EFFECT OF SEEDLINGS PER HILL AND WEED MANAGENMENT STRATEGIES ON GROWTH AND YIELD OF BRRI dhan50

MD. ARAFAT HASAN

MASTER OF SCIENCE

IN

AGRONOMY

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

DECEMBER, 2013

EFFECT OF SEEDLINGS PER HILL AND WEED MANAGENMENT STRATEGIES ON GROWTH AND YIELD OF BRRI dhan50

By

MD. ARAFAT HASAN

REGISTRATION NO. 11-04706

A Thesis

Submitted to the Department of Agronomy,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JULY-DECEMBER, 2013

Approved by:

………………………………..	...………………………………
(Dr. Md. Hazrat Ali)	**(Dr. Md. Abdullahil Baque)**
Professor	**Associate Professor**
Supervisor	**Co-supervisor**

…………………………………

(Prof. Dr. H.M.M. Tariq Hossain)
Chairman
Examination Committee

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF SEEDLINGS PER HILL AND WEED MANAGENMENT STRATEGIES ON GROWTH AND YIELD OF BRRI dhan50"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY,** embodies the result of a piece of *bona fide* research work carried out by **MD. ARAFAT HASAN,** Registration No. **11-04706** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated:

Place: Dhaka, Bangladesh

(Dr. Md. Hazrat Ali)
Professor
Research Supervisor

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

Alhamdulillahi Rabbil Al-Amin, all praises are due to the almighty Allah Rabbul Al-Amin for His gracious kindness and infinite mercy in all the endeavors the author to let him successfully complete the research work and the thesis leading to Master of Science degree.

The author would like to express his heartfelt gratitude and most sincere appreciations to his Supervisor Dr. Md. Hazrat Ali, Professor, Department of Agronomy and Treasurer, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-supervisor Dr. Md. Abdullahil Baque, Associate Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

Finally the author appreciate the assistance rendered by the staff member of the Department of Agronomy and farm, Sher-e-Bangla Agricultural University, Dhaka, who have helped him during the period of study.

The author

EFFECT OF SEEDLINGS PER HILL AND WEED MANAGENMENT STRATEGIES ON GROWTH AND YIELD OF BRRI dhan50

ABSTRACT

A field experiment was conducted at the farm of Sher-e-Bangla Agricultural University (90º33´ E longitude and 23º77´ N latitude), Dhaka, Bangladesh during November 30, 2012 to May 05, 2013 in *boro* season with a view to find out the performance of BRRI dhan50 with different seedlings per hill under different weed management strategies. The experiment was carried out with four plant population densities *i.e*. 2 seedlings hill^{-1} (P_1), 4 seedlings hill^{-1} (P_2), 6 seedlings hill^{-1} (P_3) and 8 seedlings hill^{-1} (P_4) in the main plot and five weed management strategies viz. no weeding (control) (W_0), two hand weeding at 20 and 35 DAT (W_1), Weeding by BRRI rice weeder at 20 and 35 DAT (W_2), Topstar 400SC (Oxadiargyl 400 g L^{-1}) @ 100 ml ha^{-1} as pre-emergence (W_3) and Sunrice 150WG (Ethoxysulfuron 150 g L^{-1}) @ 185 ml ha^{-1} as post-emergence herbicide (W_4) in the sub plot in split plot design. Twenty two different weed species found in the field among which *Cyperus michelianus* (36.73%) at 30 DAT, *Cyperus esculentus* (25.13%) and *Alternanthera sessilis* (21.54%) at 60 DAT, *Fimbristylis miliaceae* (19.50%) at 90 DAT were dominant. Application of Sunrice 150WG showed highest weed control efficiency at 30 DAT 80.94% and 61.52% at 60 DAT. Two seedlings hill^{-1} (P_1) showed highest weed control efficiency (58.92%) at 30 DAT and 4 seedlings hill^{-1} (P_2) also showed highest weed control efficiency (39.18%) at 60 DAT. Both seedlings per hill and weed management strategies significantly influenced the growth, yield and yield contributing characters of BRRI dhan50. The result showed that 2 seedlings hill^{-1} (P_1) performed highest grain yield (5.70 t ha^{-1}), straw yield (7.81 t ha^{-1}), biological yield (13.52 t ha^{-1}) and harvest index (42.06 %) and post-emergence herbicide Sunrice 150WG control weeds very successfully resulting highest growth and yield contributing characters of rice. Among the weed management strategies Sunrice 150WG (W_4) showed best in producing highest grain yield (5.36 t ha^{-1}), straw yield (7.42 t ha^{-1}), biological yield (12.77 t ha^{-1}) and harvest index (41.63%). The interaction between seedlings per hill and weed management strategies showed that 2 seedlings hill^{-1} with Sunrice 150WG appeared as a good combination in producing highest grain yield (6.81 t ha^{-1}), straw yield (8.69 t ha^{-1}), biological yield (15.49 t ha^{-1}) and harvest index (43.96%) in BRRI dhan50.

CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENT	i
	ABSTRACT	ii
	LIST OF CONTENTS	iii
	LIST OF TABLES	vii
	LIST OF FIGURES	viii
	LIST OF APPENDICES	ix
	LIST OF ACRONYMS	x
1	**INTRODUCTION**	1-3
2	**REVIEW OF LITERATURE**	4-16
2.1	Effect of seedlings per hill	4-7
2.1.1	Effect on growth characters	4
2.1.1.1	Plant height	4
2.1.1.2	Tillering pattern	5
2.1.2	Effect on yield contributing characters	5
2.1.2.1	Effective tillers hill^{-1}	5
2.1.2.2	Panicle length, filled grains panicle^{-1}	5
2.1.2.3	1000-grain weight	5
2.1.3	Effect on grain yield, straw yield, biological yield and harvest index	6
2.2	Effect of weed management strategies	8-13
2.2.1	Effect on growth characters	8
2.2.1.1	Plant height	8
2.2.1.2	Tillering pattern	9
2.2.1.3	Total dry matter production	9
2.2.2	Effect on yield contributing characters	10
2.2.2.1	Effective tillers hill^{-1}	10
2.2.2.2	Panicle length, filled grains panicle^{-1}, 1000-grain weight	10
2.2.3	Effect on grain yield and straw yield	11
2.2.4	Effect on weed population and weed control efficiency	14

CONTENTS (Cont'd)

CHAPTER	TITLE	PAGE
3	**MATERIALS AND METHODS**	17-24
3.1	Location	17
3.2	Soil	17
3.3	Climate	17
3.4	Plant materials and features	17
3.5	Treatments	18
3.6	Description of herbicides	19
3.7	Design and Layout	19
3.8	Seed collection, sprouting and sowing	19
3.9	Land preparation	19
3.10	Fertilizer application	20
3.11	Uprooting and transplanting of seedling	20
3.12	Intercultural operation	20
3.12.1	Gap filling	20
3.12.2	Weeding	20
3.12.3	Irrigation and drainage	20
3.12.4	Plant protection measures	21
3.13	General observation of the experimental field	21
3.14	Harvest and post-harvest operation	21
3.15	Collection of data	21-22
3.15.1	Weed parameters	21
3.15.2	Crop growth parameters	22
3.15.3	Yield contributing characters	22
3.15.4	Yield and harvest index	22
3.16	Procedure of sampling for growth study during the crop growth period	23
3.17	Procedure of data collection for yield and yield components	23
3.18	Statistical analysis	24
4	**RESULTS AND DISCUSSION**	25-53
4.1	Infested weed species in the experimental field	25
4.2	Relative weed density	25
4.3	Weed population	26
4.3.1	Effect of seedlings per hill	26
4.3.2	Effect of weed management strategies	28
4.3.3	Interaction effect of seedlings per hill and weed management strategies	28
4.4	Weed biomass	29
4.4.1	Effect of seedlings per hill	29
4.4.2	Effect of weed management strategies	30
4.4.3	Interaction effect of seedlings per hill and weed management strategies	31

CONTENTS (Cont'd)

CHAPTER	TITLE	PAGE
4.5	Weed control efficiency	32
4.5.1	Effect of seedlings per hill	32
4.5.2	Effect of weed management strategies	33
4.5.3	Interaction effect of seedlings per hill and weed management strategies	34
4.6	Crop growth parameters	36
4.6.1	Plant height	36
4.6.1.1	Effect of seedlings per hill	36
4.6.1.2	Effect of weed management strategies	36
4.6.1.3	Interaction effect of seedlings per hill and weed management strategies	37
4.6.2	Number of tillers $hill^{-1}$	38
4.6.2.1	Effect of seedlings per hill	38
4.6.2.2	Effect of weed management strategies	39
4.6.2.3	Interaction effect of seedlings per hill and weed management strategies	40
4.7	Yield contributing characters	42
4.7.1	Panicle length	42
4.7.1.1	Effect of seedlings per hill	42
4.7.1.2	Effect of weed management strategies	42
4.7.1.3	Interaction effect of seedlings per hill and weed management strategies	42
4.7.2	Effective tillers $hill^{-1}$	42
4.7.2.1	Effect of seedlings per hill	42
4.7.2.2	Effect of weed management strategies	43
4.7.2.3	Interaction effect of seedlings per hill and weed management strategies	43
4.7.4	Filled grains $panicle^{-1}$	43
4.7.4.1	Effect of seedlings per hill	43
4.7.4.2	Effect of weed management strategies	43
4.7.4.3	Interaction effect of seedlings per hill and weed management strategies	44

CONTENTS (Cont'd)

CHAPTER	TITLE	PAGE
4.7.7	1000-grain weight	44
4.7.7.1	Effect of seedlings per hill	44
4.7.7.2	Effect of weed management strategies	44
4.7.7.3	Interaction effect of seedlings per hill and weed management strategies	44
4.8	Yield	46
4.8.1	Grain yield	46
4.8.1.1	Effect of seedlings per hill	46
4.8.1.2	Effect of weed management strategies	46
4.8.1.3	Interaction effect of seedlings per hill and weed management strategies	47
4.8.2	Straw yield	47
4.8.2.1	Effect of seedlings per hill	47
4.8.2.2	Effect of weed management strategies	48
4.8.2.3	Interaction effect of seedlings per hill and weed management strategies	49
4.8.3	Biological yield	49
4.8.3.1	Effect of seedlings per hill	49
4.8.3.2	Effect of weed management strategies	50
4.8.3.3	Interaction effect of seedlings per hill and weed management strategies	51
4.8.4	Harvest index	51
4.8.4.1	Effect of seedlings per hill seedlings per hill	51
4.8.4.2	Effect of weed management strategies	51
4.8.4.3	Interaction effect of seedlings per hill seedlings per hill and weed management strategies	53
5	**SUMMARY AND CONCLUSION**	54-56
6	**REFERENCES**	57-63
7	**APPENDICES**	64-67

LIST OF TABLES

TABLE	TITLE	PAGE
1	Weed species found in the experimental plots of BRRI dhan50	26
2	Relative density (%) of different weed species infested the experimental area	27
3	Interaction effect of seedlings per hill and weed management strategies on total number of weeds m^{-2} at different days after transplanting	29
4	Interaction effect of seedlings per hill and weed management strategies on weed biomass (g m^{-2}) in BRRI dhan50	32
5	Interaction effect of seedlings per hill and weed management strategies on weed control efficiency (%) in BRRI dhan50	35
6	Interaction effect of seedlings per hill and weed management strategies on plant height (cm) of BRRI dhan50	38
7	Interaction effect of seedlings per hill and weed management strategies on number of tiller $hill^{-1}$ of BRRI dhan50	41
8	Effect of seedlings per hill, weed management strategies and interactions on yield contributing characters of BRRI dhan50	45
9	Interaction Effect of seedlings per hill and weed management strategies on yield and harvest index of BRRI dhan50	53

LIST OF FIGURES

FIGURE	TITLE	PAGE
1	Effect of seedlings per hill on total number weeds (m^{-2}) of BRRI dhan50 at different days after transplanting	27
2	Effect of different weed management strategies on weed population (m^{-2}) of BRRI dhan50 at different days after transplanting	28
3	Effect of seedlings per hill on weed biomass of BRRI dhan50 at different days after transplanting	30
4	Effect of weed management strategies on weed biomass of BRRI dhan50 rice field at different days after transplanting	31
5	Effect of seedlings per hill on weed control efficiency of BRRI dhan50 at different days after transplanting	33
6	Effect of weed management strategies on weed control efficiency of BRRI dhan50 at different days after transplantation	34
7	Effect of seedlings per hill on plant height of BRRI dhan50 at different days after transplanting	36
8	Effect of weed management strategies on plant height of BRRI dhan50 rice field at different days after transplanting	37
9	Effect of seedlings per hill on number of tiller $hill^{-1}$ of BRRI dhan50 at different days after transplanting	39
10	Effect of weed management strategies on number of tillers $hill^{-1}$ of BRRI dhan50 rice field at different days after transplanting	40
11	Effect of seedlings per hill on the grain yield of BRRI dhan50	46
12	Effect of weed management strategies on grain yield of BRRI dhan50	47
13	Effect of seedlings per hill on the straw yield of BRRI dhan50	48
14	Effect of weed management strategies on straw yield of BRRI dhan50	49
15	Effect of seedlings per hill on the biological yield of BRRI dhan50	50
16	Effect of weed management strategies on biological yield of BRRI dhan50	50
17	Effect of seedlings per hill on the harvest index of BRRI dhan50	51
18	Effect of weed management strategies on harvest index of BRRI dhan50	52

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
I	Physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka	62
II	Means square values for total number of weed m^{-2} of BRRI dhan50 at different days after transplanting	62
III	Means square values for weed biomass (gm^{-2}) of BRRI dhan50 at different days after transplanting	63
IV	Means square values for weed control efficiency (%) of BRRI dhan50 at different days after transplanting	63
V	Means square values for Plant height (cm) of BRRI dhan50 at different days after transplanting	63
VI	Means square values for number of tillers $hill^{-1}$ of BRRI dhan50 at different days after transplanting	64
VII	Means square values for yield contributing characters of BRRI dhan50	64
VIII	Means square values for yield and harvest index of BRRI dhan50	65

LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agriculture Information Service
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
B:C	=	Benefit Cost ratio
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and associates
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
HI	=	Harvest Index
HYV	=	High Yielding Varieties
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local Varieties
LYV	=	Low Yielding Varieties
LSD	=	Least Significant Difference
m	=	Meter
m^2	=	Square meter
MV	=	Modern Varieties
mm	=	Millimeter
viz.	=	namely
ns	=	Not significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
ppm	=	Parts per million
SAU	=	Sher-e- Bangla Agricultural University
t ha^{-1}	=	Tons per hectare

Chapter 1

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for many countries in Asia and Pacific, South and North America as well as Africa (Mobasser *et al.*, 2007). In Asia more than 2 billion people obtain 60% to 70% of their calories from rice (Dowling *et al.*, 1998). In Bangladesh rice occupies 11.30 million of hectares land (about two third of the total cultivated land) and it stands first among the cereals (BBS, 2013). Rice is grown under three distinct seasons namely *aus*, *aman* and *boro* under irrigated, rainfed and deep water conditions in Bangladesh. The area and the production of rice in our country in 2011-2012 are 11.53 million hectares and 33.91 million tons, respectively (AIS, 2013).

Among the cultivated rice, however, Aromatic rice constitutes a small but special group of rice which is considered best in quality. Aromatic rice as reported by Singh *et al.* (2000), had 15 times more 2- acetyl -1- pyrroline content than non - aromatic rice (0.14 and 0.009 ppm, respectively). In addition to 2- acetyl -1- pyrroline, there are about 100 other volatile compounds, including 13 hydrocarbons, 14 acids, 13 alcohols, 16 aldehydes, 14 ketones, 8 esters, 5 phenols and some other compounds, which are associated with the aroma development in rice (Singh *et al.*, 2000). The demand for special purpose aromatic rice has dramatically increased over the past two decades in the world.

Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive types and are grown during *aman* season (Baqui *et al.*, 1997). Cultivation of fine as well as aromatic rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export (Das and Baqui, 2000). The average yield of aromatic rice is much lower as compared to other varieties of rice grown in the country. The crop plant growing depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. Among the factors excess or poor population might be a limiting factor against maximizing rice yield. Significant effect of planting density on the yield and yield components of rice was also found by Baloch *et al.*, (2002).

Weeds compete with rice plant severely for space, nutrients, air, water and light by affecting adversely on plant height, leaf architecture, tillering habit, shading ability, growth pattern and crop duration (Miah *et al.*, 1990). Weed depresses the normal yield of grains per panicle and grain weight (Bari *et al.*, 1995). Weeds in tropical zones cause yield loss on rice of about 35% (Oerke and Dehne, 2004). Subsistence farmers of the tropics spend more time, energy and money for weed control than any other aspect of crop production (Alam *et al.* 1996). Poor weed control is one of the major factors for yield reduction in rice (Amarjit *et al*, 1994).

In Bangladesh the traditional methods of weed control practices include preparatory land tillage, hand weeding by weeder and hand pulling. Usually two or three hand weeding are normally done for growing a rice crop depending upon the nature of weeds, their intensity of infestation and the crop grown. Increasing the frequency of hand weeding one or two times at 21 and 40 days after transplanting (DAT) was found to reduce the weed density and weed dry matter resulting in two fold increase in grain yield (Anonymous, 1976). Hand weeding is highly labor-intensive (as much as 190 person days ha^{-1}) (Roder, 2001). Due to high wages as well as unavailability of labor during peak season, hand weeding is not an economically viable option for the farmers. Weed control in transplant rice by mechanical and cultural methods is expensive (Mitra *et al.*, 2005). In contrast, chemical weed control is easier and cheaper. On the other hand chemical methods lead to environmental pollution and negative impact on public health (Phuong *et al.*, 2005). However, herbicide selectivity and application dose may reduce the pollution in some extent.

Thus, the best weed management strategies need to be find out with a view to reduce yield losses due to weed infestation and getting maximum yield of transplant *boro* rice. Keeping the above facts in view, the present study was conducted to determine the optimum seedlings per hill for getting the maximum yield best combination of seedlings per hill in combination of weed management strategies for yield improvement of transplanted *boro* rice cv. BRRI dhan50.

Therefore, the study was undertaken to fulfill the following objectives.

1. To find out the effect of seedlings per hill on the growth and yield of BRRI dhan50
2. To evaluate the performance of different weed management strategies in BRRI dhan50
3. To investigate the interaction effect of seedlings per hill and weed management strategies on the growth and yield of BRRI dhan50.

Chapter 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Seedlings per hill is an important factor as it influences the availability of sunlight, nutrient competition, photosynthesis, respiration etc. which ultimately influence the growth and development of the crops. Weed management for modern rice cultivation has become an important issue. Considering the above points, available literature on plant population and weed management methods were reviewed under different rice varieties.

2.1 Effect of seedlings per hill

Seedlings per hill contributes a lot for producing yield and yield components. Different researcher reported the effect of seedlings per hill on yield contributing component and grain yield. Some available information and literature related to the effect of seedlings per hill on the yield of rice are discussed below.

2.1.1 Effect on growth characters

2.1.1.1 Plant height

Bozorgi *et al.* (2011) found highest plant height from 1 seedling hill^{-1} and the lowest plant obtained from 5 seedling hill^{-1}.

Hassan *et al.* (2010) stated that plant height was statistically significant for the planting density. They found that planting two seedlings hill^{-1} at a spacing of 20 cm × 15 cm produced tallest plant height (126.89 cm), while lowest (116.51 cm) plant height was from five seedlings hill^{-1} when planted at similar spacing.

Mobasser *et al.* (2007) showed that plant height was decreased significantly with increase of planting density.

2.1.1.2 Tillering pattern

Bozorgi et al. (2011) conducted a study to find out the effect of seedlings per hill on the growth and yield of rice. They found that the maximum number of tillers per m^2 was recorded from 5 seedlings $hill^{-1}$ however minimum was recorder from 1 seedling $hill^{-1}$.

Hassan *et al.* (2010) stated that the highest tiller number was obtained in two seedlings $hill^{-1}$ however, the lowest straw yield was from five seedlings $hill^{-1}$ treatment.

2.1.2 Effect on yield contributing characters

2.1.2.1 Effective tillers $hill^{-1}$

Hassan *et al*. (2010) found significant variation on the number of effective tillers $hill^{-1}$ due to various plant populations. They also found highest number of effective tillers $hill^{-1}$ (10.39) in two seedlings $hill^{-1}$ when planted at a spacing of 20 cm × 15 cm.

Karim *et al.* (1987) reported that 2 seedlings $hill^{-1}$ produced higher effective tillers $hill^{-1}$ than 4 seedling $hill^{-1}$.

Shah *et al.* (1991) stated that transplanting of 2 and 3 seedlings $hill^{-1}$ gave more promising results in terms of more productive tillers per unit area.

2.1.2.2 Panicle length, filled grains panicle $^{-1}$

Bozorgi et al. (2011) found highest panicle length from 1 seedling $hill^{-1}$ and the lowest panicle length obtained from 5 seedling $hill^{-1}$.

Bozorgi *et al.* (2011) conducted a study to examine the effect of plant population density in rice and they found highest number of grain per panicle from 3 seedlings $hill^{-1}$ and lowest number of grain per panicle from 1 seedlings $hill^{-1}$.

Hassan *et al.* (2010) stated that the length of panicle was also significantly influenced by different plant population treatments. They concluded that two seedlings hill^{-1} planted at 20 cm × 15 cm spacing gave the largest panicle length (24.06 cm).

It was stated that number of filled grains panicle^{-1} increased with the decrease in seedling number hill^{-1}. The maximum filled grains panicle^{-1} was obtained from 1 seedlings hill^{-1} and the minimum from 4 seedlings hill^{-1} (Hasanuzzaman *et al.* 2009, Shah *et al.* 1991 and Singh *et al.* 1987).

2.1.2.3 1000-grain weight

Baloch *et al.* (2002) conducted a study to find the effect of seedlings per hill on the yield of rice and they found maximum 1000 grain weight from comparatively lower population than the higher planting density.

Choudhury *et al*. (1995) conducted a study to find the effect of seedlings per hill on the yield of rice and they reported that seed size was not affected by the seedling(s).

Hassan *et al.* (2010) stated that the different number of seedlings hill^{-1} had also significant effect on 1000 grains weight. The maximum 1000 grain weight (23.56 g) was obtained from the treatment two seedlings hill^{-1} and the lowest weight (20.61 g) was found from maximum number of seedlings hill^{-1} when planted at a spacing of 20 cm × 15 cm.

2.1.3 Effect on grain yield, straw yield, biological yield and harvest index

Bozorgi *et al.* (2011) conducted a study to find the effect of seedlings per hill in rice and they found highest grain yield and harvest index from 3 seedlings hill^{-1} and lowest grain yield and harvest index from 1 seedlings hill^{-1}. However, the maximum amount of straw yield and biological yield was recorded from 5 seedlings hill^{-1} and minimum straw yield and biological yield was recorded from 1 seedling hill^{-1}.

Ghosh *et al.* (1998) conducted a study to find out the effect of seedlings per hill on the yield of rice and they observed that increasing seedlings $hill^{-1}$ at a constant level did not influence on grain yield production, but after that grain yield decreased.

Hassan *et al.* (2010) stated that the grain yield was significantly influenced by planting density. A gradual decrease of grain yield was recorded with the increase of seedling number $hill^{-1}$. However, two seedlings $hill^{-1}$ produced the maximum grain yield, while five seedlings produced the minimum grain yield.

Hassan *et al.* (2010) found significant variation on the straw yield due to various planting population densities. The highest straw yield was obtained in two seedlings $hill^{-1}$ however, the lowest straw yield was from five seedlings $hill^{-1}$ treatment.

Hasanuzzaman *et al.* (2009) conducted a study to find out the effect of seedlings per hill on the yield of rice and they reported that grain yield was decreased with transplanting more than 2 seedlings $hill^{-1}$.

Karim *et al.* (1987) reported that 4 seedlings $hill^{-1}$ produced higher straw than 1 seedling $hill^{-1}$.

Mobasser *et al.* (2007) conducted a study to find out the effect of seedlings per hill on the yield of rice and they found that grain yield increased with the decreasing plant population.

Shrirame *et al.* (2000) conducted a study to find the effect of seedlings per hill on the yield of rice and they reported that harvest index significantly affected by seedlings number $hill^{-1}$.

Sarkar *et al*. (1998) conducted a study to find out the effect of seedlings per hill on the yield of rice and they reported that straw yield increased with increasing seedlings $hill^{-1}$.

2.2 Effect of weed management strategies

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

2.2.1 Effect on growth characters

2.2.1.1 Plant height

Hassan *et al.* (2010) carried out a field experiment on transplant *aman* rice cv. BRRI dhan41 and observed that highest plant height was recorded from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

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

Hasanuzzaman *et al.* (2007) conducted an experiment on transplanted (T) '*aman*' rice at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during July-November, 2006 and stated that plant height was significantly affected by different methods of weed management.

Khan and Tarique (2011) carried out an experiment during June to December 2006 and observed that the longest plant was observed in completely weed free condition throughout the crop growth period. On the other hand, plant height appeared next to the highest under in two hand weeding treatment. However, lowest value was observed in no weeding treatment.

2.2.1.2 Tillering pattern

Ashraf *et al.* (2006) conducted an experiment in Lahore, Pakistan, during 2004 and 2005 in kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000). Hand weeding regimes with two seedlings hill^{-1} resulted in highest tillers plant^{-1}.

Hassan *et al.* (2010) carried out a field experiment on transplant *aman* rice cv. BRRI dhan41 and recorded data on total effective tillers hill^{-1}. Highest value was recorded from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

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

2.2.1.3 Total dry matter production

Bhuiyan *et al.* (2011a) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI *aman* varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) in 2008 and 2009 at Bangladesh Rice Research Institute, regional station, Rajshahi and found that total dry matter was significantly highest in plot of three hand weeding at 15, 30 & 45 DAT, 20.17 g m^{-2} and post-emergence herbicide + 1 hand weeding at 30 DAT, 22.2 g m^{-2}.

Reza *et al.* (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period from January to April 2008 and found that *Echinochloa crusgalli* was the major weed having the highest absolute density (12.70 m^{-2}), relative density (36.95 m^{-2}), dry matter accumulation (1.85 g m^{-2}) and intensity of weed infestation (0.46).

2.2.2 Effect on yield contributing characters

2.2.2.1 Effective tillers hill^{-1}

Hassan *et al.* (2010) carried out a field experiment on transplant *aman* rice cv. BRRI dhan41 and found that highest number of effective tillers hill^{-1} was recorded from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

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

2.2.2.2 Panicle length, filled grains panicle $^{-1}$, 1000-grain weight

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

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

Karim and Ferdous (2010) conducted an experiment at the net house of the Department of Agronomy, Bangladesh Agricultural University during the period from June to December 2008 to study the effects of plant density of grass weeds on plant characters and grain production of transplanted *aus* rice cv. BR26. They found that the number of filled grains panicle^{-1} and 1000 grain weight were negatively related to weed density.

Nahar *et al.* (2010) carried out a field experiment to study the effect of spacing and weeding regime on the performance of transplant *aman* rice cv. BRRI dhan41 and observed that weeding regime had significant effect on all the parameters except 1000 grain weight.

2.2.3 Effect on grain yield and straw yield

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and observed that the highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10WP @ 150g ha^{-1}, which was 49% higher than control. BRRI dhan29 produced also the highest grain yield when treated with same treatment, which was 37% higher than control.

Ali *et al.* (2010) concluded that among the weed control treatments Pretilachlor + one hand weeding at 40 DAT performed best for controlling weeds which ultimately contributed to the highest grain yield (3.60 t ha^{-1}).

Bhuiyan *et al.* (2011a) conducted field experiments at BRRI farm, Bhanga , Faridpur (AEZ 12-Lower Ganges River Floodplain) and at Burichang of Comilla district (AEZ 19-Old Meghna Estuarine Floodplain) during dry season (*Boro*) 2007 to assess the effectiveness of different pre-emergence herbicide for weed management in direct wet seeded rice and its impact on phytotoxic effect, plant growth and yield of rice and found that pre-emergence application of Sofit N 300EC @ 450 and 600 g a.i. ha^{-1} led to higher yield attributes and grain yield of rice that were comparable to weed free conditions at both agro-ecological zones of Bangladesh.

Bhuiyan *et al.* (2011b) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI *aman* varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) in 2008 and 2009 at Bangladesh Rice Research Institute, regional station, Rajshahi and found that, irrespective of weed management options, hand weeding and post-emergence herbicide with one supplement hand weeding produced significantly higher yield 4.89 and 4.80 t ha^{-1}, respectively while lowest yield was recorded in control (3.29 t ha^{-1}).

Bari (2010) found that the highest grain yield of 4.18 t ha^{-1} was contributed by weed free treatment, while the least (2.44 t ha^{-1}) was by weedy check. Among the herbicide treatments, the highest grain yield of 4.08 t ha^{-1} was obtained from Butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate. Results further revealed a positive relationship between Butachlor rate and grain yield, although a declining trend was apparent at higher than the recommended rates, while a negative relationship was found in MCPA treatments.

Bhuiyan *et al.* (2010) stated that among different treatment, weed free plots produced highest grain yield followed by Oxadiargyl 400SC @ 75 g a.i. ha^{-1} which is comparable with other doses of Oxadiargyl 400SC in both locations.

Gnanavel and Anbhazhagan (2010) suggested that pre-emergence application of Oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded higher grain yield of aromatic rice (5.32 t ha^{-1}).

Hassan *et al.* (2010) carried out a field experiment on transplant *aman* rice cv. BRRI dhan41 and found that highest straw yield was recorded from the treatment combination of three hand weeding regimes with two seedlings $hill^{-1}$ in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings $hill^{-1}$.

Islam *et al.* (2010) revealed that pre-emergence herbicide Rifit 500 EC showed the best performance in achieving comparatively better grain yield. As a result net income was also increased. The highest grain yield (3.61 t ha^{-1}) was obtained from Rifit 500 EC. BRRI dhan41 gave the highest grain yield (4.43 t ha^{-1}) with Rifit 25 EC @ 1.0 L ha^{-1}.

Khaliq *et al.* (2011) reported that manual weeding scored highest paddy yield of 4.17 t ha^{-1}. Bispyribac sodium with 3.51 t ha^{-1} paddy yield appeared superior to penoxsulam. Sorghum, sunflower and wheat residues resulted in statistically similar paddy yields of 2.85, 2.80 and 2.58 t ha^{-1}, respectively. Bispyribac sodium exhibited maximum marginal rate of return of 23.76%. Chemical control proved to be a viable strategy with higher economic returns.

Khan and Tarique (2011) carried out an experiment during June to December 2006 and stated that the highest grain yield and straw yield were observed in completely weed free condition throughout the crop growth period. On the other hand, values that appeared next to the highest were found in two hand weeding treatment and lowest in no weeding treatment.

Karim and Ferdous (2010) stated that the highest grain yield (15.09 g pot^{-1}) was found under weed free condition. Grain yield was reduced by 2.66%, 12.59%, 44.93% and 54.01% due to competition from 2, 4, 6 and 8 number of weeds of *E. indica*, whereas the yield was reduced by 57.19%, 58.98%, 82.31% and 79.26%, respectively due to competition from 2, 4, 6 and 8 number of weeds of *E. crusgalli*.

Mamun *et al.* (2011) observed that application of Bensulfuron methyl + Pretilachlor 6.6% GR @ 652 g a.i. ha^{-1} resulted in higher yield attributes and grain yield of transplanted rice that were comparable to the standard in both seasons.

Nahar *et al.* (2010) carried out a field experiment to study the effect of spacing and weeding regime on the performance of transplant *aman* rice cv. BRRI dhan41 and reported that weed free condition produced the highest grain yield (4.35 t ha^{-1}) whereas no weeded condition produced the lowest grain yield (2.02 t ha^{-1}).

Shultana *et al.* (2011) conducted an experiment at Bangladesh Rice Research Institute, Gazipur, during winter season 2009 to evaluate the weed management efficiency of some pre-emergence herbicides in transplanted rice and found that among the evaluated herbicides, Rigid 50 EC (pretilachlor) @ 1L, Alert 18WP (bensulfuron + acetachlor) @ 400 g, Kildor 5G (butachlor) @ 25 kg, Bigboss 500EC (pretilachlor) @ 1L, Rifit 500EC (pretilachlor) @ 1L, Ravchlor 5G (butachlor) @ 25 kg, Succour 50EC (pretilachlor) @ 1L and Topstar 80WP (oxadiazon) @ 75 g ha^{-1}

showed grain yields above 4.00 t ha^{-1} which were comparable to the standard check; however, weed free plots gave the highest grain yield as anticipated.

2.2.4 Effect on weed population and weed control efficiency

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy farm of Bangladesh Rice Research Institute, Gazipur, during December 2008 to June 2009 in winter season to find out an effective and economic herbicide to manage weeds. Surjamoni and BRRI dhan29 were used as rice cultivars. Weed management methods were assigned using three rates of Becolor 5G (butachlor), Bouncer 10WP (pyrazosulfuron ethyl) and Becofit 500EC (Pretilachlor). Visual observation indicates that these herbicides were not toxic to rice plants. Weed management efficiency ranged (WCE) from 42 to 84%. Above 80% WCE was obtained by Becolor 5G @ 30 kg ha^{-1}, Bouncer 10WP @ 150 g ha^{-1} and Becofit 500EC @ 1.20 L ha^{-1}, respectively.

Ali *et al.* (2010) conducted an experiment at the Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during the period July-December, 2006 to evaluate weed control and yield of transplanted *aman* rice (cv. BRRI dhan37) as affected by integrated weed management and spacing and observed that among the weed control treatments Pretilachlor + one hand weeding at 40 DAT performed best for controlling weeds at 30 DAT (79.53%) and moderate for controlling weeds at 60 DAT (75.65%) which ultimately contributed to the highest grain yield (3.60 t ha^{-1}).

Bhuiyan *et al.* (2011a) conducted Field Experiments at BRRI farm, Bhanga, Faridpur (AEZ 12-Lower Ganges River Floodplain) and at Burichang of Comilla district (AEZ 19-Old Meghna Estuarine Floodplain) during dry season (*Boro*) 2007 to assess the effectiveness of different pre-emergence herbicide for weed management in direct wet seeded rice and its impact on phytotoxic effect, plant growth and yield of rice and found that pre-emergence application of Sofit N 300EC @ 450 and 600 g a.i. ha^{-1} led to more than 80% weed management efficiency, lowest weed number and dry weight of weeds which eventually resulted in lower weed index, higher yield attributes and grain yield of rice that were comparable to weed free conditions at both agro-ecological zones of Bangladesh.

Bari (2010) carried out an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh (BSMRAU) during 2007-08 using eight herbicides, i.e. Oxadiazone, Butachlor, Pretilachlor and Anilphos from pre-emergence category, and MCPA, Ethoxysulfuran, Pyrazosulfuran Ethyl and Oxadiarzil from post-emergence category in transplanted wetland rice during *aman* (autumn), *aus* (summer) and *boro* (winter) growing seasons to study their effects on weed management and rice yield and found that pre-emergence herbicides performed better regarding weed management efficiency and rice yield. Based on the initial performance, butachlor and MCPA were further applied at concentrations ranging from 50% to 150% of the recommended rates in transplanted *aus* rice in 2009. Data indicated that butachlor provided better weed management efficiency and contributed to better crop growth and grain yield compared to MCPA irrespective of concentration. It might be due to that pre-emergence application of Butachlor provided effective early season weed management, which MCPA could not since apply as post-emergence.

Bhuiyan *et al.* (2010) conducted an experiment during *boro* 2006 at Gazipur and Comilla location for the control of mixed weed flora in transplanted rice (*Oryza sativa L.*) and reported that pre-emergence application of Oxadiargyl 400SC @ 75 g a.i. ha^{-1} had minimum population and dry weight of weeds which resulted satisfactory weed control efficiency than other herbicide and doses. They also reported that Oxadiargyl 400SC caused light phytotoxicity to rice plants when applied @ 100 g a.i. ha^{-1}.

Gnanavel and Anbhazhagan (2010) conducted a field experiment during 2008-09, to study the bio-efficacy of promising pre and post-emergence herbicides against weeds in transplanted aromatic basmati rice. They concluded that pre-emergence application of oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded highest WCE (90.12%) favoring higher grain yield of aromatic rice (5.32 t ha^{-1}).

Kabir *et al.* (2008) stated that weed control efficiency were significantly influenced by different weed control treatments under water management practices. Other than weed free treatment, Butachlor 5G @ 2 kg ha^{-1} applied at 7 DAT along with one hand weeding at 40 DAT showed the best performance under good water management with the highest weed management efficiency (82.57%).

Mamun *et al*. (2011) conducted field experiments at Bangladesh Rice Research Institute (BRRI), Gazipur during *boro*, 2009 and *aus*, 2010 to evaluate the performance of Bensulfuron methyl + Pretilachlor 6.6% GR for weed suppression and its impacts on transplanted rice and found that application of Bensulfuron methyl + Pretilachlor 6.6% GR @ 652 g a.i. ha^{-1} gave more than 80% weed management efficiency.

Shultana *et al.* (2011) conducted an experiment at Bangladesh Rice Research Institute, Gazipur, during winter season 2009 to evaluate the weed management efficiency of some pre-emergence herbicides in transplanted rice and among the evaluated herbicides, Rigid 50 EC (pretilachlor) @ 1 L, Alert 18WP (bensulfuron + acetachlor) @ 400 g, Kildor 5G (butachlor) @ 25 kg, Bigboss 500EC (pretilachlor) @ 1 L, Rifit 500EC (pretilachlor) @ 1 L, Ravchlor 5G (butachlor) @ 25 kg, Succour 50EC (pretilachlor) @ 1 L and Topstar 80WP (oxadiazon) @ 75 g ha^{-1} showed above 80% weed management efficiency.

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

From the above presentation of the review of literature it may be said that seedlings per hill and weed management methods either single or in combination have decisive influence on crop performance of rice. The literature review above suggested that a considerable amount of work is still to be carried out in order to evaluate the objective of this study.

Chapter 3

MATERIALS AND METHODS

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design, crop growing procedure, fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

3.1 Location

The field experiment was conducted at the Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2012 to May, 2013.

3.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcareous dark grey soil. The pH value of the soil was 5.6. The physical and chemical properties of the experimental soil have been shown in Appendix I.

3.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from November to May, but scanty rainfall associated with moderately low to high temperature prevailed during the period from November to May.

3.4 Plant materials and features

Boro rice variety cv. BRRI dhan50 was used as a plant material for the present study. It is recommended for boro season. The features of the variety are presented below:

BRRI dhan50: BRRI dhan50 is the only aromatic rice for boro season released by BRRI in 2008. Since it has no photosensitivity, it can be cultivated throughout the year. It is recommended for high land areas with good irrigation facilities and for *boro* season. The grain is long, slender, whitish and scented. It takes about 155 days to mature. The plant height of this cultivar is about 82cm. It has the average yield potential of about 6.0 t ha^{-1} (BRRI, 2011).

3.5 Treatments

The experiment consisted of two factors as mentioned below:

Factor a: Seedlings per hill

i) 2 seedlings hill^{-1} (P_1)
ii) 4 seedlings hill^{-1} (P_2)
iii) 6 seedlings hill^{-1} (P_3)
iv) 8 seedlings hill^{-1} (P_4)

Factor b: Weed management strategies

i) No weeding (control) (W_0)
ii) Two hand weeding at 20 & 35 DAT (W_1)
iii) Two weeding by BRRI rice weeder at 20 & 35 DAT (W_2)
iv) Topstar 400SC (Oxadiargyl) @ 100 ml ha^{-1} (W_3)
v) Sunrice 150WG (Ethoxysulfuron) @ 185 ml ha^{-1} (W_4)

The description of the weed control treatments is given below.

1) No weeding: Weeds were allowed to grow in the plots from transplanting to harvesting of the crop. No weeding was done.

2) Hand weeding: One hand weeding was done at 20 DAT and another at 35 DAT.

3) Weeding by BRRI rice weeder: Two weedings were done by BRRI rice weeder at 20 and 35 DAT, respectively.

4) Topstar 400SC (Oxadiargyl): Topstar 400SC was applied @ 100 ml ha^{-1} at 5 DAT in 4-5 cm standing water for 3-5 days as pre-emergence herbicide.

5) Sunrice 150WG (Ethoxysulfuron): Sunrice 150WG was applied @ 185 ml ha^{-1} at 10 DAT when weeds were 2-3 leaf stage as post-emergence herbicide.

3.6 Description of herbicides

A short description of the herbicides used in the experiment is given below.

Trade name	Common name	Mode of action	Selectivity	Time of application
Topstar 400 SC	Oxadiargyl	Systemic	Transplanted rice, Sunflower and transplanted vegetables.	Pre-emergence
Sunrice 150 WG	Ethoxysulfuron	Systemic	Rice, cotton, sugar cane, turf and wheat.	Post-emergence

3.7 Design and layout

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 5.0 m x 2.25 m and total numbers of plots were 60. There were 20 treatment combinations. Each block was divided into 20 unit plots. Plant population was placed along the main plot and weeding treatments were placed in the sub plot. Lay out of the experiment was done on 30 December, 2012 with interplot spacing of 0.50 m and inter block spacing of 0.75 m.

3.8 Seed collection, sprouting and sowing

Seeds of BRRI dhan50 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur. Initially seed soaking was done in water for 24 hours and after wards they were kept tightly in jute sack for 2 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed on November 30, 2012. Seed bed size was 10 m long and 1.5 m wide.

3.9 Land preparation

The experimental field was opened by a tractor driven rotavator 15 days before transplanting. It was then ploughed well to make the soil nearly ready for transplanting. Weeds and stubble were removed and the field was leveled by repeated laddering. The experimental field was then divided into unit plots and prepared before transplantation.

3.10 Fertilizer application

The field was fertilized with nitrogen, phosphate, potash, sulphur and zinc at the rate of 150, 100, 70, 60 and 10 kg ha^{-1} respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT (BRRI, 2000).

3.11 Uprooting and transplanting of seedlings

The seedbeds were made wet by the application of water both in the morning and evening on the previous day before uprooting on January 05, 2013. The seedlings were then uprooted carefully to minimize mechanical injury to the roots and kept on soft mud in shade before they were transplanted. The thirty five days old seedlings were transplanted on the well puddled experimental plots maintaining 25x15 cm spacing on January 05, 2013 according to plant population treatments.

3.12 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.12.1 Gap filling

Seedlings in some hills were died off and those were replaced by healthy seedling within 10 days of transplantation.

3.12.2 Weeding

Weeding was done as per the experimental treatment.

3.12.3 Irrigation and drainage

The experimental plots were irrigated during the crop growth season and sometimes drainages were done at the time of heavy rainfall.

3.12.4 Plant protection measures

There were negligible infestations of insect-pests during the crop growth period. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control stem borer and rice bug.

3.13 General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

3.14 Harvest and post-harvest operation

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. From the centre of each plot 1 m^2 area was harvested to determine yield of individual treatment and converted into t ha^{-1}. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after required drying in sun. Before harvesting, ten hills were selected randomly outside the sample area of each plot and harvested at the ground level for collecting data on yield contributing characters.

3.15 Collection of data

3.15.1 Weed parameters

Weed density

The data on weed infestation as well as density were collected from each unit plot at 30 days interval up to 90 DAT. A quadrate of 1.0 m^2 was placed at three different spots of 11.25 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

Weed biomass

The weeds inside each quadrate were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for

72 hours maintaining a constant temperature of 80^{0}C. After drying, weight of each species was taken and expressed to g m^{-2}.

Weed control efficiency

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

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

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

Relative weed density (%)

Relative weed density was calculated by using the following formula:

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

3.15.2 Crop growth parameters

a. Plant height (cm) at 30 days interval up to harvest.
b. Tillers hill^{-1} at 30 days interval up to harvest.

3.15.3 Yield Contributing Characters

a. Effective tillers hill^{-1}
b. Length of panicle (cm)
c. Fertile spikelets (filled grains) panicle^{-1}
d. Weight of 1000 grains (g)

3.15.4 Yield and harvest index

a. Grain yield (t ha^{-1})
b. Straw yield (t ha^{-1})
c. Biological yield (t ha^{-1})
d. Harvest index (%)

3.16 Procedure of sampling for growth study during the crop growth period

Plant height (cm)

The height of the rice plants was recorded from 30 days after transplanting (DAT) with 30 days interval up to harvest, beginning from the ground level up to tip of the flag leaf was counted as height of the plant. The average height of ten hills was considered as the height of the plant for each plot.

Tillers hill^{-1}

Total tiller number was taken from 30 DAT with 30 days interval up to harvest. The average number of tillers of ten hills was considered as the total tiller no hill^{-1}.

3.17 Procedure of data collection for yield and yield components

For assessing yield parameters except the grain and straw yields data were collected from 10 randomly selected hills from each of the plots. For yield measurement, an area of 1.0 m^2 from center of each plot was harvested.

Effective tillers hill^{-1}

The total number of tillers hill^{-1} was counted from selected samples and were grouped in effective and non-effective tillers hill^{-1}.

Number of filled grains panicle^{-1}

Number of filled grains from randomly selected 10 hills were counted and average of which gave the number of filled grains panicle^{-1}. Presence of any food material in the grains was considered as filled grains.

Weight of 1000 grains (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 10 hills of each plot and were sun dried properly at 14% moisture content and weight by using an electric balance.

Grain and straw yield (t ha^{-1})

An area of 1.0 m^2 harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

Biological yield

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

Harvest index (%)

Harvest index is the relationship between grain yield and biological yield (Gardner *et al.*, 1985). It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.18 Statistical analysis

The recorded data were subjected to analyzed statistically. Analysis of variance was done following two factor split plot design with the help of computer package MSTAT-C. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Chapter 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter comprises of presentation and discussion of the results obtained from a study to investigate the influence of different seedlings per hill and weed management strategies on the growth, development and yield of transplanted aromatic *boro* rice variety cv. BRRI dhan50. The results of the weed parameters and crop characters of the production of the crop as influenced by different seedlings per hill and weed management strategies have been presented and discussed in this chapter.

4.1 Infested weed species in the experimental field

Twenty two weed species belonging to ten families were found to infest the experimental crop. Local name, common name, scientific name, family and morphological type of the weed species have been presented in Table 1. The density and dry weight of weeds varied considerably in different weed control treatments.

The most important weeds of the experimental plots were *Cyperus rotundus, Echinochloa crussgalli, Cyperus michelianus, Fimbristylis miliaceae*, *Cyperus difformis, Cyperus esculentus* and *Eleusine indica*. Mamun *et al.* (2011) reported that *Echinochloa crus-galli, Scirpus maritimus, Monochoria vaginalis, Cyperus difformis, Cynodon dactylon, Marsilea minuta, Ludwigia octovalvis,Nymphaea nouchali* and *Desmodium trifolium* were important weed species of rice. Among the twenty two species six were grasses, six sedges, six aquatic, three broad leafed and one fern (Table 1).

4.2 Relative weed density (%)

Weed competes with another weed plants for their existence. In this experiment, several weed species were observed at different dates (Table 2). This may be due to crop-weed competition, weed-weed competition or probable allelopathic effect of one plant to others. At 30 DAT *Cyperus michelianus* (36.73%) and *Cyperus esculentus* (17.31%) dominated the experimental field. At 60 DAT *Cyperus esculentus* (17.31%), *Alternanthera sessilis* (21.54%) and *Cyperus difformis* (15.79%) dominated the experimental field. However, at 90 DAT *Fimbristylis miliaceae* (19.50%), *Cyperus esculentus* (15.32%), *Echinochloa crussgalli* (12.53%) and *Eleusine indica* (12.26%) dominated the experimental field. This result is dissimilar with the findings of

Hasanuzzaman *et al.* (2009) who observed that grasses and sedges were less dominating weed species. This might be due to seasonal and varietal variation.

Table 1. Weed species found in the experimental plots of BRRI dhan50

SL No.	Local name	Common name	Scientific name	Family	Types
1	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae	Grass
2	Chanci	Sessile joyweed	*Alternanthera sessilis*	Amaranthaceae	Aquatic
3	Malancha	Alligatorweed	*Alternanthera philoxeroides*	Amaranthaceae	Aquatic
4	Boro Shama	Barnyard Grass	*Echinochloa crussgalli*	Poaceae	Grass
5	Chandmala	Duck weed	*Sagittaria guyanensis*	Alismataceae	Aquatic
6	Sushni	European waterclover	*Marsilea quadrifolia*	Marsileaceae	Fern
7	Nakful	Nutsedge	*Cyperus michelianus*	Cyperaceae	Sedge
8	Joyna	Fringerush	*Fimbristylis miliaceae*	Cyperaceae	Sedge
9	Mutha	Nutgrass	*Cyperus rotundus*	Cyperaceae	Sedge
10	Jhilmorich	Gooseweed	*Sphenoclea zeylanica*	Sphenocleaceae	Broadleaf
11	Panilong	Willow primrose	*Ludwigia octovalvis*	Onagraceae	Broadleaf
12	Arail	Rice grass	*Leersia hexandra*	Poaceae	Grass
13	Behua	Small flower umbrella	*Cyperus difformis*	Cyperaceae	Sedge
14	Holdemutha	Yellow nutsedge	*Cyperus esculentus*	Cyperaceae	Sedge
15	Keshuti	Eclipta	*Eclipta alba*	Asteraceae	Broadleaf
16	Moyurleja	Red sprangletop	*Leptochloa panicea*	Poaceae	Grass
17	Chapra	Indian goosegrass	*Eleusine indica*	Poaceae	Grass
18	Chotoshama	Jungle rice	*Echinochloa colonum*	Poaceae	Grass
19	Ghagra	Cocklebur	*Xanthium indicum*	Compositae	Aquatic
20	Chech	Mud sedge	*Fimbristylis diphylla*	Cyperaceae	Sedge
21	Kanai bashi	Spider wort	*Commelina benghalensis*	Commelinaceae	Aquatic
22	Choto pani kochu	Monochoria	*Monochoria vaginalis*	Pontederiaceae	Aquatic

4.3 Weed population

4.3.1 Effect of seedlings per hill

Significant variation were observed due to different plant population of BRRI dhan50 field (Figure 1). It was observed that the weed population increased from 30 to 60 DAS and then decreased considerably. This may be due to death of several weed species due to completion of their life cycle. It was observed that the plot with 2 seedlings hill^{-1} (P_1) recorded lowest (80.93) number of weed population and 8 seedlings hill^{-1} (P_4) showed the highest (111.1) at 30, 60 and 90 DAT (Figure no. 1).

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

SL No.	Common name	Scientific name	Days after transplanting		
			30 DAT	60 DAT	90 DAT
1	Bermuda grass	*Cynodon dactylon*	1.84	0.43	0.70
2	Sessile joyweed	*Alternanthera sessilis*	5.25	21.54	3.06
3	Alligatorweed	*Alternanthera philoxeroides*	0.47	0.57	0.84
4	Barnyard Grass	*Echinochloa crussgalli*	4.20	6.46	12.53
5	Duck weed	*Sagittaria guyanensis*	2.36	0.79	0.70
6	European waterclover	*Marsilea quadrifolia*	4.20	0.43	0.84
7	Nutsedge	*Cyperus michelianus*	36.73	1.58	0.70
8	Fringerush	*Fimbristylis miliaceae*	1.31	8.61	19.50
9	Nutgrass	*Cyperus rotundus*	6.82	0.57	1.11
10	Gooseweed	*Sphenoclea zeylanica*	2.20	2.15	0.70
11	Willow primrose	*Ludwigia octovalvis*	3.67	3.59	9.19
12	Rice grass	*Leersia hexandra*	0.79	0.36	0.84
13	Small flower umbrella	*Cyperus difformis*	4.72	15.79	3.06
14	Yellow nutsedge	*Cyperus esculentus*	17.31	25.13	15.32
15	Eclipta	*Eclipta alba*	4.72	0.36	0.84
16	Red sprangletop	*Leptochloa panicea*	0.10	3.59	9.75
17	Indian goosegrass	*Eleusine indica*	2.31	4.74	12.26
18	Jungle rice	*Echinochloa colonum*	0.31	2.73	6.13

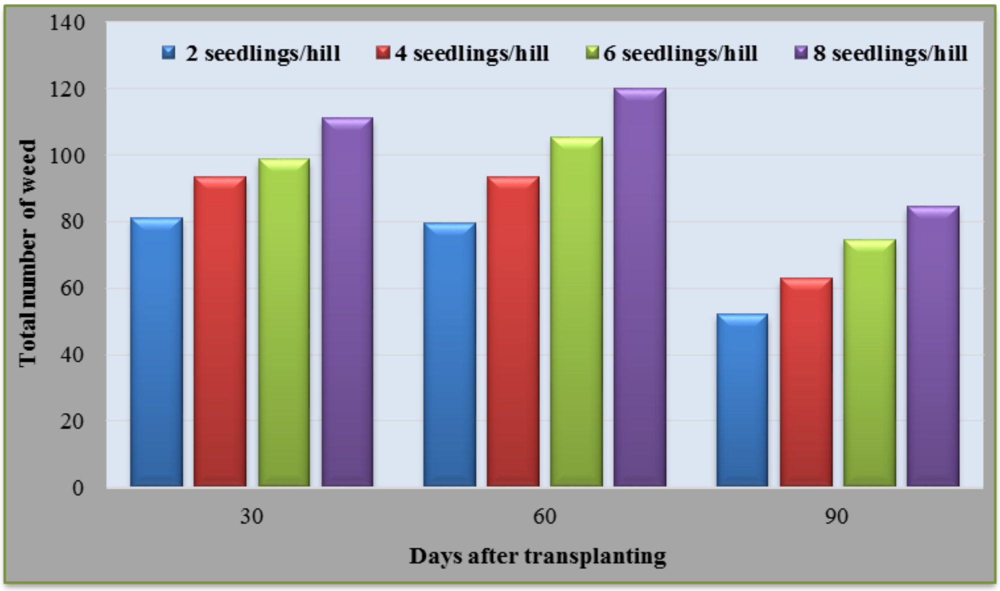

Figure 1. Effect of seedlings per hill on total number of weeds (m^{-2}) of BRRI dhan50 at different days after transplanting (SE ± = 13.64, 1.54 and 1.44 for 30, 60 and 90 DAT)

4.3.2 Effect of weed management strategies

Weed management strategies had significant variation on the weed population of the experimental BRRI dhan50 field (Figure 2). It was observed that the total number of weeds were highest for no weeding (control) treatment at 30, 60 and 90 DAT (Figure 2). Weeding twice by BRRI rice weeder revealed with the second highest number of weeds at 30, 60 and 90 DAT. However, the lowest number of weeds at 30 DAT, 60 DAT and 90 DAT were observed in Sunrice 150WG treated plots. Similar results were also stated by Bhuiyan *et al.* (2011a).

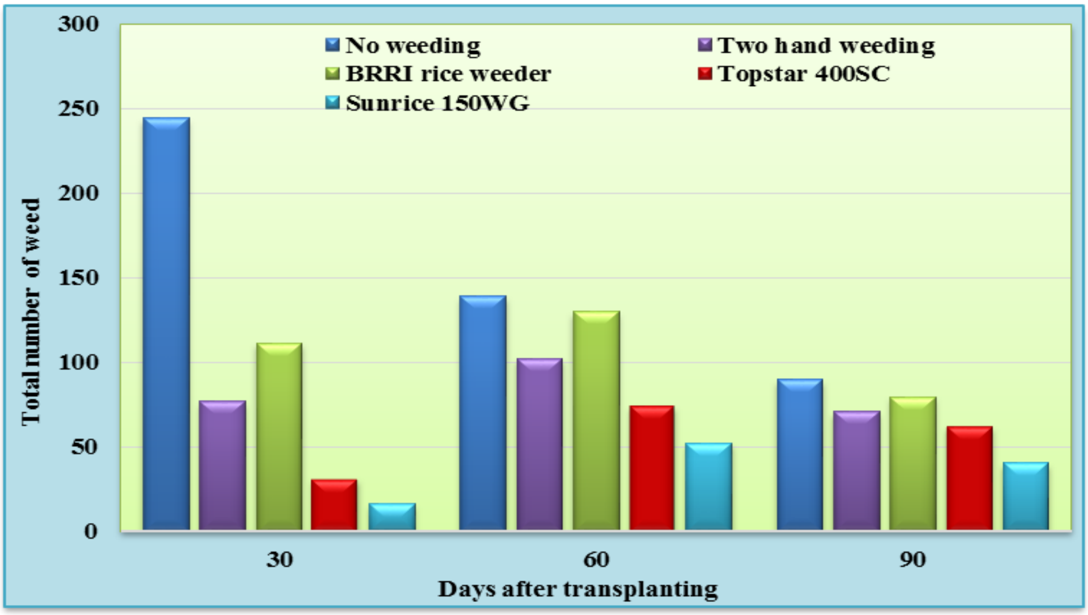

Figure 2. Effect of weed management methods on total number of weeds (m^{-2}) of BRRI dhan50 at different days after transplanting (SE(±)= 15.25, 1.72 and 1.614 for 30, 60 and 90 DAT)

4.3.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variations were observed due to various treatment combinations of plant population and weed management methods at only 30 DAT (Table 3). At 30 DAT P_4W_0 treatment showed the highest (264.1) number of weed m^{-2} which was statically similar with P_4W_0. At 60 DAT and 90 DAT P_4W_0 showed the highest (167, 105.7) number of weeds m^{-2}. However, P_1W_4 showed the lowest (9, 33, 21.78) number of weeds m^{-2} at 30 DAT, 60 DAT and 90 DAT. This result was similar with the findings of Gnanavel and Anbhazhagan (2010) who observed that Pre-emergence application of oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded the least weed count (11.00 m^{-2}) in transplanted aromatic basmati rice.

Table 3. Interaction effect of seedlings per hill and weed management strategies on total number of weeds m^{-2} at different days after transplanting

Treatments interactions	Days after transplanting		
	30 DAT	60 DAT	90 DAT
P_1W_0	227.8 a	110.6	74.33
P_1W_1	57.89 b-d	86.78	56.67
P_1W_2	88.31b-d	113.0	64.00
P_1W_3	21.66cd	54.00	43.66
P_1W_4	9.000d	33.00	21.78
P_2W_0	251.1a	135.3	85.00
P_2W_1	69.89b-d	97.00	62.00
P_2W_2	108.7 b-d	120.3	72.33
P_2W_3	25.00 b-d	65.00	62.00
P_2W_4	11.67d	48.66	33.00
P_3W_0	234.4a	143.0	93.67
P_3W_1	85.33b-d	107.7	73.00
P_3W_2	122.0bc	134.3	86.33
P_3W_3	33.66b-d	83.00	70.66
P_3W_4	18.33cd	58.65	48.66
P_4W_0	264.1a	167.0	105.7
P_4W_1	94.55b-d	117.6	91.33
P_4W_2	127.0b	152.3	95.33
P_4W_3	43.33b-d	95.00	71.67
P_4W_4	26.33b-d	68.88	58.65
SE	30.51	ns	ns
CV (%)	35.04	5.97	8.16

P_1= 2 seedlings $hill^{-1}$, P_2= 4 seedlings $hill^{-1}$, P_3 = 6 seedlings $hill^{-1}$, P_4= 8 seedlings $hill^{-1}$, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.4 Weed biomass

4.4.1 Effect of seedlings per hill

Weed biomass varied significantly due to various plant population treatments (Figure 3). It was observed that at 30 DAT 8 seedlings $hill^{-1}$ plant population treatment showed highest weed biomass (19.46) which was statistically similar with 6 seedlings $hill^{-1}$ (P_3), 4 seedlings $hill^{-1}$ (P_2) treatments. However, 2 seedlings $hill^{-1}$ (P_1)

showed lowest weed biomass (11.21) which was statistically similar with 4 seedlings hill^{-1} and 6 seedlings hill^{-1} (P_3). At 60 DAT, 8 seedlings hill^{-1} (P_4) treatment showed highest weed biomass (52.56) and 2 seedlings hill^{-1} (P_1) showed lowest weed biomass (32.91) which was statistically similar with 4 seedlings hill^{-1} (P_2) treatment. At 90 DAT, 8 seedlings hill^{-1} (P_4) treatment showed highest weed biomass (24.46) which was statistically similar with 6 seedlings hill^{-1} (P_3) and 4 seedlings hill^{-1} (P_2) treatments. However, 2 seedlings hill^{-1} (P_1) showed lowest weed biomass (16.21) which was statistically similar with 4 seedlings hill^{-1} (P_2) and 6 seedlings hill^{-1} (P_3).

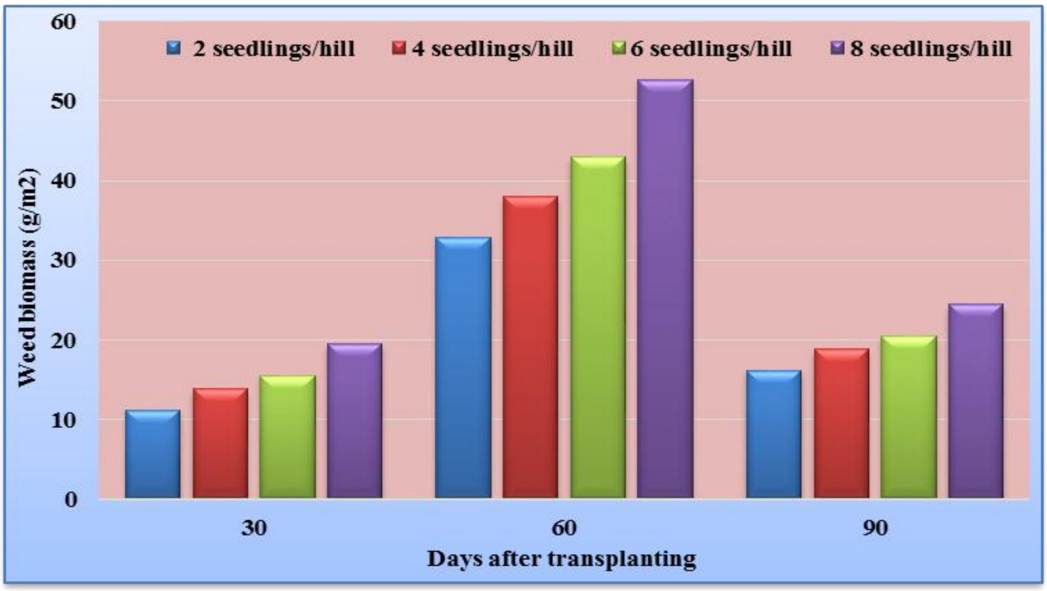

Figure 3. Effect of seedlings per hill on weed biomass of BRRI dhan50 at different days after transplanting (SE(±)= 2.04, 2.55 and 2.04 and 1.614 for 30, 60 and 90 DAT)

4.4.2 Effect of weed management strategies

Weed biomass varied significantly due to various weed management strategies (Figure 4). It was observed that at 30 DAT no weeding (control) showed the highest weed biomass (34.34) and Sunrice 150WG treated plots showed lowest weed biomass (5.719) which was statistically similar with Topstar 400SC and two hand weeding. At 60 DAT no weeding (control) showed the highest weed biomass and Sunrice 150WG treated plots showed lowest weed biomass which was statistically similar with Topstar 400SC. At 90 DAT no weeding (control) showed the highest weed biomass (39.34) and Sunrice 150WG treated plots showed lowest weed biomass (10.72) which was statistically similar with Topstar 400SC and two hand weeding. This result is also similar with the findings of Bhuiyan *et al.* (2011a), Bhuiyan *et al.* (2011b) and Gnanavel and Anbhazhagan (2010).

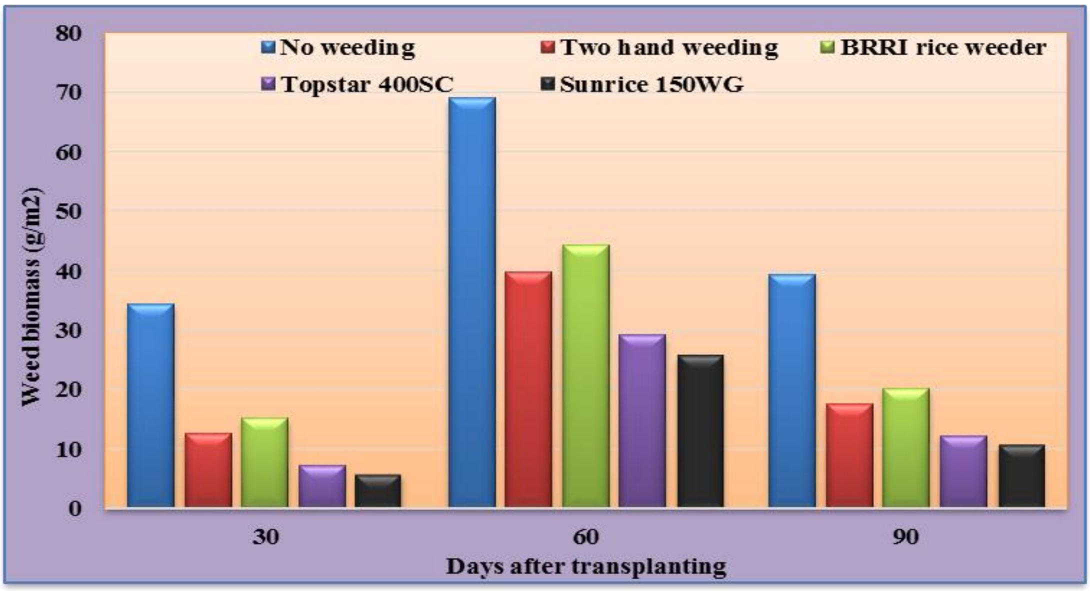

Figure 4. Effect of weed management strategies on weed biomass of BRRI dhan50 rice field at different days after transplanting (SE(±)= 2.28, 2.85 and 2.28 for 30, 60 and 90 DAT)

4.4.3 Interaction effect of seedlings per hill and weed management strategies

No significant variations were observed on weed biomass (g m^{-2}) due to various combinations of seedlings per hill and weed management strategies (Table 4). Numerically at 30 DAT, 60 DAT and 90 DAT, P_4W_0 showed the highest weed biomass (36.89, 86.37 & 41.89 g m^{-2}). However, P_1W_4 showed the lowest weed biomass (2.217, 22.22 & 7.217 g m^{-2}) at 30 DAT, 60 DAT and 90 DAT.

Table 4. Interaction effect of seedlings per hill and weed management strategies on the weed biomass (g m^{-2}) in BRRI dhan50

Treatment interactions	Days after transplanting		
	30 DAT	60 DAT	90 DAT
P_1W_0	32.30	55.11	37.30
P_1W_1	10.89	32.22	15.89
P_1W_2	7.330	31.65	12.33
P_1W_3	3.330	23.33	8.330
P_1W_4	2.217	22.22	7.217
P_2W_0	33.10	63.89	38.10
P_2W_1	12.78	35.89	17.78
P_2W_2	13.66	40.66	18.66
P_2W_3	5.260	25.26	10.26
P_2W_4	4.553	24.55	9.553
P_3W_0	35.06	70.66	40.06
P_3W_1	12.67	41.89	17.67
P_3W_2	15.00	47.33	20.00
P_3W_3	8.997	29.00	14.00
P_3W_4	5.887	25.89	10.89
P_4W_0	36.89	86.37	41.89
P_4W_1	13.96	49.42	18.96
P_4W_2	24.66	57.88	29.66
P_4W_3	11.55	38.89	16.55
P_4W_4	10.22	30.22	15.22
SE	4.559	5.704	4.559
CV (%)	52.59	23.74	39.45

P_1= 2 seedlings hill^{-1}, P_2= 4 seedlings hill^{-1}, P_3 = 6 seedlings hill^{-1}, P_4= 8 seedlings hill^{-1}, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.5 Weed control efficiency

4.5.1 Effect of seedlings per hill

Weed control efficiency varied significantly due to various seedlings per hill treatment (Figure 5). It was observed that at 30 DAT weed control efficiency was highest (58.92) for 2 seedlings hill^{-1} (P_1) treatment which was statistically similar with 4 seedlings hill^{-1} (P_2). And 6 seedlings hill^{-1} showed lowest (45.25) weed control efficiency which was statistically similar with 8 seedlings hill^{-1} (P_4). At 60 DAT, 4 seedlings hill^{-1} (P_2) showed highest (39.18) weed control efficiency however, at 90 DAT 2 seedlings hill^{-1} (P_1) recorded the highest (49.93) weed control efficiency.

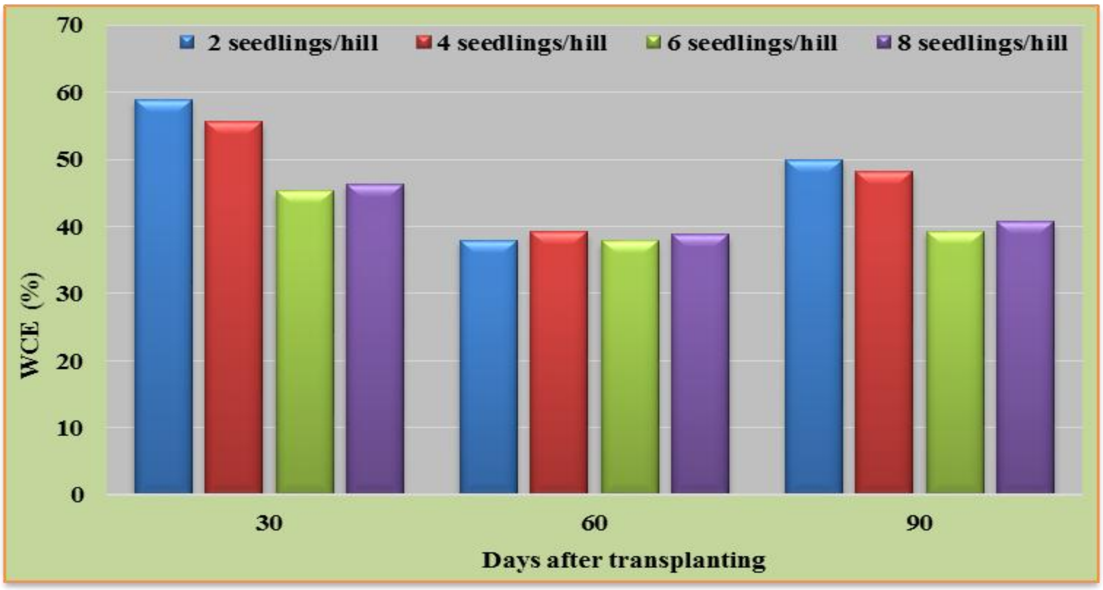

Figure 5. Effect of seedlings per hill on weed control efficiency of BRRI dhan50 at different days after transplanting (SE(±)= 3.09, 2.99 and 2.82 for 30, 60 and 90 DAT)

4.5.2 Effect of weed management strategies

Weed control efficiency varied significantly due to various weed management strategies (Figure 6). It was observed that Sunrice 150WG showed highest weed control efficiency at 30 DAT, 60 DAT and 90 DAT. Apart from the control (no weeding) and BRRI rice weeder showed the least weed control efficiency at 30 DAT, 60 DAT and 90 DAT. On the other hand, this result was in agreement with the findings of Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011a), Mamun *et al.* (2011), Ali *et al.* (2010), Gnanavel and Anbhazhagan (2010) and Kabir *et al.* (2008).

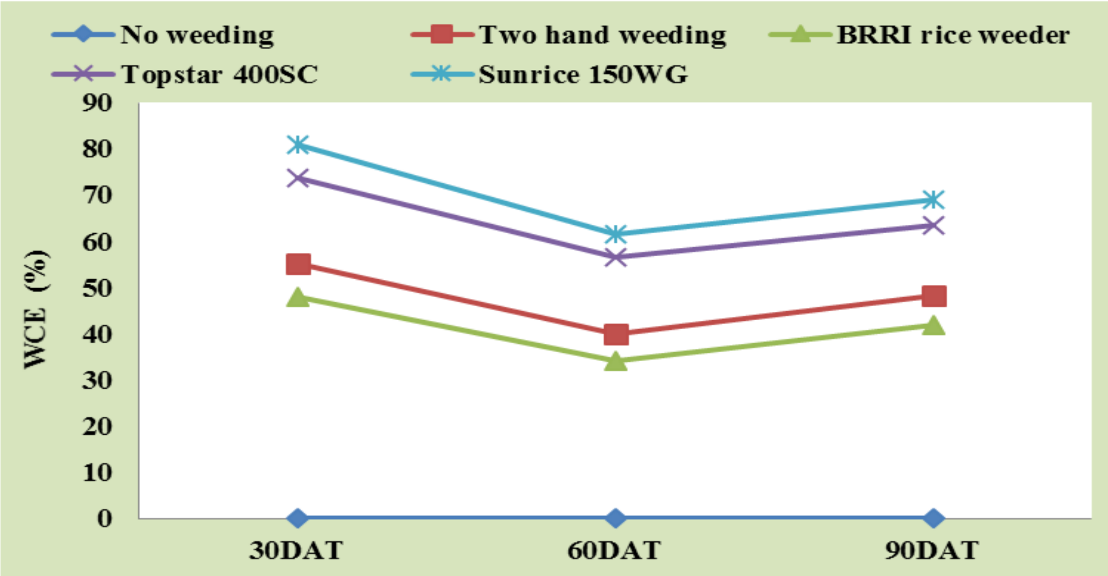

Figure 6. Effect of weed management strategies on weed control efficiency of BRRI dhan50 at different days after transplanting (SE(±)= 3.45, 3.44 and 3.14 for 30, 60 and 90 DAT)

4.5.3 Interaction effect of seedlings per hill and weed management strategies

No significant variations were observed on weed control efficiency (%) due to various combinations of seedlings per hill and weed management strategies (Table 5). Numerically at 30 DAT and 90 DAT, P_1W_4 showed the highest weed control efficiency (92.12% & 76.44%). At 60 DAT P_4W_4 showed the highest weed control efficiency (65.14%). However, P_1W_0, P_2W_0, P_3W_0 and P_4W_0 showed the lowest weed control efficiency (%) at 30 DAT, 60 DAT and 90 DAT.

Table 5. Interaction effect of seedlings per hill and weed management strategies on weed control efficiency (%) in BRRI dhan50

Treatment interactions	Days after transplanting		
	30DAT	60DAT	90DAT
P_1W_0	0	0	0
P_1W_1	54.52	38.50	47.25
P_1W_2	64.64	38.90	55.76
P_1W_3	83.35	54.92	70.21
P_1W_4	92.12	57.62	76.44
P_2W_0	0	0	0
P_2W_1	57.39	41.63	49.93
P_2W_2	54.29	34.36	47.30
P_2W_3	81.98	59.30	70.83
P_2W_4	84.12	60.63	72.69
P_3W_0	0	0	0
P_3W_1	47.27	38.11	41.95
P_3W_2	41.48	30.72	36.97
P_3W_3	61.31	57.84	53.01
P_3W_4	76.19	62.68	64.50
P_4W_0	0	0	0
P_4W_1	61.44	41.36	54.03
P_4W_2	31.21	32.78	27.63
P_4W_3	67.92	54.81	59.74
P_4W_4	71.33	65.14	62.77
SE	6.907	6.687	6.309
CV (%)	23.22	30.11	24.53

P_1= 2 seedlings hill^{-1} (P1), P_2= 4 seedlings hill^{-1} (P2) , P_3 = 6 seedlings hill^{-1}, P_4= 8 seedlings hill^{-1}, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.6 Crop growth parameters

4.6.1 Plant height

4.6.1.1 Effect of seedlings per hill

Plant height varied significantly due to various plant population treatments (Figure 7). It was observed that 2 seedlings hill^{-1} (P_1) showed the highest plant height (41.92, 68.08, 79.48 & 78.34) at 30 DAT, 60 DAT, 90 DAT and at harvest. The lowest plant height (35.15, 61.03, 72.43 & 71.26) was observed from 8 seedlings hill^{-1} (P_4) at 30 DAT, 60 DAT, 90 DAT and at harvest which was statistically similar with 6 seedlings hill^{-1} at 30 DAT, 60 DAT, 90 DAT and at harvest. These results are in agreement with Bozorgi *et al.* (2011) and Mobasser *et al.* (2007) who showed that plant height was decreased significantly with the increase of planting density.

Figure 7. Effect of seedlings per hill on plant height of BRRI dhan50 at different days after transplanting (SE ± = 0.74, 0.73, 0.71 and 0.71 for 30, 60, 90 DAT and at harvest)

4.6.1.2 Effect of weed management strategies

Plant height also varied significantly due to various weed management strategies (Figure 8). It was observed that Sunrice 150 WG showed the highest plant height (41.53, 67.91, 79.65 & 78.48) at 30 DAT, 60 DAT, 90 DAT and at harvest which was statistically similar with Topstar 400SC at 30 DAT, 60 DAT, 90 DAT and at harvest. However, no weeding (control) treatment recorded lowest plant height (33.55, 59.29, 69.79& 69.79) at 30 DAT, 60 DAT, 90 DAT and at harvest. The results were in consistence with the findings of Hasanuzzaman *et al.* (2008) and Hasanuzzaman *et al.* (2007).

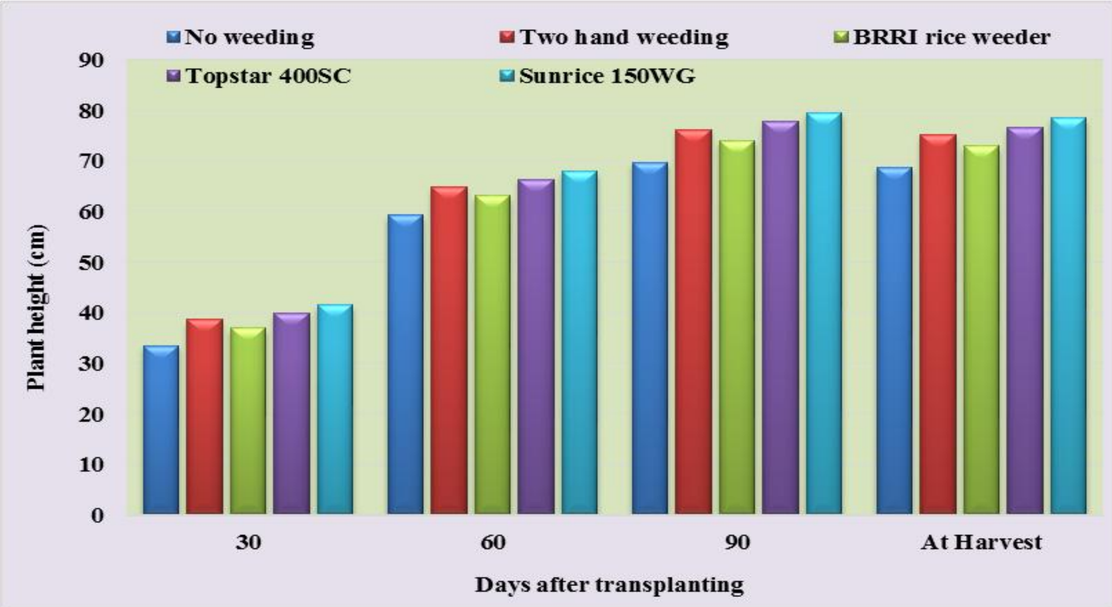

Figure 8. Effect of weed management strategies on plant height of BRRI dhan50 rice field at different days after transplanting (SE(±)= 0.83, 0.81, 0.79 and 0.79 for 30, 60, 90 DAT and at harvest)

4.6.1.3 Interaction Effect of seedlings per hill and weed management strategies

No significant variations were observed on plant height of BRRI dhan50 due to various combinations of seedlings per hill and weed management strategies (Table 6). At 30 DAT, 60 DAT, 90 DAT and at harvest, P_1W_4 showed the highest (46.61, 72.92, 85.56 & 84.42) plant height. However, P_4W_0 showed the lowest plant height (31.66, 56.43, 67.16 & 66.09) at 30 DAT, 60 DAT, 90 DAT and at harvest.

Table 6. Interaction effect of seedlings per hill and weed management strategies on the plant height (cm) of BRRI dhan50

Treatment interactions	Days after transplanting			
	30 DAT	**60 DAT**	**90 DAT**	**At Harvest**
P_1W_0	35.13	60.67	71.46	70.55
P_1W_1	42.72	69.03	80.22	79.01
P_1W_2	40.96	67.27	78.46	77.25
P_1W_3	44.20	70.51	81.70	80.49
P_1W_4	46.61	72.92	85.56	84.42
P_2W_0	33.32	59.63	69.89	68.86
P_2W_1	39.81	65.82	77.31	76.10
P_2W_2	37.99	64.30	75.49	74.28
P_2W_3	41.51	67.82	79.01	77.80
P_2W_4	42.08	68.65	79.77	78.61
P_3W_0	34.10	60.42	70.65	69.51
P_3W_1	36.70	63.01	74.70	73.72
P_3W_2	35.15	61.20	71.83	70.76
P_3W_3	37.69	64.00	75.19	73.98
P_3W_4	39.62	65.93	77.12	75.91
P_4W_0	31.66	56.43	67.16	66.09
P_4W_1	35.40	61.57	72.83	71.76
P_4W_2	34.00	59.87	70.66	69.52
P_4W_3	36.86	63.17	75.37	73.93
P_4W_4	37.82	64.13	76.14	75.00
SE	1.655	1.625	1.583	1.589
CV (%)	7.51	4.38	3.63	3.70

P_1= 2 seedlings hill^{-1}, P_2= 4 seedlings hill^{-1}, P_3 = 6 seedlings hill^{-1}, P_4= 8 seedlings hill^{-1}, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.6.2 Number of tillers hill^{-1}

4.6.2.1 Effect of seedlings per hill

Number of tillers hill^{-1} varied significantly due to various plant population treatments (Figure 9). It was observed that 2 seedlings hill^{-1} (P_1) showed highest (20.44, 19.34 & 18.21) number of tillers hill^{-1} at 60 DAT, 90 DAT and at harvest which was statistically similar with 4 seedlings hill^{-1} (P_2) at 60 DAT, 90 DAT and at harvest. However, 8 seedlings hill^{-1} (P_4) showed the lowest (16.81, 15.66 & 14.46) number of tillers hill^{-1} at 60 DAT, 90 DAT and at harvest which was statistically similar with 6 seedlings hill^{-1} (P_3) at 60 DAT, 90 DAT and at harvest. These results are in agreement with the findings of Hassan *et al.* (2010) however, *Bozorgi et al.* (2011) found decreased tiller number with decreased seedlings hill^{-1}.

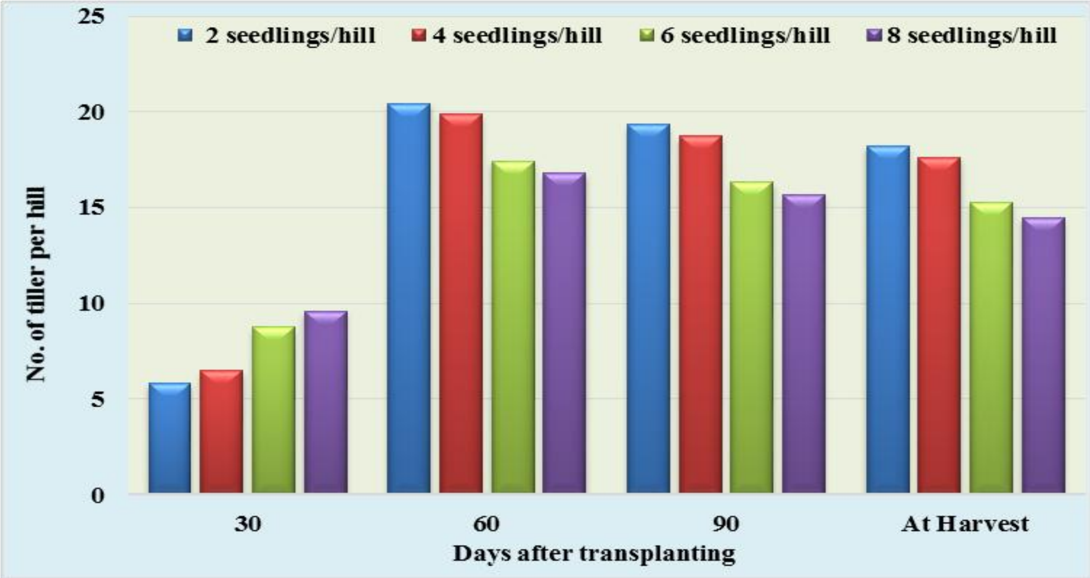

Figure 9. Effect of seedlings per hill on number of tiller hill^{-1} of BRRI dhan50 different days after transplanting (SE(±)= 0.40, 0.43, 0.42 and 0.40 for 30,60, 90 DAT and at harvest)

4.6.2.2 Effect of weed management strategies

Number of tillers hill^{-1} also varied significantly due to various weed management strategies (Figure 10). It was observed that Sunrice 150WG showed the highest (9.551) number of tillers hill^{-1} at 30 DAT which was statistically similar with Topstar 400SC. At 60 DAT, 90 DAT and at harvest Sunrice 150WG showed the highest number of tiller hill^{-1}. Similar findings were reported by Khan and Tarique (2011) who observed that highest number of tillers plant^{-1} was observed in completely weed free condition throughout the crop growth period.

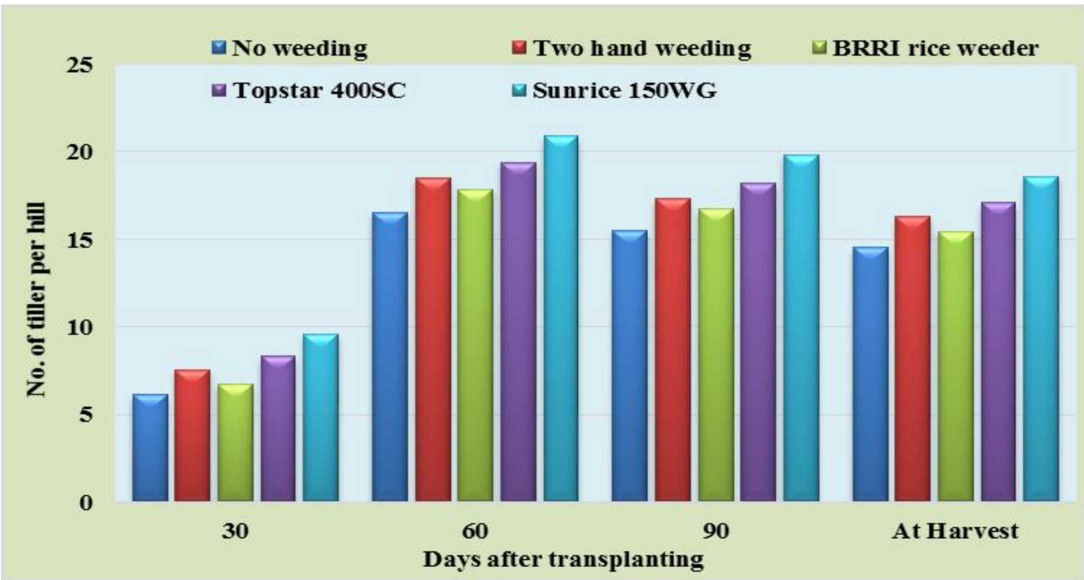

Figure 10. Effect of weed management strategies on number of tillers hill^{-1} of BRRI dhan50 at different days after transplanting (SE(±)= 0.45, 0.48, 0.47 and 0.45 for 30, 60, 90 DAT and at harvest)

4.6.2.3 Interaction Effect of seedlings per hill and weed management strategies

No significant variations were observed on the number of tiller hill^{-1} of BRRI dhan50 due to various combinations of seedlings per hill and weed management strategies (Table 7). At 30 DAT, 60 DAT, 90 DAT and at harvest, P_1W_4 showed the highest (13.63, 24.74, 23.65 & 22.26) number of tiller hill^{-1}. However, P_4W_0 showed the lowest number of tiller hill^{-1} at 30 DAT, 60 DAT, 90 DAT and at harvest.

Table 7. Interaction effect of seedlings per hill and weed management strategies on number of tiller hill^{-1} of BRRI dhan50

Treatment interactions	Days after transplanting			
	30DAT	60DAT	90DAT	At Harvest
P_1W_0	6.737	17.14	16.28	15.37
P_1W_1	9.220	19.70	18.43	17.26
P_1W_2	7.737	18.85	17.72	16.63
P_1W_3	10.66	21.77	20.64	19.55
P_1W_4	13.63	24.74	23.65	22.26
P_2W_0	6.887	18.00	16.87	15.78
P_2W_1	8.693	19.80	18.67	17.58
P_2W_2	7.847	18.96	17.83	16.74
P_2W_3	9.330	20.44	19.31	18.22
P_2W_4	10.95	22.06	20.93	19.84
P_3W_0	5.703	16.11	14.99	14.19
P_3W_1	6.630	17.74	16.61	15.52
P_3W_2	6.033	17.14	16.01	14.92
P_3W_3	6.663	17.77	16.64	15.55
P_3W_4	7.293	18.40	17.27	16.18
P_4W_0	5.253	14.96	13.77	12.88
P_4W_1	5.663	16.63	15.64	14.81
P_4W_2	5.330	16.44	15.31	13.55
P_4W_3	6.590	17.63	16.25	15.12
P_4W_4	6.330	18.40	17.32	15.92
SE	0.90	0.96	0.95	0.90
CV (%)	20.45	8.92	9.38	9.51

P_1= 2 seedlings hill^{-1}, P_2= 4 seedlings hill^{-1}, P_3 = 6 seedlings hill^{-1}, P_4= 8 seedlings hill^{-1}, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.7 Yield contributing characters

4.7.1 Panicle length

4.7.1.1 Effect of seedlings per hill

Panicle length varied significantly due to various plant population treatments (Table 8). It was observed that 2 seedlings hill^{-1} (P_1) showed the highest (22.93) panicle length. On the contrary, 8 seedlings hill^{-1} (P_4) showed the lowest (17.19) panicle length which was statistically similar with 6 seedlings hill^{-1}. These results are in similar to the findings of Hassan *et al.* (2010) and *Bozorgi et al.* (2011) who stated that the length of panicle was also significantly influenced by different plant population treatments and concluded that two seedlings hill^{-1} gave the longest panicle length.

4.7.1.2 Effect of weed management strategies

Panicle length varied significantly due to various weed management strategies (Table 8). It was observed that Sunrice 150WG showed the highest (23.86 cm) panicle length. However, no weeding (control) showed the lowest (15.53 cm) panicle length. This confirms the report of Khan and Tarique (2011) and Hasanuzzaman *et al.* (2008) who observed that panicle length differed due to different weed management strategies.

4.7.1.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various combinations of seedlings per hill and weed management strategies on the panicle length of BRRI dhan50 (Table 8). It was observed that the treatment combination P_1W_4 showed the highest (26.47 cm) panicle length which was statistically similar with the treatment combination of P_1W_1, P_1W_2, P_1W_3, P_2W_3, P_2W_4, P_3W_3 and P_3W_4.

4.7.2 Effective tillers hill^{-1}

4.7.2.1 Effect of seedlings per hill

Number of effective tillers hill^{-1} varied significantly due to various plant population treatments (Table 8). It was observed that 2 seedlings hill^{-1} (P_1) showed the highest (15.01) number of effective tillers hill^{-1}. However, 8 seedlings hill^{-1} (P_4) showed the lowest (8.742) number of effective tillers hill^{-1} which was statistically similar with 6 seedlings hill^{-1} (P_3). This confirms the report of Ashraf *et al.* (1999) who stated that transplanting of rice with 2 and 3 seedlings hill^{-1} gave more promising results in terms of more productive tillers unit per area.

4.7.2.2 Effect of weed management strategies

Number of effective tillers hill^{-1} varied significantly due to various weed management strategies (Table 8). It was observed that Sunrice 150WG showed the highest (15.22) number of effective tillers hill^{-1}. However, no weeding (control) showed the lowest (7.5) number of effective tillers hill^{-1}. These results were in similar to the findings of Hasanuzzaman *et al.* (2008) and Raju *et al.* (2003) who stated that use of weedicide (Ronstar 25 EC, Safener and Butachlor) gave the highest effective tiller.

4.7.2.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various treatment combinations of seedlings per hill and weed management strategies on number of effective tiller hill^{-1} of BRRI dhan50 (Table 8). It was observed that the treatment combination of P_1W_4 showed the highest (19.81) number of effective tiller hill^{-1} which was statistically similar with the treatment combination of P_1W_3 and P_2W_4.

4.7.4 Filled grains panicle^{-1}

4.7.4.1 Effect of seedlings per hill

Number of filled grain panicle^{-1} varied significantly due to various plant population treatments (Table 8). It was observed that 2 seedlings hill^{-1} (P_1) showed the highest (80.26) number of filled grain panicle^{-1}. However, 8 seedlings hill^{-1} (P_4) showed the lowest (60.16) number of filled grain panicle^{-1} which was statistically similar with 6 seedlings hill^{-1} (P_3). The result is in agreement with Hasanuzzaman *et al.* (2009), Shah *et al.* (1991) and Singh *et al.* (1987) who stated that number of filled grains panicle^{-1} increased with the decrease in seedling number hill^{-1}.

4.7.4.2 Effect of weed management strategies

Number of filled grain panicle^{-1} varied significantly due to various weed management strategies (Table 8). It was observed that Sunrice 150WG showed the highest (83.53) number of filled grain panicle^{-1}. However, no weeding (control) showed the lowest (54.56) number of filled grain panicle^{-1}. This result supports the findings of

Hasanuzzaman *et al.* (2008) and Salam *et al.* (2010) who showed that application of herbicide contributed mainly increasing the number of grain panicle^{-1}.

4.7.4.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various combinations of seedlings per hill and weed management strategies on the number of filled grain panicle^{-1} of BRRI dhan50 (Table 8). It was observed that the treatment combination of P_1W_4 showed the highest (92.64) number of filled grain panicle^{-1} which was statistically similar with the treatment combinations of P_1W_1, P_1W_2, P_1W_3, P_2W_3, P_2W_4, P_3W_3 and P_3W_4.

4.7.7 1000 grain weight

4.7.7.1 Effect of seedlings per hill

1000-grain weight varied significantly due to various plant population treatments (Table 8). It was observed that 2 seedlings hill^{-1} (P_1) showed the highest (18.7) 1000-grain weight. However, 8 seedlings hill^{-1} (P_4) showed lowest (16.39) 1000-grain weight. This findings are with the agreement of Baloch *et al.* (2002); however Choudhury *et al.* (1995) reported that seed size was not affected by the number of seedlings hill^{-1}.

4.7.7.2 Effect of weed management strategies

1000-grain weight varied significantly due to various weed management strategies (Table 8). It was observed that Sunrice 150WG showed the highest (18.36 g) 1000-grain weight. However, no weeding (control) showed lowest (16.52 g) 1000-grain weight. This finding was in agreement with Khan and Tarique (2011), Hassan *et al.* (2010) and Raju *et al.* (2003) who showed that weeding regime had significant effect on 1000 grain weight. But this result was dissimilar with the findings of Nahar *et al.* (2010) and Karim and Ferdous (2010) who observed that 1000 grain weight was negatively related to weed density.

4.7.7.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various treatment combinations of seedlings per hill and weed management strategies on 1000-grain weight of BRRI dhan50 (Table 8). It was observed that the treatment combination P_1W_4 showed the highest (19.81 g) 1000-grain weight which was statistically similar with the treatment combination of P_1W_3.

Table 8. Effect of seedlings per hill, weed management strategies and interaction on the yield contributing characters of BRRI dhan50

Treatments	Panicle length (cm)	No. of effective tiller $hill^{-1}$	No. of filled grain $panicle^{-1}$	1000-grain weight (g)
Seedlings per hill				
P_1	22.93 a	15.01 a	80.26 a	18.70 a
P_2	20.30 b	12.16 b	70.33 b	17.52 b
P_3	18.60 bc	9.655 c	65.12 bc	17.14 b
P_4	17.19 c	8.742 c	60.16 c	16.39 c
SE	0.6745	0.6093	2.347	0.1356
Weed management strategies				
W_0	15.53 d	7.597 d	54.56 d	16.52 d
W_1	19.59 bc	11.47 bc	68.19 bc	17.38 bc
W_2	18.12 c	9.659 c	63.05 c	17.12 c
W_3	21.67 b	13.02 b	75.50 b	17.81 b
W_4	23.86 a	15.22 a	83.53 a	18.36 a
SE	0.7542	0.6812	2.624	0.1517
Interactions				
P_1W_0	19.43 b-f	9.347 f-h	68.00 b-e	17.65 c-f
P_1W_1	23.08 a-c	15.00 b-d	80.77 a-c	18.77 b
P_1W_2	21.65 a-e	13.03 c-f	75.77 a-d	18.35 bc
P_1W_3	24.04 ab	17.85 ab	84.13 ab	18.94 ab
P_1W_4	26.47 a	19.81 a	92.64 a	19.81 a
P_2W_0	15.77 f-h	7.417 h	56.00 e-g	16.22 hi
P_2W_1	19.66 b-f	12.29 d-g	67.33 b-e	17.29 d-g
P_2W_2	17.83 d-g	10.02 e-h	61.00 d-g	17.19 e-h
P_2W_3	22.22 a-e	14.23 b-e	76.33 a-d	18.19 b-d
P_2W_4	26.00 a	16.85 a-c	91.00 a	18.69 b
P_3W_0	12.82 h	6.737 h	44.88 g	16.21 hi
P_3W_1	18.48 c-g	9.887 e-h	64.66 c-f	17.01 f-i
P_3W_2	17.46 e-h	7.737 gh	61.10 d-g	16.65 g-i
P_3W_3	21.59 a-e	10.66 d-h	75.55 a-d	17.71 c-f
P_3W_4	22.68 a-d	13.25 c-f	79.39 a-c	18.14 b-e
P_4W_0	14.11 gh	6.887 h	49.39 fg	16.02 i
P_4W_1	17.14 e-h	8.693 f-h	60.00 d-g	16.44 g-i
P_4W_2	15.52 f-h	7.847 gh	54.33 e-g	16.31 g-i
P_4W_3	18.86 c-g	9.330 f-h	66.00 c-f	16.41 g-i
P_4W_4	20.31 b-f	10.95 d-h	71.11 b-e	16.79 f-i
SE	1.51	1.36	5.25	0.30
CV (%)	13.22	20.71	13.18	3.01

P_1= 2 seedlings $hill^{-1}$, P_2= 4 seedlings $hill^{-1}$, P_3 = 6 seedlings $hill^{-1}$, P_4= 8 seedlings $hill^{-1}$, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

4.8 Yield

4.8.1 Grain yield

4.8.1.1 Effect of seedlings per hill

Grain yield varied significantly due to various plant population treatments (Figure 11). It was observed that 2 seedlings hill^{-1} (P_1) plant population treatment showed highest (5.703) grain yield. However, 8 seedlings hill^{-1} (P_4) showed lowest (3.394) grain yield. Hasanuzzaman *et al.* (2009) reported that grain yield was decreased with transplanting more than 2 seedlings hill^{-1} (P_1). Ghosh *et al.* (1998) also observed that increasing seedling number hill^{-1} at a constant level did not influence on grain yield production, but after that grain yield decreased.

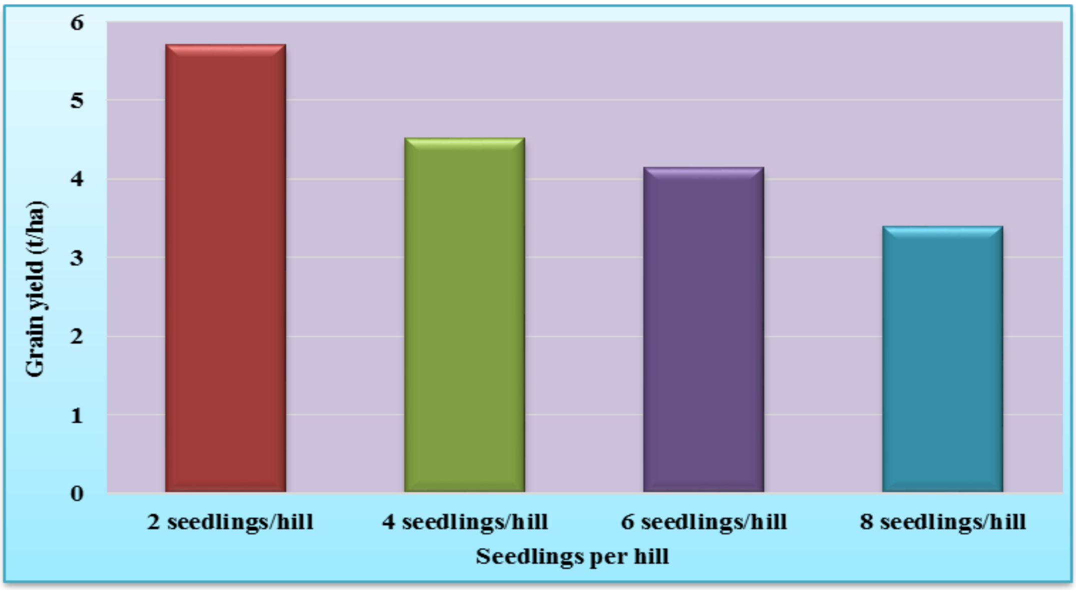

Figure 11. Effect of seedlings per hill on the grain yield of BRRI dhan50 (SE(±)= 0.14)

4.8.1.2 Effect of weed management strategies

Grain yield varied significantly due to various weed management strategies (Figure 12). It was observed that Sunrice 150WG treated plots showed highest (5.358) grain yield. No weeding (control) showed lowest (3.525) grain yield. Similar findings were reported by Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011a), Bhuiyan *et al.* (2011b), Khan and Tarique (2011), Shultana *et al.*(2011), Ali *et al.* (2010), Bhuiyan *et al.* (2010), Gnanavel and Anbhazhagan (2010), Islam *et al.* (2010), Nahar *et al.* (2010) and Salam *et al.* (2010) who observed that application of chemical herbicides significantly increases grain yield of rice.

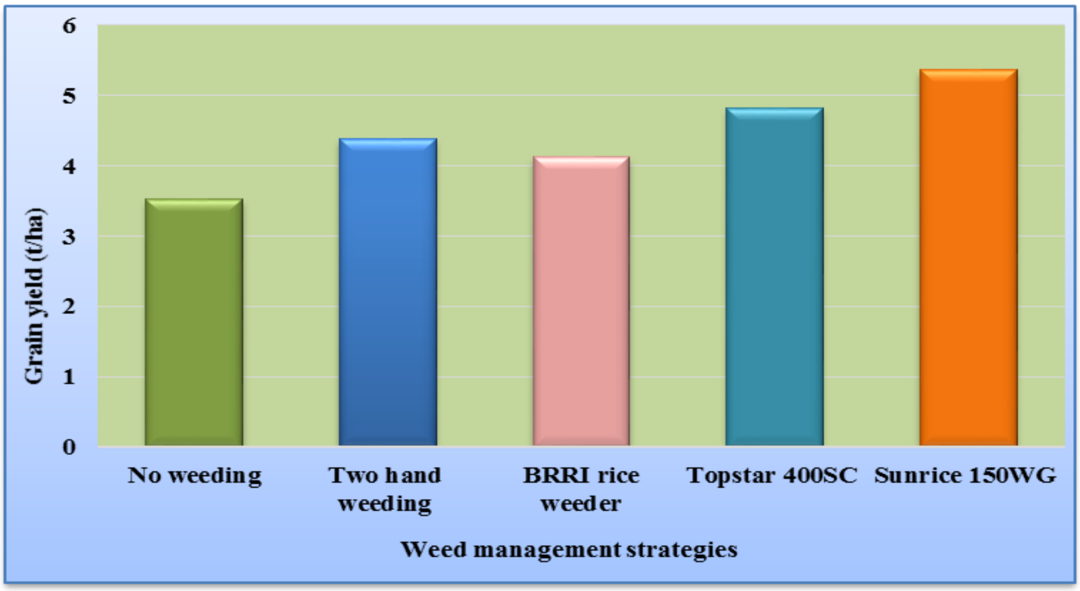

Figure 12. Effect of weed management strategies on grain yield of BRRI dhan50 (SE(±)= 0.15)

4.8.1.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various treatment combinations of seedlings per hill and weed management strategies on grain yield of BRRI dhan50 (Table 9). It was observed that the treatment combination P_1W_4 showed the highest (6.80 t ha^{-1}) grain yield which was statistically similar with the treatment combination P_1W_3.

4.8.2 Straw yield

4.8.2.1 Effect of seedlings per hill

Straw yield varied significantly due to various plant population treatments (Figure 13). It was observed that 2 seedlings $hill^{-1}$ (P_1) showed the highest (7.817) straw yield and 8 seedlings $hill^{-1}$ (P_4) showed the lowest (5.514) straw yield. Straw yield decreased with the increased number of seedlings $hill^{-1}$ which may have been due to decreased tiller formation with increased number of seedlings $hill^{-1}$. Hassan *et* *al.* (2010) found significant variation on straw yield due to various planting population densities and they found highest straw yield in two seedlings hill^{-1} however, the lowest straw yield was from five seedlings hill^{-1}. However, these results are dissimilar with Sarkar *et al.* (1998) and Karim *et al.* (1987) who reported that straw yield increased with increasing seedling number hill^{-1}.

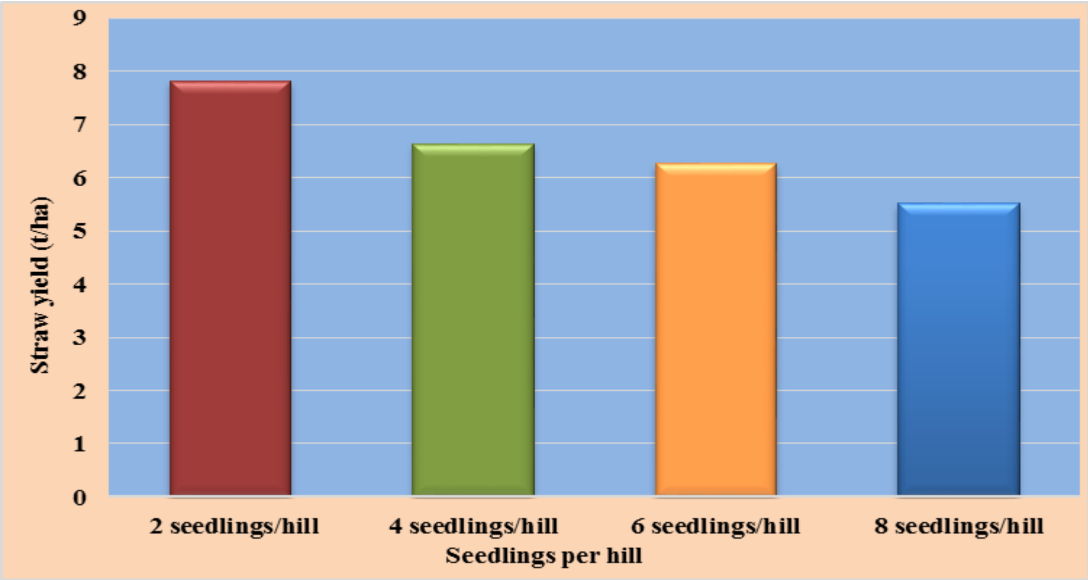

Figure 13. Effect of seedlings per hill on the straw yield of BRRI dhan50 (SE(±)= 0.15)

4.8.2.2 Effect of weed management strategies

Straw yield varied significantly due to various weed management strategies (Figure 14). It was observed that Sunrice 150WG treated plots showed highest (7.418) grain yield which was statistically similar with Topstar 400SC. However, No weeding (control) showed lowest (5.673) straw yield. This result was in agreement with the findings of Khan and Tarique (2011), Salam *et al.* (2010), Manish *et al.* (2006) and Chandra and Solanki (2003) who demonstrated that weeding had significant variation on straw yield of rice.

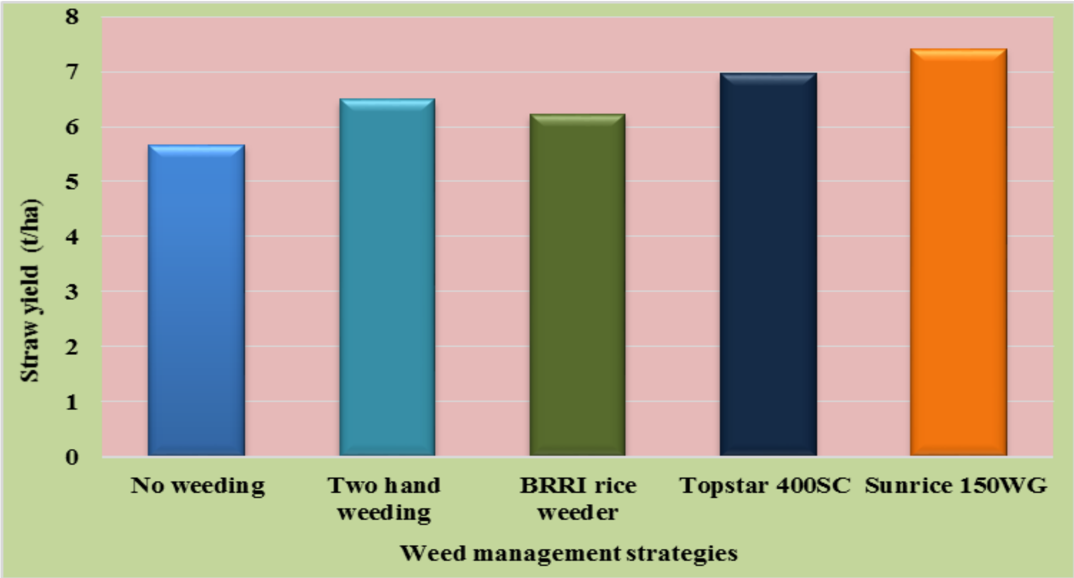

Figure 14. Effect of weed management strategies on straw yield of BRRI dhan50 (SE(±)= 0.16)

4.8.2.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various combinations of seedlings per hill and weed management strategies on straw yield of BRRI dhan50 (Table 9). It was observed that treatment combination P_1W_4 showed the highest (8.69 t ha^{-1}) straw yield which was statistically similar with the treatment combination P_1W_1, P_1W_3 and P_2W_4.

4.8.3 Biological yield

4.8.3.1 Effect of seedlings per hill

Biological yield varied significantly due to various plant population treatments (Figure 15). It was observed that 2 seedlings $hill^{-1}$ (P_1) showed the highest (13.52) biological yield and 8 seedlings $hill^{-1}$ (P_4) showed the lowest (8.908) straw yield. These findings however are dissimilar with Bozorgi *et al.* (2011) who found maximum amount of biological yield from 5 seedlings $hill^{-1}$ and minimum from 1 seedling $hill^{-1}$.

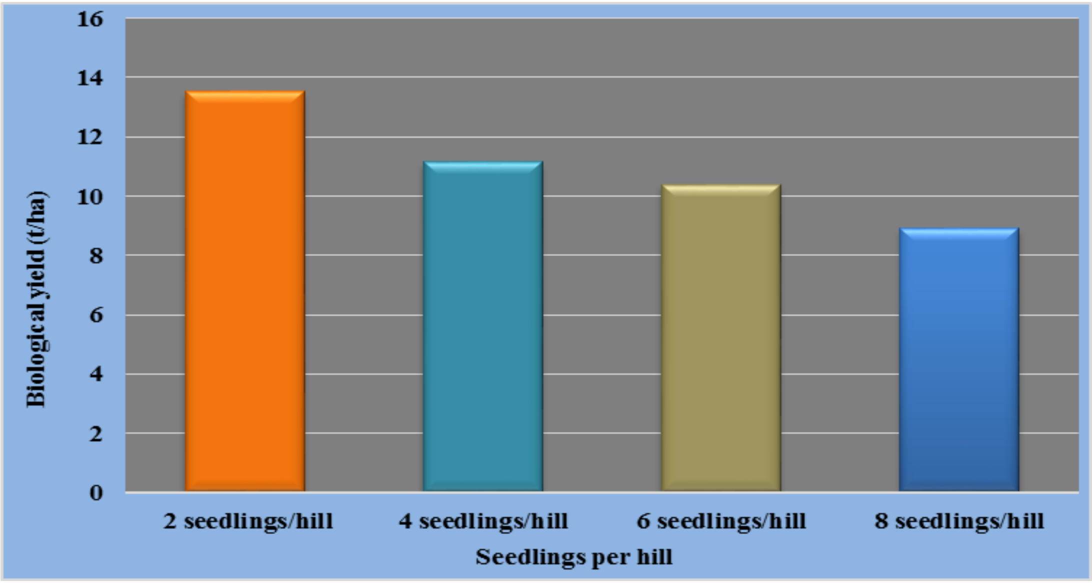

Figure 15. Effect of seedlings per hill on the biological yield of BRRI dhan50 (SE(±)= 0.28)

4.8.3.2 Effect of weed management strategies

Biological yield varied significantly due to various weed management strategies (Figure 16). It was observed that Sunrice 150WG treated plots showed highest (12.77) biological yield where as no weeding (control) showed lowest (9.197) biological yield.

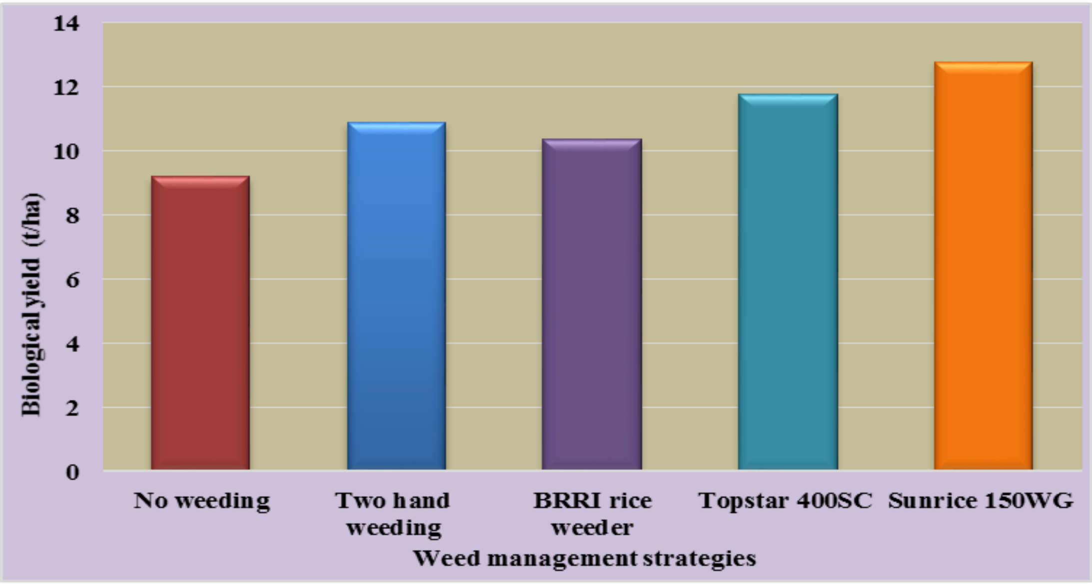

Figure 16. Effect of weed management strategies on biological yield of BRRI dhan50 (SE(±)= 0.31)

4.8.3.3 Interaction effect of seedlings per hill and weed management strategies

Significant variation were observed due to various combinations of seedlings per hill and weed management strategies on biological yield of BRRI dhan50 (Table 9). It was observed that the treatment combination P_1W_4 showed the highest (15.49 t ha^{-1}) biological yield which was statistically similar with the treatment combination P_1W_1 and P_1W_3.

4.8.4 Harvest index

4.8.4.1 Effect of seedlings per hill

Harvest index varied significantly due to various plant population treatments (Figure 17). It was observed that 2 seedlings $hill^{-1}$ (P_1) showed the highest (42.06%) harvest index and 8 seedlings $hill^{-1}$ (P_4) showed the lowest (38.01%) harvest index. The result is in agreement with the findings of Shrirame *et al.* (2000) who reported that harvest index significantly affected by seedlings number $hill^{-1}$.

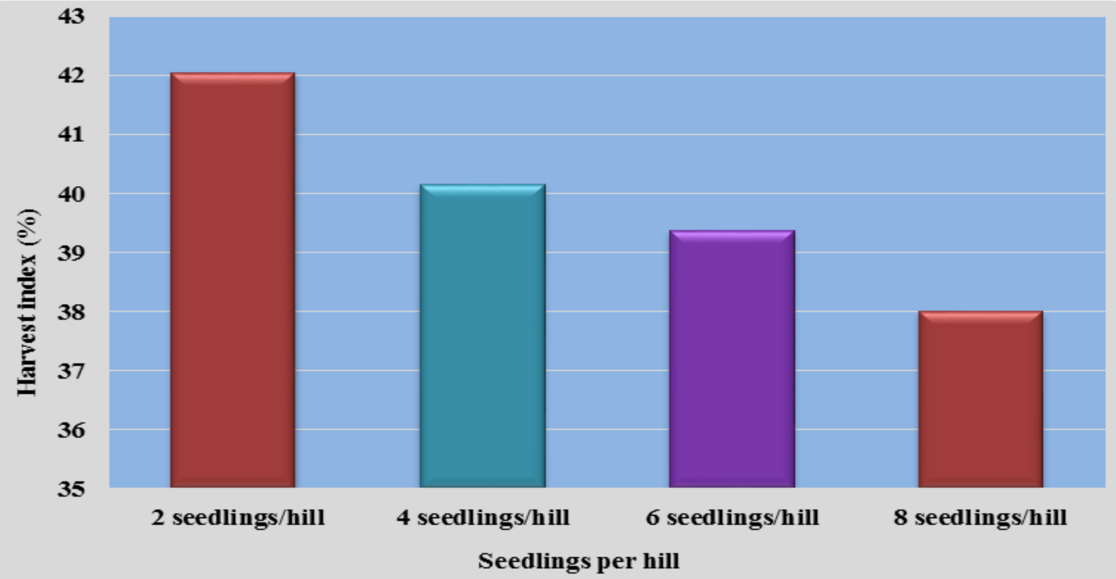

Figure 17. Effect of seedlings per hill on the harvest index of BRRI dhan50 (SE(±)= 0.31)

4.8.4.2 Effect of weed management strategies

Harvest index varied significantly due to various weed management strategies (Figure 18). It was observed that the Sunrice 150WG treated plots showed highest (41.63) harvest index whereas no weeding (control) showed lowest (37.87) harvest index. Similar findings were observed by Manish *et al.* (2006) who stated that weeding had significant variation on harvest index.

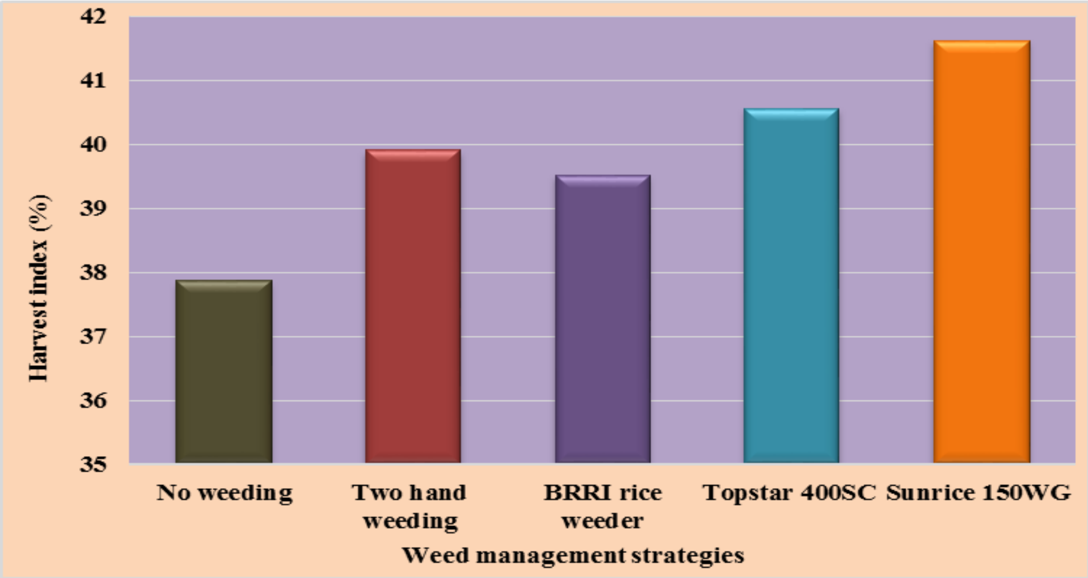

Figure 18. Effect of weed management strategies on harvest index of BRRI dhan50 (SE(±)= 034)

4.8.4.3 Interaction Effect of seedlings per hill and weed management strategies

Significant variation were observed due to various combinations of seedlings per hill and weed management strategies on harvest index of BRRI dhan50 (Table 9). It was observed that treatment combination P_1W_4 showed the highest (43.96) harvest index which was statistically similar with the treatment combination P_1W_1, P_1W_2 and P_1W_3

Table 9. Interaction effect of seedlings per hill and weed management strategies on yield and harvest index of BRRI dhan50

Treatment interactions	Yield and harvest index			
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
P_1W_0	4.653 c-f	6.883 c-f	11.53 cde	40.33 b-f
P_1W_1	5.770 b	7.890 a-c	13.66 ab	42.20 ab
P_1W_2	5.350 bc	7.430 b-d	12.78 bc	41.80 a-c
P_1W_3	5.937 ab	8.193 ab	14.13 ab	42.02 a-c
P_1W_4	6.807 a	8.687 a	15.49 a	43.96 a
P_2W_0	3.220 hi	5.340 gh	8.557 gh	37.54 g-i
P_2W_1	4.287 d-g	6.407 d-g	10.69 d-f	39.81 c-g
P_2W_2	4.190 e-h	6.310 e-g	10.50 d-g	39.83 c-g
P_2W_3	5.190 b-d	7.310 b-e	12.50 b-d	41.51 b-d
P_2W_4	5.690 b	7.810 a-c	13.50 bc	42.08 a-c
P_3W_0	3.207 hi	5.327 gh	8.533 gh	36.61 i
P_3W_1	4.007 f-i	6.127 f-h	10.13 e-h	39.41 d-g
P_3W_2	3.647 ghi	5.767 gh	9.407 f-h	38.68 e-i
P_3W_3	4.707 c-f	6.827 c-f	11.53 c-e	40.73 b-e
P_3W_4	5.140 b-e	7.260 b-e	12.40 b-d	41.40 b-d
P_4W_0	3.020 i	5.140 h	8.163 h	37.00 hi
P_4W_1	3.443 g-i	5.563 gh	9.003 f-h	38.21 f-i
P_4W_2	3.307 g-i	5.427 gh	8.733 f-h	37.78 g-i
P_4W_3	3.407 g-i	5.527 gh	8.933 f-h	38.00 g-i
P_4W_4	3.793 f-i	5.913 f-h	9.707 e-h	39.05 e-h
SE	0.3033	0.3246	0.6245	0.6848
CV	11.84	8.57	9.87	2.97

P_1= 2 seedlings hill^{-1}, P_2= 4 seedlings hill^{-1}, P_3 = 6 seedlings hill^{-1}, P_4= 8 seedlings hill^{-1}, W_0 =No weeding (control), W_1 = Hand weeding at 20 & 35 DAT, W_2 = Weeding by BRRI rice weeder at 20 & 35 DAT, W_3 =Topstar 400SC, W_4 = Sunrice 150WG

Chapter 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present work was done at the Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 30, 2012 to May 05, 2013 in *boro* season with a view to find out the effect of different seedling per hill and different weed management strategies on weed control efficiency and yield of BRRI dhan50.

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 5.0 m x 2.25 m and total numbers of plots were 60. There were 20 treatment combinations. Seedling per hill treatments were assigned along the main plot and weed management strategies were assigned along the main plots and the sub plots, respectively.

The experiment was carried out with four plant densities per hill *i.e*. 2, 4, 6 and 8 seedlings hill^{-1} in the main plot and five weed management strategies viz. no weeding (control), two hand weeding at 20 and 35 DAT, two hand hoe weeding at 20 and 35 DAT, Topstar 400SC (Oxadiargyl 400 g L^{-1}) @ 100 ml ha^{-1} as pre-emergence and Sunrice 150WG (Ethoxysulfuron 150 g L^{-1}) @ 185 ml ha^{-1} as post-emergence herbicide in the sub plot in split plot design. The thirty five days old seedlings of BRRI dhan50 were transplanted on the well puddled experimental plots maintaining 25x15 cm spacing on January 05, 2013 according to plant population treatments.

The data on weed parameters were collected at 30 DAT, 60 DAT and 90 DAT. Weed parameters such as total weed population (no. m^{-2}); relative weed density (RWD %), weed biomass (g m^{-2}) and weed control efficiency (%) were examined. The data on growth parameters viz. plant height, total tillers hill^{-1} were recorded during the period from 30 to 90 DAT. At harvest, characters like plant height, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, 1000 grain weight, grain yield, straw yield, biological yield and harvest index were recorded.

Twenty two weed species belonging to ten families were found to infest the experimental field and the most important weeds of the experimental plots were *Cyperus rotundus, Echinochloa crussgalli, Cyperus michelianus, Fimbristylis miliaceae, Cyperus difformis, Cyperus esculentus* and *Eleusine indica*. Among the twenty two species six were grasses, six sedges, six aquatic, three broad leaved and one fern. Weed density, relative weed density, weed biomass and weed control efficiency were significantly influenced by the weed management strategies. The highest weed density and weed biomass were observed in the no weeding treatment throughout the growing period.

Seedlings per hill treatments significantly affected the growth characters viz. plant height, number of total tillers hill^{-1} of BRRI dhan50. Highest plant height and number of tillers hill^{-1} were observed in 2 seedlings hill^{-1} (P_1). Seedlings per hill treatments also significantly affected the yield contributing characters of BRRI dhan50 like panicle length, effective tillers hill^{-1}, number of filled grain panicle, 1000-grain weight. Grain yield, straw yield, biological yield and harvest index varied significantly due to various seedlings per hill treatments. Two seedlings hill^{-1} (P_1) treatment produced highest grain yield (5.70 t ha^{-1}), straw yield (7.81 t ha^{-1}), biological yield (13.52 t ha^{-1}) and harvest index (42.06 %).

The lowest weed density and weed biomass were found in the plots treated with Sunrice 150WG. Sunrice 150WG showed highest weed control efficiency at 30 DAT, 60 DAT and 90 DAT. Different weed management strategies had significant effect on crop growth parameters viz. tillers hill^{-1}, plant height at different DAT. The highest plant height (41.53, 67.91, 79.65, 78.48) of BRRI dhan50 was observed with Sunrice 150WG (W_4) at 30, 60, 90 DAT and at harvest respectively. Moreover, highest tillers hill^{-1} was observed in Sunrice 150WG (W_4) 9.55, 20.90, 19.79, 18.55 at 30, 60, 90 DAT and at harvest, respectively. Sunrice 150WG (W_4) showed highest grain yield (5.36 t ha^{-1}), straw yield (7.42 t ha^{-1}), biological yield (12.77 t ha^{-1}) and harvest index (41.63%)

Interaction effects of seedlings per hill and weed management strategies had significant effect on yield and yield contributing characters like effective tillers hill^{-1}, grain yield, straw yield, biological yield and harvest index of BRRI dhan50. The treatment combinations of P_1W_4 (2 seedlings hill^{-1} and Sunrise 150WG) showed highest grain yield (6.81 t ha^{-1}), straw yield (8.69 tha^{-1}), biological yield (15.49 t ha^{-1}) and harvest index (43.96%).

Based on the results of the present experiment, the following conclusion can be drawn:

1. Sedge and grass weeds dominated the crop field throughout the growing period with the highest relative weed density in the study area.
2. Weed management strategies played a vital role for the growth and yield of aromatic T. *boro* rice.
3. Two seedlings $hill^{-1}$ (P_1) treatment showed highest grain yield (5.70 t ha^{-1}), straw yield (7.81 t ha^{-1}), biological yield (13.52 t ha^{-1}) and comparatively higher weed control efficiency.
4. Among the weed management strategies, Sunrice 150WG was found as best treatment for controlling weeds at 30 DAT (80.94%) and moderate for controlling weeds at 60 DAT (61.52%).

REFERENCES

REFERENCES

AIS (Agricultural Information Service). (2013). Krishi Diary (In Bangla). Agril. Inform. Ser. Khamarbari, Farmgate, Dhaka, Bangladesh. p.16.

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

Ali, M., Sardar, M. S. A. and Biswas, P. K. (2010). Weed control and yield of transplanted *aman* rice as affected by integrated weed management and spacing. *Bangladesh J. Weed Sci.* **1**(1):33-40.

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.

Ashraf, M. and Mahmood, S. (1999). Effect of seedling on Basmati growth and yield. *Int. Rice Res. Newsl.* **14**(1): 8.

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.

Amarjit, D., Angiras, N. N. and Rana, S. S. (1994). Integrated weed management in direct seeded puddled sprouted rice. *Indian J. Agron.* **43**(4): 644-649.

BBS (Bangladesh Bureau of Statistics). (2013). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. Peoples' Repub. Bangladesh, Dhaka, Bangladesh, p. 187.

Bhuiyan, M. K. A., Mridha, A. J., Ahmed, G. J. U., Begum, J. A. and Sultana, R. (2011a). Performance of chemical weed control in direct wet seeded rice culture under two agro-ecological conditions of Bangladesh. *Bangladesh J. Weed Sci.* **1**(1):1-7.

Bhuiyan, M. R., Rashid, M. M., Roy, D., Karmakar, B., Hossain, M. M. and Khan, M. A. I. (2011b). Sound weed management option for sustainable crop production. *Bangladesh J. Weed Sci.* **1**(1):25-29.

Bozorgi, H. R., Faraji, A., Danesh, R. K., Keshavarz, A., Azarpour, E. and Tarighi, F. (2011). Effect of Plant Density on Yield and Yield Components of Rice. *World Applied Sci. J.* **12**(11): 2053-2057.

BRRI. (2011). Annual Report for 2010. Bangladesh Rice Research Institute, Bangladesh. Joydebpur, Gazipur. P. 9-20.

Bari, M. N. (2010). Effects of herbicides on weed suppression and rice yield in transplanted wetland rice. *Pak. J. Weed Sci. Res.* **16**(4):349-361.

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

Baloch, A. W., Soomro, A. M., Javed, M. A., Ahmed, M., Bughio, H. R. and Bughio, M. S. (2002). Optimum plant density for high yield in rice (*Oryza sativa* L.). *Asian J. Plant Sci.* **01**(02): 114-116.

BRRI. (2000). Annual Report for 1999. Bangladesh Rice Research Institute, Bangladesh. Joydebpur, Gazipur. P. 13.

Baqui, M. A., Harun M. E., Jones, D. and Straingfellow, R. (1997). The export potential of traditional varieties of rice from Bangladesh. Bangladesh Rice Research Institute, Gazipur, Bangladesh.

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

Chandra, S. and Solanki, O. S. (2003). Herbicidal effect on yield attributing characters of rice in direct seeded puddled rice. *Agril. Sci. Digest Karnal.* **23**(1):75-76.

Choudhury, J. K., Thakuria, R. K. and Das, G. R. (1995).Effect of hill density, seedlings per hill and potassium on late transplanted sail (rainfed low land winter) rice yield in Assam, India. *IRRN*. **20**(4): 18.

Das, T. and Baqui, M. A. (2000). Aromatic rices of Bangladesh. In: *Aromatic rices,* pp.184-187. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi.

Dowling, N. G., Greenfield, S. M. and Fisher, K. S. (1998). Sustain ability of rice in the global food system. International Rice Research Institute. Los Banos, Philippines. p. 404.

Gnanavel, I. and Anbhazhagan, R. (2010). Bio-efficacy of pre and post emergence herbicides in transplanted aromatic basmati rice. *Res. J. Agric. Sci*. **1**(4):315-317.

Ghosh, B. C., Raghavian, C. V. and Jana, M. K. (1998).Effect of seedling age and number of seedlings per hill and nitrogen on growth and yield of direst sown rice (*Oryza sativa* L.) under intermediate deep water condition. *Indian Journal of Agronomy*.**36**: 227-228.

Gardner, Y. P., Gill, P.S. and Shahi, H.N. (1985). Effect of Nitrogen levels in relation of age of seedlings and time of transplanting oil growth yield and milling characteristics of rice. *Indian J. Agric. Sci.* **57**(9):6310-614.

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

Hasanuzzaman, M., Rahman, M. L., Roy, T. S., Ahmed, J. U. and Zobaer, A. S. M. (2009). Plant Characters, Yield Component and Yield of Late Transplanted Aman Rice as Affected by Plant Spacing and Number of Seedlings Hill^{-1}. *Advanced Bio. Res.* **3**(5-6):201-207.

Hasanuzzaman, M., Islam, M. O. and Bapari, M. S. (2008). Efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. *Australian J. Crop Sci.* **2**(1):18-24.

Hasanuzzaman, M., Nahar, K. and Karim, M. R. (2007). Effectiveness of different weed control methods on the performance of transplanted rice. *Pak. J. Weed Sci. Res.* **13**(1-2):17-25.

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

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

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

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

Kabir, M. H., Bari, M. N., Haque, M. M., Ahmed, G. J. U. and Islam, A. J. M. S. (2008). Effect of water management and weed control treatments on the performance of transplanted *aman* rice. *Bangladesh J. Agril. Res.* **33**(3):399-408.

Karim, M. A., Gaffer, M. A., Maniruzzaman, A. F. M. and Islam, M. A. (1987).Effect of spacing, number of seedling hill^{-1} and planting depth on the yield of *aman* rice. *Bangladesh Journal of Agricultural Science.***14** (2): 99-103.

Mohanty, S. (2013). IRRI (International Rice Research Institute). Rice Today, January-March 2013. http://www.irri.org/Knowledge/Publications/RiceToday/Rice Facts/Trends in global rice consumption.

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

Mobasser, H. R., Delarestaghi, M. M., Khorgami, A., Tari, B. D. and Pourkalhor, H. (2007). Effect of planting density on agronomical characteristics of rice (*Oryza sativa* L.) varieties in North of Iran. *Pakistan J. Biological Sci*. **10**(18): 3205-3209.

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

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

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

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

Oerke, E. C. and Dehne, H. W. (2004). Safe guarding production losses in major crops and the role of crop protection. *Crop Production.* **23**(4): 275-285.

Phuhong, L. T., Denich, M., Vlek, P. L. G. and Balasubramanian, V. (2005). Suppressing weeds in direct seeded lowland rice: effects of methods and rates of seeding. *J. Agron. Crop Sci.* **191**: 185-194.

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

Raju, A., Pandian, B. J., Thukkaiyannan, P. and Thavaprakash, N. (2003). Effect of weed management practices on the yield attributes and yield of wet seeded rice. *Acta. Agron. Hungarica.* **51**(4):461-464.

Roder, W. (2001). Slash-and-burn rice systems in the hills of northern Lao PDR. In: Description, challenges and Opportunities, IRRI, Los Banos, Philippines, p. 201.

Shultana, R., Al-Mamun, M. A., Rezvi, S. A. and Zahan, M. S. (2011). Performance of some pre emergence herbicides against weeds in winter rice. *Pak. J. Weed Sci. Res.* **17**(4):365-372.

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

Samar S., Ladha, J. K., Gupta, R. K., Lav, B., Rao, A. N., Sivaprasad, B. and Singh, P. P. (2007). Evaluation of mulching, intercropping with *Sesbania* and herbicide use for weed management in dry-seeded rice (*Oryza sativa* L.). *Crop Protec.* **26**(4):518-524.

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

Shrirame, M. D., Rajgire, H. J. and Rajgire, A. H. (2000).Effect of spacing and seedlings number hill^{-1} on growth attributes and yield of rice under lowland condition. *Indian Journal Soils Crops.***10** (1): 109-113.

Singh, R. K., Singh, U. S., Khush, G. S. and Rohilla, R. (2000). Genetics and biotechnology of quality traits in aromatic rices In: Aromatic rices, Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, p.58.

Singh, M. K., Thakur, R., Verma, U. N., Upasani, R. R. and Pal, S. K. (2000). Effect of planting time and nitrogen on production potential of Basmati rice cultivars in Bhiar Plateau. *Indian J. Agron*. **45**(2): 300-303.

Sarkar, R. K., Sanjukta, Das. and Das, S. (1998). Yield of rainfed lowland rice with medium water depth under anaerobic direct seeding and transplanting. *Tropical Science*. **19**(4): 161-173.

Singh, O. 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.

Shah, M. H., Khushu, M. K., Khanday, B. A. and Bali, A. S. (1991).Effect of spacing and seedlings hill^{-1} on transplanted rice under late sown condition. *Indian Journal of Agronomy*.**36** (2): 274-275.

Singh O. P., Pal, D. and Om, H. (1987). Effect of seed rate in nursery and seedling hill^{-1} on the yield of transplanted rice. *Indian Journal of Agricultural Science*.**59** (1): 63-65.

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.

APPENDICES

APPENDICES

Appendix I: Physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Characteristics	*Value*
Partical size analysis	
% 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 (Soil Resources Development Institute), Farmgate, Dhaka

Appendix II. Means square values for total number of weed m^{-2} of BRRI dhan50 at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30DAT	60DAT	90DAT
Replication	2	10996.828	130.316	41.583
Plant population (P)	3	2344.556*	4509.422*	2968.350*
Error	6	100.614	66.850	30.571
Weed control (W)	4	99574.256*	16081.391*	4197.337*
PxW	12	153.457 ^{ns}	62.962 ^{ns}	40.238 ^{ns}
Error	32	2791.696	35.368	31.257
CV (%)		35.04	5.97	8.16

*Significant at 5% level
^{ns}- Non significant

Appendix III. Means square values for weed biomass (g/m2) of BRRI dhan50 at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30DAT	60DAT	90DAT
Replication	2	247.660	102.134	247.660
Plant population (P)	3	178.793*	1050.181*	178.793*
Error	6	32.325	34.215	32.325
Weed control (W)	4	1576.525*	3509.876*	1576.525*
PxW	12	16.859^{ns}	46.884^{ns}	16.859^{ns}
Error	32	62.357	97.604	62.357
CV (%)		52.59	23.74	39.45

*Significant at 5% level
^{ns}- Non significant

Appendix IV. Means square values for weed control efficiency (%) of BRRI dhan50 at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting		
		30DAT	60DAT	90DAT
Replication	2	4428.607	1405.194	4918.460
Plant population (P)	3	684.223*	6.112*	417.119*
Error	6	215.860	180.409	243.596
Weed control (W)	4	12106.211*	7093.621*	8895.653*
PxW	12	165.531^{ns}	21.412^{ns}	114.992^{ns}
Error	32	143.111	134.158	119.463
CV (%)		23.22	30.11	24.53

*Significant at 5% level
^{ns}- Non significant

Appendix V. Means square values for plant height of BRRI dhan50 at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	25.238	24.389	20.640	22.744
Plant population (P)	3	130.475*	138.692*	142.115*	142.746*
Error	6	11.547	10.679	11.212	11.986
Weed control (W)	4	113.281*	132.168*	173.079*	167.536*
PxW	12	3.948^{ns}	4.243^{ns}	5.043^{ns}	4.688^{ns}
Error	32	8.220	7.926	7.513	7.570
CV (%)		7.51	4.38	3.63	3.70

*Significant at 5% level
^{ns}- Non significant

Appendix VI. Means square values for number of tiller per hill of BRRI dhan50 at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	1.321	0.647	0.593	0.301
Plant population (P)	3	48.435*	47.549*	48.580*	49.221*
Error	6	4.401	6.156	5.157	5.048
Weed control (W)	4	21.478*	32.154*	31.517*	28.311*
PxW	12	3.240^{ns}	2.650^{ns}	2.582^{ns}	2.418^{ns}
Error	32	2.454	2.763	2.698	2.430
CV (%)		20.45	8.92	9.38	9.51

*Significant at 5% level
ns- Non significant

Appendix VII. Means square values for yield contributing characters of BRRI dhan50

Sources of variation	DF	Means square values			
		Panicle length (cm)	Effective tiller per hill	Filled grain per panicle	1000-grain weight (g)
Replication	2	1.728	0.249	32.470	1.103
Plant population (P)	3	91.485*	118.452*	1108.798*	13.925*
Error	6	6.365	4.812	83.066	0.601
Weed control (W)	4	123.357*	104.003*	1493.743*	5.761*
PxW	12	2.860*	4.348*	38.620*	0.314^{ns}
Error	32	6.825	5.568	82.641	0.276
CV (%)		13.22	20.71	13.18	3.01

*Significant at 5% level
^{ns}- Non significant

Appendix VIII. Means square values for yield and harvest index of BRRI dhan50

Sources of variation	DF	Yield Means square values			
		Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	1.103	1.162	4.525	7.395
Plant population (P)	3	13.925*	13.841*	55.489*	43.045*
Error	6	0.601	0.533	2.255	3.352
Weed control (W)	4	5.761*	5.391*	22.310*	23.024*
PxW	12	0.314*	0.293*	1.202 *	1.215*
Error	32	0.276	0.316	1.170	1.407
CV (%)		11.84	8.57	9.87	2.97

*Significant at 5% level
^{ns}- Non significant