EFFICACY AND RESIDUAL ACTIVITY OF HERBICIDE ON GROWTH AND YIELD OF BROADCAST AUS RICE

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JUNE, 2016

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REGISTRATION NO: 09-03550

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

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JANUARY- JUNE, 2016

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This is to certify that the thesis entitled **"EFFICACY AND RESIDUAL ACTIVITY OF HERBICIDE ON GROWTH AND YIELD OF BROADCAST AUS RICE"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY,** embodies the results of a piece of bonafide research work carried out by **NAJMUN NAHAR,** Registration No. **09-03550** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated:

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ACKNOWLEDGEMENTS

*Alhamdulillah, all praises are due to the almighty **Allah Rabbul Al-Amin** for His gracious kindness and infinite mercy in all the endeavors the author to let her successfully completes the research work and the thesis leading to Master of Science.*

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

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

The author wishes to extend her honest and heartfelt thankfulness to Prof. Dr. Md. Fazlul karim, Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his kind cooperation and facilities to conduct the experiment.

The author wishes to extend her special thanks to Nazmun Nahar Neela, Logna, Imrul Kaes and MD.Ahsan Habib for their help during the experimental period. Special thanks to all other friends for their support and encouragement to complete this study.

The author wishes to extend her special thanks to HEQEP authority for facilitating with the weather data.

The author is deeply indebted to her father and grateful to her respected mother, husband, brother and other relatives for their moral support, encouragement and love with cordial understanding.

Finally the author appreciates the assistance rendered by the staff members of the Department of Agronomy, Sher-e-Bangla Agricultural University Farm, Dhaka, who have helped her during the period of study.

The author

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ABSTRACT

An experiment was conducted at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, from April to August 2015 to evaluate the different herbicidal efficacy and residual activity on weed control and growth & yield of aus rice cv. BRRI dhan48.There were ten treatments *viz*. T_1: Propyrisulfuran@ 500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil@ 3750 ml ha^{-1}, T_4: Propyrisulfuran+ Propanil @ (500ml+3750g) ha^{-1}, T_5: Propyrisulfuran + Propanil @ (500 ml + 2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @ (750ml + 3750g) ha^{-1}, T_7: Propyrisulfuran + Propanil@ (750ml + 3125g) ha^{-1}, T_8: Propyrisulfuran + Propanil (750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Sixteen weed species belongs to nine families were observed in the experimental field. Weed population, weed dry weight and weed control efficiency were significantly influenced by different herbicidal treatments. Among the herbicidal treatments, Propyrisulfuran + Propanil (750 ml + 3125 g) ha^{-1} was most effective with the lowest weed population, weed dry weight and the highest weed control efficiency compared to other treatments. Application of Propyrisulfuran + Propanil (750ml + 3125g) ha^{-1} showed the best performance to control all kind of weeds and its residual activity remained upto 45 days.Yield and yield contributing characters (total number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length , number of primary branch panicle^{-1}, number of secondary branch panicle^{-1}, total number of grains panicle^{-1}, number of filled grains panicle^{-1},1000-grain weight and grain yield) were also influenced significantly by the herbicidal treatments. The highest grain yield (3.75tha^{-1}) and harvest index (44.23%) were obtained from the application of Propyrisulfuran +Propanil (500ml +3125g) ha^{-1} .The lowest yield (1.80 tha^{-1}) and harvest index (37.89%) were obtained from the control plot. It can be concluded that application of Propyrisulfuran + Propanil (500ml +3125g) ha^{-1} may be an alternative to effective weed control of broadcast aus rice (BRRI dhan48).

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds of millions of people in Africa and Latin America (IRRI, 2006). Among the rice producing countries of the world Bangladesh ranks forth. Bangladesh is predominantly an agrarian country. Agriculture sector contributes about 17 percent to the country`s Gross Domestic Product (GDP) and employs more than 45 percent of total labour force (BBS, 2015). Rice is the staple food of about 135 million people of Bangladesh and provides two-third of total calorie supply and about one-half of the total protein intake on an average for a person in the country (BRRI, 2006). Area under rice cultivation is about 10.5 million hectares. About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice (BBS, 2015). Area, production and average yield of rice in our country are 11.3 million hectares, 35.06 million metric ton and 3.103 t ha^{-1}, respectively (DAE, 2016). Thus, rice plays a vital role in the livelihood of the people of Bangladesh. Geographical and agro-climatic conditions of Bangladesh are favorable for rice cultivation. Rice alone contributes 95 % of food production in Bangladesh (Julfiquar *et al.*, 1998). Rice is extensively grown in three season i.e. aus, aman and boro. Aus is one of the major crops in Bangladesh. It has been contributing to food production in addition to aman and boro. Aus covers only 7% of total paddy production and rest 38% for aman and 55% for boro (BBN, 2014). So, more emphasis should be given to increase aus rice production in Bangladesh. Total area under aus rice has been estimated at 1.025 million hectares with average yield is 2.44 tons per hectare (DAE, 2016). Agricultural land is shrinking day by day, rice production need to be increased by 50% or more to meet the food demand of rising population (Sunyob *et al*., 2015).

A weed is an unwanted plant which is the major biotic constraint to increase rice production worldwide and most expensive part of crop production (Fischer *et al*., 2001). Weeds are self-cultivating and grow in all crop fields throughout the world. Where there is crop, there is existence of weeds. The prevailing agro-climatic conditions of Bangladesh are very much suitable for luxuriant growth of weeds that strongly compete with rice plant (Sharmin, 2014). In direct seeded upland rice, yield loss varied from 40 to 100% depending on the weed species, their density and duration of competition (Choubey *et al*., 2001). According to the morphological characters three groups of weed *viz*. grass , sedge and broadleaf are found in rice field (Chowdhury, 2012). Weed competes with crop for nutrient, moisture, space, sunlight resulting in reduction of expected yield (Sunyob *et al.*, 2015). Weeds were reported to reduce rice yields by 12 to 98%, depending on method of rice establishment (Singh and Angiras, 2008 and Singh *et al*., 2011). Higher temperature at aus season causes severe weed infestation. Due to weed infestation, yield loss in aus rice (early summer) caused by 70-80%, 30-40% for transplanted aman (autumn) and 22-36% for modern boro rice (winter rice) in Bangladesh (Mamun, 1990).

Weed imposes serious threat to the productivity of rice by exerting competition with the crop for light, nutrient, moisture and other resources (Rahman and Rahman, 2016). Weeds are the most competitors in their early growth stages than the later and 2-4 weeks are critical period for weed competition in case of broadcasting rice, hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). In crop production system, both crops and weeds compete for same limited resources. Weeds removed nutrients (N, P and K) eight times higher under direct seeded rice (DSR) compared to that of puddled transplanting (Singh *et al.*, 2002). Grassy weeds are heavy competitor with rice, followed by sedge and broadleaved weeds (Umapathy and Sivakumar, 2000). Grass weeds are also more difficult to hand weeding because of their similar morphology to that of rice (Budhar and Tamilselvan, 2002). It is often said, "Crop production is a fight against weeds".

In Bangladesh, weeds in rice field are traditionally controlled by hand weeding, hand pulling and land tillage. Usually two to three hand weeding are done in rice field depending on the nature of weeds, their intensity and the crop grown which are labour intensive, time consuming and also costly. Labour availability is decreased day by day due to migration of landless people towards the urban areas with a hope of better life. During peak period of labour crisis weeding become delay causing drastic yield losses of rice. At present, farmers very often fail to remove weeds due to unavailability of labour at peak demand. Moreover, labour cost increasing day by day thus cost of rice production also increased which making rice production as non-profitable business to farmers. Chemical weed control has increased significantly over the past ten years due to its rapid effect and easy to spray compared to traditional methods. Uses of herbicides in rice field are easier to control weeds and involved comparatively lower costs. In extensive farming system herbicide is the most efficient method of weed control. In the past experience shows that although herbicide use has increased productivity, there are several weed problems that remain unsolved by the use of the herbicides commonly applied in rice cultivation. Karim (2008) stated that rapid effect and lower cost of herbicides is gaining popularity in rice field compared to traditional method. However, herbicides offers the most practical and economic means of weed management.

In 2008, annual consumption of herbicide was more than 4000 MT in our country (BCPA, 2010) compared to only 108 tons during 1986-87 (BBS, 1991) and the growth is almost exponential. Herbicides that are available in Bangladesh Propanil, Butachlor, Acetachlor, Pretilachlor, Oxadiazon, Bensulfuran, Pyrosulfuran-ethyl, Propyrisulfuran, Bispyribac Sodium etc, but information regarding their effect is highly scarce. Most of the herbicides are effective and selective against weeds in rice but use at higher rate may be injurious to rice plant. Rate of herbicides depend on intensity of weed species, climatic and other edaphic factors. Using herbicides at proper dose and appropriate time may be an alternative mean of weed control in the rice cultivation. But less information are available to determine the efficacy of herbicide in controlling weed of rice especially aus rice.

The present study was therefore undertaken with the following objectives:

- To assess the weed control efficiency of different herbicides on broadcast aus rice
- To investigate the effect of herbicides on yield and yield parameters of broadcast aus rice
- To evaluate the residual activity of different herbicides on broadcast aus rice.

CHAPTER II

REVIEW OF LITERATURE

Weeds are major constraints to rice production through their ability to compete with rice plant for resources and also reduce the product quality. Weeds are responsible for heavy yield losses of rice under extreme conditions. Among several biotic stresses, yield losses by weed are known to account for nearly one third. Thus, weed control is a prerequisite for improved rice productivity. Chemical weed control 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 importance. At present many pre and post-emergence herbicides are available for controlling weeds. Some literatures related to the efficacy of herbicides on controlling weeds in rice field with special reference to broadcast aus rice have been reviewed in this chapter.

2.1 Presence of weed species in rice field

Weeds are dynamic and their abundance is depend on soil type, climatic condition, cropping system and other management factors include: rice seeding method, soil moisture, crop rotation, type and amount of fertilizers applied, time of fertilizers application, rice cultivar, water management; crop management and weed control methods used.

Climate suitable for rice is also suitable for weed growth. The total number of weed species in a field largely depends on the associated environment and cropping systems.

Islam (2014) found 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

There were 18 commonly growing weed species in aromatic aman rice cv. Binadhan-9 enlisted by Zannat (2014), 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 was obtained in three weeding at 15, 30 and 45 DAT. No weeding condition reduced 28.16% yield in aromatic aman rice cv. Binadhan-9.

Sharmin (2014) observed eighteen weed species infested the field at T. aman season to find out the performance of BRRI dhan56 and BRRI dhan57 under different weed control methods and among which *Cyperus michelianus*, *Cyperus esculentus* at 30 DAT; *Cyperus esculen*tus, *Alternanthera sessile* and *Cyperus difformis* at 60 DAT, *Fimbristylis miliaceae* at 90 DAT were dominated in the experimental plot.

Nath *et al*. (2014) observed the major weed species in direct seeded rice were *Echinochloa colona* L., *Echinochloa crusgalli* L., *Cyperus rotundus* L., *Cyperus difformis* L. *Caesuliaaxillaris* L. and *Commelina benghalensis L.*

Hossain and Rahman (2013) carried out an experiment with three herbicides which were applied on BR11 paddy field to control weeds and also to study the growth, yield components and yield. Among the species, the prevalence of

Fimbristylis miliacea was the highest. *Ludwigia adscssendens, Marsilea quadrifolia, Fimbristylis miliacea, Schoenoplectus erectus, Cyperus difformis, Cynodon dectylon and Monochoria vaginalis* were obtained in all the treatments.

A survey was conducted by Hakim *et al*. (2013) to identify most common and prevalent weeds associated with rice. Among the 13 most abundant weed species, there were five grasses *viz. Echinochloa crus-galli, Leptochloa chinensis, E. colona, Oryza sativa* L (weedy rice) and *Ischaemum regosum*; four sedges *viz. Fimbristylis miliacea, Cyperus iria, C. difformis* and *Scirpus grossus* and four broadleaved weeds *viz. Fimbristylis miliacea, Cyperus iria, C. difformi* and *Scirpus grossus* and four broadleaved weeds *viz. Sphenoclea zeylanica, Jussiaea linifolia, Monocharia hastata* and *Sagitaria guyanensis.* Based on relative abundance indicates that, annuals were more dominant than perennial.

Chowdhury (2012) also conducted a field experiment at Sher-e- Bangla Agricultural University Agronomy field during July to December, 2011 to evaluate the performance of aromatic rice varieties under different weed control methods and found twenty three weed species infested the field among which the dominated wed species were *Echinochola crussgali* at 15 DAT, *Cyperus michelianus* at 30 DAT, *Cyperus esculentus* and *Cyperus difformis* at 45 DAT, *Cyperus esculen*tus at 60 DAT and *Ludwigia octovalvis* at 75 DAT respectively .

Mamun *et al*. (2011) conducted field experiments at Bangladesh Rice Research Institute (BRRI), Gazipur in Aus, 2010 and BRRI Rangpur, during Boro 2011 to evaluate the performance of Acetochlor 50% EC for weed suppression, to find out an appropriate dose of the herbicide and its impacts on transplanted rice. The found the most dominant weeds were *Cyperus difformis, Monochoria vaginalis* and *Echinochloa crusgalli* 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.

Rao (2011) conducted several studies in India on weed flora of rice under different methods of rice establishment and major associated weeds were *Echinochloa colona* and *E. crus-galli* the most serious weeds affecting rice in all methods of rice establishment. Other weeds of major concern in rice include, *Ammannia baccifera*, *Cyperus iria*, *Cyperus difformis*, *Eclipta alba*, *Fimbristylis miliacea*, *Ischaemum rugosum*, *Leptochloa chinensis*, *Monochoria vaginalis*, *Paspalum distichum* and *Spaenoclea zeylanica*. *E. colona* required less moisture than *E.crus-galli* resulting in the predominance of *E. colona* in dry-seeded rice.

Bhuiyan *et al.* (2010) conduct an experiment at Gazipur and Comilla to control mixed weed flora in transplanted rice (*Oryza sativa L.*) field. Major weed species were *Cynodon dactylon*, *Scirpus maritimus*, *Monochoria vaginalis*, *Cyperus difformis*, *Fimbristylis miliacea*, *Cyperus iria*, *Marsilea quadrifolia* and *Alternanthera philoxeroides* found in the rice field.

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.

Reza *et al.* (2010) conducted a field experiment at Bangladesh Agricultural University (BAU), Mymensingh, and found eight weed species in the crop field *viz. Echinochloa crusgalli, Scirpus mucronatus, Cyperus difformis, Panicum repens, Digitaria ischaemum, Monochoria vaginalis, Leersia hexandra* and *Marsilia quadrifolia.* Among the weed species, the leading one was *E. crusgalli*.

Hasanuzzaman *et al*. (2009) conducted an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to evaluate pre-emergence herbicides and hand weeding on the weed control efficiency and performance of transplanted *aus* rice. Sixteen different weed species were observed in the unweeded plots where most of them were broadleaved weed *Sagittaria guyanensis, Sphenoclea zeylanic*, *Oxalis europea, Enhydra fluctuans, Alternanthera sessilis*, *Echinochloa cruss-galli*, *Echinochloa colona*, *Digitaria sanguinalis, Fimbristylis miliacea, Monochoria vaginalis, Leersia hexandra, Scirpus juncoides, Cyperus iria, Polygonum hydropiper*, *Pistila stratiotes, Cynodon dactylon.*

An experiment was conducted by Hasanuzzaman *et al*. (2008) on transplanted Aman (monsoon) rice at the Sher-e-Bangla Agricultural University farm , There were 14 different weed species infested the field among which *Panicum repens* was the most important. Other species were *Digitaria sanguinalis*, *Leersia hexandra*, *Cyperus difformis, Ludwigia hyssopifolia*, *Fimbristylis miliacea, Rottboellia protensa*, *Commelina benghalensis*, *Echinochloa crusgalli, Monochoria vaginalis, Hymenache pseudointerupta*, *Cyperus esculentus, Fimbristylis diphylla.*

In an ecological study of weed species in transplanted aman rice field done by Mian *et al*. (2007), eight weed species were observed, namely *Paspalum scrobiculatum* L., *Echinochloa colonum* L., *Fimbristylis littralis* (L.) , *Cyperus iria* L., *Alisma plantago* L., *Jussieua decurrens* (Walt.) DC., *Polygonum orientale* and *Sphenocelea zeylanica* Gaertn. Among them *Paspalum scrobiculatum* L. was the most dominating species inrespect of summed dominance ratio (SDR of 41.71) and relative dry weight (RDW of 60.18%).

Jesmin (2006) found commonly grown weed species in Boro rice like *Echinochloa crusgalli, Marsilea quadrifolia, Scirpus juncoides, Cyperus difformis, Monochoria vaginalis, Leersia hexandra, Lindernia anagalis and Fimbristylis miliaceae.*

Ranasinghe (2003) stated that the dominant weeds species in moderate to poor drained soils were *Monochoria vaginalis* and *Ludwigia octavalvis* and in well drained soils *Echinochloa crusgalli, Ischaemum rugosum, Leptochloa chinensis, Cyperus iria, Fimbristylis miliaces* and *Cyperus deformis* in well. He also found that the average grain yield obtained under farmer

2.2 Effect of weed species on rice yield

Singh *et al*. (2011) stated that 12 to 98 % yield reduction was caused by weeds, depending on type method of rice establishment. Rice yield losses due to uncontrolled weed growth and weed competition were least (12%) in transplanted rice and the highest in aerobic direct seeded rice on a furrow-irrigated raised-bed systems (Singh *et al*., 2008) in dry-seeded rice sown without tillage .

Singh and Tewari (2005) indicated that due to weed vegetation the yield loss in unweeded plots was the highest in the rice-wheat system followed by rice-pea-rice, and was the least in the sugarcane system.

Singh and Angiras (2003; 2008) worked out an study to know the threshold levels for a few weed species *Cyperus iria* at density of 30 m^{-2} and *Echinochloa crus-galli* density of 20 m^{-2}, is considered the threshold level for transplanted rice, as it causes the minimum loss of 6.57% and 8.74%, respectively in grain yield above which control measures are to be undertaken.

Rafiquddualla (1999) observed that weeding at 20, 40 and 60 DAT was significantly affected   weeds dry weight. The highest weed density and weed dry weight were produced by no weeding regimes. 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 obtained from three weeding. Maximum non-effective tillers $hill^{-1}$ and sterile spikelet grains were found from the no weeding regimes.

Sanjoy *et al*. (1999) reported that weeding 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.

Rao and Moody (1992) found that average rice yield reductions from transplanted *E. glabrescens* ranged from 6% at the 5% infestation level to 73% at the 40% infestation level.

Rashid (2012) stated that on an average, 43-51% yield gap of rice in the farmers field was determined in Bangladesh due to poor weed control.

Mian and Ahasan (1969) and BRRI (1981) indicated that losses due to weeds in Aus rice, range from 58% to complete failure of the crops.

Weeds not only reduce in rice yield but also increase cost of cultivation, reduce input efficiency, interfere with agricultural operations and several weeds act as alternate hosts for several insect pests and diseases.

2.3 Effect of herbicides on the rice field

Shahabuddin *et al*. (2016) carried out two experiments at the Agronomy Field laboratory, Bangladesh Agricultural University, Mymensingh to evaluate the effectiveness of pretilachlor and oxadiazon to evaluate weed control and yield performance of transplant *aman* rice. In experiment I BRRI dhan31 and in experiment II BRRI dhan46 was transplanted. There were eight weeding practices *viz.*, weedy check; one hand weeding; two hand weeding; weed free;Pretilachlor only;Oxadiazon only; Pretilachlor + one hand weeding; and Oxadiazon + one hand weeding. Eleven weed species were found to be infested in the experimental plots. Although weeds were completely controlled in weed free treatment, it is not practicable. Pretilachlor or oxadiazon with one hand was the best weeding treatment in terms of weed density and weed biomass over single application of each and even manual weeding. Weeds were completely resistant to weedy check, poorly susceptible to one hand weeding, moderately susceptible to two hand weeding and single application of both herbicide and highly susceptible to both herbicides with one hand weeding while weeds were completely susceptible to weed free treatment. Herbicides produced slight phyto-toxicity which was recovered by two weeks of application. The highest grain yield was recorded from weed free treatment and was statistically identical to pretilachlor or oxadiazon with one hand weeding.

Zahan *et al.* (2015) conducted an experiment to evaluate the performance of pre and post emergence herbicides in rice and observed 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 tha^{-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 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.

An experiment was conducted by Hassan and Upasani (2015) 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. 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.

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 methyl 0.6% + 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 from W_6 (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 tha^{-1}) and ready mix Chlorimuron + Metsulfuron methyl (6.2 t ha^{-1}). The highest net return (53950 ha^{-1}) and BCR (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 herbicidal treatment pre-emergence 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 weeding 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 which were on par with each other. Whereas, unweeded check registered significantly lower productive tillers per hill, panicle weight, thousand grain weight, filled spikelet's per panicle, grain yield, straw yield and higher total weed density and dry weight with a weed index of 91.7 %.

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

An experiment was conducted by Hossain and Rahman (2013) with eleven treatments with three herbicides applied on BR11 paddy field to control weeds and also to study the growth, yield components and yield. The effect of herbicides was found to be positive in controlling the weed species and in increasing the yield components and yield. The maximum number and length of tillers, length of panicle, area of flag leaves, number and percentage of filled grains, grain and straw yield per hectare were found at T_3 when normal dose of Rifit 500 EC was applied. Different doses of Machete 5G were also found effective in controlling weeds and increasing in yield.

Shultana *et al.* (2011) reported that more than 80% weed control efficiency was obtained by application of Rigid 50 EC (pretilachlor) @ 1L, Alert 18WP (bensulfuron + acetachlor) @ 400g, Kildor 5G (butachlor) @ 25kg, Bigboss 500EC (pretilachlor) @ 1L, Rifit 500EC (pretilachlor) @ 1L, Ravchlor 5G (butachlor) @ 25kg, Succour 50EC (pretilachlor) @ 1L and Topstar 80WP (oxadiazon) @75g ha^{-1}. Similarly, the grain yield of rice were above 4 t ha^{-1} in the aforesaid treatments which were comparable to the standard check; however, weed free condition gave the highest yield as anticipated.

Hasanuzzaman *et al*. (2008) carried out an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to evaluate preemergence herbicides and hand weeding on the weed control efficiency and performance of transplanted *aus* rice. The experiment was carried out with seven (7) weed management treatments *viz.* W_1 = Control (no weeding); W_2 = 1 hand weeding at 25 days after transplanting (DAT); W_3 = 2 hand weeding at 25 and 50 DAT; W_4 = Topstar® 400 SP (Oxadiargyl 400 g/l) @ 190 ml ha^{-1} ,W_5 = Sunrice 13.75 WG (Ethoxysulfuron 125 g/kg + Idiosulfuran 12.5 g/kg) @ 100 g ha^{-1},W_6 = Topstar 80 WP (Oxadiargyl 800 g/kg) @ 75 g ha^{-1} and W_7 = Topstar® 400 SP (Oxadiargyl 400 g/l) @ 190 ml ha^{-1} + 1 hand weeding at 25 DAT. The results showed that the treatment W_7 controlled the weeds most effectively which produced significantly the highest yield and yield contributing characters. The treatment W_3 also produced identical yield to W_7. The grain yield produced by W_7 (Topstar® 400 SP @ 190 ml ha^{-1} + 1 hand weeding at 25 DAT) and W_3 (2 hand weeding at 25 and 50 DAT) was 104.90% and 92.65% higher than the yield obtained from unweeded control (W_1). Among the pre-emergence herbicides, Sunrice 13.75 WG showed better performance to control weed. Considering weed control cost W_7 found to be the most economic weed control method for transplanted *aus* rice.

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.

Mahajan and Chauhan (2013) stated that the single application of pendimethalin (750 g a.i. ha^{-1}) PRE, pyrazosulfuron (15 g a.i. ha^{-1}) PRE, bispyribac-sodium (25 g a.i. ha^{-1}) POST, penoxsulam (25 g a.i. ha^{-1}) POST, and azimsulfuron (20 g a.i.ha^{-1}) POST reduced total weed biomass by 75, 68, 73, 70, and 72%, respectively, compared with the non-treated control at flowering stage of the crop.

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}, but there 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% and 75% of recommended rates, weed biomass decreased significantly with increasing rice density, while for the 100% 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.

Moorthy *et al.*(1999) used the combination of Pretilachlor + Safener @ (0.4kg ha^{-1} and 0.6kg ha^{-1}), Butachlor + Safener @ (1.5kg ha^{-1}) and Anoliphos + Ethoxysulfuron @ (0.375 kg ha^{-1}+ 0.04 kg ha^{-1}) and found that the most dominant weeds (*Cyperus difformis* and *Fimbristylis miliacea*) was controlled satisfactorily and produced higher yields comparable to those of the hand weeded control in direct seeded rice.

2.4 Effect of herbicides on yield and yield components of rice

Rahaman and Rahman (2016) conducted an experiment where two herbicides Vichete 5G and Rifit 500EC were applied to control weeds in BRRI dhan28 with six different treatments *viz.*, T_0 (control, no herbicide was used), T_1 (Vichete 5G half dose), T_2 (Vichete5G normal dose), T_3 (Double the dose of T_2), T_4 (Rifit 500 EC half dose) and T_5 (Rifit 500 EC normal dose) and studied their effects on the growth, yield and yield attributes of BRRI dhan28. Among the six treatments Vichete 5G (T_2) showed the most effective performance to increase the length of tiller, flag leaf area, length of panicle, number of filled grains, total number of grains per panicle, ratio of filled and unfilled grains, 1000- grain weight, fresh weight of straw and grain and dry weight of straw and grain. The NPK concentrations of both straw and grain were also found maximum from T_2 where normal dose of Viehete5G was applied.

Bhimwal and Pandey, (2014) reported that Flucetosulfuron10 WG at 25 g ha^{-1} applied at 2 days after transplanting can be used safely to achieve broad spectrum weed control in transplanted rice. It also gave the maximum grain and straw yield of rice resulting in lowest weed index.

According to Manzoor *et al.*(2014), the maximum grain yield, yield attributes and weed-control efficiency were recorded with the application of penoxulam @ 22.5 g ha^{-1}(8 days after sowing). The maximum reduction in grain yield over weed-free treatment was recorded in weedy check and the least reduction in penoxulam @ 22.5 g ha^{-1}. Application of penoxulam @ 22.5 g ha^{-1} being at par with weed-free treatment proved superior to the other weed-management practices for grain yield and yield attributes.

Hossain and Rahman (2013) found the maximum number and length of tillers, length of panicle, leaf area of flag leaves, number and percentage of filled grains, grain and straw yield per hectare were found when normal dose of Rifit 500 EC was applied. Different doses of Machete 5G were also found effective in controlling weeds and increasing in yield.

Faruk (2013) stated that Prechlor @ 1.5 L ha^{-1} showed the best performance with respect to the most yield attributes, grain and straw yields and the lowest grain yield was obtained from Prechlor @ 0 L ha^{-1}. The interaction effects of variety and herbicide Prechlor had significant effect on all yield attributes except plant height, effective tillers $hill^{-1}$, panicle length, 1000-grain weight and harvest index. The highest grain yield was obtained from variety BRRI dhan41 with Prechlor @ 1.5 L ha^{-1}. The results suggest that farmers can be advised to use herbicide Prechlor @ 1.5 L ha^{-1} to boost up the production of BRRI dhan41 controlling weeds during aman season under the agro-climatic condition of the study area.

Khaliq *et al.* (2012) observed that Bispyribac sodium suppressed both weed density and dry weight over control that was the highest among all herbicides. Higher rice grain yield and maximum marginal rate of return was also associated with this herbicide in all rice cultivars. Despite of its effectiveness against weeds and scoring higher rice yields, manual weeding was uneconomical primarily due to higher costs involved. Post emergence application of bispyribac sodium appeared to be a viable strategy for weed control in direct seeded rice with higher economic returns.

Mamun *et al.* (2010) observed that Remover 10 WP gave the lowest weed density, dry weed biomass and weed index, and the highest weed control efficiency. The yield and yield components of rice (e.g. No. of panicles m^{-2}, No. of grains per panicle, grain and straw yield) were greatly influenced by the treatments. Herbicide treatment Remover 10 WP produced similar yield to hand weeding, but the weeding cost of Remover 10 WP was almost one-sixth of hand weeding. Maximum marginal return rate with Remover 10 WP suggests that this treatment could be used as alternative tool when labor is a limiting factor in dry season rice cultivation.

Mukherjee (2006) reported that application of herbicide of almix + 2, 4-DEE provided excellent control of weeds and lower biomass production and significantly superior to all other treatments. These treatments caused significant lower uptake of nutrients (N, P and K) by weeds. It aslo improved in all yield attributing characters and maximized grain yield and was at par with hand weeding.

Bari (2010) stated that Butachlor provided better control efficiency and contributed to better crop growth and grain yield compared to MCPA irrespective of concentration. It might be due to that pre-emergence application of Butachlor provided effective early season weed control, which MCPA could not since apply as post emergence. The highest grain yield of 4.18 t ha^{-1} was contributed by weed free treatment, while the least (2.44 t ha^{-1}) was by weedy check. Among the herbicide treatments, the highest grain yield of 4.08 t ha^{-1} was obtained from Butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate. Results further revealed a positive relationship between butachlor rate and grain yield, although a declining trend was apparent at higher than the recommended rates, while a negative relationship was found in MCPA treatments.

Halder *et al.* (2005) observed that Pyrazosulfuran-ethyl (PSE) 10% WP @ 16 g a.i. $ha^{-1}$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 40 DAT gave the maximum grain yield, benefit: cost ratio clearly showed that PSE 10% WP@ 15g a.i ha^{-1} is the right herbicide to replace the hand weeding treatment.

Pal *et al*. (2012) reported that the 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%) at the rate of 42.0 g ha^{-1}applied at 3 DAT .

Singh and Tewari (2005) stated that application of herbicides as pre-emergence supplemented with two hand weeding at 30 and 60 days after transplanting, the highest yield of rice was obtained with the application of Butachlor at 1.5 kg ha^{-1} supplemented with two hand weeding in transplant rice.

Saha (2005) evaluated 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 density. The highest grain yields 5.75 t ha^{-1} was obtained from Pyrazosulfuron-ethyl applied at 40 or 50 g ha^{-1}.

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 (3.95 t ha^{-1}) was noted under three weeding conditions which was at par with weed free (4.01 t ha^{-1}), but dissimilar to two weeding regimes (3.71 t ha^{-1}).

Tamiselvan and Budhar (2001) stated that the highest number of productive tiller $hill^{-1}$ was obtained in the plots treated with Anilofos @ 0.3 kg a.i. ha^{-1}, Pretilachlor @ 0.4 kg a. i. ha^{-1} and Butanil @ 1.0 kg a.i. ha^{-1}. The number of filled grain per panicle was the highest with Anilofos @ 0.3 kg a.i. ha^{-1}, Pretilachlor @ 0.4 kg a. i. ha^{-1} and Butanil @ 1.0 kg a.i. ha^{-1}.

Hossain (2000) carried out an experiment to evaluate 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.

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* kg a.i. ha^{-1}. The weed control treatments were equally effective in increasing grain yield.

Dhiman *et al.* (1998) stated that Butachlor gave the highest yield, which remained at par with Anilophos 5G 0.60 kg ha^{-1}, Anilophos + 2,4-D (Readmix) 0.40 + 0.53 kg ha^{-1}, Anilophos + 2,4-D significantly higher the number of panicles and an increased in weed control efficiency.

2.5 Toxicity of herbicides on rice plants

Phytotoxicity may occur in crop plants if inappropriate herbicides are selected. However, most of the rice herbicides such as Pretilachlor, Bispyribac sodium, Propanil, Thiobencarb, Fenoxopro-p-ethyl, Quinclorac and Bentazon/MCPA causes no injury to the rice plants under aerobic soil conditions. In fact, rice plants show high tolerance to herbicides but may suffer slight initial injuries such as leaf chlorosis and growth stunting during 7 to 14 days after application which disappears shortly.

Mamun *et al*. (2011) carried an experiment with Acetochlor 50% EC to evaluate appropriate dose of herbicide and its impact on transplant aus rice. It was observed that very slight to slight yellowing of leaves of rice plants with the application of Acetochlor 50%. Acetochlor50% @ 200 and 250 ml ha^{-1} showed very slight yellowing of leaves while temporary yellowing with 300 ml ha^{-1}. Phytotoxicity symptoms were not more prominent for application this herbicide.

An experiment was carried out by Singh and Singh (1998) to assess the phytotoxic effects of Acetochlor on rice crops. They observed on leaf tip drying, yellowing of leaves, necrosis, epinasty and crop stand reduction were recorded 4 at 15 and 30 DAT. The observation were based on a "0 – 10" scale, where "0" denoted no phytotoxicity. No phytotoxic symptoms appeared on the crop. There was no reduction in the density of rice crop due to application of Acetochlor. On the other hand, Set-off (Chinosulfuron) @ 20g ha^{-1} resulted in 85% control of *Monochoria vaginalis, Marsilea crenata, Cyperus* spp., *Fimbristylis miliacea a*nd *Spirpus juncoides* but only 50-60% controlled of *Echinochloa crusgalli* in transplanted rice. Weed control was general, superior to that provided by 720 g ha^{-1} of 2,4 D, Cinosulfuron with 0-3% phytotoxicity less damaging to rice when applied with 6-21 days after transplanting as assessed 45 days after transplanting .

Again, Burthun *et al.*(1989) stated that Cinosulfuron was less damaging to rice and resulted in higher rice yields than unwedded control plots, comparable to that achieved by annual weeding better than that obtained after treatment with 2,4-D.

BRRI (1998) carried out a study to assess the phytotoxic effect of Ronstar on BRRI dhan29. Ronstar had a phytotoxic effect on seedling maturity and yield reduction of pre-germinated boro rice. Ronstar rates used were 1.0L ha^{-1} and 2.0L ha^{-1} applied at the same day of seedling three days before seedlings and three days after seedlings. Pre-germinated seeds of BRRI dhan29 were broadcasted at 70 kg ha^{-1} following all recommended cultural practices throughout the growth period. Ronstar applied at the same day of sowing reduced grain yield significantly irrespective of doses. The high grain yield (5.76 t ha^{-1}) was observed when 1.0 L ha^{-1} Ronstar was applied at three days after sowing.

Pampolona and Evangelista (1982) observed that application of Anolofis, 2, 4-D and Butachlor @ 0.6 kg ha^{-1} in transplant rice caused slight toxicity at 10 DAT in transplanted rice but the plant recovered within 40 days after application of herbicide.

Dayanand (1987) applied pre-emergence herbicide Oxadiazon that caused slight crop injury but reduced weed population effectively and gave maximum profit as compared to other herbicides.

Khemphel and Rangsit (1986) studied the phytotoxic effect of Oxadiazon on rice plant. Oxadiazon produced some moderate phytotoxicity in the rice plant within two weeks received toxicity after application. Oxadiazon at higher rate caused phytotoxicity to rice plant and as a result plants were shorter and flowering was delayed.

IRRI (1975) evaluated the effect of liquid herbicide on direct seeded rice in the Philippines. It was observed that Oxadiazon @0.75 kg a.i. ha^{-1} was slightly phytotoxic to the rice plants but the plants recovered fully within days after application.

Considering the above discussion and literature related to the efficacy of different herbicides on weed control, it can be concluded that herbicidal treatments have significant effect on weed population as well as the growth and yield of aus rice.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 during aus season (April to August) of 2015 to study the herbicidal efficacy on broadcast aus rice. A brief description of the experimental site, soil, land preparation, layout, design, intercultural operation, data recording procedures and statistical analysis has been presented in this chapter.

3.1. Description of the experimental site

3.1.1 Location

The experimental site was situated in $23^0 77^/$ N latitude and 90^0 $33^/$ E longitudes with an elevation of 8.2 meter from sea level. The experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.1.2. Soil

The soil of the experimental plots belongs to the Modhupur Tract (AEZ No. 28) with Tejgaon soil series. The soil of the experimental plots was silty and non-calcareous dark grey. The selected plot was medium high land with pH value around 5.8.

3.1.3. Climate

The experimental site was under the sub-tropical climate. The total rainfall of the experimental site was 762.3 mm during the study period. The average monthly maximum and minimum temperature were 39.4^0C and 17.4^0C, respectively during the experimental period. The maximum and minimum temperature, humidity, rainfall and soil temperature during the study period were collected from the

Bangladesh Meteorological Department (Climate Division) Dhaka and given in (Appendix-II).

3.2. Details of the experiment

3.2.1. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of unit plots was 30. The size of each plot was 10 m^{-2} (5m × 2m).

3.2.2. Treatments

T_1: Propyrisulfuran@500 ml ha^{-1}

T_2: Propyrisulfuran @ 750 ml ha^{-1}

T_3: Propanil @3750 g ha^{-1}

T_4: Propyrisulfuran+ Propanil @ (500ml+3750 g) ha^{-1}

T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}

T_6: Propyrisulfuran + Propanil @ (750 ml + 3750 g) ha^{-1}

T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1}

T_8: Propyrisulfuran+ Propanil @ (750ml + 2500g) ha^{-1}

T_9: Bispyribac Sodium @150 g ha^{-1}

T_{10}: Weedy check (Control)

3.2.3. Description of the herbicides

A short description of the herbicide used in the experimental plots is given in Table 1.

Table 1. Description of herbicide used in the experiment

Trade name	**Common name**	**Mode of action**	**Selectivity**	**Time of Application**
ZETA –ONE ®	Propyrisulfuron	Systemic	Sedges and broadleaved weeds in corn, sorghum and cereals	Post - emergence
Propanil 60 WG	Propanil	Contact	Broadleaved and grasses weeds in rice	Post - emergence
Extra Power	Bispyribac Sodium	Contact	Sedges, grasses and broadleaved weeds in rice	Pre -emergence

3.3 Varietal characteristics

BRRI dhan48 is a high yielding variety of rice developed by Bangladesh Rice Research Institute (BRRI). It was released by National Seed Board in 2008. The average plant height of this variety is 105cm. The grain size is medium. This variety can be harvested within 110 days of field duration. Its average yield is about 5.5 t ha^{-1} with proper care and favorable condition.

3.4 Management practices

3.4.1 Seed collection

Seeds of BRRI dhan48 were collected from Bangladesh Agricultural Development Corporation, (BADC, Gabtoli, Dhaka).

3.4.2 Herbicide collection

Selected herbicides were collected from different registered herbicide dealers at different location of Dhaka.

3.4.3 Land preparation

The land was opened with a power tiller on 2 April, 2015. The field was thoroughly prepared with the help of country plough and ladder. Weeds and stubbles were removed from the field during land preparation. The land was finally prepared on 6 April, 2015 and the field layout was done on the next day.

3.4.4 Seed sowing

Direct sowing method was followed in this experiment and seeds were sown on 7 April, 2015. Before sowing, the seeds were soaked in water overnight and kept in a shaded condition covered with wet gunny bag and rice straw for germination. After 72 hours, the seeds were uniformly germinated and then the pre germinated seeds were directly sown on each plot.

3.4.5. Fertilizer application

The field was fertilized with Urea, Triple super phosphate (TSP), Muriate of potash (MOP), Gypsum and Zinc sulphate @ 150, 90, 90, 60 and 10 kg ha^{-1}, respectively. The 1/3rd urea and whole amount of other fertilizers were applied during final land preparation. The rest 2/3rd of urea was top dressed at 25-30 DAS and 40-45 DAS.

3.4.6 Plant protection measures

During the growth period of rice, infestation of pest and diseases were also found. Rice hispa (*Dicladispa armigera*) infested in the field at early stage of growth. Spraying Marshal 20EC @ 2ml per L water was successfully controlled the pest.

3.4.7 Irrigation and drainage

Irrigation water applied frequently to keep moist condition of the plots, so that herbicide can work properly. During heavy rainfall, excess water was drained out time to time.

3.4.8 Sampling, harvesting and processing

The crop was harvested at full maturity on 14 August, 2015. For weed character, $1m^{-2}$ area was randomly selected and for plant and yield contributing character five sample hills were randomly selected and uprooted prior to harvest from each unit plot except from two border rows. After sampling the plot was harvested by cutting at the base with sickle. The harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor. The harvested crop was threshed by pedal thresher and the fresh weight of grain and straw were recorded plot wise. The grains were cleaned and sun dried and straws were also sun dried properly.

3.5. Data collection

The following parameters were recorded from five sampled hills.

3.5.1 Weed characters

i. Total weed population m^{-2}
ii. Weed dry weight (g $m^{-2)}$
iii. Weed control efficiency (%)

3.5.2. Plant characters

i. Plant height (cm)
ii. Number of total tillers $hill^{-1}$
iii. Number of effective tillers $hill^{-1}$
iv. Number of non-effective tillers $hill^{-1}$
v. Length of tiller (cm)
vi. Length of panicle (cm)
vii. Number of grains $panicle^{-1}$
viii. Number of filled grains $panicle^{-1}$
ix. Number of unfilled grains $panicle^{-1}$
x. 1000-grain weight (g)
xi. Grain yield (t ha^{-1})
xii. Straw yield (t ha^{-1})
xiii. Biological yield (t ha^{-1})
xiv. Harvest index (%)

3.6 Procedure of data collection

A brief outline of data collection procedure is given below:

3.6.1 Total weed population m^{-2}

Total number of different weed species in one square meter was counted individually before 3 days of spray and 7, 14, 21, 28, 45 days after spray.

3.6.2 Total weed dry weight (g m^{-2})

Weeds were harvested individually from each plot at 45 days after spray. Dry weight of individual weed species of each plot was taken by drying them in electric oven (Perkin-Elmer Corporation, USA) at 60°C for 72 hours followed by weighing by digital balance.

3.6.3 Weed control efficiency (WCE %)

For measuring WCE, the following formula was used:

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where; DWC = dry weight of weeds in control plots and DWT = dry weight of weeds in treated plots.

3.6.4 Plant height (cm)

Plant height was measured from the base of the plant to the tip of the longest panicle. It was measured at 30, 60 DAS and during harvesting period.

3.6.5 Total number of tillers $hill^{-1}$

Tillers which had at least one visible leaf were counted. It was counted at 30 and 60 DAS and during harvesting period.

3.6.6 Number of effective tillers $hill^{-1}$

The tillers which had at least one visible grain in the panicle were considered as productive tillers.

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

The tillers which had no grain in the panicle were regarded as non-effective tillers.

3.6.8 Tiller length (cm)

Measurement was taken from base of the plant to the apex of each panicle.

3.6.9 Panicle length (cm)

Measurement was taken from basal node of the plant rachis to the apex of each panicle.

3.6.10 Filled grains panicle^{-1}

Presence of any food material in the spikelet was considered as filled grain and total number of filled grains present on each panicle was counted.

3.6.11 Unfilled grains panicle^{-1}

Absence of any food material in the spikelet was considered as empty spikelet and total number of empty spikelet on each panicle was counted.

3.6.12 1000-grain weight (g)

Weight of 1000 grains was determined from the dried seed sample taken from each unit plot and was expressed in gram by using an electrical balance.

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

Grains of each plot including the grains of five sample hills of respective plots were sun dried and weighed carefully for recording the grain yield plot^{-1}. The grain yield was then finally converted into t ha^{-1}.

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

Straw obtained from each unit plot including the straw of five sample hills of respective unit plot were sun dried and weighed to record the final straw yield plot^{-1} and finally converted t ha^{-1}.

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

The biological yield was calculated with the following formula-

Biological yield = Grain yield + Straw yield.

3.6.16 Harvest index (%)

Harvest index (%) was calculated by using the following formula:

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

3.7 Statistical Analysis

Data recorded for different parameters were compiled and tabulated in proper form. Analysis of variance was done following Randomized Complete Block Design with the help of computer package program MSTAT-C (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

Effect of weed control treatments on weed parameters and crop characters obtained from the present study have been presented and discussed in this chapter. Weed species infested the experimental plot was shown in Table 2 and the results related to weed infestation was presented in Tables 3-8. Data on dry weight of weed at 45 days after spray were presented in Table 9, weed control efficiency in Table 10 and plant height in Table 11 and data on different crop characters was presented in Figure 1-15.

4.1 Infested weed species in the experimental field

Weed infestation is comparably higher in aus rice due to their favorable growth condition. The competitions of weeds with rice are increases when the weed population increases.

Sixteen weed species were found in the experimental field which belongs to nine families. Among these species, 4 belong to Poaceae, 3 Compositae, 2 Cyperaceae and Amaranthaceae and 1 from each of Marsiliaceae, Pontederiaceae, Genetiaceae, Sphenocleaceae and Scrophulariaceae. Weeds grown in the experimental plot were grass, broad-leaved, sedge type. The most important weeds in the experimental plots were grasses like, *Cynodon dactylon* (Bermuda grass) and *Echinochloa crusgalli* (barnyard grass); sedges like, *Fimbristylis miliaceae* (Fringerush) and *Cyperus difformis* L. (umbrella sedge) and broad leaved weeds like *Marsilea quadrifoliata* (4-leaved water clover), *Ludwigia hyssopifolia* (Water primrose), *Eclipta alba* (White eclipta) etc.

The particulars of weeds Common name, English name, Scientific name, Family name and life cycle have been presented in Table 2.

Table 2. Infested weed species of the experimental field

Common Name	English name	Scientific name	Family	Life cycle
Behua	Small leaved umbrella sedge	*Cyperus difformis*	Cyperaceae	Annual
Shusni shak	4-leaved water clover	*Marsilea quadrifolia*	Marsiliaceae	Annual
Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Perennial
Boro shama	Banyard grass	*Echinochloa crusgalli*	Poaceae	Annual
Chanchi	Chanchi	*Alternanthera sessilis*	Amaranthaceae	Perennial
Durba	Burmuda grass	*Cynodon dactylon*	Poaceae	Perennial
Khet papri	Khet papri	*Lindernia procumbens*	Scrophulariaceae	Annual
Keshuti	White eclipta	*Eclipta alba*	Compositae	Annual
Girakata	Girakata	*Spilanthes acmella*	Compositae	Annual
Moyurleja	Red Sprangletop	*Leptochloa chinensis*	Poaceae	Annual
Pani long	Water primrose	*Ludwigia hyssopifolia*	Poaceae	Annual
Pani kachu	Monochoria	*Monochoria vaginalis*	Pontederiaceae	Perennial
Chandmala	Duck weed	*Sagittaria guyanensis*	Genetiaceae	Annual
Jhilmorich	Goose weed	*Sphenoclea zeylanica*	Sphenocleaceae	Annual
Joyna	Fringerush	*Fimbristylis miliaceae*	Cyperaceae	Annual
Ghagra	Cocklebur	*Xanthium indicum*	Compositae	Annual

4.2 Weed Population (No. m^{-2})

Weed population was significantly influenced by different weed control treatments as recorded at 3 days before spray and 7, 14, 21, 28 and 45 days after spray of the rice plot (Table 3-8).

4.2.1 Effect of different herbicidal treatments before 3 days of spray

Maximum number of (456.7) *Cyperus difformis* was found in T_{10} treatment whereas the minimum number of *Cyperus difformis* (240.7) was found in T_1 treatment which was statistically similar with T_3 (262). The highest number of *Sagittaria guyanensis* was found in treatment T_6 (13.33) and the lowest number (5.5) was found in T_9 treatment. The highest number of *Marsilea quadrifolia* was found in T_3 (9) and T_9 (9.33) treatments which was statistically similar with control plot T_{10} (8.67) whereas the lowest number (2.33) was found in T_6 (5.67) and T_8 (5). Maximum infestation (15.33) of *Alternanthera sessilis* was found in T_6 treatment whereas the least infestation (0.67) was found in T_1 and T_9. The maximum number (13) of *Eclipta alba* was found in T_9 and T_{10} (12.33) whereas no *Eclipta alba* was found in T_1-T_6 and T_8 treatments. The maximum number (2.33) of *Alternanthera philoxeroides* was found in T_6 whereas no *Alternanthera philoxeroides* was found in T_2, T_5, T_8 and T_9 treatments. The highest number (0.67) of *Cynodon dactylon* was found in T_{10} whereas no *Cynodon dactylon* was found in all plots except T_4 and T_6. The maximum number (1.6) of *Xanthium indicum* was found in T_2 and T_{10} whereas no *Xanthium indicum* was found in the plot T_9. The highest number (0.67) of *Monochoria vaginalis* was found in T_2 and T_{10} treatments whereas no *Monochoria vaginalis* was found in all plots except T_8 and T_9. The maximum number (1.67) of *Ludwigia hyssopifolia* was found in T_3 and T_{10} treatments whereas no *Ludwigia hyssopifolia* was found in all the plots except T_1 and T_4. The highest infestation (3.33) of *Leptochloa chinensis* was found in T_5 treatment whereas no *Leptochloa chinensis* was found in T_3, T_7, T_8 and T_9 treatments. The highest number (2.00) of *Echinochloa crusgalli* was found in control plot T_{10} whereas no *Echinochloa crusgalli* was found any plots except T_1, T_3 and T_4. The highest number (1.0) of *Spilanthes acmella* was found in control plot (T_{10}) whereas no *Spilanthes acmella* was found in T_1, T_3, T_6, T_8 and T_9 treatments. *Fimbristylis miliaceae* was found in only one plot (T_8). *Sphenoclea zeylanica* was maximum in T_{10} treatment and *Lindernia procumbens* was not found in any plot. There were partial similarities found in weed species of aus rice enlisted by Hasanuzzaman *et al*. (2009).

Table 3. Effect of herbicides on the number of specific weed on rice field at 3 days before spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	240.7 g	9.67 d	6.67 e	0.67 g	0.00 d	1.33 b	0.00 c	0.67 d
T_2	418.3 b	7.33 e	8.00 bc	6.00 c	0.00 d	0.00 e	0.00 c	1.67 a
T_3	262.0 fg	7.00 e	9.33 a	1.67 f	0.00 d	0.33 d	0.00 c	0.33 e
T_4	284.3 ef	12.67 ab	7.00 de	3.00 d	0.00 d	1.33 b	0.33 b	0.33 e
T_5	296.3 de	3.67 g	7.67 cd	1.67 f	9.33 b	0.00 e	0.00 c	0.33 e
T_6	319.3 cd	13.33 a	5.67 f	15.33 a	0.00 d	2.33 a	0.33 b	0.33 e
T_7	333.7 c	11.33 c	7.00 de	2.67 de	2.33 c	0.66 c	0.00 c	1.33 b
T_8	305.7 c-e	11.67 bc	5.00 f	8.33 b	0.00 d	0.00 e	0.00 c	1.00 c
T_9	309.7 c-e	5.50 f	9.00 a	0.67 g	13.00 a	0.00 e	0.00 c	0.00 f
T_{10}	456.7 a	9.33 d	8.67 ab	2.00 ef	12.33 a	0.67 c	0.67 a	1.67 a
LSD $_{(0.05)}$	**33.54**	**1.23**	**0.93**	**0.86**	**0.79**	**0.16**	**0.05**	**0.14**
CV (%)	**6.06**	**7.85**	**7.32**	**11.93**	**12.39**	**14.26**	**18.31**	**10.66**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 3. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*	*Lindernia procumbens*
T_1	0.00 c	1.33 b	1.33 d	0.33 d	0.00 c	0.00 b	1.00 b	0.00
T_2	0.67 a	0.00 d	2.00 c	0.00 e	0.33 b	0.00 b	0.33 d	0.00
T_3	0.00 c	1.67 a	0.00 f	0.33 d	0.00 c	0.00 b	0.67 c	0.00
T_4	0.00 c	0.33 c	0.67 e	1.00 b	0.33 b	0.00 b	0.00 e	0.00
T_5	0.00 c	0.00 d	3.33 a	0.00 e	0.33 b	0.00 b	0.33 d	0.00
T_6	0.00 c	0.00 d	2.00 c	0.00 e	0.00 c	0.00 b	0.00 e	0.00
T_7	0.00 c	0.00 d	0.00 f	0.00 e	0.33 b	0.00 b	0.00 e	0.00
T_8	0.33 b	0.00 d	0.00 f	0.00 e	0.00 c	0.33 a	0.00 e	0.00
T_9	0.33 b	0.00 d	0.00 f	0.67 c	0.00 c	0.00 b	0.33 d	0.00
T_{10}	0.67 **a**	1.67 a	3.00 b	2.00 a	1.00 a	0.00 b	1.67 a	0.00
LSD $_{(0.05)}$	**0.05**	**0.14**	**0.21**	**0.13**	**0.05**	**0.02**	**0.09**	**0.00**
CV (%)	**16.26**	**17.16**	**9.92**	**17.89**	**13.87**	**34.55**	**13.51**	**0.00**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.2.2 Effect of different herbicidal treatments after 7 days of spray

Weeds are the major biotic constraints of most field crops. Competition of weeds drastically reduces the growth and yield of rice especially at the early stage of crops. Weed free condition at early stage is very important in the rice field. There were significant effect of herbicides was observed on all the experiment plots. In Table 4, weed control strategy was stated that maximum no. of weeds species was found in control plot (T_{10}) and minimum weed species was observed in T_7 treatment after 7 days of herbicide application, T_4 showed similar results to control weeds of listed species. To control *Cyperus difformis*, T_7 treatment showed the best result which was statistically similar to T_3, T_4 and T_5 treatments. The highest number of *Sagittaria guyanensis* was found in untreated plot (T_{10}) and the lowest number was found in T_7, T_4 and T_5 treatments. *Marsilea quadrifolia* was significantly reduced in T_7 which was statistically similar with T_3-T_6 and T_8 treatments and result was insignificant in unweeded plot. *Cynodon dactylon* become zero after 7 days of spraying in all treatments except T_1, T_6 and T_9. Controlling *Eclipta alba*, T_7 treatment showed moderate effect, the treatments significant to control *Alternanthera sessilis* were T_1, T_2, T_7 and T_9 and for *Alternanthera philoxeroides* T_2, T_3, T_5, T_7 and T_9 treatments showed the best performance. *Monochoria vaginalis, Ludwigia hyssopifolia, Sphenoclea zeylanica* were totally controlled in plots of T_4, T_5, T_6, T_7 and T_8 treatments. In case of *Fimbristylis miliaceae*, no weed was found in all the plots except T_8 treatment. The highest infestation of *Leptochloa chinensis*, *Echinochloa crusgalli*, *Spilanthes acmella*, *Lindernia procumbens*, *Xanthium indicum* were found in control plot (T_{10}). From the above discussion herbicidal treatment T_7 showed the best effect after 7 days of application to control all enlisted weed species. Hassan and Upasani (2015) reported that application of herbicides reduced weed species effectively than the weedy check.

Table 4. Effect of herbicides on the number of specific weed on rice field at 7 days after spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	64.00 d	5.33 bc	9.00 c	0.00 e	1.00 c	1.33 a	0.33 b	0.33 d
T_2	198.3 b	4.67 c	11.67 b	0.00 e	0.67 d	0.00 d	0.00 c	1.67 b
T_3	50.00 de	3.67 d	2.33 d	1.00 b	0.33 e	0.00 d	0.00 c	0.00 e
T_4	32.33 e	2.67 e	2.00 d	0.33 d	0.33 e	0.67 c	0.00 c	0.67 c
T_5	43.33 de	2.80 e	2.00 d	0.33 d	0.33 e	0.00 d	0.00 c	0.00 e
T_6	71.67 d	4.67 c	2.33 d	1.33 a	2.33 b	1.00 b	1.00 a	0.00 e
T_7	25.00 e	2.00 e	1.67 d	0.00 e	0.67 d	0.00 d	0.00 c	0.00 e
T_8	160.0 c	6.00 b	2.00 d	0.67 c	1.00 c	0.67 c	0.00 c	0.33 d
T_9	201.3 b	5.33 bc	8.67 c	0.00 e	2.33 b	0.00 d	0.33 b	0.00 e
T_{10}	541.7 a	10.67 a	22.67 a	1.33 a	8.67 a	0.67 c	1.00 a	2.00 a
LSD $_{(0.05)}$	**29.38**	**0.81**	**1.34**	**0.11**	**0.23**	**0.12**	**0.08**	**0.08**
CV (%)	**12.34**	**9.89**	**12.13**	**13.06**	**7.54**	**16.09**	**17.81**	**9.29**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 4. continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	0.00 c	0.67 b	1.33 e	0.00 d	0.00 c	0.00 c	0.00 b	0.33 b
T_2	0.67 a	0.00 c	1.67 d	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_3	0.33 b	0.67 b	0.00 g	0.33 c	0.00 c	0.33 b	0.00 b	0.00 c
T_4	0.00 c	0.00 c	0.67 f	0.67 b	0.00 c	0.00 c	0.00 b	0.00 c
T_5	0.00 c	0.00 c	3.33 a	0.00 d	0.00 c	0.33 b	0.00 b	0.00 c
T_6	0.00 c	0.00 c	2.00 c	0.00 d	0.33 b	0.00 c	0.00 b	0.00 c
T_7	0.00 c	0.00 c	0.00 g	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_8	0.00 c	0.00 c	0.00 g	0.00 d	0.00 c	0.33 b	0.32 a	0.00 c
T_9	0.33 b	0.67 b	0.00 g	0.67 b	0.00 c	0.00 c	0.00 b	0.33 b
T_{10}	0.67 a	3.33 a	3.00 b	2.00 a	0.67 a	0.67 a	0.00 b	1.67 a
LSD $_{(0.05)}$	**0.05**	**0.18**	**0.20**	**0.09**	**0.05**	**0.08**	**0.02**	**0.05**
CV (%)	**16.23**	**19.76**	**9.75**	**13.88**	**26.68**	**25.25**	**22.59**	**15.92**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.2.3 Effect of different herbicidal treatments after 14 days of spray

Effect of different herbicides significantly influenced the weed population of different treated plots after 14 days of application. Maximum infestation was found in control condition whereas minimum infestation was observed in T_7 treatment.

T_3, T_4 and T_5 treatments showed similar results with T_7 treatment to control *Cyperus difforms*, *Sagittaria guyanensis*, *Marsilea quadrifolia*. To control *Alternanthera sessilis* T_3, T_5, and T_6 treatments showed moderate result whereas the least infestation was found in T_1, T_2, T_7 and T_9 treatments. *Eclipta alba* was minimum in T_2 and T_7 treatments. T_2, T_3 and T_5 treatments were significant with T_7 to control *Alternanthera philoxeroides*, *Cynodon dactylon* whereas T_1 and T_6 treatments showed moderate results. Controlling *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Fimbristylis miliaceae*, *Sphenoclea zeylanica* all the treatments were effective except the control plots. Treatment T_7 was significant in controlling *Leptochloa chinensis* and *Spilanthes acmella* were found similar result in T_3, T_4, and T_8. The highest number (2.00) of *Echinochloa crusgalli* was found in T_{10} whereas *Echinochloa crusgalli* found to zero in all treatments except T_3, T_4 and T_9. *Xanthium indicum* was controlled in all the plots except T_1, T_2 and T_{10}. From the above observation, it was found that number of infested weeds was drastically reduced after 14 days of herbicide application, T_7 found to be the best treatment in controlling all kind of weed species and T_1, T_4, T_8 treatments also showed better results in controlling weed. Weeds competetion causes severe damage to rice crop at the early stage of growth. So weed free condition at this stage is very important which supports the findings of Shultana *et al*. (2011).

Table 5. Effect of herbicides on the number of specific weed on rice field at 14 days after spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	22.00 de	3.00 d	4.67 c	0.00 c	0.67 d	0.00 d	0.00 d	0.33 b
T_2	57.33 c	2.67 d	4.00 c	0.00 c	0.00 e	0.00 d	0.00 d	0.68 a
T_3	32.67 d	4.67 b	1.00 d	0.33 b	0.00 e	0.33 c	0.00 d	0.00 c
T_4	20.67 e	2.00 e	0.67 de	0.00 c	0.00 e	0.67 b	0.33 c	0.00 c
T_5	21.00 e	2.67 d	0.67 de	0.33 b	0.00 e	0.00 d	0.00 d	0.00 c
T_6	23.33 de	3.00 d	1.00 d	0.33 b	1.67 c	0.00 d	0.67 b	0.00 c
T_7	16.33 e	1.67 e	0.33 e	0.00 c	0.00 e	0.00 d	0.00 d	0.00 c
T_8	26.00 de	2.00 e	1.33 d	0.00 c	0.00 e	0.00 d	0.00 d	0.00 c
T_9	161.7 b	3.67 c	6.67 b	0.00 c	6.80 b	0.00 d	0.33 c	0.00 c
T_{10}	245.0 a	12.00 a	16.00 a	1.33 a	14.67 a	1.00 a	1.00 a	0.67 a
LSD $_{(0.05)}$	**11.39**	**0.65**	**0.67**	**0.05**	**0.60**	**0.08**	**0.02**	**0.02**
CV (%)	**10.61**	**10.20**	**10.74**	**11.79**	**14.68**	**21.63**	**7.37**	**2.64**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 5. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	0.00 c	0.67 b	1.33 f	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_2	0.33 b	0.00 d	1.67 e	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_3	0.67 a	0.67 b	0.00 g	0.33 c	0.00 c	0.33 b	0.00 b	0.00 c
T_4	0.00 c	0.00 d	2.33 c	0.67 b	0.00 c	0.00 c	0.00 b	0.00 c
T_5	0.00 c	0.00 d	2.67 b	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_6	0.00 c	0.00 d	2.00 d	0.00 d	0.33 b	0.00 c	0.00 b	0.00 c
T_7	0.00 c	0.00 d	0.00 g	0.00 d	0.00 c	0.00 c	0.00 b	0.00 c
T_8	0.00 c	0.33 c	0.00 g	0.00 d	0.00 c	0.00 c	0.33 a	0.00 c
T_9	0.00 c	0.00 d	0.00 g	0.33 c	0.00 c	0.00 c	0.00 b	0.33 b
T_{10}	0.67 a	3.33 a	3.00 a	2.00 a	0.67 a	0.67 a	0.00 b	0.67 a
LSD $_{(0.05)}$	**0.02**	**0.16**	**0.22**	**0.05**	**0.02**	**0.02**	**0.02**	**0.02**
CV (%)	**7.59**	**18.60**	**9.67**	**10.76**	**10.09**	**10.09**	**5.48**	**3.48**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.2.4 Effect of different herbicidal treatments after 21 days of spray

Different herbicides showed significant effect in mitigating weed species in the different experimental plots after 21 days of spraying. From the Table 6, it was assumed that massive infestation was found in T_{10} treatment and less infestation was observed in T_7 treatment. So weed control efficiency was higher in the treated plots. All the treatments showed the best results to control *Cyperus difformis* after 21 days herbicidal application except the control plot. *Sagittaria guyanensis, Alternanthera sessilis, Alternanthera philoxeroides* were found to zero in T_7 treatment, similar result was observed in T_1-T_6 and T_8 treatments. Significant result for controlling *Marsilea quadrifolia* was observed in T_7 treatment whereas T_2, T_4, T_8 treatments showed statistically similar effect in case of *Cynodon dactylon* and *Eclipta alba. Spilanthes acmella*, *Lindernia procumbens, Fimbristylis miliaceae*, *Sphenoclea zeylanica* were effectively controlled in all experimental plots except T_{10}. To control *Echinochloa crusgalli* and *Leptochloa chinensis* T_7 treatment was the most effective. Suppression of *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Sphenoclea zeylanica* were observed in all treated plots except T_3, T_9 and T_{10}. Herbicidal activity increased with adequate moisture supply in the field which reduced weed biomass rapidly. Zahan *et al.* (2015) reported that application of pre and post emergence herbicide weed biomass was drastically reduced than the untreated field.

Table 6. Effect of herbicides on the number of specific weed on rice field at 21 days after spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	0.00 b	0.00 d	2.67 b	0.00 c	0.00 b	0.33 d	0.33 c	0.33 b
T_2	0.00 b	0.00 d	0.00 c	0.00 c	0.00 b	0.00 e	0.00 d	0.00 c
T_3	0.00 b	10.0 b	2.33 b	0.33 b	0.00 b	0.33 d	0.00 d	0.33 b
T_4	0.00 b	0.00 d	0.00 c	0.00 c	0.00 b	0.58 c	0.33 c	0.00 c
T_5	0.00 b	0.00 d	0.67 c	0.00 c	0.00 b	0.00 e	0.33 c	0.00 c
T_6	0.00 b	0.33 d	0.33 c	0.33 b	0.00 b	0.00 e	0.67 b	0.00 c
T_7	0.00 b	0.00 d	0.00 c	0.00 c	0.00 b	0.00 e	0.00 d	0.00 c
T_8	0.00 b	0.00 d	0.00 c	0.00 c	0.00 b	0.65 b	0.00 d	0.33 b
T_9	0.00 b	2.33 c	3.00 b	0.00 c	0.00 b	0.00 e	0.33 c	0.00 c
T_{10}	86.0 a	13.67 a	22.67 a	1.33 a	12.33 a	1.00 a	1.00 a	2.00 a
LSD $_{(0.05)}$	**1.96**	**0.40**	**0.84**	**0.05**	**0.87**	**0.05**	**0.05**	**0.11**
CV (%)	**13.26**	**8.89**	**15.43**	**11.46**	**41.21**	**9.69**	**10.50**	**20.88**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 6. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*	*Lindernia procumbens*
T_1	0.00 c	0.67 c	1.00 e	0.00 d	0.00 b	0.00 b	0.00 b	0.00 c
T_2	0.00 c	0.00 d	1.67 d	0.00 d	0.00 b	0.00 b	0.00 b	0.00 c
T_3	1.67 a	1.33 b	0.33 f	0.33 c	0.00 b	0.00 b	0.00 b	0.00 c
T_4	0.00 c	0.00 d	2.33 b	0.67 b	0.00 b	0.00 b	0.00 b	0.00 c
T_5	0.00 c	0.00 d	1.67 d	0.33 c	0.00 b	0.00 b	0.00 b	0.00 c
T_6	0.00 c	0.00 d	2.00 c	0.00 d	0.00 b	0.00 b	0.00 b	0.33 b
T_7	0.00 c	0.00 d	0.00 g	0.00 d	0.00 b	0.00 b	0.00 b	0.00 c
T_8	0.00 c	0.00 d	0.00 g	0.00 d	0.00 b	0.33 a	0.00 b	0.00 c
T_9	0.33 b	0.67 c	0.00 g	0.33 c	0.00 b	0.00 b	0.00 b	0.00 c
T_{10}	1.67 a	6.67 a	3.00 a	2.00 a	0.67 a	0.00 b	1.67 a	0.67 a
LSD $_{(0.05)}$	**0.05**	**0.15**	**0.16**	**0.05**	**0.02**	**0.02**	**0.02**	**0.02**
CV (%)	**7.24**	**9.80**	**8.04**	**9.68**	**13.69**	**5.48**	**10.95**	**10.09**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.2.5 Effect of different herbicidal treatments after 28 days of spray

Different herbicides showed significant effect in controlling the weed population of different treated plots after 28 days of application. Maximum infestation was found in control condition (T_{10}) whereas minimum infestation was observed in T_7 treatment of enlisted species. Due to herbicidal efficacy weed population gradually reduced that enlisted in Table 7. Except the control plot, *Cyperus difformis* was totally mitigated. Better results showed by T_7 treatment in controlling *Marsilea quadrifolia* and *Leptochloa chinensis* while T_3 treatment was not significant in case of *Monochoria vaginalis* and *Echinochloa crusgalli*. To control *Echinochloa crusgalli,* T_3, T_7 and T_8 treatments were most effective and *Eclipta alba, Ludwigia hyssopifolia, Sphenoclea zeylanica, Fimbristylis miliaceae* and *Alternanthera sessilis* were totally controlled in all plots except T_{10}. *Alternanthera philoxeroides* and *Cynodon dactylon* were effectively controlled by T_7 treatment that was statistically similar with T_3 and T_8. *Sagittaria guyanensis, Spilanthes acmella* were found to zero except T_3, T_4 and T_9 treatments. Lower weed infestation facilitated more nutrient uptake (N, P, K) by rice plant thus better growth and yield of crop was observed. Mukherjee (2006) stated that combined application of herbicides reduce depletion of nutrient from the rice field.

Table 7. Effect of herbicides on the number of specific weed on rice field at 28 days after spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	0.00 b	0.00 e	6.00 b	0.00 c	0.00 b	0.00 c	0.33 c	0.00 d
T_2	0.00 b	0.00 e	4.00 c	0.00 c	0.00 b	0.00 c	0.00 d	0.00 d
T_3	0.00 b	2.33 c	1.67 d	0.67 b	0.00 b	0.00 c	0.00 d	2.00 b
T_4	0.00 b	5.67 b	0.67 ef	0.00 c	0.00 b	0.67 b	0.33 c	0.00 d
T_5	0.00 b	0.00 e	1.00 de	0.00 c	0.00 b	0.00 c	0.33 c	0.00 d
T_6	0.00 b	0.00 e	0.67 ef	0.00 c	0.00 b	0.00 c	0.67 b	0.00 d
T_7	0.00 b	0.00 e	0.33 f	0.00 c	0.00 b	0.00 c	0.00 d	0.00 d
T_8	0.00 b	0.33 e	3.67 c	0.00 c	0.00 b	0.67 b	0.00 d	0.33 c
T_9	0.00 b	1.67 d	3.67 c	0.00 c	0.00 b	0.00 c	0.00 d	0.00 d
T_{10}	10.00 a	10.00 a	14.67 a	1.33 a	5.00 a	1.00 a	2.67 a	2.33 a
LSD $_{(0.05)}$	**0.43**	**0.33**	**0.67**	**0.02**	**0.13**	**0.05**	**0.08**	**0.11**
CV (%)	**25.30**	**9.68**	**10.75**	**11.13**	**15.81**	**10.44**	**11.54**	**12.74**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 7. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	0.00 c	0.00 b	1.00 d	0.33 d	0.00 d	0.00 c	0.00 c	0.00 b
T_2	0.00 c	0.00 b	1.67 c	0.00 e	0.33 c	0.00 c	0.00 c	0.00 b
T_3	2.03 a	0.00 b	0.33 f	0.67 c	0.33 c	1.33 b	0.00 c	0.00 b
T_4	0.00 c	0.00 b	2.33 b	0.67 c	0.00 d	0.00 c	0.00 c	0.00 b
T_5	0.00 c	0.00 b	2.33 b	1.00 b	0.00 d	0.00 c	0.00 c	0.00 b
T_6	0.00 c	0.00 b	0.67 e	0.00 e	0.67 b	0.00 c	0.00 c	0.00 b
T_7	0.00 c	0.00 b	0.33 f	0.00 e	0.00 d	0.00 c	0.00 c	0.00 b
T_8	0.00 c	0.00 b	0.33 f	0.00 e	0.00 d	0.00 c	0.33 b	0.00 b
T_9	0.67 b	0.00 b	1.60 c	1.00 b	0.00 d	0.00 c	0.00 c	0.00 b
T_{10}	2.00 a	2.68 a	3.00 a	2.00 a	1.33 a	2.33 a	3.33 a	11.67 a
LSD $_{(0.05)}$	**0.14**	**0.11**	**0.20**	**0.08**	**0.05**	**0.09**	**0.15**	**0.31**
CV (%)	**18.28**	**23.81**	**8.26**	**7.94**	**11.52**	**14.47**	**24.87**	**15.65**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.2.6 Effect of different herbicidal treatments after 45 days of spray

Different herbicides showed significant effect in reducing weed species from the different experimental plots after 45 days of spray. From the Table 8 it was assumed that weed control efficiency was lowest in weedy check (T_{10}) and the highest in the herbicide treated plot especially T_7 treatment. So less infestation was observed with the treated plots. All the treatment showed the best results to control *Cyperus difformis* after 45 days of herbicide application except the control plot. *Sagittaria guyanensis*, *Alternanthera philoxeroides* were totally reduced except T_3, T_4, T_9 and T_{10} treatments. Significant result of controlling *Marsilea quadrifolia* was observed in T_7 treatment whereas T_4 and T_5 showed statistically similar effect. Regeneration of *Marsilea quadrifolia* was also found in different plots after 45 days of spray. In case of *Cynodon dactylon and Eclipta alba* best result was obtained by T_7 treatment. *Spilanthes acmella*, *Lindernia procumbens*, *Fimbristylis miliaceae*, *Sphenoclea zeylanica* were effectively controlled in all experimental plots except control plot (T_{10}). To control *Echinochloa crusgalli and Leptochloa chinensis* T_7 treatment was the most effective. T_4-T_7 treatments showed statistically similar result to control *Xanthium indicum*. Suppression of *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Sphenoclea zeylanica* was observed in all plot except T_3, T_9 and T_{10} treatments. Application of post emergence herbicide suppressed weed density that accelerate crop growth and development. The finding supported by Khaliq *et al.* (2012). Higher rice grain yield was obtained by weed free condition upto 45 days afer spray.

Table 8. Effect of herbicides on the number of specific weed on rice field at 45 days after spray (No. m^{-2})

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	0.00 b	0.00 d	2.33 c	0.00 b	0.00 b	0.00 c	0.33 c	0.33 d
T_2	0.00 b	0.00 d	1.33 d	0.00 b	0.00 b	0.00 c	0.00 d	1.00 c
T_3	0.00 b	1.67 b	3.33 b	0.00 b	0.00 b	0.00 c	0.00 d	3.00 b
T_4	0.00 b	1.00 c	0.67 ef	0.00 b	0.00 b	0.67 b	0.33 c	0.00 e
T_5	0.00 b	0.00 d	0.67 ef	0.00 b	0.00 b	0.00 c	0.33 c	0.00 e
T_6	0.00 b	0.00 d	2.00 c	0.00 b	0.00 b	0.00 c	0.67 b	0.00 e
T_7	0.00 b	0.00 d	0.33 f	0.00 b	0.00 b	0.00 c	0.00 d	0.00 e
T_8	0.00 b	0.00 d	1.00 de	0.00 b	0.00 b	1.00 a	0.00 d	0.33 d
T_9	0.00 b	1.00 c	2.00 c	0.00 b	0.00 b	0.00 c	0.00 d	3.00 b
T_{10}	3.33 a	2.67 a	19.33 a	1.00 a	5.00 a	1.00 a	2.67 a	6.33 a
$LSD_{(0.05)}$	**0.05**	**0.09**	**0.58**	**0.02**	**0.13**	**0.05**	**0.08**	**0.18**
CV (%)	**10.95**	**8.70**	**10.17**	**18.97**	**15.81**	**9.77**	**11.37**	**7.67**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 8. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	0.00 d	0.00 b	1.00 d	0.33 c	0.00 d	0.00 b	0.00 c	0.00 b
T_2	0.00 d	0.00 b	1.67 c	0.00 d	0.67 c	0.00 b	0.00 c	0.00 b
T_3	0.33 c	0.00 b	0.33 e	0.67 b	0.00 d	0.00 b	0.33 b	0.00 b
T_4	0.00 d	0.00 b	1.67 c	0.67 b	0.00 d	0.00 b	0.00 c	0.00 b
T_5	0.00 d	0.00 b	2.33 b	2.00 a	0.00 d	0.00 b	0.00 c	0.00 b
T_6	0.00 d	0.00 b	1.67 c	0.33 c	1.33 b	0.00 b	0.00 c	0.00 b
T_7	0.33 c	0.00 b	0.33 e	0.00 d	0.00 d	0.00 b	0.00 c	0.00 b
T_8	0.00 d	0.00 b	0.33 e	0.00 d	0.00 d	0.00 b	0.33 b	0.00 b
T_9	1.00 b	0.00 b	2.33 b	0.33 c	0.00 d	0.00 b	0.00 c	0.00 b
T_{10}	2.67 a	2.67 a	3.00 a	2.00 a	2.00 a	3.67 a	3.33 a	1.67 a
LSD $_{(0.05)}$	**0.09**	**0.05**	**0.22**	**0.09**	**0.05**	**0.15**	**0.08**	**0.02**
CV (%)	**11.68**	**13.69**	**8.96**	**8.00**	**9.29**	**24.90**	**12.06**	**10.95**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.3 Effect of different herbicidal treatments on dry weight of weeds after 45 days of spray

Due to spraying of different herbicides on experimental plots most of weed species were mitigated except the unweeded control plots. So dry weight of most species were also zero after 45 days of herbicide application that was enlisted in Table 9. From the table it was assumed that dry weight of *Cyperus difformis* after 45 days become zero except control plot (T_{10}) that means the treatments were significantly reduced the weed species. *Eclipta alba*, *Ludwigia hyssopifolia*, *Sphenoclea zeylanica*, *Alternanthera sessilis* and *Spilanthes acmella* were controlled in all plots so, dry weight become zero except control condition. Dry weight of *Sagittaria guyanensis* and *Alternanthera philoxeroides* were highest at T_{10} treatment and zero in all plots except T_3 and T_9. Significant result of controlling *Marsilea quadrifolia* was observed in T_7 whereas maximum dry weight was observed in weedy check (T_{10}). In case of *Cynodon dactylon* and *Monochoria vaginalis* T_3, T_7 and T_9 treatments showed moderate effect whereas T_7 treatment showed the lower most dry weight of *Leptochloa chinensis* which were statistically similar with T_3 and T_8 treatments.The maximum dry weight of *Leptochloa chinensis* was obtained from T_{10} treatment. Highest dry weight of *Echinochloa crusgalli* was obtained from T_{10} and lowest from T_7 whereas similar result was found from T_2 and T_8 treatments. In case of *Cynodon dactylon* the second highest weed dry weight was observed in T_6 treatment after T_{10} and the maximum dry weight of *Lindernia procumbens*, *Fimbristylis miliaceae* and *Xanthium indicum* found in control condition whereas T_3, T_8 and T_9 treatments showed moderate effect. Higher efficiency in controlling weed species resulted lower dry weight of weeds. Different herbicidal treatments reduced the dry weight of weed ultimately higher yield of rice. The present result was in consistant with the findings of Mamun *et al*. (2011) and Saha (2005).

Table 9. Effect of herbicides on the dry weight of specific weed (g) on rice field

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	0.00 b	0.00 d	0.48 c	0.00 b	0.00 b	0.00 d	0.20 c	0.04 d
T_2	0.00 b	0.00 d	0.31 e	0.00 b	0.00 b	0.00 d	0.00 d	0.20 c
T_3	0.00 b	1.36 b	0.68 b	0.00 b	0.00 b	0.00 d	0.00 d	0.45 b
T_4	0.00 b	0.79 c	0.13 g	0.00 b	0.00 b	0.42 b	0.19 c	0.00 d
T_5	0.00 b	0.00 d	0.14 g	0.00 b	0.00 b	0.00 d	0.26 c	0.00 d
T_6	0.00 b	0.00 d	0.41 d	0.00 b	0.00 b	0.00 d	0.43 b	0.00 d
T_7	0.00 b	0.00 d	0.07 h	0.00 b	0.00 b	0.00 d	0.00 d	0.00 d
T_8	0.00 b	0.00 d	0.20 f	0.00 b	0.00 b	0.32 c	0.00 d	0.03 d
T_9	0.00 b	0.82 c	0.51 c	0.00 b	0.00 b	0.00 d	0.00 d	0.42 b
T_{10}	0.32 a	2.18 a	4.20 a	0.17 a	4.17 a	0.44 a	1.68 a	0.92 a
$LSD_{(0.05)}$	**0.02**	**0.09**	**0.05**	**0.02**	**0.09**	**0.02**	**0.09**	**0.05**
CV (%)	**9.88**	**11.02**	**4.70**	**21.07**	**13.33**	**7.20**	**20.99**	**12.81**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 9. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	0.00 c	0.00 b	3.95 c	1.32 d	0.00 d	0.00 b	0.00 d	0.00 b
T_2	0.00 c	0.00 b	6.44 b	0.00 e	0.22 c	0.00 b	0.00 d	0.00 b
T_3	0.03 b	0.00 b	1.32 d	2.70 c	0.00 d	0.00 b	0.09 c	0.00 b
T_4	0.00 c	0.00 b	7.00 b	2.50 c	0.00 d	0.00 b	0.00 d	0.00 b
T_5	0.00 c	0.00 b	9.32 a	7.54 b	0.00 d	0.00 b	0.00 d	0.00 b
T_6	0.00 c	0.00 b	6.68 b	1.50 d	0.39 b	0.00 b	0.00 d	0.00 b
T_7	0.02 b	0.00 b	1.36 d	0.00 e	0.00 d	0.00 b	0.00 d	0.00 b
T_8	0.00 c	0.00 b	1.40 d	0.00 e	0.00 d	0.00 b	0.14 b	0.00 b
T_9	0.03 b	0.00 b	9.20 a	1.41 d	0.00 d	0.00 b	0.00 d	0.00 b
T_{10}	0.10a	3.40 a	9.81 a	8.20 a	0.68 a	3.30 a	1.05 a	1.50 a
LSD $_{(0.05)}$	**0.02**	**0.11**	**0.66**	**0.35**	**0.02**	**0.05**	**0.02**	**0.05**
CV (%)	**17.57**	**18.60**	**6.85**	**8.14**	**11.81**	**9.58**	**12.24**	**21.08**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.4 Effect of different herbicidal treatments on weed control efficiency (WCE) after 45 days of spray

Significant variation was found on weed control efficiency (%) due to application of different weed control treatments in the experimental plot. From Table 10, it was observed that 100% weed control efficiency was obtained from T_7 treatment for all kinds of weed species found in the experimental plot except *Marsilea quadrifolia* (98.33%), *Monochoria vaginalis* (80%) and *Leptochloa chinensis* (88.01%). Lowest weed control efficiency (0%) was found in control condition. In case of *Sagittaria guyanensis* 100% WCE was found in T_7 treatment that statistically similar with T_1, T_2, T_6 and T_8 treatments. Moderate efficiency obtained from T_4 and T_9. In case of *Cyperus difformis*, *Eclipta alba*, *Ludwigia hyssopifolia*, *Sphenoclea zeylanica*, *Alternanthera sessilis* and *Spilanthes acmella* maximum weed control efficiency (100%) were obtained from all treated plots except control condition. In case of *Marsilea quadrifolia* moderate efficiency was observed in T_7 treatment whereas similar result was obtained in T_5 and T_5. In case of *Xanthium indicum* T_3, T_2 and T_9 treatments showed moderate effect. Except the control plot maximum efficiency was found in all treated plots whereas T_4 and T_8 were second best. T_7 treatment along with T_2, T_3, T_8 and T_9 showed the best performance in case of *Cynodon dactylon* and minimum efficiency was observed in T_{10} treatment. For *Alternanthera philoxeroides* and *Monochoria vaginalis* moderate efficiency were observed at T_3, T_7 and T_9 treatments whereas it was zero in weedy check (T_{10}). In case of *Leptochloa chinensis* weed control efficiency was moderate at T_3, T_7 and T_8 treatments while T_2, T_7 and T_8 were most effective for controlling *Echinochloa crusgalli.* Except T_2 and T_6, all other treatments are performed well in case of *Lindernia procumbens.* Higher weed control efficiency was achieved by herbicidal mean than hand weeding. More weed control efficiency contributed to higher yield of rice crop supported by Kumaran *et al.* (2015).

Table 10. Effect of herbicides on the weed control efficiency (%) on rice field

Treatments	*Cyperus difformis*	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*
T_1	100.0 a	100.0 a	88.57 cd	100.0 a	100.0 a	100.0 a	88.09 b	95.65 a
T_2	100.0 a	100.0 a	92.61 a-c	100.0 a	100.0 a	100.0 a	100.0 a	78.26 b
T_3	100.0 a	37.61 c	83.80 d	100.0 a	100.0 a	100.0 a	100.0 a	51.08 c
T_4	100.0 a	63.76 b	83.30 d	100.0 a	100.0 a	95.45 b	88.83 b	100.0 a
T_5	100.0 a	100.0 a	96.90 a	100.0 a	100.0 a	100.0 a	84.52 b	100.0 a
T_6	100.0 a	100.0 a	90.60 bc	100.0 a	100.0 a	100.0 a	74.40 c	100.0 a
T_7	100.0 a	100.0 a	98.33 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
T_8	100.0 a	100.0 a	95.23 ab	100.0 a	100.0 a	27.27 c	100.0 a	96.73 a
T_9	100.0 a	62.38 b	87.85 cd	100.0 a	100.0 a	100.0 a	100.0 a	54.34 c
T_{10}	0.00 b	0.00 d	0.00 e	0.00 b	0.00 b	0.00 d	0.00 d	0.00 d
LSD $_{(0.05)}$	**0.02**	**2.35**	**5.87**	**0.02**	**0.02**	**2.74**	**4.64**	**4.53**
CV (%)	**0.00**	**1.79**	**4.19**	**0.00**	**0.00**	**1.94**	**3.24**	**3.41**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

Table 10. Continued

Treatments	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Lindernia procumbens*	*Spilanthes acmella*	*Fimbristylis miliaceae*	*Sphenoclea zeylanica*
T_1	100.0 a	100.0 a	61.04 b	83.90 b	100.0 a	100.0 a	100.0 a	100.0 a
T_2	100.0 a	100.0 a	36.48 c	100.0 a	67.64 b	100.0 a	100.0 a	100.0 a
T_3	70.00 c	100.0 a	86.69 a	67.07 c	100.0 a	100.0 a	91.42 b	100.0 a
T_4	100.0 a	100.0 a	30.96 d	69.51 c	100.0 a	100.0 a	100.0 a	100.0 a
T_5	100.0 a	100.0 a	8.08 e	8.04 d	100.0 a	100.0 a	100.0 a	100.0 a
T_6	100.0 a	100.0 a	34.12 cd	81.70 b	42.64 c	100.0 a	100.0 a	100.0 a
T_7	80.00 b	100.0 a	88.01 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
T_8	100.0 a	100.0 a	86.19 a	100.0 a	100.0 a	100.0 a	86.66 c	100.0 a
T_9	70.00 c	100.0 a	9.27 e	82.80 b	100.0 a	100.0 a	100.0 a	100.0 a
T_{10}	0.00 d	0.00 b	0.00 f	0.00 e	0.00 d	0.00 b	0.00 d	0.00 b
LSD $_{(0.05)}$	**4.14**	**0.02**	**3.30**	**4.20**	**2.02**	**0.02**	**2.50**	**0.02**
CV (%)	**2.95**	**0.00**	**4.37**	**3.53**	**1.46**	**0.00**	**1.66**	**0.00**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5 Crop characters, yield contributing characteristics and yield

Data on growth and yield contributing characters was affected by different weed control treatments have been presented below. It was observed that all of the crop characteristics i.e. plant height, total number of tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, number of total grains panicle^{-1}, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were affected significantly by the different herbicidal treatments.

4.5.1 Plant height (cm)

Plant height was significantly influenced by different herbicide treatments at 30 days after sowing (Table. 11). The highest plant height (49.46 cm) was obtained from T_7 treatment. The lowest plant height (34.73 cm) was obtained from control condition (T_{10}). Plant height was significantly influenced by different herbicidal treatments at 60 days after sowing. The highest plant height (105.60 cm) was obtained from T_7 treatment which was statistically similar with T_4 (102.4cm). The lowest plant height (90.32 cm) was obtained from control condition (T_{10}). Application of herbicide ensured extended period of weed free condition which facilitates more uptake of nutrient. Thus plant height enhanced positively that has similarity with the finding of Zannat (2014). Hasanuzzaman *et al*. (2008) reported that along with other yield contributing characters plant height significantly influenced by different herbicides. Tallest plants were found due to reduced rice weed competition that enhanced plant height.

Table 11: Effect of herbicides on the plant height (cm) at different days after sowing of rice

Treatments	Plant height(cm) at different days after sowing (DAS)	
	30 DAS	**60 DAS**
T_1	37.81 cd	92.20 bc
T_2	35.50 d	95.34 a-c
T_3	42.79 bc	98.43 a-c
T_4	43.65 b	102.4 ab
T_5	34.90 d	93.54 bc
T_6	40.31 b-d	97.45 a-c
T_7	49.46 a	105.6 a
T_8	42.04 bc	96.57 a-c
T_9	39.59 b-d	98.06 a-c
T_{10}	34.73 d	90.32 c
LSD $_{(0.05)}$	**5.59**	**11.44**
CV (%)	**8.13**	**6.88**

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.2 Total number of tillers hill^{-1}

Number of total tillers hill^{-1} was significantly influenced by application of different herbicides (Figure 1). The highest number of tillers (9.80) was obtained in T_7 treatment which was statistically similar with T_4 (9.4). The lowest number of tillers (6.46) was obtained in control plot (T_{10}). The massive weed infestations reduced the total no of tillers in those experimental plots. The similar result was found by Madhukumar *et al.* (2013) and reported that herbicidal treatment gave maximum number of tillers per hill.

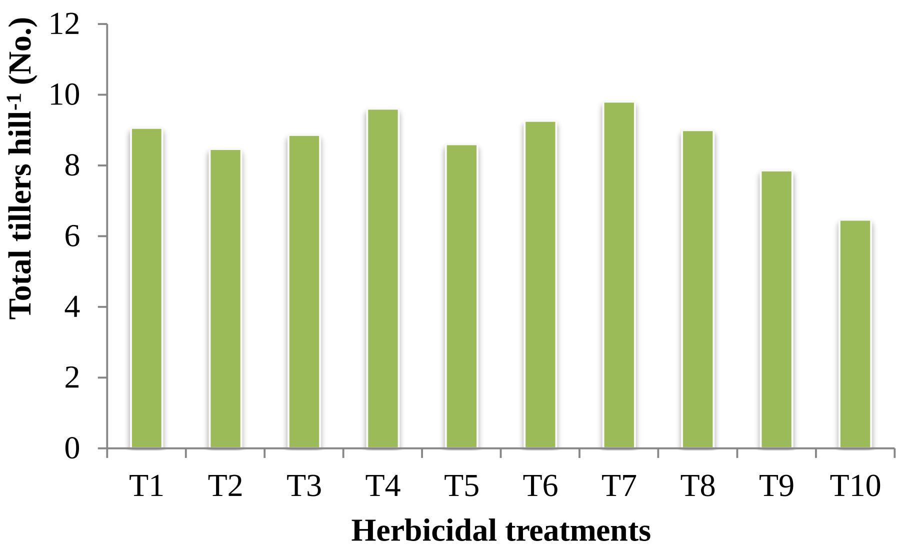

Figure 1. Effect of herbicides on the number of total tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 0.83)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.3 Number of effective tillers hill^{-1}

There was significant difference observed in number of effective tillers hill^{-1} by different weed control treatments (Figure 2). The highest number of effective tillers hill^{-1}(8.7) was obtained from T_7 treatment which was statistically identical with T_4 (7.93). The lowest one (5.11) was obtained in untreated plots (T_{10}). Herbicidal treatments reduced inter species competition between crops and weed thus increased efficient utilization of resources v*iz*. sunlight, nutrient, moisture and air to produce effective tillers. The contribution of weeding for maximum effective tillers hill^{-1} was strongly supported by Islam (2014), Hossain and Rahman (2013) and Rafiquddulla (1999). They reported that highest effective tillers hill^{-1} was observed under weed free condition.

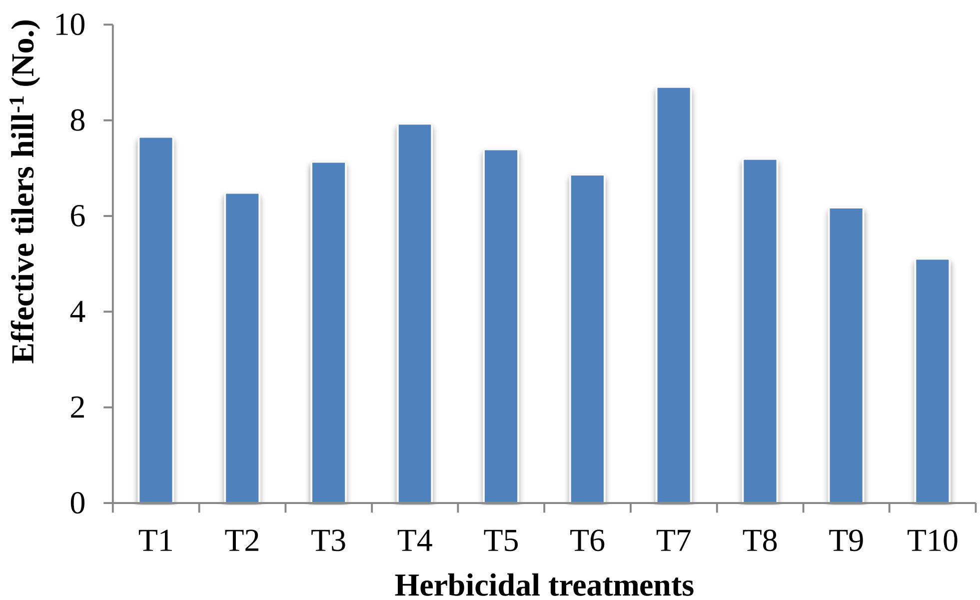

Figure 2. Effect of herbicides on the number of effective tillers hill^{-1} of rice ***(LSD $_{(0.05)}$ = 0.85)***

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

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

There was significant difference observed in number of non-effective tillers hill^{-1} by different weed control treatments (Figure 3). The highest number of non-effective tillers hill^{-1} (2.4) was obtained from T_6 treatment which was statistically identical with control plot T_{10} (2.35). The lowest one (1.10) was obtained in T_7 treatment which was statistically similar with T_4 (1.27), T_5(1.20) and T_9 (1.26) treatments.

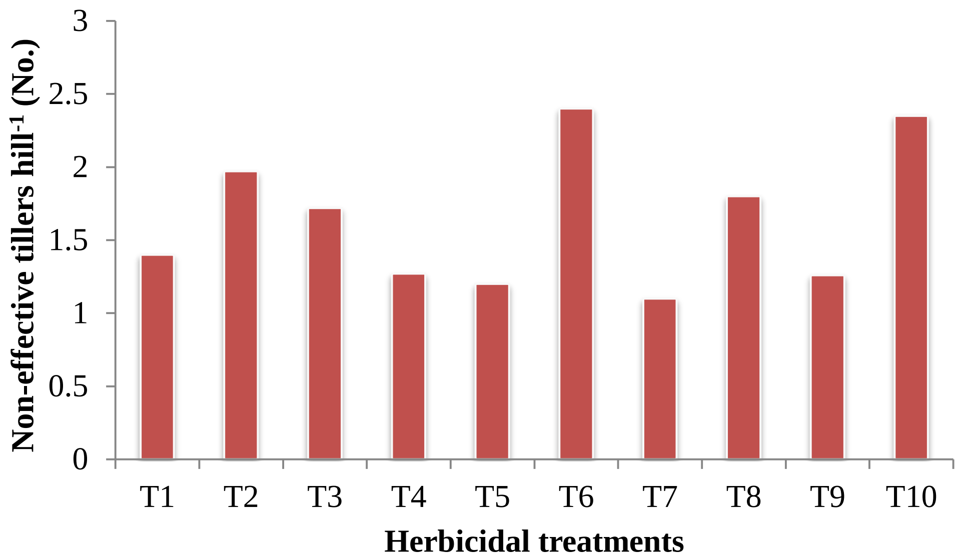

Figure 3. Effect of herbicides on the number of non-effective tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 0.23)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.5 Tiller length (cm)

Tiller length varied significantly with different herbicidal treatments (Figure 4). The highest tiller length (103.1cm) was found in T_7 treatment which was statistically similar with T_4 (99.27cm). The shortest tiller was obtained in control condition (88.28cm) which was statistically similar with T_1 treatment. Similar result was also found by Hossain and Rahman (2013).

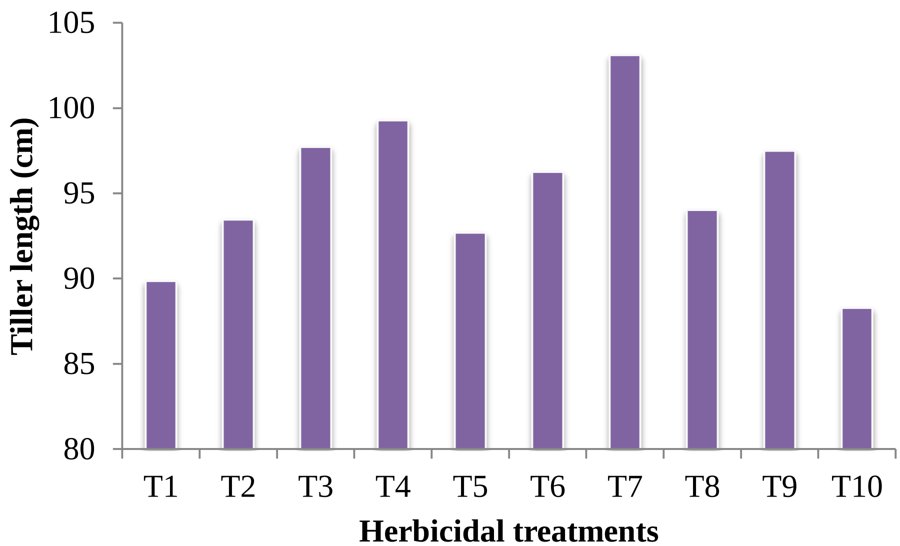

Figure 4. Effect of herbicides on the tiller length of rice (LSD $_{(0.05)}$ = 8.68)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.6 Panicle length (cm)

Length of panicle varied significantly with different herbicidal treatments (Figure 5). The highest length of panicle (24.13cm) was found in T_7 treatment which was statistically similar with T_4 (23.90cm). The second highest panicle length were found from T_5 (22.46cm), T_6 (22.30cm), T_8 (22.92cm) and T_9 (22.70cm) treatments. The shortest panicle (19.72cm) was obtained in control condition (T_{10}) which was statistically similar with T_1 (20.48cm) and T_3 (21.25cm) treatments. Rahaman and Rahman (2016) also observed that application of herbicide increased the length of panicle.

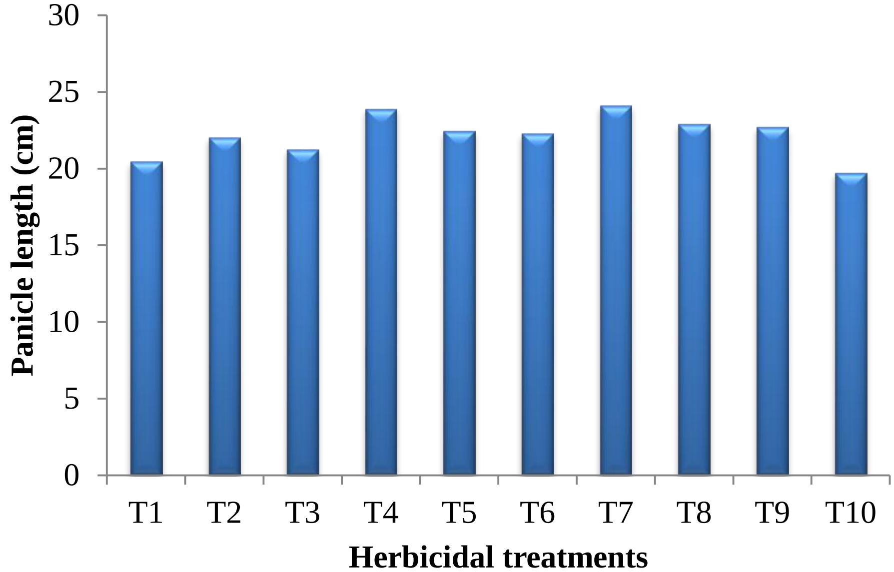

Figure 5. Effect of herbicides on the panicle length of rice (LSD $_{(0.05)}$ = 2.58)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.7 Number of primary branches panicle^{-1}

Significant variation was observed in primary branch panicle^{-1} due to application of different herbicidal treatments (Figure 6). Maximum number of primary branch panicle^{-1} (9.21) was found in T_7 treatment which was statistically similar with T_2 (9) and T_4 (9) treatments. Minimum numbers of primary branch (6.86) were found in untreated plot (T_{10}) which was identical with T_5 (7.33). Reduction of rice weed competition accelerate utilization of resources as moisture, light, nutrients etc. by rice plant that was reflected in maximum primary branches panicle^{-1}.The findings was also supported by Sing *et al.(*2006).

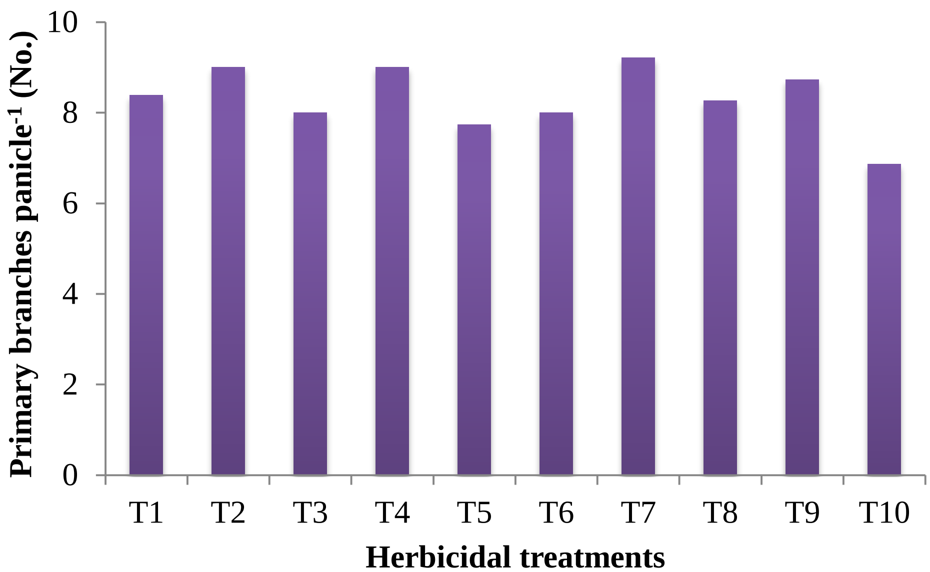

Figure 6. Effect of herbicides on the number of primary branches panicle^{-1} of rice (LSD $_{(0.05)}$ = 1.18)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.3. Number of secondary branches panicle^{-1}

Significant variation was observed in secondary branch panicle^{-1} due to application of different herbicidal treatments (Figure 7). Maximum number of secondary branch (23.22) was found in T_7 treatment which was statistically similar with all treatments except T_1 and T_{10}. Minimum number of secondary branch per panicle (17.88) was found in control plot (T_{10}) which was identical with T_1 (17.75). Higher interaction of weeds reduced the number of secondary branches in weedy check plots.

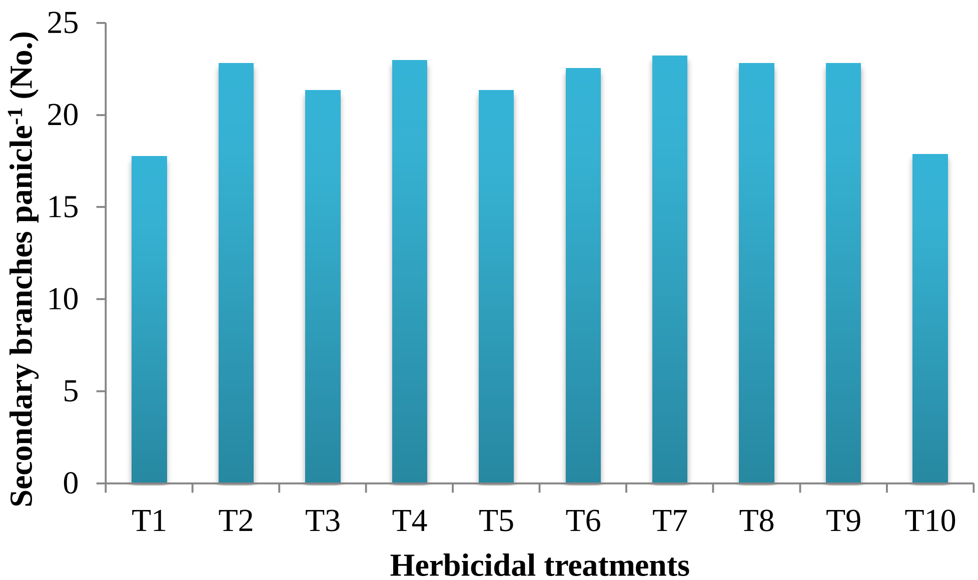

Figure 7. Effect of herbicides on the number of secondary branches panicle^{-1} of rice (LSD $_{(0.05)}$ = 2.39)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.8 Total number of grains panicle^{-1}

Number of grains panicle^{-1} is an important yield contributing character of rice. Number of total grains panicle^{-1} was significantly influenced by application of different herbicides (Figure 8). The highest number of grains (125) was obtained in T_7 treatment which was identical with T_4 (119) treatment. The lowest number of grains (86) was obtained in weedy check (T_{10}) which was similar with T_1 (90.6). Herbicide provided an excellent weed control and uptake of nutrient, increase yield contributing characters like total number of grains. Similar statement was provided by Mukherjee (2006).

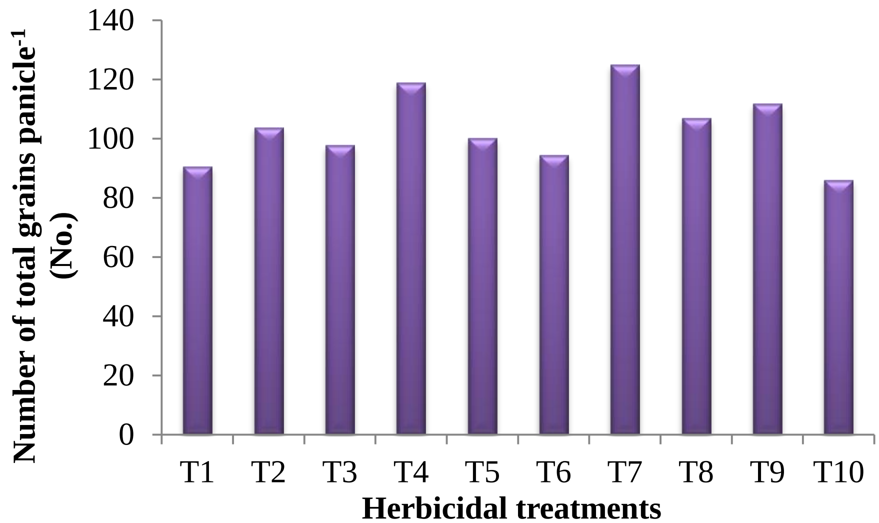

Figure 8. Effect of herbicides on the number of total grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 10.99)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.9 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} was significantly influenced by application of different herbicides (Figure 9). The highest number of filled grains (116.5) was obtained in T_7 treatment which was similar with T_4 (112). The lowest number of grains (81.47) was obtained in control plot T_{10} which was similar with T_1 (83.47), T_5 (93) and T_6 (88.2) treatments. Utilization of nutrient and sunlight facilitate more filled grains production in rice plant. This might be possible under weed free condition. Similar result was reported by Islam (2014). Application of herbicide increasing the number of filled grains panicle^{-1} corroborates with the findings of Hasanuzzaman *et al.* (2008).

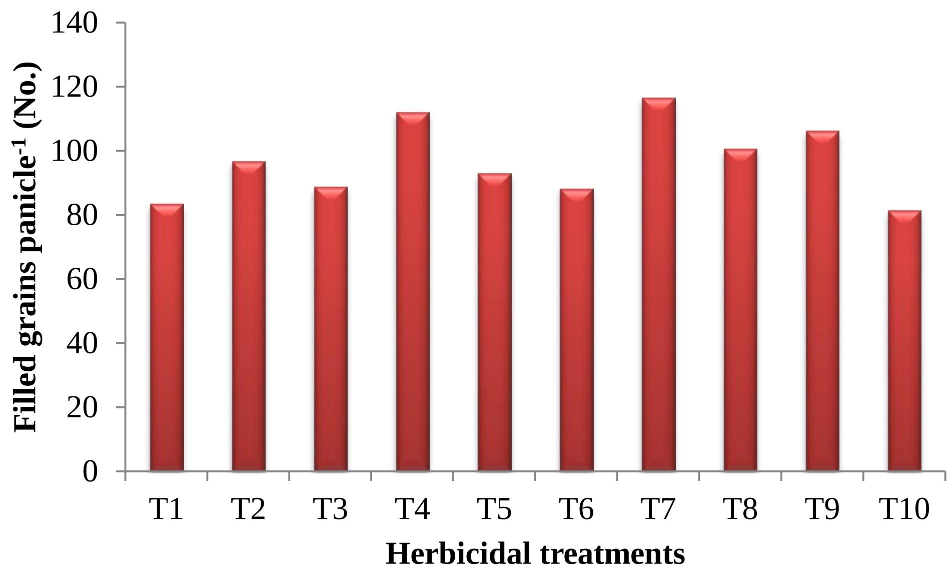

Figure 9. Effect of herbicides on the number of filled grain panicle^{-1} of rice (LSD $_{(0.05)}$ = 13.14)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.10 Number of unfilled grains panicle^{-1}

Number of total unfilled grains panicle^{-1} was significantly influenced by application of different herbicides (Figure 10). The highest number of unfilled grain (9) was obtained in T_3 treatment which was similar with T_7 (8.46). The lowest number of unfilled grains (4.53) was obtained in weedy check plots (T_{10}). Massive weed infestation increased competition with rice thus increases the number of unfilled grains. Environmental factors also responsible to sterile grains in panicles. Rafiquddualla (1999) found that maximum sterile grains per panicle were found from the no weeding regimes.

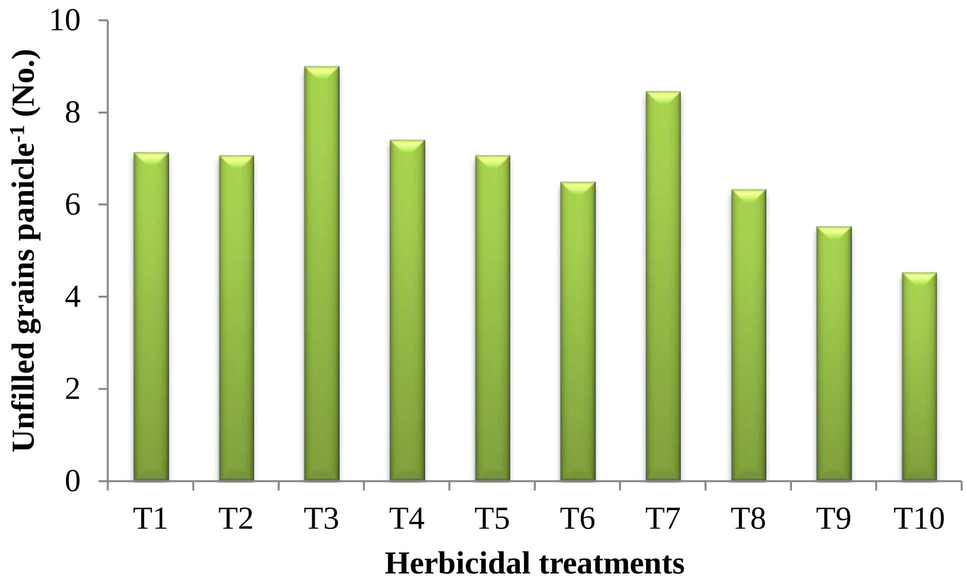

Figure 10. Effect of herbicides on the number of unfilled grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 0.83)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.11 1000- grain weight (g)

Significant variation was observed on 1000 grain weight due to application of different herbicidal treatments (Figure 11). The highest 1000 grain weight (26 g) was found in T_7 treatment which was statistically similar with all treatments except T_5 and T_{10}. The lowest 1000-grain weight (22.67 g) was found in control plot (T_{10}) which was similar with T_5 (23.33g). Khan (2013) found that the weeding regime had significant effect on all the parameters except 1000-grain weight while Zannat (2014) observed that 1000 grain weight was significantly influenced by no weeding regime.

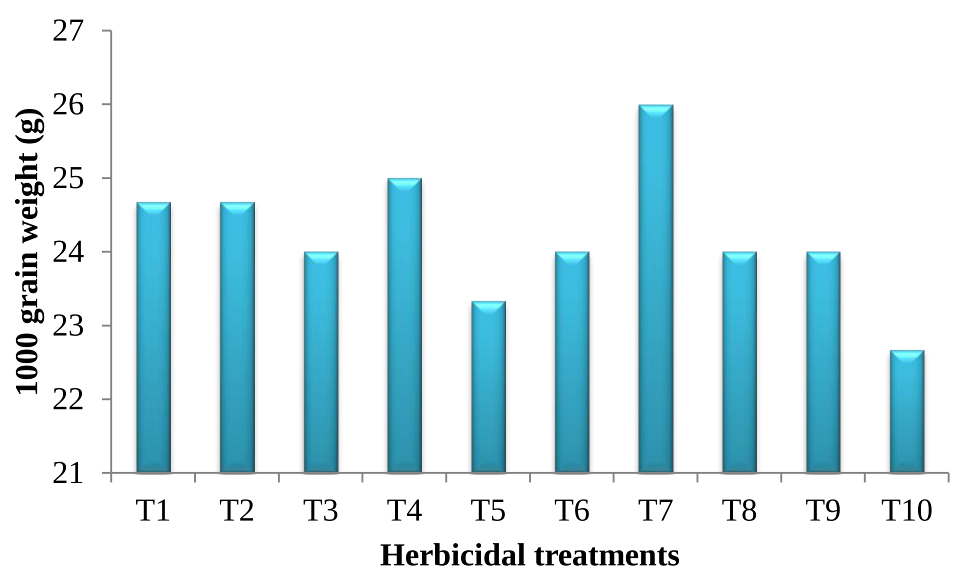

Figure 11. Effect of herbicides on the 1000 grain weight of rice (LSD $_{(0.05)}$ = 2.50)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

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

Significant variation was observed on grain yield due to application different herbicidal treatments (Figure 12). The highest grain yield (3.75 t ha^{-1}) was found in T_7 treatment which was statistically similar with T_4 (3.54 t ha^{-1}). Lowest grain yield (1.805 t ha^{-1}) was found in weedy check plot (T_{10}). Manzoor *et al.* (2014) observed that maximum reduction in grain yield was recorded in unweeded condition. Reduction of weed growth were correlated with increased yield of rice. Herbicidal treatment suppressed weed vegetation and contributed to highest yield under weed free condition. These results were corroborates with the findings of Hossain and Rahman (2013), Hashem (2014), Madhukumar *et al.* (2013), Saha (2005) and Halder *et al.*, (2005).

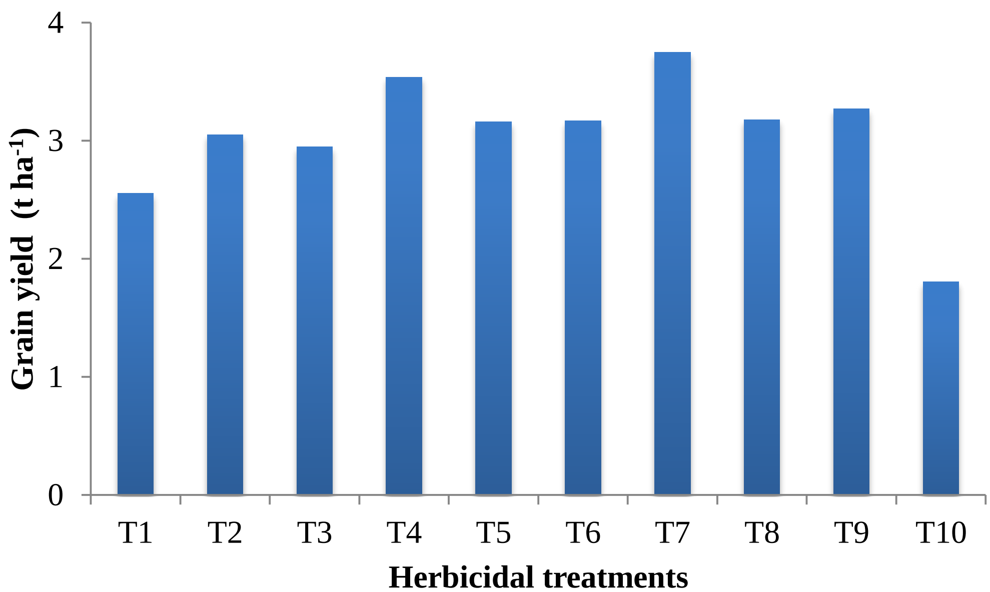

Figure 12. Effect of herbicides on the grain yield of rice (LSD $_{(0.05)}$ = 0.38)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml +3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

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

Significant variation was observed on straw yield due to application of different herbicidal treatments (Figure 13). The highest straw yield (4.737 t ha^{-1}) was found in T_7 treatment which was statistically similar with all treatments except T_1 and T_9. Lowest straw yield (2.983 t ha^{-1}) was found in control plot (T_{10}) that was similar with T_1 (3.547 t ha^{-1}). Maximum straw was obtained by different herbicidal treatments whereas plant height and total number of tillers were highest under weed free condition. The result was similar with the report of Bhimwal and Pandey, (2014).

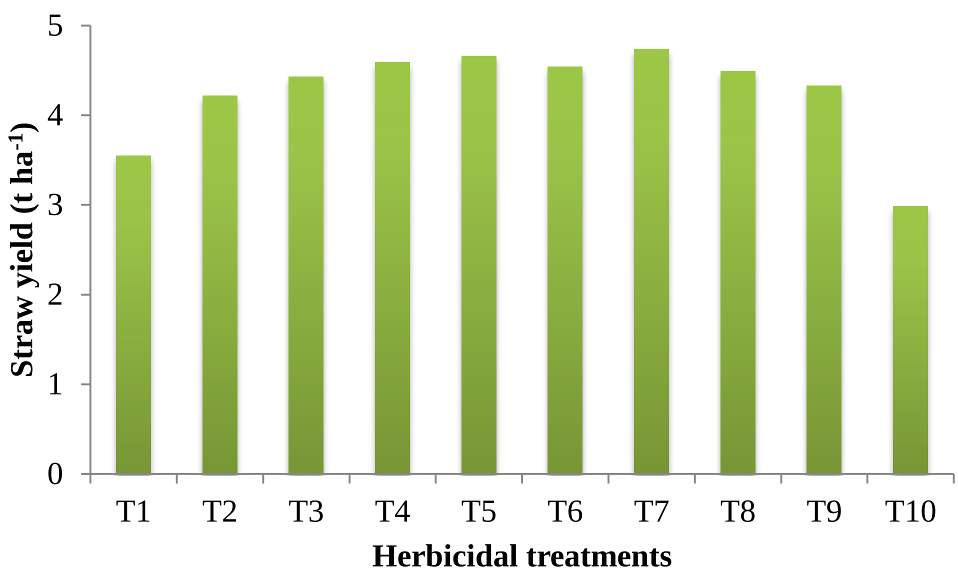

Figure 13. Effect of herbicides on the straw yield of rice (LSD $_{(0.05)}$ = 0.58)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha and T_{10}: Weedy check (Control)

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

Significant variation was observed on biological yield due to application different of herbicidal treatments (Figure 14). The highest biological yield (8.487 t ha^{-1}) was found in T_7 treatment which was statistically similar with T_4 (8.13t ha^{-1}). The lowest biological yield (4.69 t ha^{-1}) was found in control condition (T_{10}). Biological yield depended on straw yield and grain yield. Better weed management resulted highest grain and straw yield that ultimately influenced maximum biological yield.

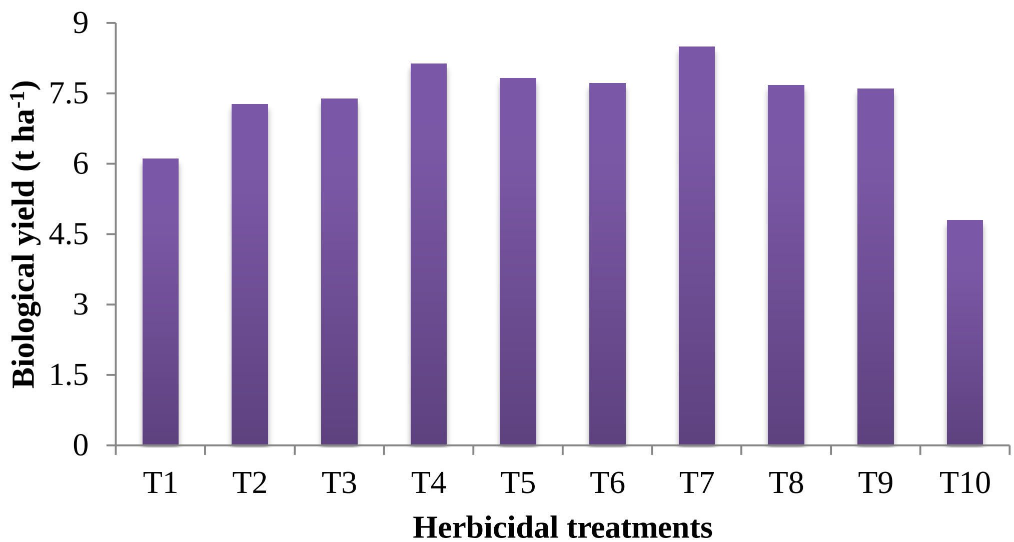

Figure 14. Effect of herbicides on the biological yield of rice (LSD $_{(0.05)}$ = 0.73)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

4.5.15 Harvest index (%)

Significant variation was observed in harvest index due to application of different herbicidal treatments (Figure 15). The highest harvest index (44.23%) was found in T_7 treatment which was statistically similar to T_4 (43.54%) and T_9 (43.02%). The lowest harvest index (37.89%) was found in untreated plots (T_{10}). Under different herbicidal treatments, maximum grain yield was obtained that contributes to the highest harvest index. Similar result was found by Islam (2014).

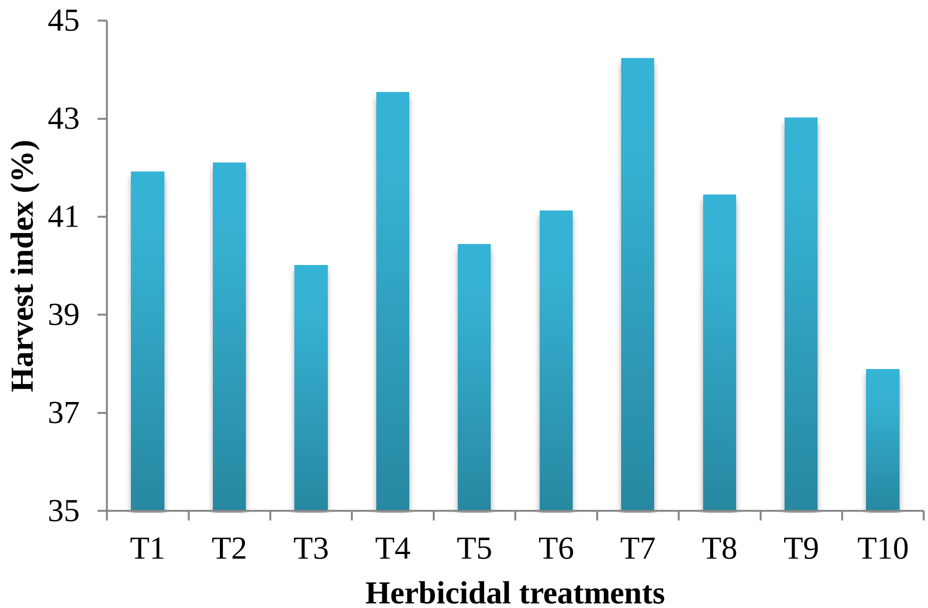

Figure 15. Effect of herbicides on the harvest index of rice (LSD $_{(0.05)}$ = 4.41)

T_1: Propyrisulfuran@500 ml ha^{-1}, T_2: Propyrisulfuran @ 750 ml ha^{-1}, T_3: Propanil @3750 g ha^{-1}, T_4: Propyrisulfuran+ Propanil @(500ml+3750 g) ha^{-1}, T_5: Propyrisulfuran+ Propanil @ (500 ml +2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @(750 ml + 3750 g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125 g) ha^{-1} , T_8: Propyrisulfuran+ Propanil @(750ml + 2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control)

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted in the agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka, during the period from April to August, 2015 to evaluate the herbicidal efficacy and residual activity on broadcast aus rice (BRRI dhan48). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment comprised ten treatments *viz.*T_1: Propyrisulfuran @ 500 ml ha^{-1},T_2: Propyrisulfuran @ 750 ml ha^{-1},T_3: Propanil @ 3750ml ha^{-1}, T_4: Propyrisulfuran+ Propanil @ (500ml+3750g) ha^{-1}, T_5: Propyrisulfuran + Propanil @ (500 ml + 2500 g) ha^{-1}, T_6: Propyrisulfuran + Propanil @ (750ml + 3750g) ha^{-1}, T_7: Propyrisulfuran + Propanil @ (750ml + 3125g) ha^{-1},T_8: Propyrisulfuran + Propanil (750ml+2500g) ha^{-1}, T_9: Bispyribac Sodium @150 g ha^{-1} and T_{10}: Weedy check (Control).

There were 16 weed species found in the experimental plots which belong to nine families. There were 4 species *Echinochloa crusgalli, Cynodon dactylon, Leptochloa chinensis*, *Ludwigia hyssopifolia* comprised Poaceae family. *Alternanthera sessilis* and *Alternanthera philoxeroides* belongs to Amaranthaceae ; *Xanthium indicum* , *Eclipta alba* and *Spilanthes acmella* belongs to Compositae ;*Cyperus difformis* and *Fimbristylis miliaceae* belongs to Cyperaceae ; *Monochoria vaginalis* belongs to Pontederiaceae ; *Sagittaria guyanensis* belongs to Genetiaceae ; *Sphenoclea zeylanica* belongs to Sphenocleaceae; *Marsilea quadrifolia* belongs to Marsiliaceae and *Lindernia procumbens* belongs to Scrophulariaceae . Among the infested species *Cyperus difformis* and *Marsilea quadrifolia* were most dominating in all experimental plots.

Data on different weed parameters and crop parameters of growth and yield was recorded to find out the appropriate herbicide which can control the most of the weed species of aus rice.The data of weed infestation were collected at 3 days before spray, 7, 14, 21, 28 and 45 days after spray (DAS). Weed parameters such as weed population (no. m^{-2}), weed dry weight (g m^{-2}) and weed control efficiency (%) were recorded. Crop characters such as plant height (cm) at 30 and 60 days after sowing , total number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, number of sterile grains $panicle^{-1}$, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were recorded. Data were analyzed using the Analysis of variance technique and mean differences were adjudged by Duncan Multiple Range Test (DMRT).

Different herbicidal treatments significantly influenced the weed population, dry weight of weeds and weed control efficiency. The maximum weed population, dry weight of weeds and minimum weed control efficiency were observed in the control condition. The least weed population, weed dry weight and the highest weed control efficiency were observed in the plot with application of Propyrisulfuran + Propanil (750ml+3125g) ha^{-1}.

Different herbicidal treatments significantly influenced all yield contributing characters. Among all treatments Propyrisulfuran + Propanil (750ml+3125g) ha^{-1} gave the tallest plants (49.46 cm) at 30 days and (105.6cm) at 60 days after sowing, the highest tiller length (103.1 cm) , the highest number of tiller $hill^{-1}$ (9.8) , the highest number of effective tiller $hill^{-1}$(8.7) , the highest panicle length (24.13cm) , maximum number of primary branch (9.217) and secondary branch (23.22) $panicle^{-1}$, the highest number of grains $panicle^{-1}$(125) , the highest number of filled grains $panicle^{-1}$ (116.5) and 1000-grain weight (26 g) . The highest grain yield (3.75 t ha^{-1}) and straw yield (4.73 t ha^{-1}) were recorded from Propyrisulfuran + Propanil (750ml+3125g) ha^{-1}. T_7 treatment gave statistically identical effect on biological yield (8.48 t ha^{-1}) and harvest index (44.23%). The lowest grain yield

(1.80 t ha^{-1}) and straw yield (2.98 t ha^{-1}) were recorded from untreated control condition (T_{10}). Maximum yield loss was observed in untreated control condition over T_7. Propyrisulfuran + Propanil (500ml+3750g) ha^{-1} also showed better performance in respect of weed control and growth and yield of the crop. In a crop production system, appropriate weed management maximize the use of resources thus increase the production efficiency. From the above study, it can be concluded that Propyrisulfuran + Propanil (750ml+3125g) ha^{-1} showed the best performance in controlling weed population and also gave the highest yield of BRRI dhan48. So Propyrisulfuran + Propanil (750ml+3125g) ha^{-1} might be suggested for controlling weeds in broadcast aus rice (BRRI dhan48).

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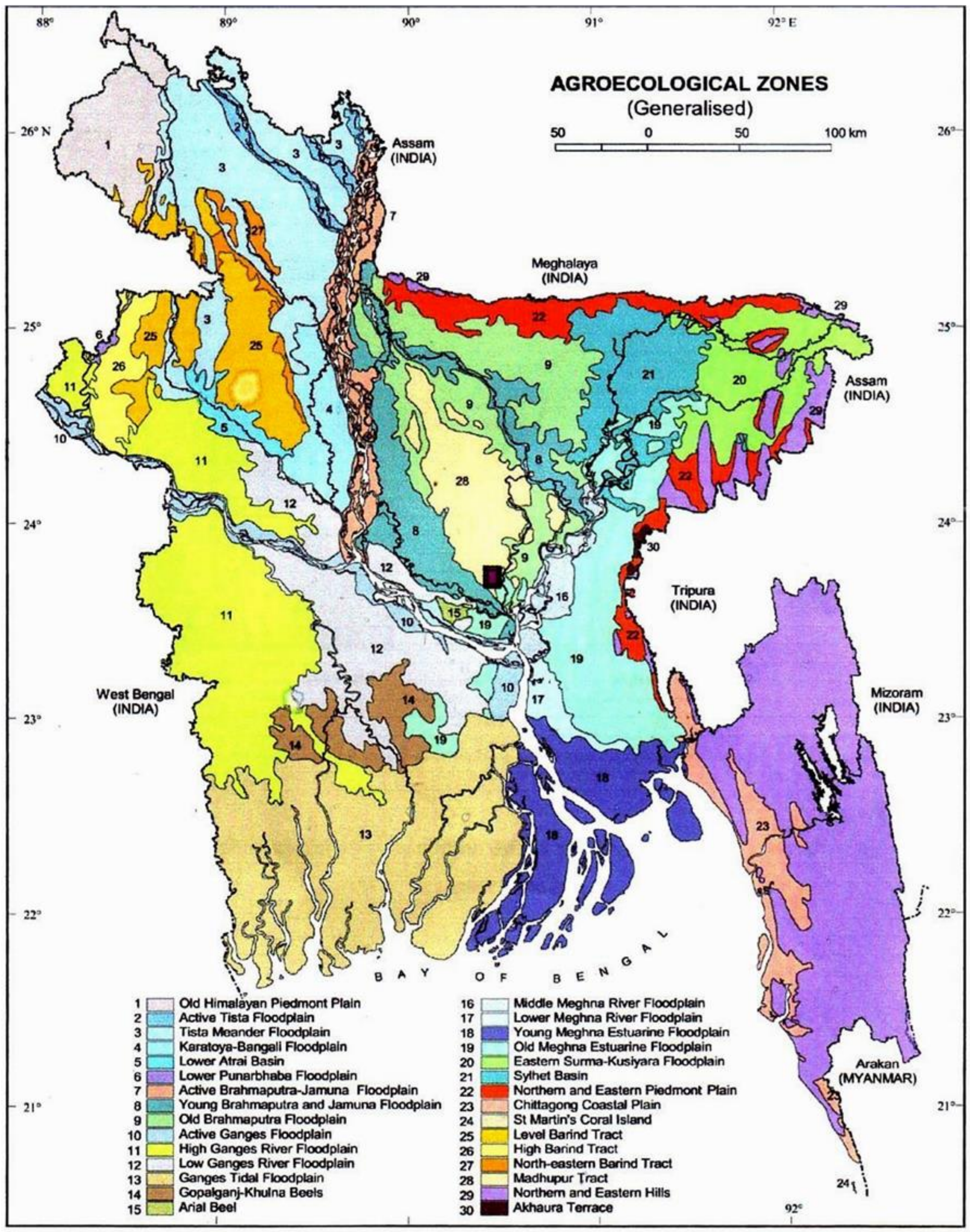
APPENDICES

Appendix I. Photograph showing location of experimental site.



Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period of April to August, 2015

Month	Air temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
April, 2015	39.4	19.4	80.2	39.2	65.60
May, 2015	38.2	19.3	89.2	40	202
June, 2015	37.2	17.4	88.4	46.3	282.7
July, 2015	35.6	18.2	88.2	55.4	107.8
August, 2015	33.2	23.2	76.30	66	105.6

Source: Sher-e-Bangla Agricultural University mini weather station.

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

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

Source: SRDI (Soil Resources Development Institute), Farmgate, Dhaka

Appendix IV. Analysis of variance of the data for weed population (no. m^{-2}) at 3 days before spray

Source of variation	df	Mean square of number of specific weeds 3 days before spray													
		Cyperus difformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	361.43	1.53	0.78	0.12	0.05	0.03	0.001	0.02	0.006	0.005	0.014	0.009	0.006	0.006
Herbicide	9	13421.85*	30.86*	5.99*	63.56*	92.26*	1.85*	0.16*	1.12*	0.24*	1.65*	5.06*	1.26*	0.29*	0.89*
Error	18	382.40	0.52	0.29	0.25	0.21	0.01	0.001	0.007	0.001	0.007	1.649	0.006	0.001	0.003

*Significant at 5% level of significance

NS Non significant

Appendix V . Analysis of variance of the data for weed population (no. m^{-2}) at 7 days after spray

Source of variation	df	Mean square of number of specific weeds 7 days after spray													
		Cyperus difformis	*Sagittaria guyanensis*	*Marsilea quadrifolia*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	629.808	0.181	0.229	0.004	0.027	0.002	0.002	0.001	0.004	0.001	0.023	0.00	0.001	0.003
Herbicide	9	73864.02*	18.045*	139.263*	0.909*	19.356*	0.744*	0.503*	1.650*	0.236*	3.200*	4.91*	1.22*	0.17*	0.82*
Error	18	293.340	0.23	0.61	0.004	0.02	0.005	0.002	0.002	0.001	0.01	0.02	0.003	0.002	0.001

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data for weed population (no. m^{-2}) at 14 days after spray

Source of variation	df	Mean square of number of specific weeds 14 days before spray													
		Cyperus difformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	115.9	0.20	0.15	0.002	0.119	0.0	0.001	0.0	0.00	0.007	0.11	0.001	0.00	0.00
Herbicide	9	18055.69*	27.62*	70.35*	0.52*	69.31*	0.38*	0.37*	0.24*	0.24*	3.2*	4.4*	1.18*	0.15*	0.16*
Error	18	44.12	0.15	0.15	0.001	0.12	0.002	0.00	0.00	0.00	0.009	0.016	0.001	0.00	0.00

*Significant at 5% level of significance

NS Non significant

Appendix VII. Analysis of variance of the data for weed population (no. m^{-2}) at 21 days after spray

Source of variation	df	Mean square of number of specific weeds 21 days before spray													
		Cyperus diformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	1.3	0.15	0.24	0.00	0.26	0.001	0.003	0.008	0.00	0.007	0.002	0.00	0.00	0.00
Herbicide	9	2218.8*	74.34*	145.22*	0.53*	45.64*	0.38*	0.33*	1.15*	1.45*	3.2*	32.17*	1.15*	0.84*	0.16*
Error	18	1.3	0.05	0.24	0.001	0.26	0.001	0.001	0.004	0.001	0.009	0.17	0.001	0.00	0.00

*Significant at 5% level of significance

[NS] Non significant

Appendix VIII. Analysis of variance of the data for weed population (no. m^{-2}) at 28 days after spray

Source of variation	df	Mean square of number of specific weeds 28 days before spray													
		Cyperus diformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	0.064	0.03	0.21	0.00	0.006	0.0	0.004	0.003	0.015	0.004	0.003	0.00	0.001	0.03
Herbicide	9	30.0*	33.49*	55.61*	0.61*	7.50*	0.49*	2.01*	2.46*	2.14*	2.16*	2.85*	1.26*	1.96*	40.84*
Error	18	0.064	0.037	0.15	0.00	0.006	0.001	0.002	0.004	0.007	0.004	0.013	0.002	0.003	0.003

*Significant at 5% level of significance

^{NS} Non significant

Appendix IX. Analysis of variance of the data for weed population (no. m^{-2}) at 45 days after spray

Source of variation	df	Mean square of number of specific weeds 45 days after spray													
		Cyperus diformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	0.064	0.03	0.21	0.00	0.006	0.0	0.004	0.003	0.015	0.004	0.003	0.00	0.001	0.03
Herbicide	9	30.0*	33.49*	55.61*	0.61*	7.50*	0.49*	2.01*	2.46*	2.14*	2.16*	2.85*	1.26*	1.96*	40.84*
Error	18	0.064	0.037	0.15	0.00	0.006	0.001	0.002	0.004	0.007	0.004	0.013	0.002	0.003	0.003

*Significant at 5% level of significance

^{NS} Non significant

Appendix X. Analysis of variance of the data for dry weight (g) of specific weeds

Source of variation	df	Mean square of number of specific weed dry weight 45 days after spray													
		Cyperus difformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	0.00	0.007	0.002	0.00	0.003	0.00	0.003	0.001	0.00	0.004	0.114	0.022	0.001	0.001
Herbicide	9	0.031*	1.74*	4.62*	0.009*	5.21*	0.11*	0.79*	0.281*	0.003*	3.46*	34.99*	26.75*	3.26*	0.675*
Error	18	0.00	0.003	0.001	0.00	0.003	0.00	0.003	0.001	0.00	0.004	0.15	0.042	0.001	0.001

*Significant at 5% level of significance

^{NS} Non significant

Appendix XI. Analysis of variance of the data for weed control efficiency (%)

Source of variation	df	Mean square of weed control efficiency 45 days after spray													
		Cyperus difformis	*Sagittaria guyanensis*	*Marsilea quadrifoli*	*Alternanthera sessilis*	*Eclipta alba*	*Alternanthera philoxeroides*	*Cynodon dactylon*	*Xanthium indicum*	*Ludwigia hyssopifolia*	*Monochoria vaginalis*	*Leptochloa chinensis*	*Echinochloa crusgalli*	*Spilanthes acmella*	*Sphenoclea zeylanica*
Replication	2	0.00	0.41	45.51	0.00	0.006	0.00	0.795	36.44	3.97	22.5	0.00	38.12	0.00	0.00
Herbicide	9	3000.0*	3679.91*	2551.93*	3000.*	7.50*	3000.0*	4055.85*	2822*	3321.78*	2986.67*	3000*	3528.84*	3000*	3000*
Error	18	0.00	1.87	11.71	0.00	0.006	0.00	2.54	7.32	6.98	5.83	0.00	3.71	0.00	0.00

*Significant at 5% level of significance

^{NS} Non significant

Appendix XII. Analysis of variance of the data for yield and yield contributing characters of rice

Source of variation	**df**	Plant height at 30 days	Plant height at 60 days	No. of effective tillers $hill^{-1}$	No. of non effective tillers $hill^{-1}$	Total no. of tillers $hill^{-1}$	Tiller length	Panicle length	No. of primary branches $panicle^{-1}$	No. of secondary branches $panicle^{-1}$
Replication	2	10.33	140.86	0.031	0.02	0.005	14.73	5.74	0.11	0.094
Herbicide	9	64.63*	63.23*	2.96*	0.68*	2.79*	59.61*	5.83*	1.52*	12.81*
Error	18	10.62	44.503	0.24	0.01	0.23	25.58	2.26	0.47	1.94

*Significant at 5% level of significance

^{NS} Non significant

Appendix XIII. Analysis of variance of the data for yield and yield contributing characters of rice

Source of variation	**df**	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Total no. of grains panicle^{-1}	1000 grain weight (g)	Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	12.61	0.32	52.28	5.24	0.012	0.18	0.14	9.91
Herbicide	9	429.38*	5.05*	460.9*	2.51*	0.874*	0.93*	3.5*	10.32*
Error	18	58.67	0.23	41.06	2.11	0.05	0.11	0.179	6.61

*Significant at 5% level of significance

^{NS} Non significant