2M_0. At 25 DAT, the maximum (1.78 g) weed biomass was observed in V_2M_1 and lowest weight (1.20 g) observed in V_1M_1. At 65 DAT, the maximum (1.76 g) weed biomass was observed in V_2M_0.

At 30, 50, 70, 90 DAT and harvest the taller plant (22.83 cm, 29.37 cm, 43.13 cm, 58.16 cm and 82.92 cm, respectively) was recorded from V_2, whereas the shorter plant (21.68 cm, 28.14 cm, 41.80 cm, 55.82 cm and 81.79 cm) from V_1. At 30, 50, 70 and 90 DAT the maximum number of tillers $hill^{-1}$ (5.78, 10.92, 20.53 and 16.98, respectively) was recorded from V_2, whereas the minimum number (5.54, 10.11, 19.25 and 15.65, respectively) from V_1. At 30, 50, 70, 90 DAT and harvest the higher dry matter content $hill^{-1}$ (0.498 g, 2.81 g, 13.33 g, 20.16 g and 53.43 g, respectively) was recorded from V_2, whereas the lower (0.430 g, 2.52 g, 11.96 g, 18.68 g and 50.58 g) from V_1. The maximum number of effective tillers $hill^{-1}$ (12.58) was recorded from V_2, whereas the minimum number (11.69) from V_1. The minimum number of non-effective tillers $hill^{-1}$ (3.34) was recorded from V_1, whereas the maximum number (3.79) from V_2. The maximum number of total tillers hill^{-1} (16.37) was recorded from V_2, whereas the minimum number (15.03) from V_1. The longer panicle (22.54 cm) was recorded from V_2, whereas the shorter (21.72 cm) from V_1. The maximum number of filled grains panicle^{-1} (83.73) was recorded from V_2, whereas the minimum number (80.93) from V_1. The minimum number of unfilled grains panicle^{-1} (7.33) was recorded from V_2, whereas the maximum number (8.47) from V_1. The maximum number of total grains panicle^{-1} (91.06) was recorded from V_2, whereas the minimum number (89.40) from V_1. The higher weight of 1000 grains (21.33 g) was recorded from V_2, whereas the lower weight (21.07 g) from V_1. The higher grain yield (6.62 t/ha) was recorded from V_2, whereas the lower yield (6.04 t/ha) from V_1. The higher straw yield (6.76 t/ha) was recorded from V_2, whereas the lower yield (6.33 t/ha) from V_1. The higher biological yield (13.39 t/ha) was recorded from V_2, whereas the lower weight (12.37 t/ha) from V_1. The highest harvest index (49.26%) was recorded from V_2, whereas the lowest (48.57%) from V_1.

At 30, 50, 70, 90 DAT and at harvest, the tallest plant (25.06 cm, 32.08 cm, 45.53 cm, 63.18 cm and 89.65 cm, respectively) was observed from M_1, while the shortest plant (19.90 cm, 25.53 cm, 39.12 cm, 50.37 cm and 74.58 cm, respectively) was recorded from M_0. At 30, 50, 70 and 90 DAT, the maximum number of tillers hill^{-1} (6.27, 12.32, 23.60 and 19.12, respectively) was observed from M_1 while the minimum number (4.85, 7.60, 14.15 and 11.43, respectively) was recorded from M_0. At 30, 50, 70, 90 DAT and at harvest, the highest dry matter content hill^{-1} (0.550 g, 3.55 g, 15.62 g, 22.79 g and 57.50 g, respectively) was observed from M_1, while the lowest dry matter content hill^{-1} (0.323 g, 1.51 g, 9.09 g, 14.51 g and 41.99 g, respectively) was recorded from M_0. The maximum number of effective tillers hill^{-1} (13.72) was observed from M_1, while the minimum number (8.98) was recorded from M_0. The minimum number of non-effective tillers hill^{-1} (2.80) was observed from M_1 while the maximum number (4.28) was recorded from M_0. The maximum number of total tillers hill^{-1} (16.52) was observed from M_1, whereas the minimum number (13.27) was recorded from M_0. The longest panicle (24.56 cm) was observed from M_1, whereas the shortest (18.13 cm) was recorded from M_0. The maximum number of filled grains panicle^{-1} (93.35) was observed from M_1 while the minimum number (64.98) was recorded from M_0. The minimum number of unfilled grains panicle^{-1} (4.72) was observed from M_1, while the maximum number (12.27) was recorded from M_0. The maximum number of total grains panicle^{-1} (98.07) was observed from M_1, while the minimum number (77.25) was recorded from M_0. The highest weight of 1000 grains (22.29 g) was observed from M_1, while the lowest yield (19.45 g) was recorded from M_0. The highest grain yield (7.56 t/ha) was observed from M_1, while the lowest grain yield (3.84 t/ha) was recorded from M_0. The highest straw yield (7.78 t/ha) was observed from M_1, while the lowest straw yield (4.53 t/ha) was recorded from M_0. The highest biological yield (15.35 t/ha) was observed from M_1, while the lowest biological yield (8.37 t/ha) was recorded from M_0. The highest harvest index (50.74%) was observed from M_4, while the lowest harvest index (45.79%) was recorded from M_0.

At 30, 50, 70, 90 DAT and at harvest the tallest plant (25.31 cm, 32.40 cm, 46.03 cm, 65.20 cm and 89.80 cm, respectively) was observed from V_2M_1, while the shortest (18.67 cm, 24.80 cm, 38.35 cm, 49.60 cm and 74.53 cm, respectively) from V_1M_0. At 30, 50, 70 and 90 DAT the maximum number of tillers hill^{-1} (6.46, 12.73, 24.70 and 19.87, respectively) was observed from V_2M_1, while the minimum (4.73, 7.20, 13.67 and 10.90, respectively) from V_1M_0. At 30, 50, 70, 90 DAT and at harvest the highest dry matter content hill^{-1} (0.585 g, 3.92 g, 16.65 g, 23.78 g and 58.62 g, respectively) was observed from V_2M_1, while the lowest (0.286 g, 1.43 g, 8.33 g, 14.04 g and 40.81 g, respectively) from V_1M_0. The maximum number of effective tillers hill^{-1} (13.93) was observed from V_2M_1, while the minimum (8.40) from V_1M_0. The minimum number of non-effective tillers hill^{-1} (2.23) was observed from V_1M_1, while the maximum number (4.20) from V_1M_0. The maximum number of total tillers hill^{-1} (17.30) was observed from V_2M_1, while the minimum (12.60) from V_1M_0. The longest panicle (24.69 cm) was observed from V_2M_1, while the shortest (17.31 cm) from V_1M_0. The maximum number of filled grains panicle^{-1} (93.73) was observed from V_2M_1, while the minimum (64.00) from V_1M_0. The minimum number of unfilled grains panicle^{-1} (4.53) was observed from V_2M_1, while the maximum number (13.80) from V_1M_0. The maximum number of total grains panicle^{-1} (98.27) was observed from V_2M_1, while the minimum (76.70) from V_2M_0. The highest weight of 1000 grains (22.34 g) was observed from V_2M_1, while the lowest weight (19.40 g) from V_1M_0. The highest grain yield (7.71 t/ha) was observed from V_2M_1, while the lowest yield (3.56 t/ha) from V_1M_0. The highest straw yield (7.90 t/ha) was observed from V_2M_1, while the lowest yield (4.34 t/ha) from V_1M_0. The highest biological yield (15.61 t/ha) was observed from V_2M_1, while the lowest yield (7.90 t/ha) from V_1M_0. The highest harvest index (51.14%) was observed from V_2M_4, while the lowest (45.08%) from V_1M_0.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed conduct in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

2. Another experiment may be carried out with different variety.

3. Another experiment may be carried out with other weed management practices.

REFERENCE

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, M. R., Rashid, M. A., Alam, M. S., Billah, K. A. and Jameel, F. (1997). Performance of Eight Transplant Aman Rice Varieties under Irrigated Conditions. *Bangladesh Rice J.* **8**(1 &2): 43-44.

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.

Amin, M. R., Hamid, A., Choudhury, R. U., Raquibullah, S. M. and Asaduzzaman M. (2006). Nitrogen Fertilizer Effect on Tillering, Dry Matter Production and Yield of Traditional Varieties of Rice. *Intl. J. Sustain. Crop Prod.* **1**(1): 17-20.

Amirthadevarathinam. (1983). Genetic variability, correlation and path analysis of yield components in upland rice. *Madras Agric. J.*, **70**: 781-785.

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.

Baloch, M. S., Awan, 1. 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.

BBS (Bangladesh Bureau of Statistics). (2008). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 68.

Begum, F., Dipti, S. S., Karim, N. H. and Kabir, K. A. (2001). Physicochemical characteristics of some Iranian and Bangladeshi rice varieties. *Bangladesh J. Sci*., **22**: 255-278.

Bhattacharya, S. P., Gash, R. P., Brahmachari, K., Pal, T. K. and Kumar, T. K. K. (1996). Efficiency of some new generation herbicides in controlling weed of transplanted born paddy. Etwiron. Exot. **14** (2): 657-661.

BINA (Bangladesh Institute of Nuclear Agriculture). (1993). Annual Report (1992-93). Bangladesh Inst. Nucl. Agric. P. O. Box No. 4. Mymensingh. pp. 143-147.

Biswas, J. C., Satter, S. A. and Siddlque, S. B. (1991). Evaluation of herbicides in direct seeded rice. *Bangladesh Rice J.* **2** (1-2): 40-46.

BRRI (Bangladesh Rice Research Institute). (1994). Annual Report for 1993. Bangladesh Rice Res. Inst., Jodebpur, Gazipur. pp. 8-9.

BRRI (Bangladesh Rice Research Institute). (2010). Adhunik Dhaner Chash (In Bangla) Bangladesh Rice Research Institute, Joydebpur, Gazipur.

Cassman, P. (1999). Physicochemical properties of starch of intermediate amylose and starch. Starke. **33**: 253-260.

Chandra Babu, R. and Kandasamy, O. S. (1997). Allelopathic effect of *Eucalyptus globulus* Labill. on *Cyperus rotundus* L. and *Cynodon dactylon* L. *J. Agron. Crop Sci.* **179**(2): 123-126.

Cheema, Z. A., Khaliq, A. and Mubeen, M. (2003). Response of Wheat and Winter Weeds to Foliar Application of Different Plant Water Extracts of Sorghum (*S. bicolor*). *Pakistan. J. Weed Sci. Res.* **9**(1-2): 89-97.

Chen-Liang, Y., Laignelet, B. and Marie, R. (2000). Variation of technological quality in rice according to genotype and environment. *Intl. J. Agron.* **3**(2): 179-183.

Creamer, N. G., Bennett, M. A., Stinner, B. R., Cardina, J. and Regnier, E. E. (1996). Mechanisms of Weed Suppression in Cover Crop-Based Production Systems. *Hort. Sci*. **31**: 410-413.

De Datta, C. (1981). Grain quality consideration in hybrid rice. In: hybrid rice technology: new development and future prospects. S.S.Virmani, (ed.).IRRI, Manilla, Philippines. pp. 123-130.

Devaraju, K. M., Gowda, H. and Raju, B. M. (1998). Nitrogen response of Karnataka Rice Hybrid 2. *Intl. Rice Res. Notes*. **23**(2): 43.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

FAO (Food and Agricultural Organization). (1988). FAO Production Yearbook, Food and Agricultural Organization, Rome, Italy. 56-77.

FAO. (2008). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 59-78.

Fujii, Y. (2001). Screening and Future Exploitation of Allelopathic Plants as Alternative Herbicides with Special Reference to Hairy Vetch. *J. Crop Prod*. **4**(2): 257 – 276.

Futsuhara, J. and Kikuchi, Y. (1984). Grain quality evaluation and improvement at IRRI. In proc. The workshop on chemical aspect of rice grain quality. *Intl*. Rice Res. Inst., Philippines.

Gallagher, J. N. and Biscoe, P. V. (1978). Radiation absorption, growth and yield of rice. *J. Agric. Sci*. **91**: 47-60.

Gawronska, H., Bernat, W., Janowiak, F., Gawronski, S. W. (2004). Comparative Studies on Wheat and Mustard Responses to Allelochemicals of Sunflower Origin. Abstract of Second European Allelopathy Symposium. p. 28.

Ghose, G. S. and Ghatge, Y. P. (1960). Variability and Genetic Parameter Analysis in Aromatic Rice. *Intl. J. Sustain. Crop Sci*., **34**: 12-16.

Ghosh, P. K. and Hossain, M. R. (1988). Rice grain quality as an emerging priority in National rice breeding programmes. In: rice grain marketing and quality issues. Los Banos, Laguna, IRRI. pp. 55-64.

Gomes, J. K. O., Silva, P. S. L., Silva, K. M. B., Rodrigues Filho F. F. and Santos, V. G. (2007). Effects of Weed Control through Cowpea Intercropping on Maize Morphology and Yield. *Planta daninha*. **25**(3):23-27.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). *Intl. Rice Res. Inst., A Willey Intl. Sci*., pp. 28-192.

Hossain, S. M. A and Alam, A. B. M. N. (1991). Productivity of cropping pattern of participating farmers. **In:** Fact searching and Intervention in two FSRDP Sites, Activities. 1980-1990. Farming system Research and Development Programme, BAU, Mymensingh, Bangladesh. pp. 41-44.

Islam, M. A., Mamun, A. A., Bhuiyan, M. S. U. and Hossain, S. M. A. (1989). Weed Biomass and Grain Yield in Wheat as affected by seed rate and duration of weed competition. *Bangladesh J. Agri*. **14**: 213-224.

Islam, S. (1995). Effect of variety and fertilization on yield and nutrient uptake in transplant *aman* rice. M.S. thesis. Dep. Agron. Bangladesh Agril. Univ. Mymensingh. pp. 26, 29.

Javaid, A., Shafique, S., Bajwa, R., and Shafique, S. (2006). Effect of Aqueous Extracts of Allelopathic Crops on Germination and Growth of *Parthenium hysterophorus* L. *South African J. Bot*. **72** (4): 609-612.

Jennings, I., Juliano, B.O. and D. Duff. (1979). Rice grain quality as an emerging priority in National rice breeding programmes. In: rice grain marketing and quality issues. Los Banos, Laguna, IRRI. pp. 55-64.

Julfiquar, A. W., Haque, M. M., Haque, A. K. G. M. E. and Rashid, M. A. (1998). Current status of Hybrid Rice Research and Future Program in Bangladesh. Proc. Workshop on Use and Development of Hybrid Rice in Bangladesh, held at BARC, 18-19, May, 1998.

Leather, G. R. (1987). Weed control using allelopathic sunflowers and herbicide. *Plant Soil*. **98**(1): 17-23.

Madhu, M., Najappa, H. V. and Naik, H. R. (1996). Economics of weed control treatment in puddled seeded rice. *Crop Res. Hisar*. **12** (2): 133-137.

Manish C., Khajanji, S. N., Sawi, 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.

Mansoor, M., Ahmad, H. K., Khan, H. and Yaqoob, M. (2004). Development of Economical Weed Management Strategies for Mungbean (*Vigna radiata* L. Wilczek.). *Pakistan. J. Weed Sci. Res.* **10**(3-4): 151-156.

Masiunas, J. B., Weston, L. A. and Weller, S. C. (1995). The Impact of Rye Cover Crops on Weed Populations in a Tomato Cropping System. *Weed Sci*. **43**: 318-323.

Meschede, D. K. (2007). Evaluation of Weed Suppression Using Different Crop Covers Under Brazilian Cerrado Soil Conditions. *Planta daninha*, **25**(3): 465-471.

Miah, M. H., Karim, M. A., Rahman, M. S. and Islam, M. S. (1990). Performance of Nizersail mutants under different row spacing. *Bangladesh J. Train. Dev.* **3**(2): 31-34.

Miller, B. C., Hill, J. E, Roberts, S. R. **(**1991). Plant population effects on growth and tied in water-seeded rice. *Agron. J.* **83***:* 291*–297.*

Mishra, P. K. and Pandey, R. (1998). Physico-chemical properties of starch and protein and their relation to grain quality and nutritional value of rice. Rice Breed. Pub. IRRI, Los Banos, Phillippines. pp.389-405.

Molla, M. A. H. (2001). Influence of seedling age and number of seedlings on yield attributes and yield of hybrid rice in the wet season. *Intl. Rice. Res. Notes.* **26**(2): 73-74.

Moorthy, B. T. S. and Das, F. C. (1992). Performance evaluation of tow manuallly operated weeders in upland rice. *Orissa J. Agril. Res*. **5** (1-2): 36-41.

Norsworthy, J. K., Malik, M. S., Jha, P. and Riley, M. B. (2007). Suppression of *Digitaria sanguinalis* and *Amaranthus palmeri* using autumn-sown glucosinolate-producing cover crops in organically grown bell pepper. *Weed Res*. **47**(5): 425-432.

Padmavathi, H., Igbeka, J. C., Verma, L. R. and Velupillai, L. (1996). Predicting selected quality attributes in parboiled rice. *App. Eng. Agric*. (USA).**7**(4): 407-412.

Patel J. R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa*). *Indian J. Agron.* **45**(1): 103-106.

Patnaik, M. M., Bautista, G.M., Lugay, J.C. and Reyes A.C. (1990). Studies on the physiochemical properties of rice. *J. Agr. Food Technol*. **19**: 1006-1011.

Penfold, C. (2003). Herbicide Reduction Strategies for Winegrape Production. Final report to Grape And Wine Research & Development Corporation. Pp. 1-46.

Prasad, R., Khush, G.S., Paule, C. M. and Delacruz, N. M. (2001). Rice grain quality evaluation and improvement of IRRI. In Proc.on Workshop of Chemicals Aspects of Rice Grain Quality. pp.21–31. Los Banos, Philippines

Putnam, A. R. and DeFrank, J. 1983. Use of Phytotoxic Plant Residues for Selective Weed Control. *Crop Prot*. **2**: 173-181.

Putnam, A. R., DeFrank, J., and Barnes, J. P. (1983). Exploitation of allelopathy for weed control in annual and perennial cropping systems. *J. Chem. Ecol.* **9**(8): 1001-1010.

Rajendra P., Shaarma, S. N., Surendra, S. and Zaman, F. U. (1998). Productivity of hybrid rice pusa HR3 under late planting conditions. *Ann. Agril. Res.* **19**(1): 92-93.

Saha, A. K., Haque, E., Quader, B., Hussain, T. Z. and Miah, N. M. (1989). Correlation and path analysis of some yield contributing characters in some high yielding and local varieties of irrigated rice. *Bangladesh J. Pl. Breed. Genet.*, **2**(1&2): 19-22.

Sanjoy, S., Morthy, B. T. S. and Jha. K. P. (1999). Influence of different production factors on the performance of rainfed upland rice. *Indian J. Agril. Sci.* **69** (6): 449-450.

Sawant, A. C. and Jadav, S. N. (1985). Efficiency of different herbicides for weed control in transplanted rice in Konkan. *Indian J. Weed Sci.* **17** (3): 35-39.

Sawant, A. C., Throat, S. T., Khadse, R. R. and Bhosalef, R. J. (1986). Response of early rice varieties to nitrogen levels and spacing in coastal Maharashtra. *J. Maharashtrta Agril. Univ.* **11**(2): 182-184.

Shamsuddin, A. M., Islam, M. A. and Hossain, A. (1988). Comparative study on the yield and agronomic characters of nine cultivars of *aus* rice. *Bangladesh J. Agril. Sci.* **15**(1): 121-124.

Sharma, S. K. and Bhunia, S. R. (1999). Weed management in transplanted rice under Ghaggar floodplains of northwest Rajasthan. *Indian J. Agron.* **44** (3): 543-547.

Singh, 0. P. and Bhan, V. M. (1992). Effect of herbicides and water submergence levels on control of weeds in transplanted rice. *Indian J. Weed Sci*. **24** (4): 226-230.

Singh, G., Singh, R. K., Singh, V. P., Nayak, R. and Singh, R. S. (1999). Weed management in transplanted rice (Oryza saliva) under rainfed lowland situation. *Indian J. Agron.* **44** (4): 728-732.

Singh, R. S. (2005). Study of Beushening in controlling weeds under rainfed lowland rice in Chotanagpur Region. *J. Applied Biology*. **15** (1): 22-24.

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.

Son, Y., Park, S. T., Kim, S. Y., Lee, H. W. and Kim, S. C. (1998). Effects plant density on the yield and yield components of low-tillering large panicle type rice. *RDA J. Crop Sci. I.* **40**: 2.

Tariful, M. I., Emran, A. K. and Gaffer, M. A. (1998). Influence of crop density and weeding frequency on crop growth and grain yield in wheat", *Pertanika J. Agri. Sci*. **21**: 123-28.

Tawaha, A. M. and Turk, M. A. (2003). Allelopathic Effects of Black Mustard (*Brassica nigra*) on Germination and Growth of Wild Barley (*Hordeum spontaneum*). *J. Agron. Crop Sci*. **189**(5): 298–303.

Thomas, C. G., Abraham, C. T. and Sreedevi, P. (1997). Weed flora and their relative dominance in semi dry rice culture. *J. Tropic. Agric*. **35**: 51-53.

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.

Xu, S and Wang, C. (2001). Study of yield attributes of some restorer and maintainer lines. *Intl. Rice Res. Newsl.,* **26**(7): 136-138.

Xu, S. and Li, B. (1998). Managing hybrid rice seed production. In hybrid rice. IRRI, Manila, Philippines, pp. 157-163.

Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos Manila, Philippines. 269pp.

APPENDICES

Appendix I. Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium hHigh land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from January to May 2009

Month (Year 2009)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
January	24.5	12.4	68	00	5.7
February	27.1	16.7	67	30	6.7
March	31.4	19.6	54	11	8.2
April	33.6	23.6	69	163	6.4
May	32.4	27.2	71	134	7.1

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix III. Analysis of variance of the data on weed population and dry matter in weed biomass as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square			
		Weed Population/m^2 at		Dry weight of weed biomass at	
		25 DAT	65 DAT	25 DAT	65 DAT
Replication	2	0.045	0.171	0.004	0.004
Variety (A)	1	4.265**	5.590*	0.381*	0.058**
Error (a)	2	0.075	0.261	0.006	0.001
Weed management (B)	4	197.10**	391.74**	0.027**	0.144**
Interaction (A×B)	4	0.575*	1.298**	0.063**	0.052*
Error (b)	16	0.166	0.088	0.004	0.004

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on plant height of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.108	0.196	0.031	0.972	0.284
Variety (A)	1	10.034*	11.396*	13.267*	41.067*	9.633*
Error (a)	2	0.384	0.519	0.317	1.305	0.212
Weed management (B)	4	26.081**	42.877**	36.440**	162.41**	233.36**
Interaction (A×B)	4	0.976*	1.254*	1.635*	2.126*	2.870*
Error (b)	16	0.236	0.327	0.431	0.600	0.674

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of tillers hill^{-1} of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at			
		30 DAT	50 DAT	70 DAT	90 DAT
Replication	2	0.013	0.021	0.086	0.449
Variety (A)	1	0.422**	4.880*	12.288*	13.333**
Error (a)	2	0.003	0.121	0.247	0.065
Weed management (B)	4	1.605**	18.352**	74.501**	53.305**
Interaction (A×B)	4	0.042*	0.564*	1.534*	0.649*
Error (b)	16	0.006	0.141	0.458	0.080

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on dry matter plant^{-1} of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square				
		Dry matter plant^{-1} at				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.0001	0.030	0.119	0.032	3.137
Variety (A)	1	0.034*	0.642*	13.926*	16.339*	60.919*
Error (a)	2	0.001	0.039	0.390	0.288	2.583
Weed management (B)	4	0.043**	3.337**	34.413**	71.379**	211.54**
Interaction (A×B)	4	0.0001*	0.097**	0.560**	1.918*	3.270*
Error (b)	16	0.0001	0.013	0.099	0.488	1.240

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on effective, non-effective & total tillers plant^{-1} and length of panicle of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square			
		Effective tiller hill^{-1}	Non-effective tiller hill^{-1}	Total tiller hill^{-1}	Length of panicle (cm)
Replication	2	0.005	0.004	0.016	0.103
Variety (A)	1	5.985*	1.496*	13.467*	4.945*
Error (a)	2	0.145	0.046	0.301	0.107
Weed management (B)	4	20.673**	1.816**	11.768**	39.905**
Interaction (A×B)	4	0.404*	0.235**	1.226*	1.500*
Error (b)	16	0.116	0.043	0.202	0.230

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on filled, unfilled & total grains and weight of 1000 seeds of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square			
		Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}	Weight of 1000 Seed (g)
Replication	2	1.850	0.049	2.143	0.048
Variety (A)	1	58.800**	9.747**	20.667*	0.539*
Error (a)	2	0.777	0.076	1.327	0.028
Weed management (B)	4	812.292**	48.285**	501.98**	6.764**
Interaction (A×B)	4	7.398*	1.897**	8.743*	0.153*
Error (b)	16	2.382	0.125	2.416	0.027

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on grain, straw & biological yield and harvest index of *Boro* rice as influenced by variety and weed management

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	0.012	0.012	0.017	0.338
Variety (A)	1	2.546**	1.413*	7.752**	3.644
Error (a)	2	0.044	0.036	0.010	2.684
Weed management (B)	4	12.658**	9.916**	44.314**	23.249**
Interaction (A×B)	4	0.124**	0.101*	0.442**	0.345
Error (b)	16	0.021	0.027	0.072	0.486

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability