EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON TRANSPLANTED AROMATIC BORO RICE

JANNATUL FERDOUS MOONMOON

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2015

EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON TRANSPLANTED AROMATIC BORO RICE

BY

JANNATUL FERDOUS MOONMOON

Reg. No.: 09-03619

A Thesis
Submitted to the Department of Agronomy,
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JANUARY - JUNE, 2015

APPROVED BY:

Prof. Dr. Md. Abdullahil Baque
Department of Agronomy
SAU, Dhaka-1207.
Supervisor

Prof. Dr. H. M. M. Tariq Hossain
Department of Agronomy
SAU, Dhaka-1207.
Co-Supervisor

Prof. Dr. Md. Fazlul Karim
Chairman
Examination Committee

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

Ref. No. : Date :

CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON TRANSPLANTED AROMATIC BORO RICE"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by **Jannatul Ferdous Moonmoon**, Registration No. **09-03619** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Dr. Md. Abdullahil Baque
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207
Supervisor

Dedicated To

My Beloved Parents

EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON TRANSPLANTED AROMATIC BORO RICE

ABSTRACT

A field experiment was conducted at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2014 to May 2015 to find out the herbicidal efficacy and residual activity on transplanted aromatic boro rice (cv. BRRI Dhan50). This was a single factor experiment which consisted of nine treatments, *viz*., T_0: (control), T_1: Acetochlor + Bensulfuron- methyl (changer) [750 g ha^{-1}], T_2: Pyrazosulfuron-ethyl (super powder) 150 g ha^{-1}. T_3: Bispyribac sodium (extra power) 150 g ha^{-1}, T_4: Pretilachlor (superhit) 1 L ha^{-1}. T_5: Pretilachlor + Triasulfuron (Rifit + logran) 1 L ha^{-1} + 10 g ha^{-1}, T_6: Propyrisulfuran+ Propanil [500 ml ha^{-1} +1000 g ha^{-1}], T_7: Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}], T_8: Two hand weeding at 20 DAT and 40 DAT. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. T_7 treatment had killed the highest number of weeds its residual activity remained up to 45 days. So, the highest weed control efficacy (98.74%) was found from T_7 treatment and it had checked seven weed species including the dominating weed Behua (*Cyperus difformis*) from rice field. On the other hand, the highest weed infestation and yield loss (44.09%) were recorded in T_0 (control) treatment. At the later growth stage, the highest plant height, panicle length, maximum number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, minimum non-effective tillers $hill^{-1}$, primary branch $panicle^{-1}$, secondary branch $panicle^{-1}$, filled grains $panicle^{-1}$, minimum unfilled grains $panicle^{-1}$, maximum total grains $panicle^{-1}$, 1000 grain weight, straw yield (7.11 t ha^{-1}), and the highest grain yield (6.35 t ha^{-1}) were obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment compared to the T_0 (control) treatment. It can be concluded that weed free condition throughout the growth period might be considered as an important factor for the best performance of transplanted aromatic boro rice (cv. BRRI dhan50).

ACKNOWLEDGEMENT

The author deems it a much privilege to express her enormous sense of gratitude to the almighty creator for there ever ending blessings for the successful completion of the research work.

The author feels proud to express her deep sense of gratitude, sincere appreciation and immense indebtedness to her supervisor **Prof. Dr. Md. Abdullahil Baque**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of this thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor **Prof. Dr. H. M. M. Tariq Hossain** Department of Agronomy, SAU, Dhaka, for his scholastic and continuous guidance during the entire period of course, research work and preparation of this thesis.

The author expresses her sincere respect to **Prof. Dr. Md. Fazlul Karim,** Chairman, Department of Agronomy, SAU, Dhaka, for valuable suggestions and cooperation during the study period and also expresses her heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses her sincere appreciation to her father Nur Mahammad, beloved mother Mariom Khatun, sister Jannatul naime, well wishers and friends H. E. M. Khairul Mazed, Md Anisur Rahman and Imrul Kayes.

The Author

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DMRT	Duncan`s Multiple Range Test
DAS	Days After Sowing
DAT	Days After Transplanting
LSD	Least significance difference
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization

ABBREVIATIONS	ELABORATIONS
Fig	Figure
ns	Non Significant
J.	Journal
PP.	Pages
DBA	Days Before Application
DAA	Days After Application
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percent
m^2	Square meter
$hill^{-1}$	Per hill
J.	Journal
kg	Kilogram
No.	Number
NS	Non Significant
NOS	Number of species
^0C	Degree Celsius
$Panicle^{-1}$	Per panicle
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science ’s
HI	Harvest Index
Vol.	Volume

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Bangladesh is an agro-based developing country striving hard for rapid development of its economy. The economic development of the country is mainly based on agriculture. Agriculture is the single largest producing sector of the economy of Bangladesh since it comprises about 19.29% of the country's GDP and employs around 44 % of the total labor force (BBS, 2015). The people of Bangladesh depend on rice as staple food. Geographical and agro-climatic conditions of Bangladesh are favourable for rice cultivation. Rice alone contributes 95 % of food production in Bangladesh (Julfiquar *et al.*, 1998). About 77.07 % of total cropped area of Bangladesh is used for rice production, with annual production of 33.54 million tons from 11.52 million ha of land (BBS, 2015). Rice alone contributes 11 % of GDP and accounts for 55 % labour employment in its production, processing, and marketing (BBS, 2013). More than 94 % of population derives 76 % of its daily calories and 66 % of its protein needs from rice (BBS, 2013). In Bangladesh, majority of food grains come from rice.Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. The Food and Agriculture Organization (FAO) has estimated that in 2014 rice imports of Bangladesh will rise nearly triple, that means about 400,000 tons, due to lower prices in international market (BBN, 2014). About 27.26 million tons of rice will require in our country for the year 2020. During this time total rice area will also shrink to 10.28 million hectares.

In Bangladesh three distinct classes of rice, based on the season of cultivation namely Aus, Aman and Boro, are cultivated during the period April to July, August to December and January to May, respectively. In 2014 aggregate rice production of 52 million tons (around 34.84 million tons basis milled), slightly above an estimated 2013 paddy rice production of 51.5 million tons (around

34.5 million tons basis milled) due to increased planted area backed by favorable weather conditions and government support to the rice sector. On average, Aus, Aman and Boro seasons account for 7 %, 38 % and 55% of annual paddy production, respectively (BBN, 2014).

More than four thousand wild races of rice are adapted in our country. Some of these have some good qualities i.e. taste, aroma, fineness, and protein content (kaul *et al.*, 1982). Aromatic rice is a special type of rice containing natural ingredient 2-acetyl-1-pyrroline, responsible for their fragrant taste and aroma (Hossain *et al.*, 2008; Gnanavel *et al.*, 2010) and had 15 times more 2-acetyl-1-pyrroline content than non - aromatic rice (0.14 and 0.009 ppm, respectively) (Singh *et al.*, 2000). In addition, 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). A number of fine rice namely, Chinigura, Badshabhog, Kalijira, Kataribhog, Dhadkhani, Sakkorkhora, Radhunipagal, Ukunmadhu, Tulshimala, Mohonbhog, Rajbhog, Modhumala etc. are grown by the farmers in Bangladesh in a limited area. Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive types and are grown during aman season. BRRI developed a modern scented Boro rice *viz.* BRRI dhan50. It’s shape and size similar to Basmoti rice. Demand for aromatic rice in recent years has increased to a great extent for both internal consumption and export (Singh *et al.*, 2000). Islam *et al.* (1996) observed that the yield of aromatic rice was lower (1.5-2.0 t ha^{-1}) but its higher price and low cost of cultivation generated higher profit margins compared to other varieties grown in the area. The aromatic rice is used in many ways by the people like polau, khir, firnny, jarda etc. Fine rice has high market value, because of high price and taste of this rice. Now-a-days, food security especially attaining self-sufficiency in rice production is a burning issue in Bangladesh. In such condition, increasing rice production can play a vital role. The increased rice production has been possible largely through the adoption of modern scientific knowledge and technology.

Weeds which grow in every crop field may be considered as one of the most important agricultural pests. Severe weed infestation is one of the reasons for low yield of rice (Mamun, 1988a). Weed is a nutrient absorbing competitive plant which grows out of place spontaneously and posses the characteristics of plentiful growth and reproduction, even under adverse conditions. Weeds are also responsible for the uptake and transpiration of appreciable amounts of water and this loss is particularly significant during drought. For the competitive abilities weeds form a serious negative effect on crop production and are responsible for marked losses in crop yield (Mamun *et al.*, 1993). In Bangladesh, severe weed infestation reduces the grain yield by 70.80% in Aus rice (early summer), 30-40% for transplanted Aman rice (Late summer) and 22-36% for modern Boro rice (winter rice) cultivation (Mamun, 1990a). This loss is a serious threat for the food deficit countries like Bangladesh. So proper weed management is essential for rice production in Bangladesh. Among the weed control methods, hand weeding is the common method practiced by the Bangladeshi farmers (Ahmed *et al.*, 1986). But weed control at the critical period by traditional method may not be possible due to the unfavorable weather conditions at the peak period of labour demand. Tillage for weed control has many drawbacks in comparison with herbicide is greater fuel use and greater loss of water from soils. The world facing climate change and severe water constraints, tillage has to be reduced. Chemical weed control has become popular in Bangladesh mainly due to scarcity of labour during peak growing season and lower weeding cost by using herbicides. For the last few decades, herbicides have been contributed tremendous to agriculture. In large scale rice farming, herbicide based weed management has become the smartest and most viable option as against the scarcity and high costs of labor (Singh *et al.*, 2006; Anwar *et al.*, 2012). In Bangladesh the annual consumption of herbicides grew over 4000 metric tons in 2008 (BCPA, 2010) compared to only 108 tons during 1986-87 (BBS, 1991) and the growth is almost exponential. In such a situation, weed free period during the critical period of competition can be achieved by removing the weeds by herbicidal weed control or by their combinations. Herbicides in combination with hand weeding can help in obtaining higher crop yield with less cost and efforts (Prasad and Rafy, 1995; Shathyamoorthy *et al.*, 2004). Herbicidal weed control is an effective and economic system of weed management. Acetochlor, Pretilachlor, Butachlor, Ethoxysulfuran, Pyrazosulfuron ethyl, Propyrisulfuran, Bispyribac sodium, Triasulfuron, Oxadiarzil, Anilphos, propanil, 2,4-D, etc. are the commonly used herbicides in rice cultivation in Bangladesh. Weed competition at early growth stage can be eliminated through pre-emergence herbicides like, Logran, Extra power, Rifit 500 EC and Superhit 500 EC and which are good selective, pre-emergence and post-emergence herbicides. This type of herbicides can be used in Bangladesh against mono and dicotyledonous weeds in rice fields. Replacement of traditional weeding in boro rice by herbicides would help to obtain higher crop yield with less effects and costs. Farmers need to apply, herbicides at proper rates in the field. The rate of application depends on the intensity of weed infestation. When weed infestation is occur, farmers may need to apply optimum doses of herbicide. In our country, a very little information is available on the effectiveness of herbicides in controlling weeds in rice, especially in boro rice.

The present study was therefore undertaken with the following objectives:

- To find out the different herbicidal efficacy on transplanted Boro rice
- To investigate the effect of herbicides on yield and yield components of transplanted Boro rice

Chapter II

Review of Literature

CHAPTER II
REVIEW OF LITERATURE

Control of weed is one of the important means for successful crop production. Weed control by chemical means is a common practice in many countries of the world due to its competitive advantages over other methods. However research work in the field of weed science especially with herbicide related work is scanty in Bangladesh. Recently research work regarding weed control through herbicide in rice has got due importance. In Bangladesh, weeds in rice field are controlled manually and through different cultural practices. Now a days, farmers of Bangladesh used to use herbicides to control weeds in rice field in a small scale. Although some sporadic research works have been done on herbicides but intensively research works have not been evaluated under Bangladesh condition for controlling weeds. Research work so far done at home and abroad in controlling weeds in boro rice using different herbicides with alone, their combination and other pertinent information are reviewed below:

2.1 Weed vegetation in rice field

Weed vegetation in crops field is the result of cropping system, cropping season, topography of land and management practices like time and degree of land preparation, type of cultivar, time of planting, planting rate, fertilizer management, weeding method and intensities and so on practiced by the farmers at different times during the crop cycle.

Islam (2014) observed 16 species of weeds belonging to 6 families to grow in association with boro rice. The most important species of weed was *Panicum repens*, *Leersia hexandra, Digitaria sanguinalis, Echinochloa crusgalli*, *Scirpus mucronatus*, *Parapholis incurva*, *cynodon dactyion*, *Paspalum scrobbiculatum, Fimbristylis diphylla, Eclipta alba, Echinochloa colonum, Murdania nudiflora, Cyperus rotundus, Cyperus michelianus, Polygonum* *orientale, Monochoria hastata*. The highest grain was obtained in three weeding condition and the lowest one was recorded in no weeding condition.

Zannat (2014) listed 18 commonly growing weed species in aromatic aman rice cv. Binadhan-9 and identified weed species like *Panicum repens, Oxalis corniculate, cyperus michelianus, Cyperus difformis, Fimbristylis diphylla, Leersia hexandra, Monochoria hastata, Scirpus mucronatus, Ludwigina prostrata, Echinochloa colonum, Cynodon dactylon, Polygonum orientale, Echinochloa crus-galli, Parapholis incurve and Eclipta alba*. The highest yield in three weeding at 15, 30 and 45 DAT. No weeding condition reduced 28.16% yield in aromatic aman rice cv. Binadhan-9.

Islam *et al*. (2010) observed eleven weed species belonging to six families to infest the experimental field of which *Panicum respens* was the most important weed species and the other dominant species were *Digitaria sanguinalis, Rottboellia protensa, Leersia hexandra, Fimbristylis miliacea, Monochoria hastata*, and *Scirpus mucronatus* in respect of weed density.

Rahman *et al.* (2007) from his experiment on economic study of levels of herbicide use and hand weeding method in controlling weeds in boro rice important weed species found to infest the crop were Angta (*Panicum repens*), Durba (*Cynodon dactylon*), Shama (*Echinochloa crusgalli*) and Panilong (*Ludwigia hyssopifolia*).

Jesmin (2006) listed 8 commonly growing weed species in boro rice *like Echinochloa crusgalli, Marsilea quadrifolia, Scirpus juncoides, Cyperus difformis*, *Monocoria vaginalis*, *Leersia hexandra*, *Lindernia anagalis* and *Fimbristylis miliacea*.

Jacob and Elizabeth (2005) studied the effects of spacing and weed management practices on transplanted scented rice (Pusa Basmati 1) in the sandy clay loam soil of Vellayani during the winter season of 2001-02 showed that adoption of 20×10 cm^2 spacing and pre-emergence application of anilofos

+ 2, 4-D ethyl ester (0.40 + 0.53 kg ha^{-1}) at is x days after transplanting supplemented with 2, 4-D Na salt (1.0 kg ha^{-1}) at 20 days after transplanting increased yield and net income. In addition, the weed flora consisting of *Echinochloa colonum, Echinochloa crus-galli and Leesrsia hexandra* (grasses); *Cyperus iria, Cyperus difformis and Fimbristylis miliaceae* (sedges); and *Ludwigia parviflora* and *Monochoria vaginalis* (broad-leaf weeds), had considerably lower NPK uptake in the weed management treatments compared to unweeded plots.

Sathyamoorthy *et al.* (2004) observed that intercropping of green manure significantly reduced the total weed dry weight. Regarding the weed management practices, the pre-sowing application of Glyphosate, pre-emergence application of Butachlor followed by one and two hand weeding gave the best result. The major weeds on the experimental rice field were *Cyperus iria, Echinochloa crusgalli, E. colonum, Eclipta alba* and *Ludwigia parviflora*.

Singh *et al.* (2004a) conducted a weed survey in rice field at Uttar Pradesh in India, where they observed 93 weed species belonging to 65 genera and 30 families. Of these, 22 families, 38 genera and 53 species were dicots, and 8 families, 27 genera and 40 species were monocots. The dominant families were Papilionaceae (Fabaceae), Asteraceae, Euphorbiaceae, Scrophulariaceae and Polygonaceae among Diots, and Cyperaceae and Commelinaceae among monocots. It is natural that the presence and abundance of species or groups of weeds growing in rice would vary with country, as may be seen from the weed vegetation.

Ranasinghe (2003) observed that the dominant weeds were *Monochoria vaginalis* and *Ludwigia octavalvis* moderate to poor drained soils and *Echinochloa crusgalli, Ischaemum rugosum, Leptochloa chinensis, Cyperus iria, Fimbristylis miliaces* and *Cyperus deformis* in well to moderately drained soils. He also found that the average grain yield obtained under farmers weed management practice was lower by 12.6% than that recorded under researcher's weed management choice as high weed growth.

Mamun *et al.* (1993) conducted a weed survey in boro rice grown under two agroecological zones (AEZs) viz. Old Brahmaputra Floodplain and Young Brahmaputra & Jamuna floodplain. In Old Brahmaputra Floodplain, the number of infesting species was 53 of which 39 were annuals and 14 were perennials. In Young Brahmaputra & Jamuna floodplain, the infesting species were 47 belonging to 20 families; 32 of them were annuals and 15 were perennials. In Old Brahmaputra Floodplain *Lindernia procumbens* an annual broadleaf found to be the most abundant species whereas *Fimbristylis miliacea* an annual, sedge was the most abundant species in Young Brahmaputra & Jamuna floodplain. Irrespective of AEZs, annual weeds dominated over perennials and broadleaf weeds out numbered the grasses and sedges. Co efficient of similarity of weed vegetation between these two AEZs was 73.77%.

Mamun (1990) observed 27 species of weeds in Old Brahmaputra Floodplain and Young Brahmaputra & Jamuna floodplain, the total number of infesting species were higher in high lands than those in low lands. In Old Brahmaputra Floodplain, boro rice was grown in high, medium and low lands. Coefficient of similarity of weed vegetation in three land topographic units under Old Brahmaputra Floodplain varied greatly. The maximum similarity was found between high and medium lands (67.49%) and the least was found between medium and very low lands (44.97%).

Mamun (1990) observed 27 species of weeds belonging to 13 families to grow in association with modern boro rice. The most important species of weed was *Cyperus iria* other important species were (*Cyperus difformis, Ludwigia adscendens*, *Alternanthera sessilis*, *Echinochloa crusgalli, Alternanthera philoxeroides*. Annuals were dominant over perennials, and broadleaves weeds were more important than grasses and sedges.

Mamun (1988a) reported that twenty six species of weeds were found to infest the boro rice fields and most problematic weeds in this crop under the Old Brahmaputra Agro ecological zone are *Echinochloa crusgalli, Scirpus juncoides* and *Monochoria hastata*.

Mamun *et al.* (1987) listed 19 commonly growing weed species in boro rice and they identified weed species *like Echinochloa crusgalli, Echinochloa colonum, Monochoria hastata, Commelina benghalensis, Jussidea repens, Alternathera sessilis, Ipomoea aquatica, Cyperus strigosus, Enhydra fluctuans, Fimbristylis miliacea* and *Eleocharis lantaginea* as important ones.

Islam and Paul (1978) identified weed species like *Hygroryza aristata, Eichhornia crassipes, Nymphea stettata, Ludwigia adsendens, Trapa natuns, Ipomoea aquatica*, *Ceratophyllum demersum* and *Lemna minor* to be important in rice at the pre-planting period at the recession of flood water from the field.

2.2 Effect of no weeding on rice field

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

Rafiquddualla (1999) observed that the weed dry weight at 20, 40 and 60 DAT was significantly affected by the weeding regimes. No weeding regimes produced the highest weed density and weed dry weight. He also observed that maximum number of effective tillers hill^{-1}, panicle length, grains panicle^{-1}, grain yield and straw yield from the weed free condition which was similar to three weeding. Maximum non effective tillers hill^{-1} and sterile spikelet grains were found from the no weeding regimes.

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

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

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

It is observed that no weeding is very much uneconomic for production of transplanted boro rice and that makes the production less as a result farmers get lower yield due to no weeding.

2.3 Effect of hand weeding on weed infestation and rice yield

Khan (2013) observed that weeding regime had significant effect on all the parameters except 1000-grain weight. The highest grain yield (6.29 t ha^{-1}) was obtained from the weed free condition and it produces 37.33% higher yield than the no weeding condition.

Ismail *et al.* (2011) determined the efficacy of different methods of weed control and their profitability in interspecific and intra-specific upland rice varieties (*Oryza sativa*). Two varieties of rice and seven weed control treatments were used in the experiment Results showed that three hoe weeding at 25, 45 and 65 DAS, twice at 25 and 45 and at 25 followed by orizo plus at 45 DAS gave better weed control than other treatments. However, hoe weeding at

25, 45 and 65 DAS gave significantly greater grain yield of 3.1 t ha^{-1} than other treatments.

Yeasmin (2008) evaluated the effect of weeding and fertilizer management on the yield performance of transplant aman rice. It was found that BRRI dhan44 yielded highest (4.85 t ha^{-1}) in three weeding (three weeding at 20, 35 and 50 DAT) treatment and the lowest grain yield was obtained in no weeding treatment.

Aktaruzzaman (2007) reported that weeding regime exerted significance influence on all the crop characters studied except panicle length and the highest grain yield (t ha^{-1}) was obtained from weed free treatment and the lowest value was obtained form no weeding treatment.

Masum *et al*. (2007) conducted an experiment on row spacing and weeding regime and reported that weed free condition found to give highest value for all parameters of paddy studied and yields (5.15 t ha^{-1} grain and 7.13 t ha^{-1} straw) followed by three weeding. No weeding produced the lowest value for all characters including yield.

Subramanian *et al*. (2006) conducted an experiment is Tamil Naru during the winter season to study the effect of integrated weed management practices on weed control and yield of wet seeded rice. The combination of pre-emergence herbicides + one hand weeding at 25 DAT will reduced weed density, dry weight and higher weed control efficiency resulting grain yield (58.73 g ha^{-1}).

BRRI (1996) reported that increasing the frequency of hand weeding from 1 to 2 times at 21 and 42 DAT reduced the weed density and weed dry weight and doubled the grain yield.

Dwivedi *et al*. (1991) conducted an experiment to evaluate the manual weed control once 30 DAS or twice 30 and 60 DAS and pre emergence benthiocarb at 1.5 kg ha^{-1} in rice cv. IET. 7564. The rice was sown in 3 methods broadcast drilling or by sowing sprouted seeds in a puddled field (Lehi). Manual weeding twice and benthiocarb + manual weeding once resulted in the greatest weed control. The greatest grain yields (1.35 - 1.37 t ha^{-1}) occurred when manual weeding was conducted twice.

Mishra and Singh (1987) conducted an experiment at different weeding regimes (15, 30, 45 DAS, weed free and no weeding) in direct seeded puddle rice. They reported that hand weeding twice at 15 and 30 days after sowing, weed free control and weedy control, grain yields were 1.86, 1.96 and 0.96 t ha^{-1}, respectively and weed dry weight was 93.8, 10.8 and 217.5 g m^{-2}, respectively.

Senthong (1986) reported that in direct seeded rice cv. R.D.7 hand weeding once at 25 DAS and hand weeding twice at 25 and 45 DAS and control treatments gave grain yields of 4.61, 5.65 and 3.69 t ha^{-1}, respectively. Plant height was 78.2, 78.4 and 74.5 cm, respectively and number of weeds, 0.25 m^{-2} were 42.5, 20.0 and 47.7, respectively.

Bhan *et al*. (1985) reported that manual removal of weeds twice at 15 and 30 days after sowing at 15 and 45 days after sowing, at 35 and 45 days after sowing and at 35 and 45 days after sowing resulted in significant decrease in population and dry matter of weeds at subsequent stages of rice growth. Maximum reduction in weed infestation was recorded following their removal at 15 and 45, 30 and 45 and 15, 30 and 45 DAS. Weed removal at 15 and 30, 30 and 45 or 15, 30 and 45 DAS facilitated in the production of significantly higher dry matter.

Method of weeding has a great influence on weed population and weed dry matter weight consequently on the rice yield and yield contributing characters. BRRI (1977) showed that increasing the frequency of hand weeding one to two times at 21 and 42 DAT was found to reduce the weed density and weed dry matter and caused to double the yield.

It is observed that hand weeding is very much effective for controlling weeds in transplant boro rice under different climatic conditions but it makes the production cost high.

2.4 Effect of different herbicides on weed infestation in rice field

Poornima *et al.* (2015) Pyrazosulfuron ethyl is a low dose high efficacy herbicide coming under the group of sulfonyl ureas which is effective for controlling a wide range of weeds in low land rice. Field experiments were conducted for two consecutive seasons, i.e., second and third crop seasons at the Instructional Farm, College of Agriculture, Vellayani to estimate the residues of pyrazosulfuron ethyl in soil, rice grain and straw. The experiment was laid out in randomized block design which consisted of eight treatments with three replications. The treatments included four different levels of pyrazosulfuron ethyl (15, 20, 25 and 30 g ha^{-1}), butachlor (1.5 kg ha^{-1}), weed free check, unweeded check and hand weeding twice (at 20 and 40 days after transplanting). The results of the experiment revealed a total absence of pyrazosulfuron ethyl in soil, rice grain and straw, i.e., no detectable residue could be observed.

Zahan *et al.* (2015) revealed that pyrazosulfuron ethyl followed by orthosulfamuron and (butachlor+propanil) reduced weed biomass by 96-97% compared to non-treated weedy plots. On the other hand, pyrazosulfuron ethyl with one post-emergence herbicide either (butachlor+propanil) or 2,4-D reduced weed by 91 to 92 %. Butachlor followed by orthosulfamuron followed by (butachlor+propanil) also reduce weed biomass by 91% compared to non-treated control. Only pyrazosulfuron ethyl followed by orthosulfamuron and (butachlor+propanil) achieved yields close to those of the weed-free treatments (5.42-6.04 t ha^{-1}). Among the herbicide treatments in 2014, sole application of butachlor produced low grain yield similar to the non-treated crop (2.76-3.1 vs 3.13 t ha^{-1}) suggesting low activity of this herbicide on weed control in unpuddled soil. The results suggest that pyrazosulfuron ethyl was the most effective pre-emergence herbicide in unpuddled transplanting system especially when applied with orthosulfamuron and/ or (butachlor+propanil) or 2,4-D as a post-emergence herbicides.

Kumaran *et al.* (2015) evaluated the herbicide (Bispyribac sodium 10% SC) on weed control and their nutrient management in direct seeded lowland rice. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The results revealed that Early Post Emergence (EPOE) application of bispyribac sodium 10% SC 40 g ha^{-1} recorded higher weed control efficiency and lesser weed density, nutrient uptake at reproductive stage of the crop. Different weed management practices imposed on rice crop did not affect the germination of succeeding green gram.

Hassan and Upasani (2015) conducted an experiment to find out the effect of establishment and weed control method on weed dynamics, growth and productivity of rice under wet land situation. The treatment comprised of 4 methods of crop establishment i.e. transplant, SRI, drum seeded and broadcast in main plot and 4 methods of weed control – pyrazosulfuron 0.02 kg ha^{-1} PE + mechanical weeding at 25 DAS or DAT,weeding by cono weeder at 25 DAS or DAT, hand weeding at 25 and 40 DAS or DAT, and weedy check in sub plot. The result revealed that among establishment and weed control methods, transplant and application of pyrazosulfuron 0.20 kg ha^{-1} + one mechanical weeding at 25 DAS or DAT were most productive. Application of pyrazosulfuron 0.20 kg ha^{-1} + one mechanical weeding at 25 DAS or DAT in transplanted or broadcasted rice was most effective in suppressing weed population and weed dry matter accumulation thereby producing higher rice grain yield compared to other weed control methods.

Ramesha *et al.* (2015) evaluated the phytotoxicity and bio-efficacy of pyrazosulfuron ethyl 10% WP (5, 10, 15 and 20g ha^{-1} as spray) against the weeds in transplanted rice. Sprays of Saathi (Market Sample) @ 15g ha^{-1}, Pretilachlor 50% EC @ 500 ml ha^{-1}, hand weeding at 15 and 40 days after planting (weed free check) and a weedy check (untreated check) were also maintained. The dominant weeds were *Echinochloa colona, Panicum repens, Cynodon doctylon, Ludwigia parviflora, Leptochloa chinensis and Cyperus sp*. Application of pyrazosulfuron ethyl 10% WP at 20 g ha^{-1} was most effective in controlling the associated weeds and increasing the grain yield of rice without any phytotoxic effect.

Hashem (2014) reported that at high rice density, rice grain yield increased significantly from 1927 kg ha^{-1} to 3217 kg ha^{-1} as the rate of pretilachlor increased from 0 to 1.5 L ha^{-1}, butthere was no further increase in yield above this rate. At medium and low densities, grain yield increased significantly as the rate of pretilachlor increased from 0 to 2 L ha^{-1}. In plots treated with recommended rate of pretilachlor (2 L ha^{-1}), there were no significant differences for grain yield among the crop densities, whereas in untreated plots, the grain yield increased by 51% from low to high crop density. For the 0, 25%, 50%, and75% of recommended rates, weed biomass decreased significantly with increasing rice density, while for the100% of recommended rate, weed biomass was unaffected with increasing crop density. This study illustrated that planting rice at higher density can reduce herbicide rate by 25% without adverse effect on grain yield, and can be an important component of integrated weed management strategy in lowland rice systems

Jacob *et al*. (2014) conducted an experiment, the treatments included application of both pre emergence and post emergence herbicides. The pre emergence herbicides selected were oxyfluorfen sprayed at 3 days after sowing (DAS) and butachlor and pretilachlor sprayed at 6 DAS. Pyrazosulfuron-ethyl, an early post emergence herbicide, was sprayed at 8 DAS. The herbicides cyhalofop butyl, fenoxaprop-p-ethyl, metamifop, penoxsulam, bispyribac sodium andazimsulfuron, are post emergence in action and were sprayed at 20 DAS. Hand weeded (handweeding at 20 and 40DAS) and unweeded controls were also included for comparison with the herbicide treatments. The best herbicide for control of grass weeds was either fenoxaprop-p-ethyl @ 60 g ha^{-1}

or cyhalofop butyl @ 80 g ha^{-1}, both applied at20 DAS. Broad spectrum weed control can be made possible by spraying herbicide combinations that could give higher yield and B:C ratio.

Mallikarjun *et al.* (2014) studied the effect of herbicides on weed control and yield of wet seeded rice which involves three pre-emergent herbicides viz., butachlor, anilophos and oxyflurofen applied as alone and each these followed by two post emergent herbicides 2, 4- sodium salt, bispyribac sodium and one hand weeding at 25 days. The results revealed that sequential application of butachlor and anilophos fb bispyribac sodium, 2, 4-D sodium salt and one hand weeding at 25 days was recorded significantly lower weed population and dry weight of weeds viz., monocots, dicots and sedges in equal manner which ultimately indicates that higher weed control efficiency over rest of the treatments except weed free check and hand weeding thrice. further, grain and straw yield of rice was followed the same trend as well influenced by yield parameters like number of panicles per sq.m and number of seeds/panicle ultimately sequential application butachlor and anilophos fb 2, 4-D sodium salt and bispyribac sodium and one hand weeding at 25 DAS resulted higher grain yield and profitable rice production.

Singh *et al.* (2014) conducted an experiment to evaluate the performance of transplanted rice under pre-emergence herbicides and hand weeding techniques. The treatment consist of seven weed management techniques viz., W_1= Butachlor@ 1.5 kg ai ha^{-1}, W_2 = Butachlor @ 1.0 kg ai ha^{-1} + 2 4 D @ 1.0 kg ai ha^{-1}, W_3 = Bensulfuron methyl0.6% + Pretilachlor 6% G @ 10.0 kg ha^{-1}, W_4 = Chlorimuron + Metsulfuron-methyl 20 WP @ 4 g ai ha^{-1}, W_5 = Pyrazosulfuron ethyl @ 30 g ai ha^{-1}, W_6 = Two hand weeding at 25 and 50 days after transplanting, W_7 = Weedy check (control). The highest grain yield (7.2 t ha^{-1}) was obtained fromW6 (two hand weedings) as a result of reduced dry weight of weeds and higher values of yield components. This was statistically at par with pre emergence application of Pyrazosulfuronethyl (6.7 t ha^{-1}) and ready mix Chlorimuron + Metsulfuron methyl (6.2 t ha^{-1}). The highest net return (`53950 ha^{-1}) and B:C (2.39) was also obtained with two hand weedings followed by Pyrazosulfuron ethyl and Chlorimuron + Metsulfuron methyl application.

Madhukumar *et al.* (2013) evaluated relative efficacy of different herbicides for weed control in aerobic rice. Among different herbicide treatments pre-emergent application of bensulfuron methyl @ 60 g + pretilachlor @ 600 g ha^{-1} recorded significantly higher productive tillers per hill (21.32), panicle weight (2.81 g), thousand grain weight (21.80 g), filled spikelets per panicle (88.23), weed control efficacy (91.37), grain yield (4100 kg ha^{-1}), straw yield (4961 kg ha^{-1}) and lower total weed density and dry weight (72 No.m^{-2} and 3.65 g 0.25 m^{-2}, respectively), followed by two hand weedings at 20 and 40 DAS and oxyfluorfen @ 90 g ha^{-1} as pre-emergent spray followed by 2, 4-DEE as post emergent spray @ 500 g ha^{-1} at 25 DAS.

Faruq (2013) found that application of Prechlor 500 EC @ 1.5 L ha^{-1} showed the best performance in reducing weed density and weed dry weight and in increasing weed control efficiency but reduced the grain yield.

Acharya and Bhattacharya (2013) investigated the efficacy of sulfonyl urea herbicide like pyrazosulfuron ethyl, benzothiadiazinone like bentazon alone and its combination with MCPA, clefoxydim and quinclorac were studied in comparison to traditional acetamides like butachlor and pretilachlor under field condition in transplanted boro rice. The dominating weed species in the experimental site were grasses like *Echinochloa crusgalli, Paspalum distichum,* sedges like C*yperus iria*, *Fimbristylis miliacea* and broad leaved weeds like *Ammania baccifera* and *Ludwigia parviflora*. The herbicidal treatments were significantly superior to weedy check. There was 32.97% reduction in the grain yield of rice due to competition with weeds in the weedy plots. The pyrazosulfuron ethyl @ 30 g ha^{-1} applied as pre-emergence, with an weed control efficiency of 71.78%, was found to be the most effective in controlling predominant weeds, in comparison to acetamide and benzothiadiazinone herbicides. In terms of profitability, application of pyrazosulfuron ethyl @ 20 g ha^{-1} gave the highest gross and net return than other weed control treatments.

Parvez *et al*. (2013) evaluated the effect of cultivar and weeding regime on the performance of transplant aman rice. The experiment consists of two factor namely factor A: cultivar- BRRI dhan41 (V_1) and Nizershail (V_2), and factor B: weeding regime- no weeding (T_1), one hand weeding at 21 DAT (T_2), two hand weeding at 21 and 42 DAT (T_3), application of Pretilachlor herbicide (T_4), application of Pretilachlor herbicide + one hand weeding at 21 DAT (T_5) and weed free (T_6). The maximum weed growth was noticed with the dwarf cultivar BRRI dhan41 and minimum with taller cultivar Nizershail. Complete weed free resulted in the lowest weed population and weed dry weight followed by application of Pretilachlor herbicide + one hand weeding at 21 DAT treatment. BRRI dhan41 produced the higher grain and straw yields than the cultivar Nizershail. The highest loss of grain yield was recorded in no weeding treatment and the lowest was recorded in weed free treatment followed by application of Pretilachlor herbicide + one hand weeding at 21 DAT in transplant aman rice (BRRI dhan41). The highest number of effective tillers $hill^{-1}$, highest number of grains $panicle^{-1}$ and heaviest 1000 grain weight were observed in weed free treatment followed by application of Pretilachlor herbicide + one hand weeding at 21 DAT treatment.

Rahamdad and Khan (2012) investigate among non-chemical weed management techniques, allelopathy (bioherbicides) is considered as an option for weed suppression. The results showed that pre-emergence application of plant water extracts proved to be superior to their post-emergence application in respect of weed control. Pre-emergence application of *Phragmites australis* and *Helianthus annuus* gave 68 and 65% weed control, respectively. Minimum fresh and dry weed biomass of 188 kg ha 1and 94 kg ha respectively was recorded under the pre-emergence application of *Phragmites australis*. Sorghum gave maximum grain yield 5015 kg ha^{-1} in comparison to weedy check that gave only 2700.6 kg ha^{-1}.The instant results suggest that *Phragmites* *australis* and *Helianthus annuus* could be successfully incorporated in weed management approaches in wheat.

Pal *et al*. (2012) studied the efficacy of pyrazosulfuron-ethyl against weeds in transplanted rice was studied during 2008 and 2009 at Regional Research Sub-station, Chakdaha under Bidhan Chandra Krishi Viswavidyalaya, West Bengal. The experiment was laid out in randomized block design with seven treatments replicated thrice. The major associated weeds were: *Echinochloa colona, Cyperus difformis, Ammania baccifera, Ludwigia octovalvis* and *Monochoria vaginalis*. Pyrazosulfuron-ethyl at 42.0 g ha^{-1} applied at 3 DAT was most effective in managing associated weed species and yielded maximum grain yield (3.3 t ha^{-1}) of rice with lower weed index (10.8%).

Abbassi (2012) evaluated of rice (*Oryza sativa*) general herbicide in intermission flooded conditions and control of weeds include Barnyard grass (*Echinochloa crusgalli*), Sedges (Jancus) and Broadleaves, one study was carried out in randomized complete block design with14 treatment and 4 replications during 2010. Treatment were: Butachlor 60% EC, Pertilachlor50% EC, Oxadiargy l30% EC, Pendimethalin 33% EC, Molinate 72% EC, Thiobencarb 50%EC, Clodinafop-propargyl 8% EC, Fenoxaprop 57% EW, 2,4-D 72% SL, Propanil 36% EC,Bentazone 48% SL at 4, 2, 3.4, 4, 6, 6, 0.6, 1, 2, 15 and 3 Lit ha^{-1} respectivly and Cinosulfuron 20% WG at 150 g ha^{-1}. The results indicated that “Pretilachlor + Pretilachlor” treatment based on EWRC standard evaluation and also 3471 kg ha^{-1} grain yield had the best output in comparisonother treatments Also “Thiobencarb + mixed of Bentazone and Propanil”, "Oxadiargyl + mixedof Bentazone and Propanil" and " Butachlor + mixed of Bentazone and Propanil" treatmentswith 3454, 3390 and 3349 kg ha^{-1} yield respectively had had acceptable yield in comparison three time hand weeding check treatment with 3044 kg ha^{-1} yield.

Abdul *et al*. (2011) evaluated the efficacy of pre and post emergence herbicides applied either alone or in a sequence for weed control in dry seeded fine rice cv. Super basmati. Three herbicides namely Stomp 455CS (pendimethalin) at 1650 g ha^{-1} as pre-emergence, Nominee 100SC (bis-pyribac sodium) and Ryzelan 240SC (penoxsulam) at 30 and 15 g ha^{-1} respectively, were used as early post emergence (15 DAS). Pendimethalin was also followed by either of these herbicides. A weedy check and weed free treatments were maintained for comparison. Maximum paddy yield (2.79 t ha^{-1}).

Mamun *et al*. (2011) evaluated the performance of Acetochlor 50% EC for weed suppression, to find out an appropriate dose of the herbicide and its impacts on transplanted rice. Acetochlor 50%EC @ 200, 250 and 300 ml ha^{-1} were applied. Pretilachlor 50% EC@ 1L ha^{-1}, weed free and unweeded control was used for comparison. The most dominant weeds were *Cyperus difformis,Monochoria vaginalis* and *Echinochloa crus-galli* in year 1 and *Cyperus difformis* and *Echinochloa crus-galli* in year 2. *Cyperus difformis* was at the higher rank of dominant in both years. Application of Acetochlor 50%EC @ 250 ml gave more than 80%weed control efficiency, lower number and dry weight of weeds which ultimately resulted in higher yield attributes and grain yield of transplanted rice that were comparable to the standard in both seasons.

Mamun *et al.* (2011) conducted an experiment to find out an effective and economic herbicide to control weeds. Becolor SG (Butachlor), Bouncer 10 WP (Pyrazosulfuron-ethyl) and Becofit 500 EC (Pretilachlor) were used to control 9 weeds. The highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10 WP @ 150 g ha^{-1} which was 49% higher than control. BRRI dhan29 produced also the highest grain yield (5.92 t ha^{-1}) when treated with same treatment which was 37% higher than control.

Bari (2010) conducted an experiment with eight herbicides in transplanted wetland rice during aman season to study the effect of weed control and rice yield. The highest grain yield of 4.08 t ha^{-1} was obtained from Butachlor while the lowest grain production (2.83 + t ha^{-1}) was harvested in the plots receiving MCPA @ 125% of the recommended rate.

Bakare (2008) studied that a formulated mixture of propanil + triclopyr was evaluated at 2, 3 and 4l ha^{-1} along side with a check chemical (OrizoplusR made up of propanil + 2, 4 – D Amine) showed significant difference occurred in the level of weed control. Propanil + triclopyr though controlled weeds; the control level was significantly lower than the check OrizoplusR in each respective application rate. There was no phytotoxic effect of the herbicides on rice, indicating that the hebicides are not injurious to rice crop. As post-emergence herbicide in lowland rice, formulated mixture of propanil + triclopyr is recommended to be applied at 3-4 L ha^{-1}.

Kabir *et al.* (2008) conducted an experiment from June to December, 2003 to assess weed dynamics and yield performance of transplanted aman rice (cv. BRRI dhan39) in different weed control treatments. Weed density, weed biomass and weed control efficiency were significantly influenced by different weed control treatments under good water management practices. Other than weed free treatment, Butachlor 5 G @ 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 minimum weed density (16 g m^{-2}) as well as weed biomass (9.27 g m^{-2}) and the highest weed control efficiency (82.57%). The highest grain yield (5.22 t ha^{-1}) was obtained under good water management in weed free treatment followed by Butachlor 5G @ 2 kg ha^{-1} and one hand weeding (4.96 t ha^{-1}) under same water management.

Shamim *et al.* (2008) reportd the methods of crop establishment, time of herbicide application and their interaction significantly influenced the number and dry weight of weeds. The highest number and dry weight of weed were recorded in direct seeded thin row, followed by direct seeded thick row and the lowest in transplanting. Again, the highest number and dry weight of weed were recorded in control and the lowest in herbicide application after 3 days of seeding or transplanting. Weed control efficiency was higher in those receiving early application of herbicide. The highest weed control efficiency was in herbicide application at 3 days after seeding or transplanting. Phytotoxicity of herbicide increased with the earliness of herbicide application and highest phytotoxicity was observed in direct seeded thick row having herbicide application 3 days after sowing.

Mukherjee and Malty (2007) conducted an experiment in transplanted rice, with Butachlor 1.0 kg ha^{-1} at 3 days after transplanting + almix 20 WP (Chlorimuron-7 ethyl + Metsulfuron-methyl) 4.0 g ha^{-1} at 20 days after transplanting registered higher weed control efficiency and grain yield compared with season long weed control weed-free condition.

Khan and Ashraf (2006) conducted an experiment to evaluate the effectiveness of herbicides on weed control and paddy yield in boro rice. The treatment was Ronstar 25 EC @ 2.0 L ha^{-1}. They found that use of Ronstar 25EC gave grain yield (5.65 t ha^{-1}).

Kumar and Uthayakumar (2005) conducted a field experiment at Tamil Nadu during 2001 to study the possibility of weed management with and without herbicides. They used one hand weeding at 25 DAT, Butachlor @ 1 kg ha^{-1} at 8 DAT, 2.4-D @ 0.5 kg ha^{-1} at 25 DAT, two hand weeding at 25 and 50 DAT and unweeded control. Among the treatments butachlor had significant effect on weed population and grain yield of rice. This was reflected in increased number of productive tillers $hill^{-1}$ and finally grain yield of rice. The other weed control practices produced similar effect except unweeded control.

Halder *et al.* (2005) studied the comparative efficacy of Pyrazosulfuron Ethyl (PSE) alone and its combination with Molinate against weed complex of boro paddy at the University Teaching Farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The predominant weed species were *Echinoch/oa crusgal/i, Cyperus iria, Fimbnstylis miliacea, Scripus maritimus, Monochoria vagina/is, Ludwigia parvif/ora* and *Ammania baccifera.* The result of the experiment revealed that among all the chemicals tried in this investigation PSE 10% WP @ 16 g ha^{-1} was the best in reducing weed population and weed dry weight without showing any phytotoxic symptoms in rice. Though hand weeding twice at 20 and 40DAT gave the maximum grain yield, benefit: cost ratio clearly showed that PSE 10% WP@ 15 g ha^{-1} is the right herbicide to replace the hand weeding treatment.

Saha (2005) carried out an experiment to compare the efficacy of Butachlor (948 g ha^{-1}) Pretilachlor (500 or 750 g ha^{-1}), Pyrazosulfuron-ethyl (40 or 50 g ha^{-1}), Bensulfuron methyl (40 or 50 g ha^{-1}) + Butachlor (938 g ha^{-1}) and hand weeding 2 (20 and 40 DAT) or 3 (20, 40 and 60 DAT) times for controlling weed flora. Results indicated that all treatments significantly reduced weed dry matter and densty. The highest grain yields 5.75 t ha^{-1} was obtained from Pyrazosulfuron-ethyl applied at 40 or 50 g ha^{-1}.

Singh *et al.* (2004) observed that the pre-emergence application of anilofos followed by 2,4-D as post emergence proved superior in control the weeds compared to cyhalofop butyl and nutasulfuronmethyl + chlorimuron-ethyl, and was at par with manual weeding at 25 and 50 DAS.

Saini (2003) conducted a field investigation during the Kharif season of 2001 and 2002 at the experimental farm of Department of Agronomy, Palampur, Himachal Pradesh, India, to evaluate the efficacy of Pyrazosulfuron-ethyl, in transplanted rice (cv. RP-2421). Pyrazosulfuron-ethyl at 20 g ha^{-1} applied as spray was as effective as its higher rate (25 g ha^{-1}) applied as spray and broadcast after sand mix in terms of the reduction of the dry weight of grasses, sedges, broadleaf and total weeds, and enhanced the grain yield and almost all the yield attributes of rice.

David *et al.* (2003) studied the economic consequence of applying less than the recommended propanil rates to these cultivars was also evaluated. Grain yields increased, and barnyard grass biomass decreased with increasing propanil rates. With or without propanil, the Asian rice cultivars consistently suppressed barnyard grass more and consequently produced higher grain yields than did U.S. cultivars. The economic benefit derived from propanil application was less for Asian than for U.S. cultivars. Asian cultivars produced higher rough rice yields, resulting in higher net returns (not adjusted for milling) than did the commercial cultivars, but this advantage was usually reduced when adjusting for their lower milling yields.

Rangaraju (2002) in India studied the effects of herbicide application and application time on weed flora and weed dynamics in dry seeded rainfed rice. He observed that application of either Butachlor or Thiobencarb at 1.5 kg ha^{-1} effectively controlled the weeds.

Selvam *et al.* (2001) conducted an experiment, the treatments included sowing practices and herbicide, Pendimethalin 1.24 litre ha^{-1} at 8 days after rainfall (DAR), Pretilachlor 1.0 litre ha^{-1} at 4 DAR and 8 DAR, Pretilachlor + Safener at 4 DAR and 8 DAR, hand weeding twice and unweeded control. All herbicides receiving plots were supplemented with one hand weeding at 25 DAR. Among the herbicides, Pendimethalin recorded the highest grain yield in 3773 kg ha^{-1} same as pretilachlor at 8 DAS.

Tamilselvan and Budhar (2001) conducted experiment to see the effects of pre-emergence herbicides Butachlor @ 1.0 kg ha^{-1}, Butanil @ 1.0 kg ha^{-1}, Pretilachlor @ 0.4 kg ha^{-1}, Pretilachlor @ 0.4 kg ha^{-1}. Safener and Anilofos @ 0.3 kg ha^{-1} on rice cv. ADT43. The herbicides were applied 8 days after sowing. The density and dry weight of weeds at 40 DAS were lower in herbicide treated plots than in unweeded and hand weeded plots. The highest number of productive tillers $hill^{-1}$ was obtained in the plots treated with Anilofos @ 0.3 kg ha^{-1} (14.4), Pretilachlor @ 0.40 kg ha^{-1} (14.2) and Butanil @ 1.0 kg ha^{-1} (13.3). The number of filled grain panicles was the highest with Anilofos @ 0.3 kg ha^{-1} (131.7), Pretilochlor @ 0.40 kg ha^{-1} (126.3) and Butanil @ 1.0 kg ha^{-1} (122.1). The weed control treatments were equally effective in increasing grain yield.

Rajkhowa *et al.* (2001) initiated a trial to find out the most effective weed control and nutrient management practices for rice. Results revealed that Butachlor @ 1.0 kg ha^{-1} or pretilachlor @ 0.75 kg ha^{-1} applied three days after transplanting significantly reduced weed infestation till 45 DAT and resulted in higher yield of rice over weedy check. Nutrient management practices showed no significant variation in weed density and dry matter accumulation.

Moorthy *et al.* (1999) evaluated the effects of the pre-emergence herbicides Pretialchlor + Safener, Butachlor + Safener, Butachlor, anilofos, Anilofos + Ethoxysulfuron, Thiobencarb and Anilofos for their efficiency to control weeds in direct sown rice under puddled soil condition. They observed that Pretilachlor + Safener (0.4 kg and 0.6 kg ha^{-1}), Butachlor +Safener (1.5 kg ha^{-1}) and Anilofos + Ethoxysulfuron (0.375+0.04 kg ha^{-1}) controlled the most dominant weeds (*Cyperus difformis* and *Fimbristylis miliacea*) and produced yields comparable to those of the hand weeded control.

Razzaque *et al.* (1998) conducted experiment at the Bangladesh Institute of Nuclear Agriculture, Mymensingh, to evaluate the efficiency of Ronstar (Oxadiazon) as a herbicide in boro rice. They observed that the application of Ronstar 25 EC @ 2.01 ha^{-1} or more, achieved complete control of all the weed masses growing in the field and significantly increased grain yield. They also observed that application of Ronstar 25 EC @ 2.0 L ha^{-1} achieved the greatest profit.

Mumal *et al.* (1998) observed that the weed species *Cyperus sp., Eichhornia crassipes, Echinochloa crus-galli, Echinochloa colonum, Fimbristylis sp., Monochoria vaginalis, Eclipta alba, Paspalum sp., Panicum sp., Commelina sp.* and *Cyanotis* sp. were significantly reduced by the application of Butachlor (at 1kg active ingredient ha^{-1}), with monocot weeds being controlled better. Yield was influenced by the time of herbicide application. Maximum weed control was observed when Butachlor was applied 1, 3, 5 and 7 days after broadcasting sprouted seeds.

BRRI (1997) observed that herbicide Set-off and Ronstar perform better than Golteer herbicide with weed biomass, plant population and other plant characters of rice. However, two hand weedings were the best performance in all respects. On the other hand, two hand weedings gave the highest weeding cost.

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

BRRI (1996) observed that Ronstar @ 12 L (3.0 L ha^{-1} and 2.0 L ha^{-1}) treated plots had significantly higher number of panicles and grain yield compared to two hand weedings unweeded plots had the highest weed biomass. It also indicated that 2.0 L Ronstar ha^{-1} gave significantly higher grain yield than 3.0 L Ronstar ha^{-1}. Ronstar (2.0 L ha^{-1}) controlled rice weed satisfactorily except *Cynodon dactylon*.

Mondal *et al*. (1995) observed the efficiency of Rilof H and Rifit as herbicide in comparison to hand weeding in BR11 variety of *aman* rice was investigated. The major weed in the rice field were *Cyperus iria*, *Scirpus mucronatus*, *Monochoria hatate* and *Eleusine indica*. Plots treated with Rilof H @ 3 litre ha^{-1} produced the highest grain yield (6.0 t ha^{-1}) which was identical with the treatments of hand weeding at 21, 38 and 55 DAT and Rifit @ 2 litre ha^{-1}. The lower doses of Rilof H @ 1 litre ha^{-1} and Rifit @ 1 litre ha^{-1} failed to kill the weeds properly. Higher doses of both Rilof H and Rifit had phytotoxic effects on the rice plant. The grain yield reduced due to weed infestation was 20.3 percent.

Samanta *et al.* (1995) found that Ronstar 25 EC @ 2.0-4.0 L ha^{-1} and manual weeding twice were found effective in reducing the dry matter of total weeds significantly over the control, but none of the treatment except manual weeding twice controlled *Paspalum distichum* effectively.

Chowdhury *et al.* (1995) studied the effect of Ronstar on weed management and they used six different doses 0.00, 1.50, 1.75, 2.00, 2.25 and 2.50 t ha^{-1} and Ronstar applied after 8 days of transplanting @ 2.50 L ha^{-1} gave highest plant height, maximum number of effective tillers $hill^{-1}$.

Kurmi and Das (1993) conducted an experiment on clay loam soil at Karimganj during 1989-90 to evaluate the effect of pretilachlor (0.75 - 1.25 kg ha^{-1}) applied at 3 DAT, Pyrazosulfuron-ethyl (0.005-0.01 kg ha^{-1}) at 3 and 7 DAT, anilofos (0.4 0.6 kg ha^{-1}) at 7 DAT, Oxidiazon (0.4 kg ha^{-1}) at 7 DAT, 2,4-D (0.8 kg ha^{-1}) at 7 DAT and hand weeding twice at 20 and 40 DAT in controlling weeds in rice cv. IET 6987. The most problematic weeds were found to be *Echinochloa crusgalli, Eleusine indica, Digitaria sanguinalis, Cyperus iria, Cyperus rotundus, Scirpus juncoides, Fimbristylis miliacea, Monochoria vaginalis* and *Sphenoclea zeylanica.* All weed control treatments reduced weed dry matter from unweeded control values of 164.2-249.3 g m^{-2} to 20.3 - 131.0 g m^{-2} and increased rice grain yields from 4016-2768 kg ha^{-1} to 4321-4757. Pyrazosulfuron-ethyl at 0.01 kg ha^{-1} applied at 7 DAT resulted in the greatest weed control (74.4-77.5%).

Zafar (1989) conducted an experiment to see the relative performance of Butachlor (Machete 60 EC at 1.2 kg ha^{-1}), Oxadiazon (Ronstar at 0.54 kg ha^{-1}), Thiobencarb (Stam F 10 G at 1.43 kg ha^{-1}) and Endimethalin (Stam 33 EC at 1.43 kg ha^{-1}). All herbicides gave above 83% weed control. Tillering was not significantly enhanced by Oxadiazon but increased rice yield.

Mian and mamun (1989) observed that the weed species *Cyperus spp., Eichhornia crassipes, Echinochloa crus-galli, Echinochloa colonum, Fimbristylis sp., Monochoria vaginalis, Eclipta alba, Paspalum sp., Panicum sp., Commelina sp.* and *Cyanotis sp.* were significantly reduced by the application of Butachlor (at 1 kg active ingredient ha^{-1}). Yield was influenced by the time of herbicide application. Maximum weed control was observed when Butachlor was applied at 1, 3, 5 and 7 days after broadcasting the sprouted seeds.

BRRI (1987) evaluated the performance of herbicides Set-off, Ronstar and Golteer for controlling weeds and optimum grain yield of wet seeded aus rice. The treatments were (a) Sett-off 20 WG 100g ha^{-1} (b) Ronstar 25 EC 2.0 L ha^{-1} (c) Golteer 5G 25 kg ha^{-1} (d) two hand weeding at 20 and 35 DAT and (e) no weeding (control). Set off and Ronstar showed better performance than Golteer in term of reduction of weed biomass and plant population.

2.5 Effect of weeding on yield and yield components of rice

Weed is one of the major pests of rice. It competes with rice plant for light, nutrient, space. As a result grain yield of rice become affected due to weed. For this reason timely weeding is necessary.

Dhiman (2006) was reported the efficacy of various combination of 2,4-D axilofos and chlorinuron in controlling weed infesting rice. Application of 500g 2,4-D ha^{-1} in combination with chlorinuron resulted in the highest control of grasses, sedges and broad level weeds and produced to the tallest plants, highest number of effective tillers $hill^{-1}$ and grain yield (5.83 t ha^{-1}).

Dhiman and Singh (2005) conducted an experiment at 2001 and 2002 in India to evaluate the effects of low doses of herbicides on weeds, nutrient uptake and yield of transplanted rice. The treatments were 2,4-D @ 500 g ha^{-1}, anilofos @ 400 g ha^{-1}, hand weeding at 20, 40 and 60 days after transplanting and weedy control. Pre-emergence applications of 2,4-D recorded the lowest weed density and biomass among the herbicidal treatments 2,4-D and hand weeding significantly influenced nutrient uptake by the crop and gave the highest grain yields. The lowest uptake was recorded in weedy control. 2,4-D registered 88% and 83% higher grain yield in 2001 and 2002 respectively, compared with the weedy control.

Hoque *et al*. (2003) conducted an experiment to assess the effect of varieties of transplanted aman rice and weeding regimes on weed growth and yield of transplanted aman rice. Five weeding were used in the experiment. The effect of weeding regimes produced significant differences on the weed growth and grain yield of transplant aman rice. The reduction of weed dry matter was similar in both two weeding and three weeding regimes. The highest grain yield was noted under three weeding conditions (3.95 t ha^{-1}) which was at par with weed free (4.01 t ha^{-1}), but dissimilar to two weeding regimes (3.71 t ha^{-1}).

Hossain (2000) studied the effects of different weed control treatments in rice as one hand weeding, two hand weeding, three hand weeding, Ronstar, Ronstar + hand weeding. He observed that yield and yield contributing characters increased with the increase in frequency of hand weeding.

Ganeshwor and Gadadhar (2000) conducted a study during kharif season to evaluate the herbicides in controlling weeds and improving grain yield in rice. The treatment were 2,4-D @ sodium salt @ 0.80 kg ai. ha^{-1}. All herbicides were effective in controlling the weeds at 21 DAT. The most effective wee control was exhibited by 20 2,4-D amine. All herbicides gave higher rice grain yields compared with the weedy control, the 2.4-D amine gave highest values for grain yield (3.89 t ha^{-1}), total number of spikelets (19.30 m^{-2}), number of grains (18.65 m^{-2}), percentage seed setting (96.6%) and 1000-grain weight (24.69 g).

Ahmed *et al*. (1998) conducted an experiment was conducted in Pakistan to investigate the effects of weed control on rice yield and its components. Six treatments were included in the study: no weed control continuous weeding, weeds control via herbicide application and weed removal at 30, 45 and 60 DAT. The highest number of tillers m^{-2} (331) was recorded under continuous weeding followed by weed control at 30 DAT and herbicide. The highest yield was found 5.14 t ha^{-1} in continuous weeding, followed by weed control at 30 DAT and herbicide.

Fofana *et al.* (1995) reported that rice farmers in West Africa largely rely on hand weeding as the main weed control method. Due to the limited availability of labour, weeding of the crop is often delayed or inadequate and crop losses due to weeds are severe. Rice varieties, which are able to compete strongly with weeds, would make a significant contribution to productivity and yield stability on farmer's field. Research was conducted to identify rice varieties, which can compete with weeds, and to determine the characteristics of rice plant which contribute to competitiveness with weeds. They observed that weed biomass at harvest was lower with those rice varieties developing a large number of tillers and good root growth.

BRRI (1991) observed that Ronstar @ using of 3.0 L ha^{-1} had significantly improved the number of panicles and grain yield of rice compared to two hand weeding. It also indicated that 2.0 L Ronstar 25 EC ha^{-1} gave slightly higher grain yield than 3.0 L Ronstar 25 EC ha^{-1}. Ronstar 25 EC @ 2.0 L ha^{-1} controlled rice weeds satisfactorily except *Cynodon dactylon* L.

Manna (1983) reported that weed reduced the grain yield in India by 25% for low land rainfed rice, In Bangladesh it was 75% for rainfed low land rice and found that yield loss might raise 68 - 100% for direct seeded aus rice, 48.16% for transplant aus rice, 75.98% for mixed aus, aman rice, 60.29% for deep water rice and 22.36% for modern boro rice.

All the information indicate that the effect of different weed control methods vary under different agro-ecological conditions. Manual weed control methods may be supplemented by chemicals of different natures. As the severity of weed infestation varies under different weed management systems.

Chapter III

Materials & Methods

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Location of the experimental field

The experiment was conducted at Agronomy research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December 2014 to May 2015. The location of the experimental site was at $23^{0}46^{'}$ N latitude and $90^{0}22^{'}$ E longitudes with an elevation of 8.24 meter from sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix II.

3.3 Soil of the experimental field

Soil of the experimental site was silty clay loam in texture belonging to Tejgaon series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix III.

3.4 Characteristics of test variety

BRRI dhan50 (Banglamoti), a modern fine rice variety, was used as the test variety. It is a well established boro rice variety which was developed by Bangladesh Rice Research Institute (BRRI). It was released by the National Seed Board in 2008. The average plant height of this variety is about 82 cm. Its life cycle ranges is around 155 days. The grain is characterized by long, thin, aromatic and white in color. The average grain yield of BRRI dhan50 is 6-7.5 t ha^{-1}.

3.5 Description of the herbicides in tabular form

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

Trade Name	Common Name	Mode of Action	Selectivity	Time of Application
Chinese herbicide	Acetochlor + Bensulfuron-methyl	Systemic	For rice	Pre-emergence
Londax Changer	Bensulfuron-methyl	Systemic	For rice	Pre-emergence
Extra power	Bispyribac sodium	Contact	For rice	Pre-emergence
Super powder	Pyrazosulfuron - ethyl	Systemic	For rice	Pre-emergence
Rifit 500 EC	Pretilachlor	Systemic	For rice	Pre-emergence
Logran	Triasulfuron	Systemic	For rice	Pre-emergence
Superhit 500 EC	Pretilachlor	Systemic	For rice	Pre-emergence
Stam M4, Super Wham	Propanil	Contact	For rice	Pre-emergence

3.6 Experimental treatments

T_0 = Weedy check (control)
T_1 = Acetochlor + Bensulfuron- methyl (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150 g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor+ Triasulfuron (Rifit+logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1}+1500 g ha^{-1})
T_8 =Two hand weeding at 20 DAT and 40 DAT

3.7 Design and layout of the experiment

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. There was one Factor and 9 treatments. Total 27 unit plot was made for the experiment. Each plot size was 4 m × 3 m and plant spacing was 0.25 m × 0.15 m. The space between two plots and replication were kept 0.5 m and 1 m, respectively. A layout of the experiment has been shown in Appendix II.

3.8 Cultivation procedure

3.8.1 Growing of Crop

3.8.1.1 Plant materials collection

Healthy and vigorous seeds of aromatic Boro rice BRRI dhan50 were collected from the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gajipur.

3.8.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method. Seeds were then immersed in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.8.1.3 Seed bed preparation and seedling raising

A piece of high land was selected in the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka for raising seedlings. The land was puddled well with country plough followed by leveling with a ladder. The sprouted seeds were sown in the seedbed on 1 December, 2014. Proper care was taken to raise the healthy seedlings in the nursery bed. Weeds were removed and irrigation was given in the nursery bed as and when necessary.

3.8.1.4 Final land preparation

The land was first opened with a tractor drawn disc plough on 29 December, 2014. The land was then puddled thoroughly by repeated ploughing and cross ploughing with a country plough and subsequently leveled by laddering. The field layout was made on 4 January, 2015 according to experimental specification immediately after final land preparation. Weeds and stubbles were cleared off from individual plots and finally plots were leveled properly by wooden plank so that no water pocket could remain in the field

3.8.1.5 Fertilizer application

The land was fertilized with urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate at 250 kg, 120 kg, 120 kg, 100 kg, 10 kg ha^{-1} respectively. The whole amount of triple super phosphate, muriate of potash, gypsum, zinc sulphate were applied at the time of final land preparation. Urea was applied in 3 equal split at 10, 30 and 45 DAT.

3.8.1.6 Uprooting of seedlings

The seedbed was made wet by application of water in the morning and evening on the previous day before uprooting. The seedlings were uprooted without causing any mechanical injury to the roots and were kept in the soft mud in shade. The age of seedling on the day of uprooting was 36 days.

3.8.1.7 Transplanting

Seedlings were transplanted on 5 January, 2015 in 27 experimental plots which were puddled further with spade on the day of transplanting. Transplanting was done by using two seedlings $hill^{-1}$ with 25 cm × 15 cm spacing between the rows and hills, respectively.

3.8.2 Intercultural operation

3.8.2.1 Gap filling and thinning

Some seeds could not produce seedlings and some gaps were observed in some plots. The gaps were filled up with the seedlings from the same source.

3.8.2.2 Weeding

Weeding was done as per experimental specification. In case of hand weeding treatment plot, two hand weeding was done at 20 DAT and 40 DAT. In case of unweeded plot no weeding was done.

3.8.2.3 Irrigation and drainage

Flood irrigation was given to maintain a level of standing water up to 2-4 cm till maximum tillering stage and after that, a water level of 7- 10 cm was maintained up to grain filling stage and then drained out after milk stage to enhance maturity.

3.8.2.4 Herbicide application

Herbicides spraying were done by a hand crop sprayer (model- AM S021, capacity- 20 Liter, Brand name- AGROS, Made in- Zhejiang, China, Working Pressure: 0.2-0.3 Mpa) at 30 days after transplanting.

3.8.2.5 Plant protection measures

The crop was attacked by yellow rice stem borer (*Scirpopagain certulas*) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L ha^{-1}. Other pesticides and fungicides were used as per requirement.

3.8.2.6 General observations

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

3.9 Harvesting, Sampling and Processing

Five hills were randomly selected from each plot (excluding boarder rows and central 1 m^2). At maturity (when 80- 90 % of the seeds became golden yellow in color) one square meter area from each plot was selected from the central portion and was cut manually from the ground level to take grain and straw yields. The harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The harvested crops were threshed manually. The grain was cleaned and dried to a moisture content of 14 %.

Straws were sun dried properly. Final grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

3.10 Data collection

3.10.1 Data collection on weed parameter

The data were collected 1m^2 pre-selected quadrate from the each unit plot. The data on weed infestation was taken from the plots 3 DBA (days before application), 14 DAA (days after application), 28 DAA and 45DAA of following T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8 treatments.

3.10.1.1 Weed density

Data on weed population were collected from each plot at 3DBA (days before application), 14 DAA, 28 DAA and 45 DAA (days after application) of the rice plants. Weeds grown in the quadrate (1m x 1m) were identified and the quadrate was placed randomly at three places in each plot as following by Cruz *et al*. (1986) method. The weeds within the quadrate were counted species-wise and converted to number m^{-2} by the average number of two samples. The species were identified with the help of ‘Bangladesher Agacha Parichiti’ (Karim and Kabir, 1995) and Major Weeds of the Philippines (Moody *et al*.,1984). Observations on weed density were recorded using quadrate method as described by Pound and Clements (1998). Frequency of different weeds were determined and density of each species was calculated according to Odum (1971).

$$\text{Weed density (number m}^{-2}\text{)} = \frac{\text{Total number of weeds}}{\text{Total survayed unit area}}$$

3.10.1.2 Weed dry weight

After counting the weed density, the weeds grown in pre selected quadrate were uprooted, cleaned and separated. The collected weeds were dried in an electrical oven for 72 hours maintaining a constant temperature of 80°C and allowed to cool down to the room temperature. Then weight of dried weeds were taken.

3.10.1.3 Dry matter content of weed (%)

After collection all the weeds from the field, fresh weight of weed was measured by 4-digit electrical balance. Then collected weeds were dried in an electrical oven for 72 hours maintaining a constant temperature of 80°C. After drying, weight of dried weeds were measured by electrical balance. The dry matter content of weed was calculated by the following formula:

$$\text{Dry matter content of weed (\%)} = \frac{\text{Weight of oven dried weed}}{\text{Fresh weight of weed}} \times 100$$

3.10.1.4 Weed control efficacy (%)

Weed control efficiency of different weed control treatments was calculated using the following formula developed by Sawant and Jadhav (1985):

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

Where,

DWC = Dry weight of weeds in the weedy check

DWT = Dry weight of weeds in the weed management treatment

The extent of weed control by different weed control treatments and susceptibility of different weed species were graded on the basis of weed control efficiency by the following, scales as suggested by Mian and Gaffer (1968).

Degrees of weed susceptibility	Weed control efficiency	Grades of weed control
Completely susceptible (CS)	100	Completely control (CC)
Very highly susceptible (VHS)	90-99	Excellent control (EC)
Highly Susceptible (HS)	70-89	Good control (GC)
Moderately susceptible (MS)	40-69	Fair control (FC)
Poorly susceptible (PS)	20-39	Poor control (PC)
Slightly susceptible (SS)	1-19	Slightly control (SC)
Completely resistant (CR)	0	No control (NC)

3.10.1.5 Importance value of weed (%)

Importance value of weed (IVW) was calculated using the following formula according to Rao (1985):

$$\text{IVW (\%)} = \frac{\text{Weight of a given oven dried weed species}}{\text{Weight of all oven dried weed species}} \times 100$$

3.11 Data collection on crop parameters

3.11.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time harvest for all the entries on 5 randomly selected plants from the middle rows. The height was measured from ground level up to tip of the uppermost panicle.

3.11.2 Total number of tillers hill^{-1}

Tillers, which had at least one visible leaf, were counted. It included both effective and non-effective tillers.

3.11.3 Number of effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tillers per hill. Data on effective tiller per hill were recorded from 5 randomly selected hill at harvesting time and average value was recorded

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

The total number of non effective tillers hill^{-1} was counted as the tillers which have no panicle on the head. Data on non effective tiller per hill were counted from 5 pre selected (used in effective tiller count) hill at harvesting time and average value was recorded

3.11.5 Panicle length (cm)

Panicle length was measured with a meter scale from 5 selected panicles and average value was recorded.

3.11.6 Number of primary branch panicle^{-1}

How many primary branches consisted in a single panicle was counted as number of primary branches panicle^{-1}.

3.11.7 Number of secondary branch panicle^{-1}

How many secondary branches consisted in a single primary branch of panicle was counted as number of secondary branches panicle^{-1}.

3.11.8 Number of filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains per panicle was recorded.

3.11.9 Number of unfilled grains penicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot on the basis of not grain in spikelet and then average number of unfilled grains per panicle was recorded.

3.11.10 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} was calculated by summation of filled and unfilled grains panicle^{-1}.

3.11.11 Thousand (1000) grain weight (g)

One thousand clean and dried grains were randomly taken from the four sample hills of each plot and the weight was taken in an electrical balance.

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

The straw yield t ha^{-1} was measured by the following formula:

$$\text{Yield of straw (t ha}^{-1}) = \frac{\text{Straw yield per unit plot (kg) x 10000}}{\text{Area of unit plot in square meter x 1000}}$$

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

Final grain yield was adjusted at 14% moisture. The grain yield t ha^{-1} was measured by the following formula:

$$\text{Yield of grain (t ha}^{-1}) = \frac{\text{Grain yield per unit plot (kg) x 10000}}{\text{Area of unit plot in square meter x 1000}}$$

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

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

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

3.11.15 Harvest index (%)

Harvest Index denotes the ratio of economic yield to biological yield and was calculated with the following formula :

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield (Grain weight)}}{\text{Biological Yield (Total weight)}} \times 100$$

3.11.16 Yield loss (%)

Yield loss (%) of crop was calculated by the following formula:

$$\text{Yild loss (\%)} = \frac{\text{Highest Yield} - \text{Individual Plot Yield}}{\text{Highest Yield}} \times 100$$

3.12 Statistical Analysis

The recorded data were compiled and subjected to statistical analysis. Analysis of variance following randomized complete block design (single factor) and co-relation analysis were relation with MSTAT C (Russell, 1986) and Microsoft office Excel 2010 package program. The mean differences among the weed control treatments were adjudged by Duncan's New Multiple Range Test (Gomez and Gomez, 1984). The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability.

Chapter IV

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The results of the weed parameters, crop characters of the transplanted aromatic boro rice (BRRI dhan50) which were influenced by different weed control practices have been presented and discussed in this chapter. Diversity of infested weed species in the experimental plot and their details are shown in Table 1. The results related to weed infestation and weed control have been presented in Tables 2-3. Data on different crop characters have been presented in Table 1-9. The analyses of variance on different parameters were calculated and presented in Appendices V to XIX.

4.1 Weed parameters

4.1.1. Diversity of infested weed species

Weed competition is strong when the weed population increases and the weed growth is comparatively more exuberant and rapid than those of the desired crop plants. The plots without herbicide and no hand weeding were infested with different weed species. Fourteen weed species infested the total experimental field which belongs to eight families. Among these species 4 belonged to Gramineae, 2 Cyperaceae, 2 Amaranthaceae, 2 Compositae and 1 from each of Marsileaceae, Commelinaceae, Cruciferae, Scrophulariaceae families. Among the total weed vegetation most of them were annual. Weeds grown in the experimental plot were grass, broad-leaved, sedge type. The particulars of weed's common name, english name, scientific name, family name and life cycle have been presented in Table 1.

Table 1. Diversity of infested weed species in the experimental plot

Common Name	English name	Scientific name	Family name	Life cycle
1. Behua	Small flowered umbrella sedge	*Cyperus difformis*	Cyperaceae	Annual
2. Bara Shama	Barnyard grass	*Echinochloa crusgalli* L. Beauv.	Gramineae	Annual
3. Shusni Shak	Shusni Shak	*Marsilea crenata*	Marsileaceae	Annual
4. Arail	Southern cutgrass	*Leersia hexandra*	Gramineae	Annual
5. Keshuti	White eclipta	*Eclipta alba*	Compositae	Annual
6. Kanaibashi	Spider wort	*Commelina diffusa*	Commelinaceae	Annual
7. Matichaise	Alligator weed	*Fimbristylis miliacea*	Cyperaceae	Annual
8. Khetpapri	Khetpapri	*Lindemia procumbens*	Scrophulariaceae	Annual
9. Mourleja	Mucronate sprangletop	*Leptochloa panicea*	Gramineae	Annual
10. Chanchi	Chanchi	*Alternathera sessilis*	Amaranthaceae	Perennial
11. Durba	Bermuda grass	*Cynodon dactylon* L.	Gramineae	Perennial
12. Banmula	Wild radish	*Raphanus raphanisrum*	Cruciferae	Perennial
13. Gira kata	Gira kata	*Spilanthes acmell*	Compositae	Perennial
14. Malancha	Mud sedge	*Alternathera philoxeroides*	Amaranthaceae	Perennial

4.1.2 Number of weed species and infestation density

Table 2 Represents the data of weed/m^2, weed density and total no of weed with their local name and Scientific name.

In T_0 (control) there was no herbicide used. No significance was observed. Appendix V). In T_0 treatment there were 7 species of weed were found like Behua (*Cyperus difformis*), Shusni shak (*Marsilea crenata*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Chanchi (*Alternathera sessilis*), Banmula (*Raphanus raphanisrum*) and Gira kata (*Spilanthes acmell*). Among them at 3 DBA (days before application), the highest number of weed was Behua (349.00) and the density was 90.89 % and lowest number of weed was Gira kata (3.66) and the density was 0.95 %. At 14 DAA, the highest number of behua (640.00) was observed and density was 87.20 % and the lowest number of weed was Halancha (7.33) and the density was 1.00 %. At 28 DAA, the highest number of Behua (680.33) and density 84.45% was observed and the lowest number of weed was Keshuti (9.33) and density was 1.16 %. At 45 DAA the highest number of weed was Behua (705.33) and density was 81.14 % and the lowest number of weed was Keshuti (12.66) and the density was 1.46 %. In T_0 treatment the total number of weed was (383.97) at the early growth stage and the total number of weed was (869.30) at the later stage. So it is suggested that all the weeds were increased in number and density in course of time increasing in control treatment (Table 2). Rafiquddualla (1999) observed that no weeding regimes produced the highest weed density and weed dry weight. Madhukumar *et al*. (2013) reported that unweeded field produces significantly higher total weed density and dry weight (253 No.m^{-2} and 42.30 g 0.25 m^{-2}, respectively) with importance value of weed (91.7 %).

Significant variation was found in T_1 treatment on number of weed species (Appendix VI). In T_1 treatment, there were 8 species of weeds like Behua (*Cyperus difformis*), Bara Shama (*Echinochloa crusgalli*), Shusni Shak (*Marsilea crenata*), Chanchi (*Alternathera sessilis*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.) Gira Kata (*Spilanthes acmell*) and Khet

Papri (*Lindemia procumbens*) were found in the early growth stage of the field. (Table 2). At 3 DBA, the highest number of weed was Behua (367.00) and the density was 98.23 % and the lowest number of weed was Khetpapri (1.66) and the density was 0.42 %. At 14 DAA, the highest number of weed was Behua (183.00) and density was 91.21 % and the lowest number of weed were Bara Shama (1.33) and Durba (1.33) and the density was 0.66 %. At 28 DAA, the highest number of weed was Behua (95.66) and the density was 82.01 %. At 45 DAA, The highest number of weed was Behua (93.00) and the density was 80.88%. The total number of weed before application of T_1 treatment was 393.65 and the total number of weed was 114.98 at the later growth stage. So it is suggested that T_1 (Acetochlor + Bensulfuron- methyl (changer) 750 g ha^{-1}) treatment can reduce the weed population. T_1 (Acetopchlor + Bensulfuron-methyl (changer) 750 g ha^{-1}) treatment can control the Chanchi (*Alternathera sessilis*) weed for the rice field. Except Chanchi (*Alternathera sessilis*) all the weeds have reduced in number but did not checked by T_1 treatment (Table 2). Sharif and Bhagirath (2014) found that herbicides reduced weed density and biomass by a significant amount. Mamun *et al*. (2011) observed that Application of Acetochlor 50 % EC @ 250 ml gave more than 80% weed control efficiency in terms of number and weed dry weight which ultimately resulted in higher yield attributes and grain yield of transplanted rice

Significant variation was found in T_2 treatment on number of weed species (Appendix VII). In T_2 treatment, there were 7 species of weeds like Behua (*Cyperus difformis*), Bara Shama (*Echinochloa crusgalli*), Shusni Shak (*Marsilea crenata*), Halancha (*Enhydra fluctuans*), Matichaise (*Fimbristylis miliacea*), Moyorleja (*Leptochloa panicea*) and Durba (*Cynodon dactylon* L.) were found in the experimental rice field at the early growth stage (Table 2).At 3 DBA, the highest number of weed was Behua (107.33) and the density was 78.93 % and the lowest number of weed was Bara Shama (2.33) and the density was 1.71 %. At 14 DAA, the highest number of weed was Behua (31.66) and density was 63.79 % and the lowest number of weed was Bara Shama (1.66) and Matichaise (1.66) and the density was 3.34 % for both of them. At 28 DAA, the highest number of weed was Behua (19.33) and the density was 62.40 %. At 45 DAA, the highest number of weed was Behua (11.33) and the density was 52.33 %. The total number of weed was 135.98 at the early growth stage and total number of weed was 21.65 at the later growth stage. So it is suggested that T_2 (Pyrazosulfuron-ethyl (super powder) 150 g ha^{-1}) treatment reduces the weed population in rice field and T_2 Treatment can also control 2 weed species like Matichaise (*Fimbristylis miliacea*) and Durba (*Cynodon dactylon* L.). Except these 2 weed species all the weeds were reduced in number and density but did not checked by T_2 (Pyrazosulfuron-ethyl (super powder) 150 g ha^{-1}) treatment from the rice field (Table 2). Ramesha *et al.* (2015) found that application of pyrazosulfuron ethyl 10% WP at 20 g ha^{-1} was most effective in controlling the associated weeds. Halder *et al.* (2005) also stated that among all the chemicals tried in in his experiment pyrazosulfuron ethyl 10% WP @ 16 g ha^{-1} was the best in reducing weed population and weed dry weight without showing any phytotoxic symptoms in rice.

Significant variation was found in T_3 treatment on number of weed species (Appendix VIII). In T_3 treatment, there were 7 species of weeds like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.) and Gira Kata (*Spilanthes acmell*) were found in the experimental rice field at the early growth stage (Table 2). At 3 DBA, the highest number of weed was Behua (183.33) and the density was 73.53 % and the lowest number of weed was Durba (3.66) and the density was 1.47 %. At 14 DAA the highest number of weed was Behua (101.00) and density was 66.60 % and the lowest number of weed was Halancha (2.33) and Durba (2.33) and the density was 1.54 % for both of them. At 28 DAA, the highest number of weed was Behua (70.00) and the density was 68.42%. At 45 DAA, the highest number of weed was Behua (57.00) and the density was 74.70 %. The total number of weed was 249.31 at the early growth stage and total number of weed was 76.31 at the later growth stage. So it is suggested that T_3 (Bispyribac sodium (extra power) 150 g ha^{-1}) treatment reduces the weed population in rice field and T_3 Treatment can also control 2 weed species like Keshuti (*Eclipta alba*) and Durba (*Cynodon dactylon* L.). Except these 2 weed species all the weeds were reduced in number and density but did not checked by T_3 (Bispyribac sodium (extra power) 150 g ha^{-1}) treatment from the rice field (Table 2). Kumaran *et al.* (2015) evaluated the application of bispyribac sodium 10% SC @ 40 g ha^{-1} recorded higher weed control efficiency and lesser weed density, nutrient uptake at reproductive stage of the crop.

Significant variation was found in T_4 treatment on number of weed species (Appendix IX). In T_4 treatment, there were 8 weed species like Behua (*Cyperus difformis*), Bara Shama (*Echinochloa crusgalli*), Shusni Shak (*Marsilea crenata*), Arail (*Leersia hexandra*), Keshuti (*Eclipta alba*), Moyorleja (*Leptochloa panicea*), Banmula (*Raphanus raphanisrum*) and Gira Kata (*Spilanthes acmell*) were found in the experimental rice field at the early growth stage (Table 2). At 3 DBA, the highest number of weed was Behua (366.00) and the density was 85.25 % and the lowest number of weed was Gira Kata (3.33) and the density was 0.78 %. At 14 DAA, the highest number of weed was Behua (350.33) and density was 88.93 % and the lowest number of weed was Gira Kata (2.33) and the density was 0.59 % for Gira Kata. At 28 DAA, the highest number of weed was Behua (338.66) and the density was 91.38 % and the lowest number of weed was Banmula (1.33) and the density was 0.36 % for Banmula. At 45 DAA, the highest number of weed was Behua (310.33) and the density was 93.20 % and the lowest number of weed were Bara Shama (1.33) and Banmula (1.33) and the lowest density was also 0.40 % for both of them. The total number of weed was 429.31 at the early growth stage and total number of weed was 332.96 at the later growth stage. So it is suggested that T_4 (Pretilachlor (superhit) 1L ha^{-1}) 150 g ha^{-1}) treatment reduces all the weed population in rice field but T_4 (Pretilachlor (superhit) 1L ha^{-1}) treatment can't control or check any weed species in rice field (Table 2). Saha (2005) observed that Pretilachlor (500 or 750 g ha^{-1}) treatment significantly reduced weed dry matter and density. Parvez *et al.* (2013) stated that Complete weed free resulted in the lowest weed population and weed dry weight followed by application of Pretilachlor herbicide + one hand weeding at 21 DAT treatment.

Significant variation was found in T_5 treatment on number of weed species (Appendix X). In T_5 treatment, there were 9 weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Matichaise (*Fimbristylis miliacea*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.), Banmula (*Raphanus raphanisrum*) and Khetpapri (*Lindemia procumbens*) were found in the experimental rice field at the early growth stage (Table 2). At 3 DBA (days before application) the highest number of weed was Behua (358.33) and the density was 87.69 % and the lowest number of weed was Durba (2.33) and the density was 0.57 %. At 14 DAA (days after application) the highest number of weed was Behua (300.33) and density was 85.33 % and the lowest number of weed was Durba (1.33) and the density was 0.38 %. At 28 DAA, the highest number of weed was Behua (201.66) and the density was 78.08 % and the lowest number of weed was Durba (0.66) and the density was 0.26 %. At 45 DAA, the highest number of weed was Behua (201.66) and the density was 76.88 % and the lowest number of weed was Durba (0.33) and the lowest density was also 0.13 %. The total number of weed was 408.62 at the initial stage and total number of weed was 262.29 at the final stage. So it can be suggested that T_5 (Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment reduces total weed population in rice field but T_5 (Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment can't check any weed species in rice field. T_5 (Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment has no effect on Shusni shak (*Marsilea crenata*), Matichaise (*Fimbristylis miliacea*), Moyorleja (*Leptochloa panicea*), Banmula (*Raphanus raphanisrum*) and Khetpapri (*Lindemia procumbens*) weed species. Because these weeds have increased in number and density though Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1} have been used in the rice field. On the other hand, T_5 treatment has the good effect on Behua (*Cyperus* *difformis*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), and Durba (*Cynodon dactylon* L.) weed species. Because these weed species have reduced in number and density from the rice field (Table 2). Mondal *et al*. (1995) found that the lower doses of Rilof H @ 1 litre ha^{-1} and Rifit @ 1 litre ha^{-1} failed to kill the weeds properly.

Significant variation was found in T_6 treatment on number of weed species (Appendix XI). In T_6 treatment, there were 8 weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Keshuti (*Eclipta alba*), Kanaibashi (*Commelina diffusa*), Halancha (*Enhydra fluctuans*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.) and Khetpapri (*Lindemia procumbens*) were found in the experimental rice field at the early growth stage (Table 2). At 3 DBA the highest number of weed was Behua (365.00) and the density was 89.32 % and the lowest number of weed was Kanaibashi (3.66) and the density was 0.90 %. At 14 DAA, the highest number of weed was Behua (69.66) and density was 78.30 % and the lowest number of weed was Kanaibashi (0.33) and the density was 0.37 %. At 28 DAA, the highest number of weed was Shusni Shak (4.33) and the density was 42.00 %. At 45 DAA, the highest number of weed was Shusni Shak (3.66) and the density was 42.31 %. The total number of weed was 408.63 at the early growth stage and total number of weed was 7.32 at the later growth stage. It is suggested that T_6 (Propyrisulfuran + Propanil (500 ml ha^{-1} + 1000 g ha^{-1}) treatment reduces total weed population in rice field. T_6 treatment can also check 5 weed species like Behua (*Cyperus difformis*), Keshuti (*Eclipta alba*), Kanaibashi (*Commelina diffusa*), Durba (*Cynodon dactylon* L.) and Khetpapri (*Lindemia procumbens*). On the other hand the another three weed species like Shusni shak (*Marsilea crenata*), Halancha (*Enhydra fluctuans*) and Moyorleja (*Leptochloa panicea*) did not check by T_6 (Pyrazosulfuron-ethyl + Propanil (500 ml ha^{-1} +1000 g ha^{-1}) treatment but those species reduced in number and density (Table 2). Kurmi and Das (1993) found that Pyrazosulfuron-ethyl at 0.01 kg ha^{-1} applied at 7 DAT resulted in the greatest weed control (74.4-77.5%). Saha *et al.* (2003) also experimented that Pyrazosulfuron-ethyl + Molinate at 1500 g ha^{-1} controlled the weeds effectively and increased the rice grain yield compared to hand-weeded control.

Significant variation was found in T_7 treatment on number of weed species (Appendix XII). In T_7 treatment, there were 9 weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Arail (*Leersia hexandra*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Chanchi (*Alternathera sessilis*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.) and Banmula (*Raphanus raphanisrum*) were found in the experimental rice field at the initial stage (table 2). At 3 DBA, the highest number of weed was Behua (351.00) and the density was 88.50 % and the lowest number of weed was Keshuti (4.33) and the density was 1.09 %. At 14 DAA, the highest number of weed was Behua (8.33) and density was 51.10 %. At 28 DAA, the highest number of weed was Halancha (1.66) and the density was 55.52 %.

At 45 DAA, the highest number of weed was Halancha (0.66) and the density was 33.17 %, The total number of weed was 396.63 at the initial stage and total number of weed was 1.99 at the later growth stage. So it is suggested that T_7 (Propyrisulfuran + Propanil (380 ml ha^{-1} + 1500 g ha^{-1}) treatment reduces total weed population in rice field. T_7 treatment can also check 7 weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Arail (*Leersia hexandra*), Keshuti (*Eclipta alba*), Chanchi (*Alternathera sessilis*), Durba (*Cynodon dactylon* L.) and Banmula (*Raphanus raphanisrum*). On the other hand the other two weed species like Halancha (*Enhydra fluctuans*) and Moyorleja (*Leptochloa panicea*) did not check by T_6 (Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1}) treatment but those species reduced better in number and density. Zahan *et al.* (2015) revealed that pyrazosulfuron ethyl followed by orthosulfamuron and (butachlor + propanil) reduced weed biomass by 96-97% compared to non-treated weedy plots. On the other hand, pyrazosulfuron ethyl with one post-emergence herbicide either (butachlor + propanil) or reduced weed by 91 to 92%. This results strongly supports my result. Acharya and Bhattacharya (2013) conducted an experiment with

Table 2. Effect of weed management methods on different weed species and their density in rice field

Treat-ment	Local Name	Scientific Name	3 DBA		14 DAA		28 DAA		45 DAA	
			Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density
T_0	1.Behua	*Cyperus difformis*	349.00	90.89	640.00	87.20	680.33	84.45	705.33	81.14
	3.Shusni shak	*Marsilea crenata*	9.33	2.43	51.00	6.95	61.66	7.65	73.66	8.47
	5.Keshuti	*Eclipta alba*	6.33	1.65	7.66	1.04	9.33	1.16	12.66	1.46
	7.Halancha	*Enhydra fluctuans*	5.66	1.47	7.33	1.00	12.66	1.57	18.33	2.11
	8.Chanchi	*Alternathera sessilis*	4.66	1.21	10.33	1.41	15.66	1.94	22.33	2.57
	12.Banmula	*Raphanus raphanisrum*	5.33	1.39	8.33	1.13	12.33	1.53	17.66	2.03
	13.Gira kata	*Spilanthes acmell*	3.66	0.95	9.33	1.27	13.66	1.70	19.33	2.22
	Total Weed		383.97	100.00	733.98	100.00	805.63	100.00	869.30	100.00
	CV %		8.56		9.45		10.23		9.45	
T_1	1.Behua	*Cyperus difformis*	367.00	93.23	183.00	91.21	95.66	82.01	93.00	80.88
	2.Bara Shama	*Echinochloa crusgalli*	2.00	0.51	1.33	0.66	2.66	2.28	2.66	2.31
	3.Shusni shak	*Marsilea crenata*	8.00	2.03	4.00	1.99	10.00	8.57	12.00	10.44
	8.Chanchi	*Alternathera sessilis*	5.33	1.35	2.66	1.33	0.00	0.00	0.00	0.00
	10.Moyorleja	*Leptochloa panicea*	5.00	1.27	1.66	0.83	1.66	1.42	1.66	1.44
	11. Durba	*Cynodon dactylon* L.	2.66	0.68	1.33	0.66	0.33	0.28	0.33	0.29
	13.Gira kata	*Spilanthes acmell*	2.00	0.51	2.66	1.33	1.00	0.86	1.00	0.87
	14.Khetpapri	*Lindemia procumbens*	1.66	0.42	4.00	1.99	5.33	4.57	4.33	3.77
	Total Weed		393.65	100.00	200.64	100.00	116.64	100.00	114.98	100.00
	CV %		11.74		9.45		8.62		9.32	

Continued Table 2. Effect of weed management methods on different weed species and their density in rice field

Treat-ment	Local Name	Scientific Name	3 DBA		14 DAA		28 DAA		45 DAA	
			Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density
T_2	1.Behua	*Cyperus difformis*	107.33	78.93	31.66	63.79	19.33	62.40	11.33	52.33
	2.Bara Shama	*Echinochloa crusgalli*	2.33	1.71	1.66	3.34	1.33	4.29	1.33	6.14
	3.Shusni shak	*Marsilea crenata*	10.33	7.60	6.00	12.09	4.33	13.98	3.00	13.86
	7.Halancha	*Enhydra fluctuans*	3.33	2.45	2.66	5.36	1.33	4.29	1.33	6.14
	9.Matichaise	*Fimbristylis miliacea*	3.33	2.45	1.66	3.34	0.00	0.00	0.00	0.00
	10.Moyorleja	*Leptochloa panicea*	4.00	2.94	3.66	7.37	4.66	15.04	4.66	21.52
	11. Durba	*Cynodon dactylon* L.	5.33	3.92	2.33	4.69	0.00	0.00	0.00	0.00
	Total Weed		135.98	100.00	49.63	100.00	30.98	100.00	21.65	100.00
	CV %		9.84		11.23		8.15		10.53	
T_3	1.Behua	*Cyperus difformis*	183.33	73.53	101.00	66.60	70.00	68.42	57.00	74.70
	3.Shusni shak	*Marsilea crenata*	35.00	14.04	30.33	20.00	23.66	23.13	13.66	17.90
	5.Keshuti	*Eclipta alba*	6.00	2.41	4.00	2.64	0.00	0.00	0.00	0.00
	7.Halancha	*Enhydra fluctuans*	5.66	2.27	2.33	1.54	1.66	1.62	1.33	1.74
	10.Moyorleja	*Leptochloa panisea*	8.33	3.34	6.00	3.96	5.33	5.21	3.66	4.80
	11. Durba	*Cynodon dactylon* L.	3.66	1.47	2.33	1.54	1.66	1.62	0.66	0.86
	13.Gira kata	*Spilanthes acmell*	7.33	2.94	5.66	3.73	0.00	0.00	0.00	0.00
	Total Weed		249.31	100.00	151.65	100.00	102.31	100.00	76.31	100.00
	CV %		11.49		12.29		9.37		8.18	

Continued Table 2. Effect of weed management methods on different weed species and their density in rice field

Treat-ment	Local Name	Scientific Name	3 DBA		14 DAA		28 DAA		45 DAA	
			Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density
T_4	1.Behua	*Cyperus difformis*	366.00	85.25	350.33	88.93	338.66	91.38	310.33	93.20
	2.Bara Shama	*Echinochloa crusgalli*	5.33	1.24	3.33	0.85	2.66	0.72	1.33	0.40
	3.Shusni shak	*Marsilea crenata*	27.00	6.29	17.33	4.40	12.33	3.33	9.66	2.90
	4. Arail	*Leersia hexandra*	4.33	1.01	2.66	0.68	1.66	0.45	0.66	0.20
	5.Keshuti	*Eclipta alba*	14.33	3.34	11.66	2.96	9.66	2.61	7.33	2.20
	10.Moyorleja	*Leptochloa panicea*	5.33	1.24	3.66	0.93	2.66	0.72	1.66	0.50
	12.Banmula	*Raphanus raphanisrum*	3.66	0.85	2.66	0.68	1.33	0.36	1.33	0.40
	13.Gira kata	*Spilanthes acmell*	3.33	0.78	2.33	0.59	1.66	0.45	0.66	0.20
	Total Weed		429.31	100.00	393.96	100.00	370.62	100.00	332.96	100.00
	CV %		9.48		8.21		10.51		9.14	
T_5	1.Behua	*Cyperus difformis*	358.33	87.69	300.33	85.33	201.66	78.08	201.66	76.88
	3.Shusni shak	*Marsilea crenata*	6.33	1.55	8.33	2.37	10.66	4.13	11.33	4.32
	5.Keshuti	*Eclipta alba*	11.66	2.85	9.66	2.74	8.33	3.23	6.66	2.54
	7.Halancha	*Enhydra fluctuans*	13.66	3.34	8.33	2.37	5.33	2.06	2.33	0.89
	9.Matichaise	*Fimbristylis miliacea*	3.66	0.90	5.66	1.61	7.33	2.84	9.66	3.68
	10.Moyorleja	*Leptochloa panicea*	4.66	1.14	6.66	1.89	8.33	3.23	11.33	4.32
	11. Durba	*Cynodon dactylon* L.	2.33	0.57	1.33	0.38	0.66	0.26	0.33	0.13
	12.Banmula	*Raphanus raphanisrum*	3.33	0.81	5.33	1.51	8.66	3.35	9.33	3.56
	14.Khetpapri	*Lindemia procumbens*	4.66	1.14	6.33	1.80	7.33	2.84	9.66	3.68
	Total Weed		408.62	100.00	351.96	100.00	258.29	100.00	262.29	100.00
	CV %		8.45		9.63		8.47		7.42	

Continued Table 2. Effect of weed management methods on different weed species and their density in rice field

Treat-ment	Local Name	Scientific Name	3 DBA		14 DAA		28 DAA		45 DAA	
			Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density
T_6	1.Behua	*Cyperus difformis*	365.00	89.32	69.66	78.30	0.00	0.00	0.00	0.00
	3.Shusni shak	*Marsilea crenata*	11.66	2.85	6.33	7.12	4.33	50.06	3.66	50.00
	5.Keshuti	*Eclipta alba*	4.33	1.06	0.66	0.74	0.00	0.00	0.00	0.00
	6.Kanaibashi	*Commelina diffusa*	3.66	0.90	0.33	0.37	0.00	0.00	0.00	0.00
	7.Halancha	*Enhydra fluctuans*	7.66	1.87	3.66	4.11	1.66	19.19	1.33	18.17
	10.Moyorleja	*Leptochloa panicea*	5.33	1.30	3.66	4.11	2.66	30.75	2.33	31.83
	11. Durba	*Cynodon dactylon* L.	4.66	1.14	2.33	2.62	0.00	0.00	0.00	0.00
	14.Khetpapri	*Lindemia procumbens*	6.33	1.55	2.33	2.62	0.00	0.00	0.00	0.00
	Total Weed		408.63	100.00	88.96	100.00	8.65	100.00	7.32	100.00
	CV %		9.61		10.24		8.48		7.67	
T_7	1.Behua	*Cyperus difformis*	351.00	88.50	8.33	51.10	0.00	0.00	0.00	0.00
	3.Shusni shak	*Marsilea crenata*	8.33	2.10	2.66	16.32	0.00	0.00	0.00	0.00
	4. Arail	*Leersia hexandra*	5.33	1.34	0.33	2.02	0.00	0.00	0.00	0.00
	5.Keshuti	*Eclipta alba*	4.33	1.09	0.66	4.05	0.00	0.00	0.00	0.00
	7.Halancha	*Enhydra fluctuans*	6.33	1.60	2.66	16.32	1.66	55.52	0.66	33.17
	8.Chanchi	*Alternathera sessilis*	4.66	1.17	0.00	0.00	0.00	0.00	0.00	0.00
	10.Moyorleja	*Leptochloa panicea*	6.33	1.60	2.33	14.29	1.33	44.48	1.33	66.83
	11. Durba	*Cynodon dactylon* L.	5.66	1.43	1.66	10.18	0.00	0.00	0.00	0.00
	12.Banmula	*Raphanus raphanisrum*	4.66	1.17	0.00	0.00	0.00	0.00	0.00	0.00
	Total Weed		396.63	100.00	18.63	114.29	2.99	100.00	1.99	100.00
	CV %		10.24		10.84		9.51		8.33	

Continued Table 2. Effect of weed management methods on different weed species and their density in rice field

Treat-ment	Local Name	Scientific Name	3 DBA		14 DAA		28 DAA		45 DAA	
			Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density	Weed/ m^2	Weed density
T_8	1.Behua	*Cyperus difformis*	316.00	81.59	11.66	41.20	22.66	41.72	9.66	39.74
	3.Shusni shak	*Marsilea crenata*	12.66	3.27	10.33	36.50	15.33	28.23	8.33	34.27
	5.Keshuti	*Eclipta alba*	4.33	1.12	0.66	2.33	0.00	0.00	0.00	0.00
	7.Halancha	*Enhydra fluctuans*	26.66	6.88	0.00	0.00	0.00	0.00	0.00	0.00
	8.Chanchi	Alternathera sessilis	3.66	0.95	0.00	0.00	0.00	0.00	0.00	0.00
	9.Matichaise	*Fimbristylis miliacea*	4.66	1.20	1.33	4.70	4.66	8.58	1.66	6.83
	10.Moyorleja	*Leptochloa panicea*	6.33	1.63	0.00	0.00	0.00	0.00	0.00	0.00
	11. Durba	*Cynodon dactylon* L.	5.66	1.46	1.66	5.87	6.33	11.66	2.33	9.58
	14.Khetpapri	*Lindemia procumbens*	7.33	1.89	2.66	9.40	5.33	9.81	2.33	9.58
	Total Weed		387.29	100.00	28.30	100.00	54.31	100.00	24.31	100.00
	CV %		11.23		9.41		8.52		9.17	

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150 g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1}+1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

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

pyrazosulfuron ethyl @ 30 g ha^{-1} which supports my results. Pal *et al.* (2012) also found that Pyrazosulfuron-ethyl is most effective in managing associated weed species and yielded maximum grain yield of rice with lower weed density percentage. The results of this study also in agreement with Hassan and Upasani (2015) who conducted an experiment with Propyrisulfuran and pyrazosulfuron.

Significant variation was found in T_8 treatment on number of weed species (Appendix XIII). In T_8 treatment, there were 9 weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Chanchi (*Alternathera sessilis*), Matichaise (*Fimbristylis miliacea*), Moyorleja (*Leptochloa panicea*), Durba (*Cynodon dactylon* L.) and Khetpapri (*Lindemia procumbens*) were found in the experimental rice field at the early growth stage (Table 2). At 3 DBA, the highest number of weed was Behua (316.00) and the density was 81.59 % and the lowest number of weed was Chanchi (3.66) and the density was 0.95 %. At 14 DAA, the highest number of weed was Behua (11.66) and density was 41.20 %. At 28 DAA, the highest number of weed was Behua (22.66) and the density was 41.72 %. At 45 DAA, the highest number of weed was Behua (9.66) and the density was 39.74 %. The total number of weed was 387.29 at the early growth stage and total number of weed was 24.31 at the later growth stage. So it is suggested that T_8 (Two hand weeding at 20 DAT and 40 DAT) treatment reduces total weed population in rice field. T_8 (Two hand weeding at 20 DAT and 40 DAT) treatment can also check 4 weed species like Keshuti (*Eclipta alba*), Halancha (*Enhydra fluctuans*), Chanchi (*Alternathera sessilis*), Moyorleja (*Leptochloa panicea*). On the other hand the other five weed species like Behua (*Cyperus difformis*), Shusni Shak (*Marsilea crenata*), Matichaise (*Fimbristylis miliacea*), Durba (*Cynodon dactylon* L.) and Khetpapri (*Lindemia procumbens*) did not check by T_8 (Two hand weeding at 20 DAT and 40 DAT) treatment but those species reduced in number and density at different DAA. But in Hand weeding the labour cost is high and it is time consuming and

Table 3. Number of weed species and infestation percentage at 45 DAA as per treatment

Treatment	Behua	Bara Shama	Shusni shak	Arail	Kesh-uti	Kanai-bashi	Halan-cha	Chan-chi	Mati-chaise	Mour-leja	Durba	Ban-mula	Gira kata	Khet-papri	**Total**
T_0	705.33	0.00	73.66	0.00	12.66	0.00	18.33	22.33	0.00	0.00	0.00	17.66	19.33	0.00	869.3
T_1	93.00	2.66	12.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	0.33	0.00	1.00	4.33	114.98
T_2	11.33	1.33	3.00	0.00	0.00	0.00	1.33	0.00	0.00	4.66	0.00	0.00	0.00	0.00	21.65
T_3	57.00	0.00	13.66	0.00	0.00	0.00	1.33	0.00	0.00	3.66	0.66	0.00	0.00	0.00	76.31
T_4	310.33	1.33	9.66	0.66	7.33	0.00	0.00	0.00	0.00	1.66	0.00	1.33	0.66	0.00	332.96
T_5	201.66	0.00	11.33	0.00	6.66	0.00	2.33	0.00	9.66	11.33	0.33	9.33	0.00	9.66	262.29
T_6	0.00	0.00	3.66	0.00	0.00	0.00	1.33	0.00	0.00	2.33	0.00	0.00	0.00	0.00	7.32
T_7	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	1.33	0.00	0.00	0.00	0.00	1.99
T_8	9.66	0.00	8.33	0.00	0.00	0.00	0.00	0.00	1.66	0.00	2.33	0.00	0.00	2.33	24.31
Total	1388.31	5.32	135.3	0.66	26.65	0.00	25.31	22.33	11.32	26.63	3.65	28.32	20.99	16.32	**1711.11**
% Weed	81.14	0.31	7.91	0.04	1.56	0.00	1.48	1.31	0.66	1.56	0.21	1.66	1.23	0.95	

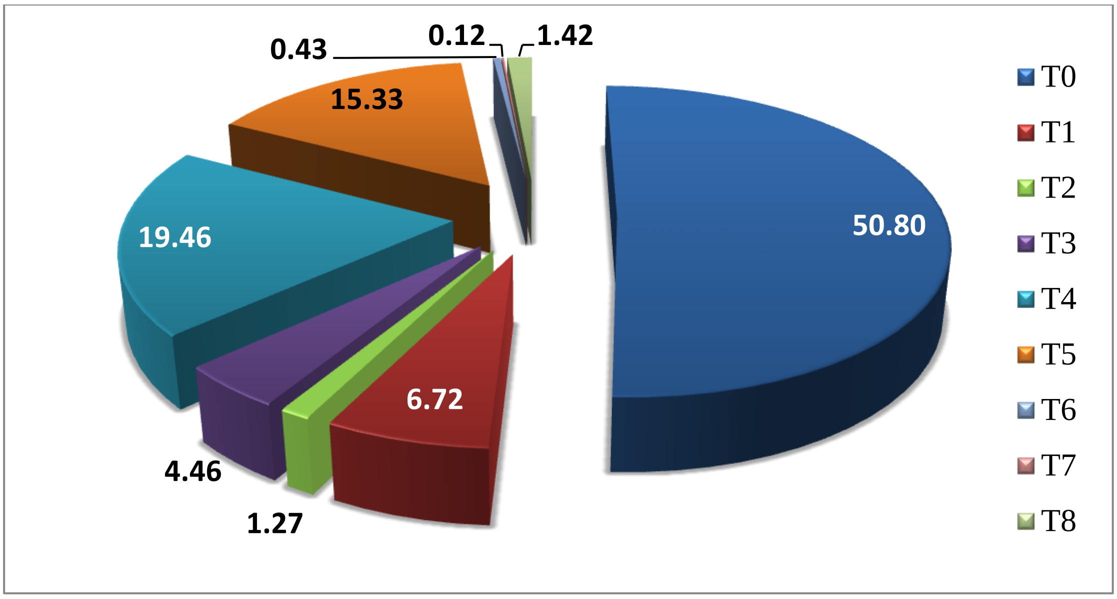
T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

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

sometimes it injures the crop plants (Table 2). It has been reported that increasing the frequency of hand weeding from 1 to 2 times at 21 and 42 DAT reduced the weed density and weed dry weight and doubled the grain yield (BRRI,1996). Subramanian *et al*. (2006) showed hand weeding at 25 DAT reduced weed density, dry weight and higher weed control efficiency resulting grain yield (58.73 g ha^{-1}). Gul-Hassan *et al.* (2002) found that grain yield increased in hand weeded and Basagran EC (post-emergence) treated plots (2560 and 3256 kg ha^{-1}), respectively.

Table 3 Represents the individual weed number and total weed number (1711.11) and their percentage of infestation as per weed species and treatments at the later growth stage of rice. In the total experimental plot the highest number of weed was Behua (1388.31) followed by Shusni shak (135.3), Banmula (28.32), Keshuti (26.65), nearly followed by Moyorleja (26.63), Halancha (25.31), Chanchi (22.33), Gira kata (20.99), Khetpapri (16.32), Matichaise (11.32), Barashama (5.32) and the second lowest was Arail (0.66) and the third lowest was Durba (3.65) (Table 3). All these weeds were not present in the single plot at the same time. The highest number of weed species were observed in T_5, T_7, T_8 treatment treated plot (9) and lowest were observed in T_0, T_2, and T_3 treatment Treated plot (7) (Table 3).

Among 14 weed species, the highest weed infestation was occurred at the T_0 (control) treated plot (50.80 %) followed by T_4 (Pretilachlor (superhit) 1L ha^{-1}) treated plot (19.46 %), T_5 (Pretilachlor + Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treated plot (15.33 %), T_1 (Acetochlor + Bensulfuron- methyl (changer) 750 g ha^{-1}) treated plot (6.72 %), T_3 (Bispyribac sodium (extra power) 150 g ha^{-1}) treated plot (4.46 %), T_8 (Two hand weeding at 20 DAT and 40 DAT) treated plot (1.42 %), T_2 (Pyrazosulfuron-ethyl (super powder) 150 g ha^{-1}) treated plot (1.27 %) and the lowest weed infestation occurred at T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1}+1500 g ha^{-1}]) treated plot (0.12 %) and followed by T_6 (Propyrisulfuran + Propanil [500 ml ha^{-1} +1000 g ha^{-1}]) treated plot (0.43 %) at the later growth stage (Fig. 2).



T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

Fig. 1 The weed infestation percentages in the total rice field at the later growth stage.

4.1.3 Weed Dry weight (g)

The dry weight of weed varied significantly due to the application of different doses of herbicides in the rice field (Appendix XIV). The maximum weed dry weight (112.3 g) was obtained from T_0 (control) treatment, while the minimum weed dry weight (1.413 g) was found from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1}+1500 g ha^{-1}]) treatment, which is statistically identical to T_4 (Pretilachlor (superhit) 1L ha^{-1}) treatment and statistically similar to T_2, T_3 T_6, and T_8 treatment (Table 4).

4.1.4 Dry matter content of weed (%)

The dry matter content of weed varied significantly due to the application of different doses of herbicides (Appendix XIV). The maximum weed dry matter content (18.94) was obtained from T_0 (control) treatment, which is statistically identical (18.75) to T_5 and statistically similar to T_1, T_2, T_3, and T_4 treatments. The minimum weed dry matter content (14.90) was found from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment, which is statistically identical (15.51) to T_6 (Propyrisulfuran + Propanil [500 ml ha^{-1} +1000 g ha^{-1}]) treatment and statistically similar to T_2 and T_8 treatments (Table 4). Gogoi *et al*. (2000) reported that different weed control practices significantly reduced the dry matter accumulation of weed and increased the rice yield over the unweeded control in Boro rice.

4.1.5 Weed control efficacy (%)

The weed control efficacy varied significantly due to the application of different doses of herbicides in the rice field (Appendix XIV). The maximum weed control efficacy (98.74 % EC) was obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment. According to Mian and Gaffer (1968) this percentage can be categories in excellent control (EC) category and the weeds which were grown in T_7 treated plot are very highly susceptible (VHS) to T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment. The second highest (98.48 % EC) weed control efficacy was recorded from T_6 (Propyrisulfuran + Propanil [500 ml ha^{-1} +1000 g ha^{-1}]) treatment which is very close to T_7 treatment. The third highest (95.07 % EC) weed control efficacy was found from T_8 (Two hand weeding at 20 DAT and 40 DAT) treatment followed by T_2 (93.20 % EC), T_5 (81.82 % GC), T_1 (78.85 % GC), T_4 (72.79 % GC), T_5 (47.68 % FC) treatments. On the other hand, the lowest weed control efficacy (0.00 %) was obtained from T_0 (control) treatment that means no weed was checked in this treatment. According to Mian and Gaffer (1968) the extent of weed control by different weed control treatments and susceptibility of different weed species were graded on the basis of weed control efficiency by the following scales.

Degrees of weed susceptibility	Weed control Efficiency (%)	Grades of weed control
Completely susceptible (CS)	100	Completely control (CC)
Very highly susceptible (VHS)	90-99	Excellent control (EC)
Highly Susceptible (HS)	70-89	Good control (GC)
Moderately susceptible (MS)	40-69	Fair control (FC)
Poorly susceptible (PS)	20-39	Poor control (PC)
Slightly susceptible (SS)	1-19	Slightly control (SC)
Completely resistant (CR)	0	No control (NC)

4.1.6 Importance value of weed (%)

Significant variation was found in importance value of weed due to the application of different doses of herbicides in the rice field (Appendix XIV). The maximum importance value of weed (42.85) was obtained from T_0 (control) treatment. The minimum importance value of weed (0.54) was found from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment which is very close to (0.65) to T_6 (Propyrisulfuran + Propanil [500 ml ha^{-1} +1000 g ha^{-1}]) treatment and statistically identical to T_2, T_3, T_4, T_6, T_8, treatments (Table 4).

4.2 Crop parameters

4.2.1 Plant height (cm)

The plant height varied significantly due to the application of different doses of herbicides in the rice field (Appendix XV). The highest plant height (70.37 cm) was obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1}+1500 g ha^{-1}]) treatment which is statistically similar to T_2, T_3, T_6 and T_8 treatment. The lowest plant height was obtained from T_0 (control) treatment. The plant height was highest at T_7 treatment due to the lowest weed infestation. Attalla and Kholosy (2002) reported that herbicide application significantly enhanced plant height of rice. Weeding reduced crop-weed competition thus enhanced plant height significantly. Similar results were observed by Zannat (2014) and Islam (2014).

Table 4. Effect of different herbicides on weed growth characteristics and control of BRRI dhan50 rice field

Treatments	Dry weight of weed (g)	Dry matter content of weed (%)	Weed control efficiency (%)	Importance value of weed (%)
T_0	112.3 a	18.94 a	0.00	42.85 a
T_1	23.75 bc	18.35 ab	78.85	9.06 bc
T_2	7.640 c	17.27 abc	93.20	2.92 c
T_3	20.42 c	18.08 ab	81.82	7.79 c
T_4	30.56 bc	18.40 ab	72.79	11.66 bc
T_5	58.76 b	18.75 a	47.68	22.42 b
T_6	1.703 c	15.51 c	98.48	0.65 c
T_7	1.413 c	14.90 c	98.74	0.54 c
T_8	5.537 c	15.99 bc	95.07	2.11 c
LSD $_{(0.05)}$	**38.03**	**2.466**	**-**	**14.51**
CV%	**15.12**	**17.36**	**-**	**15.12**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

4.2.2 Total number of tillers hill^{-1}

Significant variation was found in total number of tillers hill^{-1} due to the application of different doses of herbicides in the rice field (Appendix XV). The maximum number of total tillers hill^{-1} (19.67) was obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment which is statistically identical to (19.40) T_6 treatment and statistically similar to T_1, T_2, T_3, T_4 and T_8 treatment. The minimum number of tillers hill^{-1} was obtained from T_0 (control) treatment which is statistically identical to T_5 (Pretilachlor + Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment. The Total number of tillers hill^{-1} was highest at T_7 treatment due to the lowest weed infestation. In no weeding treatment, weed crop competition was higher and weed suppressed the rice plant growth ultimately tiller number was reduced. But different weed management treatments reduced weed population and thereby decreased weed-crop competition during entire growth stage. Thus increases the productive tillers and other yield attributes. Similar result was reported by Amarajit *et al.* (2005). Ahmed *et al*. (1998) reported the highest number of tillers m^{-2} (33.1) obtained by using herbicide.

4.2.3 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} varied significantly due to the application of different doses of herbicides in the rice field (Appendix XV). The maximum number of effective tillers hill^{-1} (15.80) was obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment which is statistically similar to T_2, T_3, T_4, T_6 and T_8 treatments. The minimum number of effective tillers hill^{-1} was obtained from T_0 (control) treatment which is statistically similar to T_1 (Acetochlor + Bensulfuron- methyl (changer) [750 g ha^{-1}]) and T_5 (Pretilachlor + Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment. The minimum number of effective tillers hill^{-1} in the control plot was the result of higher competition for nutrient, air space, light and water between crop plants and

Table 5. Effect of different herbicides on growth parameters of BRRI dhan50

Treatments	Plant height (cm)	Total number of tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}
T_0	63.23 d	13.87 b	9.60 d	4.26 bc
T_1	67.67 bc	18.30 ab	11.73 bcd	7.59 a
T_2	68.90 ab	18.07 ab	13.60 abc	4.47 bc
T_3	69.17 ab	17.76 ab	12.20 abc	5.56 ab
T_4	66.23 c	17.67 ab	13.57 abc	4.10 bc
T_5	66.10 c	14.80 b	11.00 cd	3.80 bcd
T_6	69.57 ab	19.40 a	14.67 abc	4.73 bc
T_7	70.37 a	19.67 a	15.80 a	3.87 bcd
T_8	69.47 ab	18.33 ab	15.53 ab	2.81 cd
LSD $_{(0.05)}$	**2.58**	**4.48**	**3.84**	**2.77**
CV%	**4.74**	**8.70**	**6.96**	**8.56**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

weeds. Result of this study revealed that control treatment failed to produce more effective tillers hill^{-1} due to severe infestation of weeds in rice field (Hasanuzzaman *et al.,* 2009).

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

The number of non-effective tillers hill^{-1} varied significantly due to the application of different doses of herbicides (Appendix XV). The maximum number of non-effective tillers hill^{-1} (7.59) was obtained from T_1 (Acetochlor + Bensulfuron- methyl (changer) [750 g ha^{-1}]) treatment which is statistically similar to T_3 (Bispyribac sodium (extra power) 150 g ha^{-1}) treatment. The minimum number of non-effective tillers hill^{-1} was obtained from T_8 (Two hand weeding at 20 DAT and 40 DAT) treatment which is statistically similar to T_0 (control), T_2, T_4, T_5, T_6, T_7 and T_8 treatments. Different weed management treatment kept the land clear and soil was aerated which facilitated the crop for absorption of greater amount plant nutrient, moisture and greater reception of solar radiation for growth resulted in lower number of non-effective tillers hill^{-1}.

4.2.5 Panicle length (cm)

Panicle length (cm) varied significantly due to the application of different doses of herbicides in the rice field (Appendix XVI). The highest panicle length (21.23 cm) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment which is statistically identical (21.20 cm) to T_6 treatment and statistically similar to T_1, T_2, T_3, T_4 and T_8 treatments. The lowest panicle length (17.86 cm) was obtained from T_0 (control) treatment which is statistically identical (19.47 cm) to T_5 treatment and statistically similar to T_1, T_2, T_3, T_4 and T_8 treatments. Rafiquddulla (1999) observed the maximum number of panicle length from the weed free condition.

4.2.6 Number of Primary branch panicle^{-1}

Number of primary branch panicle^{-1} varied significantly due to the application of different doses of herbicides (Appendix XVI). The highest number of

Table 6. Effect of different herbicides on yield characteristics of BRRI dhan50

Treatments	Panicle length (cm)	Number of primary branch $penicle^{-1}$	Number of secondary branch $penicle^{-1}$
T_0	17.86 b	7.60 c	15.27 d
T_1	20.20 ab	9.00 b	19.53 c
T_2	20.10 ab	8.66 b	19.80 c
T_3	20.73 ab	9.20 ab	20.93 bc
T_4	19.77 ab	8.93 b	20.13 c
T_5	19.47 b	8.93 b	22.73 abc
T_6	21.20 a	9.33 ab	22.87 abc
T_7	21.23 a	10.40 a	25.20 a
T_8	21.00 ab	9.33 ab	24.40 ab
LSD $_{(0.05)}$	**1.537**	**1.237**	**3.637**
CV%	**4.33**	**7.81**	**9.91**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

primary branch panicle^{-1} (10.40) was recorded from T_7 (Pyrazosulfuron-ethyl + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment which is statistically similar to T_3, T_6 and T_8 treatments. The lowest number of primary branch panicle^{-1} (7.60) was obtained from T_0 (control) treatment. Weeds were controlled effectively thus primary branch panicle^{-1} increased due to lack of crop-weed competition for the nutrients, water, light etc. Similar results also reported by Singh *et al*. (2006).

4.2.7 Number of Secondary branch panicle^{-1}

Significant variation was found in number of secondary branch panicle^{-1} due to the application of different doses of herbicides in the rice field (Appendix XVI). The highest number of secondary branch panicle^{-1} (25.20) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1}+1500 g ha^{-1}]) treatment which is statistically similar to T_5, T_6 and T_8 treatments. The lowest Number of secondary branch panicle^{-1} (15.27) was obtained from T_0 (control) treatment.

4.2.8 Number of filled grains panicle^{-1}

Significant variation was found in filled grains per panicle due to the application of different doses of herbicides in the rice field (Appendix XVII). The maximum number of filled grain per panicle (101.30) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment which is statistically similar to T_1, T_2, T_3 and T_6 treatments. The minimum number of filled grain per panicle was obtained from T_0 (control) treatment which is statistically similar to T_1, T_2, T_4, T_5, and T_8 treatments. Weeding reduce crop-weed competition and provides scope to the plants for efficient utilization of solar radiation and nutrients. This might be responsible to higher number of grains panicle^{-1}. Similar results were reported by Islam (2014) and Zannat, (2014). On other hand, the highest number of grains was produced in the weed free condition in rice field (Khan, 2013; Sanjoy *et al*., 1999 and Chowdhury *et al.*,1995).

Table 7. Effect of different herbicides on yield characteristics of BRRI dhan50

Treatments	Number of filled grains penicle^{-1}	Number of unfilled grains penicle^{-1}	Number of total grains panicle^{-1}	1000 grain weight
T_0	84.47 c	15.33 a	99.80 b	18.27
T_1	92.13 abc	10.40 cd	102.53 ab	19.08
T_2	91.00 abc	10.73 cd	101.73 ab	19.18
T_3	93.87 abc	12.73 abc	106.60 ab	19.10
T_4	87.47 bc	15.00 ab	102.47 ab	18.78
T_5	87.53 bc	13.67 abc	101.20 ab	18.49
T_6	99.20 ab	11.40 bcd	110.60 ab	19.54
T_7	101.30 a	8.20 d	109.50 a	19.86
T_8	87.80 bc	13.80 abc	101.60 ab	19.20
LSD $_{(0.05)}$	**12.14**	**3.766**	**11.75**	**1.843**
CV%	**7.66**	**7.60**	**6.53**	**5.59**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150 g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

4.2.9 Number of Unfilled grains panicle^{-1}

Unfilled grains per panicle varied significantly due to the application of different doses of herbicides (Appendix XVII). The maximum number of unfilled grains per panicle (15.33) was recorded from T_0 (control) treatment which is statistically similar to T_3, T_4, T_5 and T_8 treatments. The minimum number of unfilled grain per panicle (8.20) was obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment which is statistically similar to T_1, T_2 and T_6 treatments. Rafiquddualla (1999) observed that maximum non effective tillers hill^{-1} and sterile grains were found from the no weeding regimes.

4.2.10 Number of total grains panicle^{-1}

Number of total grains per panicle varied significantly due to the application of different doses of herbicides (Appendix XVII). The maximum number of total grains per panicle (109.50) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment which is statistically similar to T_1, T_2, T_3, T_4, T_5, T_6 and T_8 treatments. The minimum number (99.80) of total grains per panicle was obtained from T_0 (control) treatment which is statistically similar to T_1, T_2, T_3, T_4, T_5, T_6 and T_8 treatments. Geethu *et al.* (2014) reported that plants were affected by weed competition resulting reduce the total number of grains panicle^{-1}. Singh *et al*. (1999) also reported that weeding increase the number of grains panicle^{-1}.

4.2.11 Thousand (1000) grain weight (g)

No significant variation was found in 1000 grain weight due to the application of different doses of herbicides (Appendix XVII). The maximum 1000 grain weight (19.86 g) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} +1500 g ha^{-1}]) treatment while the minimum 1000 grain weight (18.27 g) was obtained from T_0 (control) treatment. Khan (2013) found that the weeding regime had significant effect on all the parameters except 1000-grain weight.

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

Rice straw yield per hectare varied significantly due to the application of different doses of herbicides (Appendix XVIII). The maximum straw yield (7.11 t ha^{-1}) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment which is statistically similar to T_8 treatment. The minimum straw yield per hectare (3.92 t ha^{-1}) was obtained from T_0 (control) treatment. Rafiquddaulla (1999) observed that the weed dry weight was significantly affected by the weeding regimes. The maximum straw yield was obtained from weed free condition which was similar to three hand weeding at 20, 40 and 60 DAT.

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

Rice grain yield per hector varied significantly due to the application different doses of herbicides in the rice field (Appendix XVIII). The maximum grain yield per hectare (6.35 t ha^{-1}) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment which is statistically similar to T_2, T_3, T_6 and T_8 treatments. On the other hand the minimum grain yield per hectare (3.55 t ha^{-1}) was obtained from T_0 (control) which is statistically similar to T_1, T_2, T_3, T_4, T_5 and T_8 treatments. These might be due to the fact that the weeding kept the rice field less infested and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth. Chowdhury *et al.* (1995) reported that the highest grain yield was produced from weed free plot as a result of less competition with weeds. The similar results also reported by several authors (Tamilselvan and Budhar, 2001; Saha, 2005; Singh *et al.*, 2014; Acharya and Bhattacharya, 2013; Halder *et al.*, 2005).

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

Significant variation was found in biological yield due to the application of different doses of herbicides in the rice field (Appendix XIX). The biological

Table 8. Effect of different herbicides on straw and grain yield of BRRI dhan50

Treatments	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_0	3.92 e	3.55 c
T_1	4.54 d	4.58 bc
T_2	5.25 c	4.94 abc
T_3	4.50 d	4.80 abc
T_4	6.53 b	4.33 bc
T_5	6.38 b	3.91 bc
T_6	5.73 c	5.18 ab
T_7	7.11 a	6.35 a
T_8	6.68 ab	5.03 abc
LSD $_{(0.05)}$	**0.56**	**1.554**
CV%	**6.64**	**8.92**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} + 1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} + 1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

yield is the combined of grain yield and straw yield. The maximum biological yield per hectare (11.57 t ha^{-1}) was recorded from T_4 (Pretilachlor (superhit) 1L ha^{-1}) treatment. On the other hand the minimum biological yield per hectare (8.83 t ha^{-1}) was obtained from T_1 (Bispyribac sodium (extra power) 150 g ha^{-1}) treatment. Variations of biological yield among the treatment were dependent upon the severity of weed infestation thus affected grain yield and straw yield. Ahmed *et al.* (1998) reported that grain and straw yield (biological yield) decreased with increasing weed population and weed competition duration that also partially supported the present experimental result.

4.2.15 Harvest index (%)

Harvest index of rice varied significantly due to the application of different doses of herbicides in the rice field (Appendix XIX). The maximum harvest index (58.33 %) was recorded from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment. On the other hand, the minimum harvest index (33.32 %) was obtained from T_0 (control) treatment. These findings are further supported with the work of Al-Mamun *et al.* (2011) and Bhuiyan *et al.* (2011), who obtained better yields in rice with herbicide use.

4.2.16 Yield loss (%)

Significant variation was found in yield loss percentage due to the application of different doses of herbicides (Appendix XIX). The maximum yield loss (44.09 %) was recorded from T_0 (control) followed by T_5 (38.43 %), T_4 (31.81 %), T_1 (27.87 %), T_3 (24.41 %), T_2 (22.20 %), T_8 (20.79 %) treatments compared to T_7 treatment. Mamun (1990) found that yield loss might raise 68^{-1}00% for direct seeded aus rice, 48.16% for transplant aus rice, 75.98% for mixed aus, aman rice, 60.29% for deep water rice and 22.36% for modern boro rice. Acharya and Bhattacharya (2013) are agreed with the similar results. Halder *et al.* (2005) also found that more yield loss occur in the no weeding rice plot. Parvez *et al.* (2013) reported that the highest loss of grain yield was

Table 9. Effect of different herbicides on yield characteristics and yield loss of BRRI dhan50

Treatments	Biological yield (t ha^{-1})	Harvesting index (%)	Yield Loss (%)
T_0	7.47 g	47.52 c	44.09
T_1	9.12 f	50.22 b	27.87
T_2	10.19 d	48.48 c	22.20
T_3	9.30 e	51.61 a	24.41
T_4	10.86 c	39.87 e	31.81
T_5	10.29 d	38.00 f	38.43
T_6	10.91 c	47.48 c	18.43
T_7	13.46 a	47.18 c	0.00
T_8	11.71 b	42.95 d	20.79
LSD $_{(0.05)}$	**0.1731**	**1.346**	**-**
CV%	**8.54**	**11.45**	**-**

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

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150g ha^{-1})
T_4 = Pretilachlor (superhit) (1L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} + 1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} + 1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

recorded in no weeding treatment and the lowest was recorded in weed free treatment followed by application of Pretilachlor herbicide + one hand weeding treatment.

4.3 Functional relationship between dry matter content (%) of weed, Weed control efficacy (%), Total number of tillers hill^{-1}, yield loss (%), grain yield (t ha^{-1}) and filled grains per panicle of boro rice (cv. BRRI dhan50)

4.3.1 Relationship between weed control efficacy (%) and grain yield (t ha^{-1})

Relationship between weed control efficacy (%) and grain yield was shown in the graph (Figure 3). Weed control efficacy (%) was recorded in later growth stage of the plant. A significant relationship was observed in grain yield and weed control efficacy (%). Grain yield increases progressively with the increase in weed control efficacy (%). Grain yield was the lowest (3.55 t ha^{-1}) when the weed control efficacy was (0.00 %) under unweeded treatment. On the other hand, grain yield was found the highest (6.35 t ha^{-1}) in higher weed control efficacy (98.74 %) under the T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment throughout the later growth stage period.

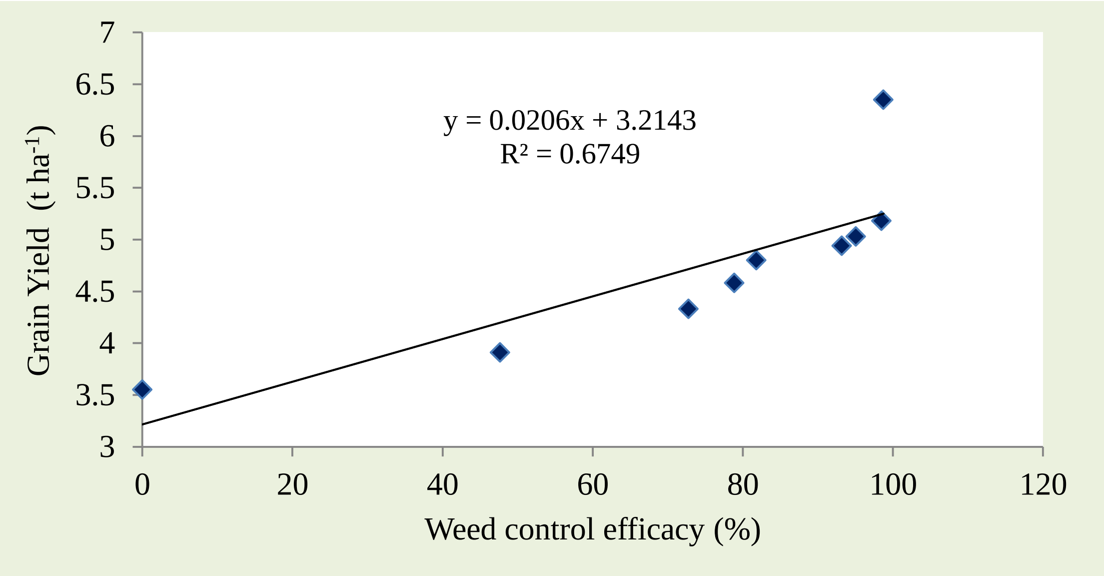


Fig. 2 Relationship between weed control efficacy (%) and grain yield (t ha^{-1}) of boro rice (cv. BRRI dhan50) at later growth stage

4.3.2 Relationship between weed dry matter content (%) and number of filled grains panicle^{-1}

Relationship between dry matter content of weeds (%) and filled grains per panicle was shown in the graph (Figure 4). A reciprocal relationship was observed between dry matter content of weeds (%) and filled grains per panicle at later growth stage of boro rice. Filled grains per panicle decreased due to increase in weed dry matter content. The response of weed dry matter content (%) to the filled grains per panicle followed a linear negative relationship which could be adequately described by regression equation. Filled grains panicle^{-1} was the lowest (84.87) when the dry matter content of weed (18.94 %) was highest. On the other hand filled grains panicle^{-1} was found to be highest (101.30) when the weed dry matter content (14.90 %) is the lowest.

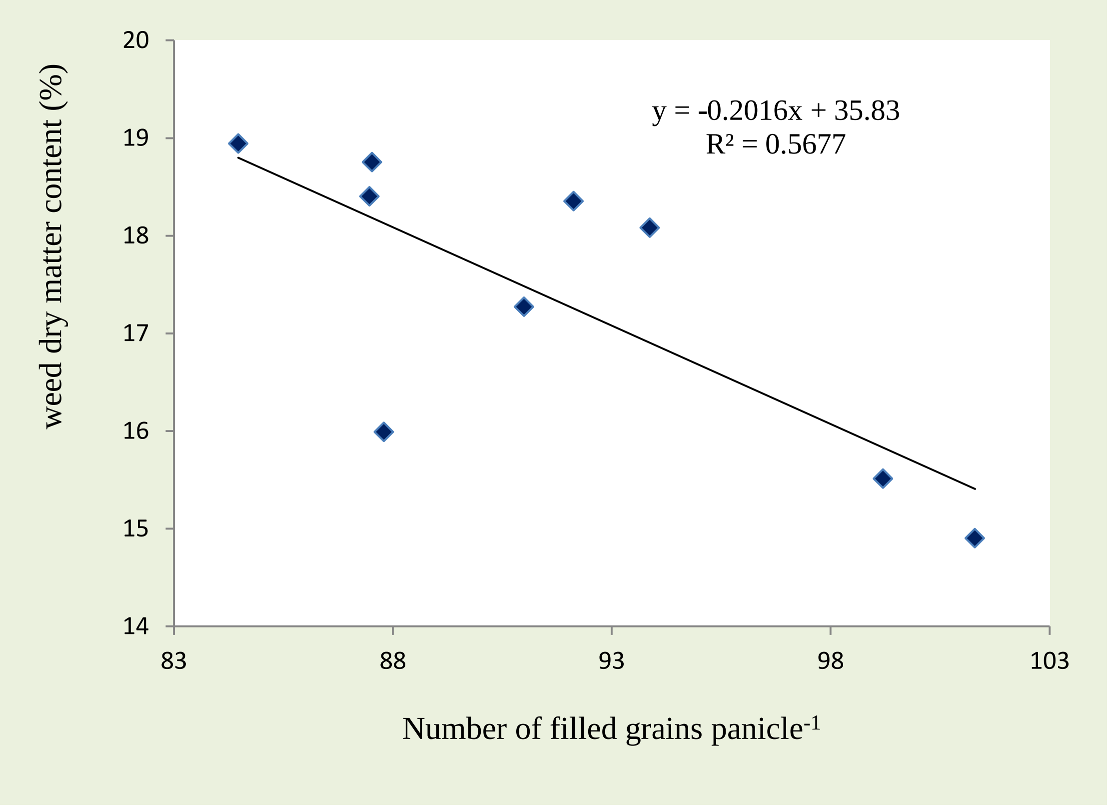


Fig. 3 Relationship between weed dry matter content (%) and number of filled grains panicle^{-1} of boro rice (cv. BRRI dhan50) at later growth stage

4.3.3 Relationship between weed control efficacy (%) and total number of tillers hill^{-1}

Relationship between weed control efficacy (%) and tiller number was shown in the graph (Figure 5). Weed control efficacy (%) was recorded in later growth stage of the plant. A significant relationship was observed in tiller number and weed control efficacy (%). Total number of tillers hill^{-1} increases progressively with the increase in weed control efficacy (%). Total number of tillers hill^{-1} was lowest (13.87) when the weed control efficacy was (0.00 %) under unweeded treatment. On the other hand, total number of tillers hill^{-1} was found highest (19.67) in higher weed control efficacy (98.74 %) under the T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment throughout the later growth stage period.

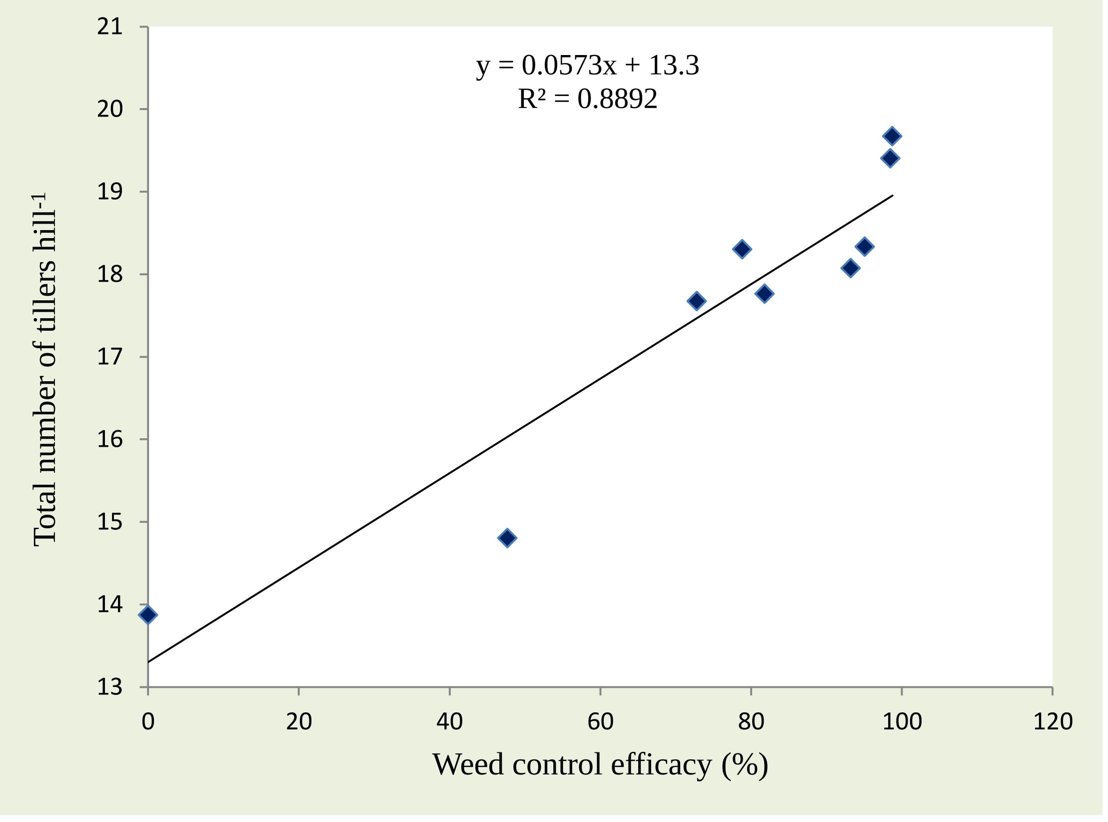


Fig. 4 Relationship between weed control efficacy (%) and total number of tillers hill^{-1} of boro rice (cv. BRRI dhan50) at later growth stage

4.3.4 Relationship between dry matter content of weeds (%) and yield loss (%)

Relationship between dry matter content of weeds and yield loss (%) was shown in the graph (Figure 6). A positive relationship was observed between dry matter content of weeds (%) and yield loss (%) at later growth stage of boro rice. When dry matter content of weeds (%) increases then yield loss (%) also increases. The response of dry matter content of weed to the yield loss (%) followed a linear strongly positive relationship which could be adequately described by regression equation. Yield loss (%) was the lowest (0.00) when the dry matter content of weed (14.90 %) was also lowest. On the other yield loss (%) was found to be highest (44.09) when the dry matter content of weed (18.94 %) is also highest.

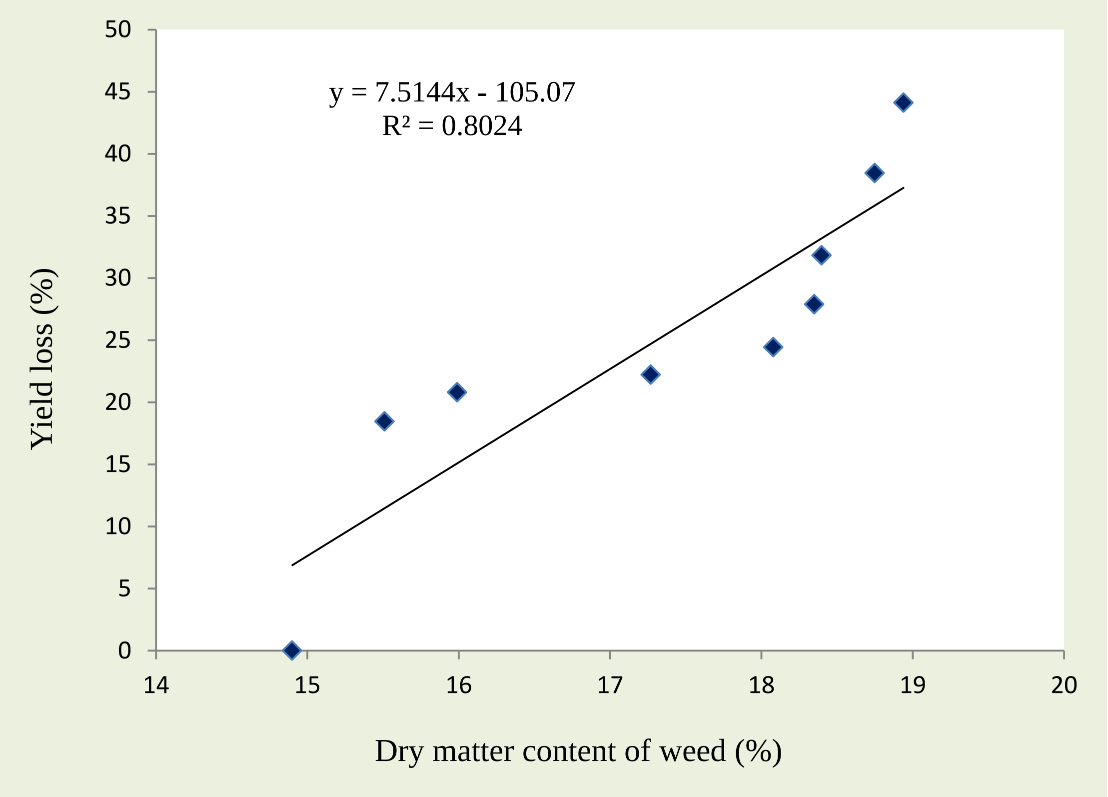


Fig. 5 Relationship between dry matter content of weeds (%) and yield loss (%) of boro rice (cv. BRRI dhan50) at later growth stage

Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the Agronomy research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December 2014 to May 2015 to find out the herbicidal efficacy and residual activity on transplanted aromatic boro rice (cv. BRRI dhan50). This was a single factor experiment, with nine treatments, *viz.*, T_0: (control), T_1: Acetochlor + Bensulfuron- methyl (changer) [750g ha^{-1}], T_2: Pyrazosulfuron-ethyl (super powder) 150 g ha^{-1}. T_3: Bispyribac sodium (extra power) 150 g ha^{-1}, T_4: Pretilachlor (superhit) 1L ha^{-1}. T_5: Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}, T_6: Propyrisulfuran + Propanil [500 ml ha^{-1} +1000 g ha^{-1}], T_7: Propyrisulfuran + Propanil [380 ml ha^{-1}+1500 g ha^{-1}], T_8: Two hand weeding at 20 DAT and 40DAT. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different weed parameters and crop parameters contributing on yield were recorded to find out the appropriate herbicide which can check the most of the weed species of boro rice.

In T_0 treatment total number of infested weed species 7, total number of weed 869.3 and total weed infestation percentage 50.80 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*). In T_1 treatment total number of infested weed species 8, total number of weed 114.98 and total weed infestation percentage 6.72 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*) and total number of checked weed species 1(one) at the final stage. In T_2 treatment total number of infested weed species 7, total number of weed 21.65 and total weed infestation percentage 1.27 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*) and total number of checked weed species 2 (two) at the final stage. In T_3 treatment total number of infested weed species 7, total number of weed 76.31 and total weed infestation percentage 4.46 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*) and total number of checked weed species 2 (two) at the final stage. In T_4 treatment total number of infested weed species 8, total number of weed 332.96 and total weed infestation percentage 19.46 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*). All the weed species have reduced in number from early stage to later stage. In T_5 treatment total number of infested weed species 9, total number of weed 262.29 and total weed infestation percentage 15.33 % and dominating weed species at later growth stage was Behua (*Cyperus difformis*). Some of the weed species have increased in number and some have decreased in number from early stage to later stage of crop. In T_6 treatment total number of infested weed species 8, total number of weed 7.32 and total weed infestation percentage 0.43 % and dominating weed species at later stage was Shusni shak (*Marsilea crenata*) and total number of checked weed species 5 (five) at the final stage and the other weed species have reduced in number from early stage to later stage. In T_7 treatment total number of infested weed species 9, total number of weed 1.99 and total weed infestation percentage 0.12 % and dominating weed species at later growth stage was Moyorleja (*Leptochola panicea*) and total number of checked weed species 7 (seven) at the later growth stage and the other 2 (two) weed species have greatly reduced in number from early stage to later stage. In T_8 treatment total number of infested weed species 9, total number of weed 24.31 and total weed infestation percentage 1.42 % and dominating weed species at later stage was Behua (*Cyperus difformis*) and total number of checked weed species 4 (four) at the final stage and the other 5 (five) weed species have greatly reduced in number from early stage to later stage.

The maximum weed dry weight (112.3 g) was obtained from T_0 treatment and the minimum weed dry weight (1.41 g) was recorded from T_7 treatment. The highest dry matter content of weed (18.94 %) was obtained from T_0 treatment and the lowest dry matter content of weed (1.41 g) was recorded from T_7 treatment. The highest weed control efficacy (98.74 %) was obtained from T_7 treatment and the lowest weed control efficacy (0.00 %) was recorded from T_0

treatment. The maximum importance value of weed (42.85 %) was obtained from T_0 treatment and the minimum importance value of weed (0.54 %) was recorded from T_7 treatment.

At the later growth stage the highest plant height (70.37 cm), maximum number of tillers hill^{-1} (19.67), maximum number of effective tillers hill^{-1} (15.80), highest panicle length (21.23 cm), maximum primary branch panicle^{-1} (10.40), maximum secondary branch panicle^{-1} (25.20), maximum filled grains per panicle (101.30), minimum unfilled grains per panicle (8.20), maximum total grains per panicle (109.50), maximum 1000 grain weight (19.86), highest grain yield per hectare (6.35 t ha^{-1}), maximum straw yield per hectare (7.11 t ha^{-1}), maximum biological yield (13.46 t ha^{-1}), minimum yield loss (0.00 %) were obtained from T_7 (Propyrisulfuran + Propanil [380 ml ha^{-1} + 1500 g ha^{-1}]) treatment. The maximum harvest index (51.61%) is recorded from T_3 (Bispyribac sodium (extra power) 150 g ha^{-1}) treatment. On the other hand, at the later growth stage the lowest plant height (63.23 cm), minimum number of tillers hill^{-1} (13.87), minimum number of effective tillers hill^{-1} (9.60), lowest panicle length (17.86 cm), minimum primary branch panicle^{-1} (7.60), minimum secondary branch panicle^{-1} (15.27), minimum filled grains per panicle (84.47), maximum unfilled grains per panicle (15.33), minimum total grains per panicle (99.80), minimum 1000 grain weight (18.27) and lowest yield per hectare (3.55 t ha^{-1}), minimum straw yield per hectare (3.92 t ha^{-1}), minimum biological yield (7.47 t ha^{-1}), maximum yield loss (44.09 %) were obtained from T_0 (control) treatment. The minimum harvest index (38.00 %) was recorded from T_5 (Pretilachlor+ Triasulfuron (Rifit+logran) 1L ha^{-1} + 10 g ha^{-1}) treatment.

Conclusion

Based on the result of the present study it was found that application of Propyrisulfuran + Propanil (380 ml ha^{-1}+1500 g ha^{-1}) performed the highest weed control and gave the highest yield. Highest number of weed species (9 out of 14) was observed in T_7 treated plot. Among 9 weed species 7 were checked strongly and only 2 species (Halancha and Moyorleja) were greatly reduced in number and density.

- So in conclusion it can be said that Propyrisulfuran + Propanil (380 ml ha^{-1} + 1500 g ha^{-1}) is suitable for contolling weed successfully in transplanted boro rice.

Recommendation

All the herbicides used in this study were proved to be effective and economic means of weed control as an alternative to traditional weed control practices in transplanted aromatic boro rice. Due to some limitations it was unable to find out the effect of other commercially available herbicides at different concentrations for boro rice fields both on-station and on-farm trial. So, from this study the following recommendations can be drown:

- Propyrisulfuran and Propanil (380 ml ha^{-1}+1500 g ha^{-1}) herbicides can be used at field level at recommended dose due to their higher weed control efficacy and satisfactory grain yield.
- Further studies should be done to see the effect of these commercially available herbicides on crop and soil environment.

Chapter VI

References

CHAPTER VI
REFERENCES

Abdul, K., Amar, M., Hafiz M.S., Zahid, A.C. and Abdul, W. (2011). Evaluating sequential application of pre and post emergence herbicides in dry seeded fine rice. *Pak. J. Weed Sci. Res.* **17**(2): 111-123.

Abbassi, H, Shultana, R., Bhuiyan, M.K.A., Mridha, A.J. and Majid, M. (2011). Evaluation of rice (*Oryza sativa*) general herbicide in intermission flooded conditions and control of weeds. *Ind. J. Weed Sci. Res*. **17**(4): 21-31.

Acharya, S.S. and Bhattacharya, S.P. (2013). Comparative Efficacy of Pyrazosulfuron Ethyl and Bentazon with Acetamides for Weed Control in Transplanted Boro Rice (*Oryza sativa* L.) in the Lower Gangetic Plain Zone of West Bengal, India. *Intl. J. Bio-res. and Str. Mangt. 2013*. **4**(4): 506-509.

Ahmed, S., Mamun, A.A., Islam M.A. and Hossain, S.M.A. (1986). Critical period of weed competition in transplant Aus rice. *Bangladesh J. Agric*. **11**(2): 1-9.

Ahmed, Z., Khan, D.R., Alim, S.D., Tahir, M. and Marwat, K.B. (1998). Effect of economics of time and weeds removal on the yield and yield components of rice. *Sarhad J. Agric.* **14**(4): 335-338.

Aktaruzzaman, M. (2007). Effect of weeding regime and nitrogen level on the growth and yield of transplant Aman rice cv. BRRI dhan 32. M.S. Thesis, Dept. Agron., Bangladesh Agricultural University, Mymensingh. Bangladesh.

Al-Mamun, M.A., Rakiba, S.M.K.A., Bhuiyan, A.J.M. and Mazid, A. (2011). Economic Weed Management Options in Winter Rice. *Pak. J. Weed Sci. Res*. **17**(4): 323-331.

Amarajit, S.B., Bali, A.S., Singh, M., Kachord, D., Sharma, B.C. and Shirvam, D.R. (2005). Efficiency of herbicide in transplanted medium duration of rice under sub-tropical condition of jammu. *Indian J. Agron*. **51**(2): 128-130.

Anawar, M.P., Juraimi, A.S., Puteh., Man, A. and Rahman., M.M. (2012). Efficiency, phytotoxicity and economics of different herbicides in aerobic rice. *Acta Agric. Scandin*. **62**: 604-615.

Attalla, S.I. and Kholosy, A.S. (2002). Effect of weed control treatments transplanted rice. *Bull. Fac. Agric. Cairo Uni.* **53**(4): 531-538.

Bakare, S.O., Ndarubu, A.A., Ukwungwu, M.N. and Ochigbo, A.A. (2008). Evaluation of Formulated Mixtures of Propanil plus Triclopyr for Post-Emergence Weed Control in Lowland Rice Production. *Afr. J. Gen. Agric.* **4**(3): 123-127

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

BBN (Bangladesh Business News). (2014). Dhaka, Bangladesh

BBS (Bangladesh Bureau of Statistics). (2015). Statistical Year Book of Bangladesh, Bur. Stat. Div., Minis. Plan., Govt. People's Repub. Bangladesh, Dhaka. pp. 47-55.

BBS (Bangladesh Bureau of Statistics). (2013). Statistical Year Book of Bangladesh,Bur. Stat., Stat. Div., Min. Plan., Govt. People's Repub. Bangladesh, Dhaka. pp. 32-37.

BBS (Bangladesh Bureau of Statistics). (2011). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bur. Stat. Div., Minis. Plan., Govt. People's Repub. Bangladesh, Dhaka. p. 45.

BBS. (1991). Statistical Yearbook Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka.

BCPA. (2010). Office Records of the Bangladesh Crop Protection Association. Dhaka, Bangladesh

Bhan, V.H., Habagwan, S. and Balayam, R.S. (1985). Time of weed removal in upland rice. *Haryana Indian J. Weed Sci*. **17**(4): 28-33.

Bhuiyan, M.K.A., Mridha, A.J., Ahmed, G.J.U., Begum, J.A., Sultana, R. (2011). 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.

BRRI (Bangladesh Rice Research institute). (1977). Annual Report for 1974-75. Bangladesh Rice Res Inst. Joydebpur, Gazipur, Pub No. 26. pp. 6-7.

BRRI (Bangladesh Rice Research Institute). (1987). Annual Report for 1986. Bangladesh Rice Res. Inst. Joydebpur, Gazipur, Bangladesh. pp. 12-13.

BRRI (Bangladesh Rice Research Institute). (1991). In: Workshop of Experience with Modern Rice Cultivation in Bangladesh. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. p. 9.

BRRI (Bangladesh Rice Research Institute). (1996). Annual Internal Review for 1996. Plant Breeding Division, BRRI, Joydebpur, Gazipur. pp. 45-46.

BRRI (Bangladesh Rice Research Institute). (1997). Internal Review for 1996 held in 1997. Bangladesh Rice Res. Inst. Agron. Wing. Joydevpur, Gazipur, Bangladesh. pp. 7-8.

Chowdhury, S.A., Majib, M.A., Haque, K.S., Islam, M. and Rahman, M.M. (1995). Effect of variety on yield and nutritive value of rice straw. *Asian J. Anim. Sci.* **8**(4): 329-335.

Cruz, E.D., Moody, K. and Ramos, M.B.D. (1986). Reducing variability sampling weeds in upland rice (*oryza sativa*). *Phillip. J. Weed Sci.* 13: 56-59.

David, R.G., Eric, J.W., Leopoldo, E., Estorninos, J. and Rebecca, S.C.C. (2003). Rice cultivar differences in suppression of barnyard grass (*Echinochloa crus-galli*) and economics of reduced propanil rates. *Weed Sci*. **51**: 601–609.

Dhiman, M. (2006). Effect of different chemical control methods on weed growth pattern and yield of transplanted rice. *Environ. Ecol.* **245** : pp. 253-256.

Dhiman, M. and Singh, R.P. (2005).Effect of low doses of herbicides on weeds, nutrient uptake and yield of transplanted rice. *Indian J. Agron.* **50**(3): 194-195.

Dwivedi, V.D., Pandey, R.P. and Namadeo, K.N. (1991). Weed management in upland rice sown with different methods. *Indian J. Agron*. **36**(3): 248.

Faruq, M.S.A. (2013). Effect of herbicide (Prechlor 500 EC) on the growth and yield of transplant Aman rice. M.S Thesis, Dept. Agron. Bangladesh Agricultural University, Mymensingh, Bangladesh.

Fofana, B., Koupur, T., Jones, M.P. and Johnson, D.E. (1995).The development of rice varieties competitive with weeds. In: Proc. Brighton Crop Protection conf. Weeds. **1** : 187-192.

Ganeshwor, T. and Godadhar, M. (2000). Effectiveness of herbicides on controlling weeds in transplanted rice. *Nio-Botanica.* **8**(1/2): 1-6.

Geethu, J., Meera, V.M. and Abraham, C.T. (2014). Comparative efficacy of new herbicides in direct seeded rice. *J. Tropic. Agric.* **52** (2): 174-177.

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

Gul-Hassan, K., Khan, Q.N. and Khan, S.U. (2002). Studies on herbicidal efficacy and spectrum of activity of different herbicides in transplanted rice. *Pak. J. Weed Sci. Res.* **8**(1 and 2): 13-17.

Gogoi, A.K., Rajkhowa, D.J. and Kandali, R. (2000). Effect of varieties and weed control practices on rice productivity and weed growth. *Indian J. Agron*. **45**(3): 580-585.

Gomez, M.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research.Johnwiley and sons. New York, Chichesten, Brisbane, Torobto. pp. 97-129, 207-215.

Halder, P., Maiti, S., Bhattacharya, S.P., and Banerjee, H. (2005). Comparative efficacy of Pyrazosulfuron Ethyl (PSE) alone and its combination with Molinate against weed complex of boro paddy. *J. Crop and Weed.* **1** (1) : 49-53.

Hasanuzzaman, M., Islam, M.O., Bapari, M.S. (2009). Efficacy of different herbicides over manual weeding in weed control in transplanted rice. *Aust. J. Crop Sci.* **2**(1): 18-24.

Hashem, A. (2014). Effects of Crop Density and Reduced Rates of Pretilachlor on Weed Control And Grain Yield In Rice. *Romanian Agri. Res.* **31**: 229-240.

Hassan, D. and Upasani, R.R. (2015). Effect of crop establishment and weed control methods on productivity of rice (*Oryza sativa* L.). *J. Crop and Weed*. **11**(Special Issue): 228-230.

Hoque, M.M., Hossain, M.M., Khan, M.R.H., Khalequzzaman, K.M. and Karim, S.M.R. (2003).Effect of varieties of rice and weeding on weed growth and yield of transplant Aman rice. *Asian J. of Plant Sci*. **2**(13): 993-998.

Hossain, M.B., Islam, M.O., Hasanuzzaman, M. (2008). Influence of different nitrogen levels on the performance of four aromatic rice varieties. *Int. J. Agric. Biol*. **10**: 693-696.

Hossain, M.D. (2000). Autecology of *Echinochloa crus galli* and its control in direct seeded Aus rice. M.S. Thesis, Dept. Agron. Bangladesh Agril.Univ.Mymensingh.

Islam, A.K.M. and Paul, L. (1978). Hydrology study of the haor Hakaluki in Sylhet. *J. Asiatic Soc. Bangladesh*. **3**(2): 83-91.

Islam, M., Rafiqul, B.A.A., Mustafi, S. and Hossain, M. (2010). Socio-economic aspects of fine quality rice cultivation in Simulation of Yield Losses Caused by Rice Diseases, Insects, and Weeds in Tropical Asia. IRRI Discussion Paper Series No. 34. pp. 18-20.

Islam, S.M.M. (2014). Effect of weeding regime and integrated nutrient management on growth and yield of transplant Aman rice (cv. BRRI dhan49). M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Ismail, U., Kolo, M.G.M. and Gbanguba, U.A. (2011). Efficacy of some weed control practices in upland rice (*Oryza sativa*) at, Badeggi, Nigeria. *Americal J. Exp. Agric.* **1** (4): 174-186.

Jacob, D. and Elizabeth, K.S. (2005). Performance of transplanted scented rice (*Oryza sativa* L.) under different spacing and weed management regimes in southern Kerala. *J. Tropic. Agric*. **43** (1-2): 71-73.

Jacob, D., Khan, M.R.I. and Munir, K.M. (2014). Application of both pre emergence and post emergence herbicides rice (*Oryza sativa* L.). *J. Tropic. Agric*. **43** (1-2): 71-73.

Jesmin, F.A. (2006). Study on the effectiveness of different herbicides in controlling weeds in boro rice. M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. Bangladesh.

Julfiquar, A.W., Hoque, M.M., Enamul, H.A.K.G.M. and Rashid, M.A. (1998). Current Status of Hybrid Rice Research and Future Programme in Bangladesh. A Country Report Presented in the Workshop on Use and Development of Hybrid Rice in Bangladesh. BARC. Dhaka, Bangladesh.

Kabir, M.H., Bari, M.N., Haque, M.M., Ahmad, 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, S.M.R. and Kabir, M.H. (1995). Bangladesher Agacha Parichiti (Bengali). Bangla Academy,Dhaka, Bangladesh.

Kaul, A.K., Khan, M.R.I. and Munir, K.M. (1982). Rice quality; A survey of Bangladesh germplasm Bangladesh Rice Res. Inst. Joydebpur Gazipur Bangladesh. pp. 1-10.

Khan, K.Z. (2013). Influence of plant spacing and weeding regime on the performance of transplant Aman rice cv. BINA Dhan 7. M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. Bangladesh.

Khan, M. and Ashraf, M. (2006). Effect of herbicides on weed control and paddy yield in rice. *Sarhad J. Agric*. **22**(11): 131-135.

Kumar, G.P. and Uthayakumar, B. (2005). Effect of sequential application of pre and post emergence herbicides in wet seeded rice. *Crop Res*. **29**(3): 366-370.

Kumaran, S.T., Kathiresan, G., MuraliArthanari, P., Chinnusamy, C. and Sanjivkumar, V. (2015). Efficacy of new herbicide (bispyribac sodium 10% SC) against different weed flora, nutrient uptake in rice and their residual effects on succeeding crop of green gram under zero tillage. *J. of App. and Nat. Sci*. **7** (1) : 279 – 285.

Kurmi, K. and Das, G.R. (1993). Effect of herbicides on weed control in transplanted rice integrated weed management for sustainable agriculture. Pro. Int. Symp. Indian Society of weed science held at Hisar. India. pp. 18-20.

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

Madhukumar, V., Kalyana, M.K.N, Prashanth, R., Basavaraj K. and Dinesha, M. S. (2013). Relative efficacy of different herbicides for weed control in aerobic rice (*Oryza sativa* L.). *Int. J. Sci . & Nature*. **4**(3): 473-477.

Mallikarjun, A.S.C., Sudheendra, S., and Shrinivas, C.S. (2014). Effect of Herbicides on Weed Control and Yield of Wet Seeded Rice (*Oryza sativa* L.). *International J. Sci*. **9**(2): pp. 581-583.

Mamun, A.A. (1988a). Crop ecosystem weed vegetation and weed management in Dakshin Chimaria and Jawar. In: proc. Mid Term Review Workshop of JSARD. Jawal-24, 1988.JICA.Gulshan, Dhaka, Published by the college of Agriculture, University, Philipp, Los Banos, Philippines. pp. 83-84 and 172.

Mamun, A.A. (1990a). Agro-ecological studies of weeds and weed control in flood prone village of Bangladesh. JSARD pub.No. 17. JICA (Japan Intl. Co-op. Agency). Dhaka, Bangladesh. pp. 28-29, 129 and 165.

Mamun, A.A. (1990). Weeds and their control: A review of weed research in Bangladesh. Agricultural and Rural Development in Bangladesh.Japan Intl. Co-operation Agency, Dhaka, Bangladesh. JSARD. **19**: pp. 45-72.

Mamun, A.A., Karim, S.M.R., Begum, M., Uddin, M.I. and Rahman, M.A. (1993). Weed survey in different crops under three agro-ecological zones of Bangladesh. BAURES Prog. **8**: pp. 41-51.

Mamun, A.A., Salim, M., Wahab, M.A. and Ali, M.A. (1987).Aquatic weeds of Bangladesh and their control. *Trop. Pest. Mgt*. **33**(3): 224-228.

Mamun, M.A.A., Mridha, A.J., Akter, A. and Parvez, A. (2011). Bio-efficacy of Acetochlor 50% EC against Weed Suppression Transplanted Rice Ecosystem. *J. Environ. Sci. & Natural Res*. **4**(2): 73 – 77.

Mamun, M.A.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.

Manna, G.B. (1983). Weed control in rice under different situation. Paper presented at the Annual Workshop of the all India Co-oriented Rice Improvement Project, Hyderabad. India (Unpublished). pp. 45-57.

Masum, M.A., Bhuya, M.S.U., Begum, M., Akter, H. and Rashid, M.H. (2007). Effect of row management and weeding regime on the performance of rice cv. BRRI dhan 29. *Bangladesh J. Crop Sci*. **1**(2): 323-330.

Mian, A.L. and Gaffer, M.A. (1968).Tokgranular as a weedicide in transplant *aman* rice in East Pakistan. *Pak. J. Sci. Res*. **20**(3): 119-124.

Mian, A.L. and Mamum, A.A. (1989). Chemical Control of Weeds in Transplant Aman rice. *The Nucleus.* **6**(3): 155-163.

Mishra, B.P. and Singh, K.K. (1987). Studies on weed control in transplanted rice. *Indian J. Agron*. **34**(4): 457-458.

Mondal, I. and Nandal, D.P. (1995).Efficacy of Rilof and Rifit herbicide in comparison to hand weeding in BR11 variety of aman rice. *Haryana Agril. Univ. J. Res.* **24**(4): 154-157.

Moody, K., Munroe, C.E., Lubigan, R.T. and Paller, J.E.C. (1984). Major weeds of the Philippines. Weed Science Society of the Philippines, University of the Philippines at Los Banos College, Laguna,Philippines.

Moorthy, B.T.S., Sanjay, S. and Sanjoy, S. (1999). Relative efficacy of different herbicides for weed control in direct seeded rice on puddled soil. *Indian J. Sci.* **31**: 3-4, 210-213.

Mukherjee, P. K. and Malty, S.K. (2007). Weed control in transplanted and wet seeded rainy season rice (*Oryza sativa*). *Indian J. Agric. Sci*. **81(**2): 134-139.

Mumal, S.M., Joshi. V.R., Honnannavar, S.Y. and Kumar, P. (1998). Effect of butachlor for weed control in sprouted direct seeded paddy field under rainfed conditions. *Karnataka J. Agril. Sci.* **11**(2): 487-489.

Odum, E.P. (1971). Fundamentals of Ecology. W.B. Saunders Company, Philadelphia. p. 574

Pal, S.R.K., Ghosh, H., Banerjee, R., Kundu, H. and Alipatra, G. (2012). Effect of pyrazosulfuron-ethyl on yield of transplanted rice. *Indian J. Weed Sci*. **44**(4): 210–213.

Parvez, M.S., Salam, M.A., Kato-Noguchi H., and Mahfuza, B. (2013). Effect of cultivar and weeding regime on the performance of transplant aman rice. *Intl. J. Agri. Crop Sci.* **6** (11): 654-666.

Poornima, Y.P.I., Elizabeth, K.S., Thomas, G. and Samuel, M. (2015). Studies on harvest time residue of Pyrazosulfuron ethyl, a new generation Herbicide, in transplanted rice in the Entisols of vellayani, south kerala. *Int. J. Agric. Sc & Vet. Med.* **3**(3) : 48-54.

Pound, R. and Clements, P.E. (1998). A method of determining the abundance of secondary Weeds species. Minn. Bot. Studies. **2**: p. 9

Prasad, K. and Rafey, A. (1995). Effect of integrated weed management on weed growth, nutrient uptake, economics and energetics in rainfed upland rice (*Oryza sativa*). *India J. Agril. Sci*. **65**(4): 260-264.

Rafiquddualla, M. (1999). Effect of weeding regimes and time of harvesting on the yield and quality of fine rice cv. Kalizira. M.S. Thesis, Dept.Agron. BAU, Mymensingh.

Rahamdad, K. and Khan, M.A. (2012). Weed Control Efficiency of Bioherbicides and Their Impact on Grain Yield of Wheat (*Triticum aestivum* L.). *European J. App. Sci*. **4** (5): 216-219.

Rahman, A.B.M.Z., Islam, M.A., Haque, M. A. and Karim, S.M.R. (2007). Economic study on use of different level of herbicide and hand weeding methods in controlling weeds in transplant Aman rice (*Oryza sativa* L.). *J. Socioecon. Res. Dev*. **3**(1): 66-73.

Rajkhowa, D.J., Gogoi, A.K. and Kandali, R. (2001). Effect of weed control and nutrient management practices in rice. *Indian J. Wed Sci.* **33** (1 and 2): 41-55.

Ramesha Y.M , Ajayakumar, M.Y., Manjunatha, B., Krishna, M.D. and Roopashree, D.H. (2015). Bio-Efficacy of Pyrazosulfuron Ethyl 10% Wp against Weeds in Transplanted Rice. *Acta Sci. Intl. J. Agric*. **1**(1): 6-11.

Ranasinghe, L. L. (2003). Evaluation of factors responsible for low efficacy of farmer's weed management practices in rice cultivation. *Ann. Sri Lanka Dep. Agric.* **5**: 199-205.

Rangaraju, G. (2002). Weed flora and weed dynamics of pre-monsoon dry seeded rainfed rice as influenced by herbicides and its time of application. *Indian J. Dryland Agril. res. Dev*. **17**(2): 100-103.

Rao, A.N. (19850). Weed vegetation analysis.Lecture presented to participants attending the Weed Science Workshop, July-September, IRRI,Los Bonos,Phillippines.

Razzaque, A.H.M., Enamul, M. and Goffer, M.A. (1998). Performance of Ronstar as a herbicide in transplant Aman rice. *Bangladesh J. Sci. Ind. Res*. **33**(4): 503-507.

Russell, D.F. (1986). MSTAT-C Package Programme.Dept. of Crop and Soil Science, Michigan State University, USA.

Saha, S. (2005). Efficiency of certain new herbicides formulation in transplanted rice under rainfed shallow lowland. *Indian J. Weed Sci*. **37** (1/2): 109-110.

Saini, J.P. (2003). Efficacy of Pyrazosulfuron-ethyl against mixed flora in transplanted rice. *Pesticide Res. J.* **15** (2): 157-159.

Samanta, S.C., Gaffer, M.A., Kashem, M.A., Sultan, A. and Ahmed, S. (1995). Effect of time of herbicide application on weed and yield of rice. *J. Agrofor. Environ.* **2**(3): 127-133.

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

Sathyamoorthy, N.K., Mahhendran, S., Babu, R. and Ragavan, T. (2004). Effect of integrated weed management practices on total weed dry weight, nutrient removal of weeds in rice-rice wet seedbed system. *J. Agron*. **3** (4): 263-267.

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

Selvam, V. Boopathi, S.N.M.R., Ali, N., Poonguzhalan, R. and Narayan, A. (2001). Effect of time of sowing and weed management practices in some dry rice. *Madras Agril. J*. **88**(1-3): 12-16.

Senthong, C. (1986). The effect of weed control on yield and growth of direct seeded lowland rice. BIOTROP special Pub., No. 24. pp. 203-208.

Shamim, M., Bhuiya, M.S.U., and Islam, N. (2008). Effect of time of herbicide application on weed and yield of boro rice cv. BRRI dhan29. *J. Agrofor. Environ.* **2**(2): 187-192.

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

Singh, R.K., Singh, U.S. and Khush, G.S. (2000). Aromatic Rices. Oxford and IBH Publishing Co. Ltd. New Dellhi. p. 279

Singh, S.P. and Kumar, R.M. (1999). Efficacy of single and sequential application of herbicides on weed control in transplanted rice. *Indian J. Weed Sci*. **13**(3-4): 222-224.

Singh, S.P., Ladha, J.K., Gupta. R.K., and Kumar, R.M. (2014). Evaluation herbicide performance of transplanted rice under pre-emergence herbicides and hand weeding techniques. *Indian J. Weed Sci*. **13**(4): 22-27.

Singh, U.P. Singh, R.K., Singh, Y. and Singh, R.P. (2004a). Performance of herbicides and cultivars under zero tillage situations of rainfed lowland rice ecosystem. *Indian J. Weed Sci.* **36**(1&2): 122-123.

Singh, U.P., Sing, Y. and Vinod, K. (2004). Effect of weed management cultivars on boro rice (*Oryza sativa* L.) and weeds. *Indian J. Weed Sci*. **36** (1/2): 57- 59.

Singh, V.P., Govendra, S., Singh, R.K., Singh, S.P., Abneils, K., Dhyani, V.C., Kumar, M. and Sharma, G. (2006). Effect of herbicides alone in combination on direct seeded rice. *Indian J. Weed Sci*. **37**(3/4): 197-201

Subramanian, E., Martin, G.J. and Balasubramanian. R. (2006). Effect of integrated weed management practices on growth and yield of wet seeded rice. *Indian J Agron.* **51**(2): 93-96.

Tamilselvan, N. and Budhar, M.N. (2001). Weed control in direct seeded puddled rice. *Madras Agril. J*. **88**(10-12): 745-746.

Yeasmin, T. (2008). Effect of weeding and fertilizer management on the yield performance of transplant Aman rice M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Zafar, M.A. (1989). Studies on Weed control in irrigated transplanted rice and its cost-benefits. *Sarhad J. Agril*. **5**(5): 413-419.

Zahan, T., Rahman, M.M., Hashem, A., Begum, M., Bell, R.W. and Haque, M.E. (2015). Performance of pre and post emergence herbicides in rice (*Oryza sativa*) Established by Minimum Tillage Unpuddled Transplanting. Conference: Workshop on Minimum Tillage Unpuddled

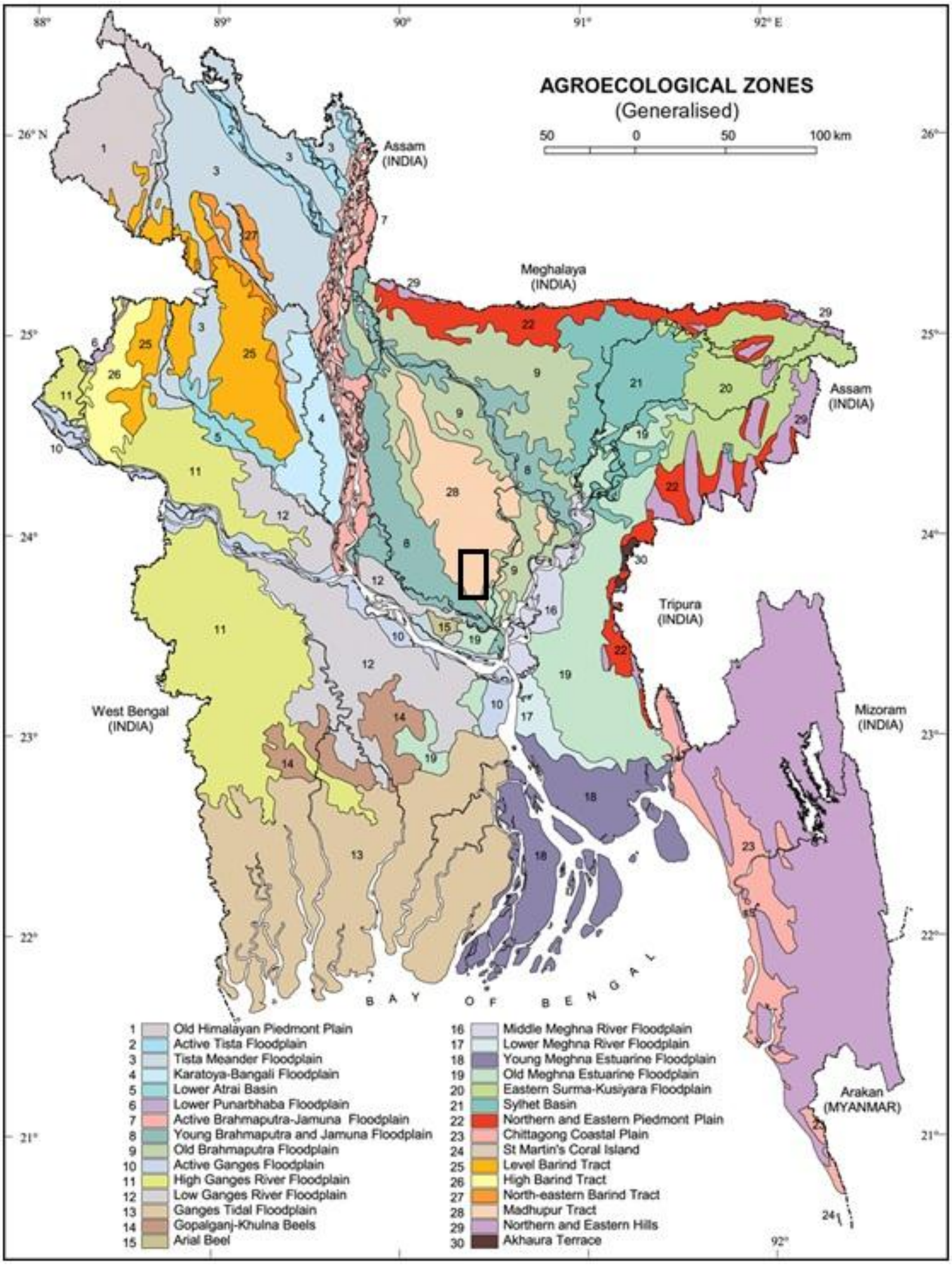
Rice Transplanting (MTURT), September, At Bangladesh Rice Research Institute, Gazipur, Bangladesh

Zannat, S.T. (2014). Effect of weeding regime and nitrogen management from prilled urea and USG on the performance of aromatic rice. M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Appendices

APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2014 to July, 2015

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October ,14	32.18	21.26	76	134
November,14	31.82	14.04	81	24
December,14	26.40	13.50	87	5
January,15	28.51	11.40	74	8
February ,15	28.10	12.70	79	32
March ,15	34.40	17.60	70	61
April , 15	37.30	21.40	66	137
May, 15	36.20	23.25	72	245
June, 15	36.42	25.50	81	315
July, 15	34.25	27.20	80	329

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	**Characteristics**
Location	Agronomy Research Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

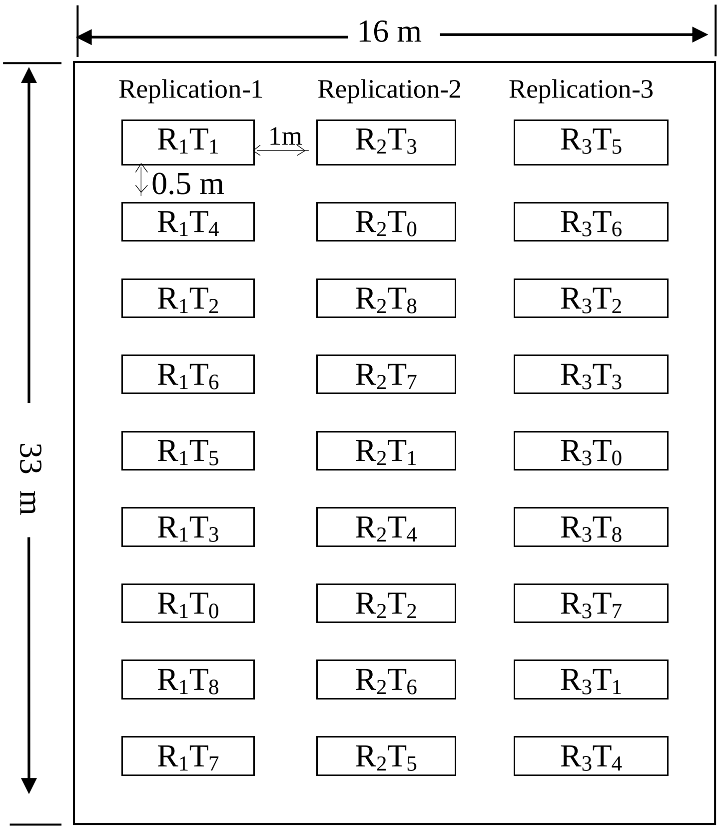
Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

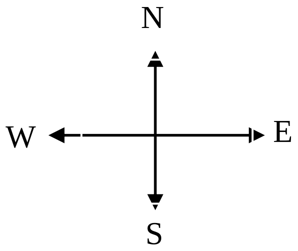
C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix IV: Field layout of the experimental plot





Plot size: 4 m x 3 m
Spacing: 25 cm x 15 cm
Spacing between plots: 0.50 m
Spacing between replication: 1 m

T_0 = No weeding (control)
T_1 = Acetachlor + Bensulfuron (changer) (750 g ha^{-1})
T_2 = Pyrazosulfuron-ethyl (super powder) (150 g ha^{-1})
T_3 = Bispyribac sodium (extra power) (150 g ha^{-1})
T_4 = Pretilachlor (superhit) (1 L ha^{-1})
T_5 = Pretilachlor + Triasulfuron (Rifit + logran) (1 L ha^{-1} + 10 g ha^{-1})
T_6 = Propyrisulfuran + Propanil (500 ml ha^{-1} +1000 g ha^{-1})
T_7 = Propyrisulfuran + Propanil (380 ml ha^{-1} +1500 g ha^{-1})
T_8 = Two hand weeding at 20 DAT and 40 DAT

Appendix-V. Analysis of variance of data on number of weed species in T_0 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	1366.467	2050.489	1650.489	1850.489
Factor A (Different weed species)	13	24148.990	91700.508	71700.508	61700.508
Error	26	1487.014	2729.727	2229.727	2129.727
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VI. Analysis of variance of data on number of weed species in T_1 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	634.200	961.800	1538.489	1552.089
Factor A (Different weed species)	13	26804.962**	6618.571**	1794.470*	1769.460*
Error	26	659.819	944.157	1721.251	1733.041
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VII. Analysis of variance of data on number of weed species in T_2 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	137.156	52.622	19.289	17.282
Factor A (Different weed species)	13	2282.508**	195.689**	35.851**	33.841**
Error	26	122.465	36.098	10.479	9.453
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VIII. Analysis of variance of data on number of weed species in T_3 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	1476.867	18.756	253.889	258.467
Factor A (Different weed species)	13	6644.724**	2047.603**	1087.022**	1088.000**
Error	26	1635.176	180.017	269.008	268.610
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-IX. Analysis of variance of data on number of weed species in T_4 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	1201.489	2552.600	2976.156	2942.142
Factor A (Different weed species)	13	19081.260**	27594.467**	26503.422**	26548.441**
Error	26	1728.370	2362.910	2692.227	2683.256
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-X. Analysis of variance of data on number of weed species in T_5 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	304.200	3498.822	6412.289	6402.285
Factor A (Different weed species)	13	25366.667**	17814.260**	8011.994*	8017.999*
Error	26	238.581	2462.846	5110.479	5123.412
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-XI. Analysis of variance of data on number of weed species in T_6 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	186.689	353.356	2.067	2.032
Factor A (Different weed species)	13	25172.746**	956.222**	4.752**	4.624**
Error	26	138.022	326.856	0.590	0.562
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-XII. Analysis of variance of data on number of weed species in T_7 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	1092.356	9.867	0.800	1.156
Factor A (Different weed species)	13	16691.470**	14.133**	0.676**	0.460**
Error	26	1113.427	14.486	0.490	0.465
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-XIII. Analysis of variance of data on number of weed species in T_8 treatment

Source of variation	Degrees of freedom (df)	Mean square of number of weed species at			
		3 DBA	14 DAA	28 DAA	45 DAA
Replication	2	9834.956	6.067	25.956	21.622
Factor A (Different weed species)	13	19728.994*	43.181**	65.756**	61.308**
Error	26	7584.432	3.733	11.432	9.741

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-XIV. Analysis of variance of data on weed growth characteristics of weed in boro rice field

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at			
		Dry weight of weed (g)	Dry matter content of weed (%)	Weed control efficiency	Importance value of weed
Replication	2	631.642	2.185	-	6.250
Factor A (Different herbicides)	8	3913.845**	6.870*	-	35.527**
Error	16	482.789	9.071	-	5.115

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-XV. Analysis of variance of data on growth parameters of BRRI dhan50

Source of variation	Degrees of freedom (df)	Mean square of plant height at			
		Plant height (cm)	Total number of tillers $hill^{-1}$	Number of effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$
Replication	2	0.310	9.124	0.908	4.641
Factor A (Different herbicides)	8	8.258**	12.390*	13.300*	14.344**
Error	16	7.503	6.726	4.922	15.710
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-XVI. Analysis of variance of data on yield characteristics of BRRI dhan50

Source of variation	Degrees of freedom (df)	Mean square of plant height at		
		Panicle length (cm)	Primary branch $panicle^{-1}$	Secondary branch $panicle^{-1}$
Replication	2	4.741	0.618	5.730
Factor A (Different herbicides)	8	23.165**	0.857*	27.195**
Error	16	5.412	0.511	4.414
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-XVII. Analysis of variance of data on yield characteristics of BRRI dhan50

Source of variation	Degrees of freedom (df)	Mean square of plant height at			
		Number of filled grains per panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	1000 grain weight
Replication	2	97.833	11.633	116.004	9.000
Factor A (Different herbicides)	8	95.970*	16.667**	60.477*	0.728
Error	16	49.221	4.733	46.076	1.134

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-XVIII. Analysis of variance of data on straw and grain yield of BRRI dhan50

Source of variation	Degrees of freedom (df)	Mean square of plant height at	
		Straw yield (t/ha)	Grain yield (t/ha)
Replication	2	5.474	0.283
Factor A (Different herbicides)	8	27.063*	1.954**
Error	16	20.275	0.806

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-XIX. Analysis of variance of data on yield characteristics of BRRI dhan50

Source of variation	Degrees of freedom (df)	Mean square of plant height at		
		Biological yield (t/ha)	Harvesting index (%)	Yield loss (%)
Replication	2	0.801	0.112	-
Factor A (Different herbicides)	8	12.650**	62.116**	-
Error	16	9.652	7.652	-
** : Significant at 1% level of probability; * : Significant at 5% level of probability				