EFFICACY AND RESIDUAL ACTIVITY OF HERBICIDE ON GROWTH AND YIELD OF TRANSPLANTED *AUS* RICE

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CERTIFICATE

This is to certify that the thesis entitled " ***EFFICACY AND RESIDUAL ACTIVITY OF HERBICIDE ON GROWTH AND YIELD OF TRANSPLANTED AUS RICE"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. HASENUR HOSSAIN,*** *Registration. No.* **08-02917** *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:

Dhaka, Bangladesh

(Prof. Dr. Md. Abdullahil Baque)
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Dedicated To

My

Respectable

Parents

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ABSTRACT

A field experiment was carried out at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, during April to August, 2014 in order to study the efficacy of herbicides to control weeds and its residual activity on growth and yield of transplanted *aus* rice, (Nerica). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications that consisted of 13 treatments viz. T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14 % +Bensulfuron-methene 4% @ 742 g ha^{-1}) and T_{13} (Weedy check). Nineteen different weed species infested the field among which *Marsilea quadrifolia* and *Cyperus difformis* were dominanted throughout the growing period (45.25 % and 48.51 %, 42.24 % and 40.67 %, 47.06 % and 38.91%, 56.04 % and 32.59 %, 56.25 % and 32.45%, 57.83 % and 31.21 % at before 3 days of spray, 7, 14, 21, 28 and 45 days of spray, respectively). Results revealed that treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}) recorded the lowest weed population after 7, 14, 21, 28 and 45 DASP (days after spraying) while the highest weed population was recorded from the control treatment T_{13}. The maximum tiller length (107.3 cm), total number of tillers $hill^{-1}$ (13.67), effective tillers $hill^{-1}$ (11.33), total number of grains $panicle^{-1}$ (69.0), filled grains $panicle^{-1}$ (64.33), 1000 grain weight (24.33 g), grain yield (3.81 t ha^{-1}), straw yield (4.25 t ha^{-1}) and biological yield (8.06 t ha^{-1}) was recorded from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}) whereas, T_{13} (Weedy check) recorded the lowest values in all cases except no. of non-effective tillers $hill^{-1}$ and no. of sterile grains $panicle^{-1}$. Considering rapid and residual activity as well as selectivity which is a common desire of the farmers, it appeared from the above results that treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}) performed better than other herbicidal treatments.

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agriculture Information Service
BARC	=	Bangladesh Agricultural Research Council
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
CV %	=	Percentage of Coefficient of Variance
cv.	=	Cultivar
DAT	=	Days after transplanting
DASP	=	Days after spraying
^{0} C	=	Degree Centigrade
df	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
g	=	Gram
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local variety
LSD	=	Least significant difference
m	=	Meter
m^2	=	meter squares
ml	=	milliliter
mm	=	Millimeter
MV	=	Modern variety
NS	=	Non significant
%	=	Percent
SAU	=	Sher-e- Bangla Agricultural University
t ha^{-1}	=	Tons per hectare
viz.	=	namely

INTRODUCION

Rice (*Oryza sativa L.*) is one of the most important staple foods for more than half of the world's population (IRRI, 2006) and influences the livelihoods and economies of several billion people (FAO, 2004). Still more than 90% of this rice is consumed in Asia, and their primary food security is entirely dependent on the volume of rice production of the world (Chowdhury, 2012) where it is a staple food for a majority of the population including 560 million hungry people (Mohanty, 2013). Rice production needs to be increased by 50% or more above the current production level to meet the rising food demand (Sunyob *et al.,* 2015).

Bangladesh is predominantly an agrarian based economic country since agriculture comprises about 20% of the country's gross domestic product (GDP) and employs around 45% of the labor force (Mondal, 2013). The people of Bangladesh completely dependent on rice as a staple food and have remarkable influence on the economy of Bangladesh. The average yield of rice is 4.34 t ha^{-1} in Bangladesh (BRRI, 2011) which is almost less than 50% of the world average rice grain yield (Sharmin, 2014). In Bangladesh, more than four thousand landraces of rice are adopted in different parts of this country and most of these are unique for quality traits including fineness, taste, aroma and protein contents (Chowdhury, 2012). But most high quality cultivars are low yielding (Shakeel *et al.,* 2005). The population of Bangladesh became almost double over last three decade from 72 million in 1972 to 140 million in 2005 with an average increase by over 2 million per year and to feed the increased population in 2020, about 32,800 thousand metric tons of rice will be needed to produce in the country (MoA, 2007). The present population of Bangladesh is about 149.69 million with growth rate of 1.26%, the population will be 189.85 million within 2030. The estimated requirement especially rice would be 43.6 million metric tons (mmt) (Mondal, 2014). In Bangladesh, rice stands fourth position in both rice area and production among the rice producing countries and extensively grown under three distinct seasons namely *aus*, *aman* and *boro* in irrigated, rainfed and deep water conditions. The area, production and average yield of rice in our country in 2014 are 11.82 million hectares, 52.23 million tons and 4.42 t ha^{-1}, respectively (FAOSTAT, 2014).

A weed is an unwanted plant which introduce in cultivated fields, is also the important yield limiting factor of crops including rice plants (Ahmed and Shaikh, 2003). Weed competes for nutrient, space, sunlight and consumes the available moisture with crop plant resulting in crop yield reduction (Sunyob *et al.*, 2015). Weeds are the most competitors in their early growth stages than the later and hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). It is often said, "Crop production is a fight against weeds" (Mukhopadhyay and Ghosh, 1981). The prevailing climatic and soil conditions are highly suitable for luxuriant growth of numerous species of weeds which offer a keen competition with rice crop (Sharmin, 2014). In a rice field, variety of weeds grown are generally categorized into three groups namely, grasses, sedges and broadleaf weeds according to their morphological character (Chowdhury, 2012). Due to this huge yield losses weed is considering a major threat for sustainable crop production (Islam *et al*., 2010). About 33% of yield losses are caused due to weeds alone (Rahman *et al*., 2014). Weeds in tropical zones cause yield loss on rice of about 35% (Oerke and Dehne, 2004). Normally the loss in rice yield ranges between 15-20% yet in severe cases the yield losses can be more than 50% depending upon the species and intensity of weeds (BRRI, 2006). Studying competition between weeds and crops can help many societies reach their goals of increased food production (Ehteshami and Esfehani, 2005). So, proper weed management is essential for crop production.

Weed management practice is the most ancient part of crop cultivation and become more constraint to agricultural productivity and environmental concern (Upadhayaya and Blackshaw, 2007). The common practice of weed control in rice field is hand pulling which makes the practice to be labor intensive and many a times not satisfactorily. As a result, yields in farmers' fields are lower than the well managed researcher's fields. Herbicides are now the common means of weed control in most of the crop and especially for rice (Bhuiyan *et al.*, 2013 and 2014).

In Bangladesh, weeds are generally controlled by raking and nirani (hand weeding) and weeding and thinning operations involved about 50% or more of the labor cost (Ali *et al.*, 2012). Hand weeding is highly labor-intensive (as much as 190 person days ha^{-1}) (Roder, 2001). Due to high wages as well as unavailability of labor during peak season, hand weeding is not an economically viable option for the farmers. Weed control in transplant *aman* rice by mechanical and cultural methods is expensive (Mitra *et al.,* 2005).

In contrast, chemical weed control is easier and cheaper (Phuong *et al.,* 2005). Consequently, herbicide could be an excellent alternative and the use of pre and post emergence herbicide is vital for effective and cost efficient weed control technique to reduce weed infestation in rice field (Bhuiyan *et al.,* 2010). Though chemical weed management is in the infancy stage in Bangladesh but day by day this method is becoming popular among the farmers because it is the most efficient means of reducing weed competition with minimum labor cost (Baloch *et al.,* 2006) for most of the crops especially for rice (Bhuiyan *et al.*, 2013 and 2014). Now in Bangladesh there existing 78 registered herbicides. Many other are under registration process. The total use of herbicides in Bangladesh in the year 2008 was 4024.77 tons. Application of herbicides in crop production may have side effects on biological equilibrium following changes in soil environment. However, herbicide selectivity and application dose may reduce the pollution in some extent. This issue needs to examine weed management practices that help keeping lower weed population and better control (Chowdhury, 2012).
Considering potential benefit of herbicide the present study was undertaken to investigate the efficacy of different herbicidal treatments against in controlling broad spectrum weed species in transplanted *aus* rice.

The experiment has been therefore undertaken to fulfill the following objectives:

I. To study the efficacy and selectivity of herbicides for controlling weeds in transplanted *aus* rice.
II. To find out the effect of herbicides on growth and yield parameters of transplanted *aus* rice.
III. To understand the residual activity of herbicide on transplanted *aus* rice.

REVIEW OF LITERATURE

For successful rice production weed is considered the most crucial factor which performs a negative influence on the growth and development of the crops by competing for sunlight, water, nutrients and finally reduces the yield drastically. In agronomic point of view weed management for modern rice cultivation has become a vital issue. Among all weed control methods, application of herbicide is the most effective for controlling weed as well as increasing yield without harming the environment. Considering the above points, available literature and the important findings of famous scientists and research workers of home and abroad were reviewed to justify the present study.

2.1 Presence of weed species in rice field

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

Sharmin (2014) carried out an experiment at Agronomy field of Sher-e- Bangla Agricultural University, Dhaka, during August to December, 2013 in T. aman season to find out the performance of BRRI dhan56 and BRRI dhan57 under different weed control methods and observed eighteen weed species infested the field among which *Cyperus michelianus*, *Cyperus esculentus* at 30 DAT; *Cyperus esculen*tus, *Alternanthera sessi*le and *Cyperus difformis* at 60 DAT, *Fimbristylis miliaceae* at 90 DAT were dominated in the experimental plot.

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.

Juraimi *et al.* (2011) told that the weed-rice ecological relationship is very complex and dynamic. The succession and distribution of weeds are always affected by management and environmental factors. The infested notorious rice weeds viz. *Echinochloa spp.*, *Leptochloa chinensis* (L.) *Nees, Limnocharis flava* (L.) *Buch.*

Commelina benghalensis, Ipomoea aquatic, Cyperus iria and Fimbristylis miliacea were dominated in the rice field and details studies needed to be done for successful weed management.

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, on BRRI dhan29 and Surjamoni and found *Paspalum distichum w*as the dominating weed species in the experimental plot.

After conducting several field experiments at Bangladesh Rice Research Institute (BRRI), Gazipur in *Aus*, 2010 and BRRI Rangpur, during Boro 2011 Mamun *et al.* (2011) observed that the most dominant weeds were *Cyperus diffornis, Monochoria vaginalis* and *Echinochloa crus-galli* in the first year and *Cyperus difformis* and *Echinochloa crus-galli* in the next year. In both years *Cyperus diffornis* was observed as the most dominating weed species.

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*.

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

Salam *et al.* (2010) carried out a field experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, on *boro* rice (Binadhan-5) and they found ten weed species belonging to four families namely Angta, Chechra, Arail, Joina, Durba, Panee kachu, Sabuj nakphul, Shusni shak, Holud mutha and Khudeshama.

Bhuiyan and Ahmed (2010) conducted field experiment at two different agroecological zones of Bangladesh and observed that weed flora in the experimental plots in the two different agroecological zones comprised of the grasses *Cynodon dactylon, Echinochloa crusgalli, Leptochloa chinensis,* the sedges, *Cyperus difformis, Scirpus juncoides* and the broadleafs *Enhydra fluctuans, Monochoria vaginalis, Lindernia anagallis, Marsilea minuta* and *sphenoclea zeylanica.*

Hasanuzzaman *et al.* (2008) carried out an experiment on transplanted *Aman* rice at the Sher-e-Bangla Agricultural University farm, Dhaka and observed that among 14 different weed species *Panicum repens* infested severly.

Hasanuzzaman *et al.* (2007) found 16 different weed species in transplanted *aman* rice field where *Sagittaria guyanensis* and *Sphenoclea zeylanica* were the most dominating weed species.

Eight weed species in transplanted aman rice field, namely *Paspalum scrobiculatum* L., *Echinochloa colonum* L., *Fimbristylis littralis* (L.), *Cyperus iria* L., *Alisma plantago* L., *Jussieua decurrens* (Walt.) DC., *Polygonum orientale* L. and *Sphenocelea zeylanica* was found by Mian *et al.*, (2007). They added that among the weed species Paspalum scrobiculatum L. was the most dominating species while A. plantago and J. decurrens were also dominanted in semi-dwarf modern cultivars (BR11 and BR22) than in traditional tall cultivars (Nizersail and Biroi).

Cyperus iria, *Echinochloa crus-galli* and *Cyperus rotundus* were the dominant weeds in transplanted rice field which was observed by Bhowmick *et al.* (2002).

Mitra *et al.* (2005) conducted an experiment and observed that *Monochoria vaginalis, Scirpus murconatus* and *Fimbristylis miliacea* were found dominating in transplanted *aman* rice field.

Shultana *et al.* (2011) carried out an experiment at Bangladesh Rice Research Institute, Gazipur, to study the effect of *Echinochloa crusgalli* on transplanted *aman* rice and revealed that *Echinochloa crusgalli* is a severe competitor of rice and suggested that in order to get good vegetative growth of rice *Echinochloa crusgalli* should be controlled as early as possible.

2.2 Effect of herbicides

Ahmed and Chauhan (2014) conducted a field study in the boro season of 2011-12 and *aman* season of 2012 at Jessore, Bangladesh and observed that among herbicides, pendimethalin, oxadiargyl, and acetachlor+bensulfuranmethyl performed very well against grasses than pyrazosulfuron. They also revealed that to control broadleaf weed oxadiargyl (65–85%control) performed the best than pendimethalin and acetachlor+bensulfuraonmethyl. Oxadiargyl followed by ethoxysulfuron in the *boro* season and oxadiargyl followed by a one-time hand weeding in the *aman* season was suggested as the best combination for controlling weed.

Jursik *et al.* (2013) found the highest efficacy of acetochlor on *Chenopodium album*, *Amaranthus retroflexus*, *Echinochloa crus-galli* and *Solanum physalifolium*.

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.

Khaliq *et al.* (2012) evaluated that pendimethalin, Acetochlor and butachlor were effective against jungle rice while ethoxysulfuron ethyl was most efficient in controlling purple nutsedge.

Chowdhury (2012) carried out a field experiment at Sher-e-Bangla Agricultural University Agronomy field during July to December, 2011 and revealed that pre-emergence herbicide Sunrice 150WG controlled weeds very effectively.

Ikeda *et al.* (2011) revealed propyrisulfuron as a novel sulfonylurea rice herbicide to control annual and perennial paddy weeds, including *Echinochloa* spp., sedges and broadleaf weeds and suggested that Propyrisulfuron shows safer profiles for human health and the environment.

Ali *et al.* (2010) conducted an experiment at the Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during the period July-December, 2006 and observed that among the weed control treatments Pretilachlor + one hand weeding at 40 DAT performed the best for controlling weeds at 30 DAT (79.53%) and moderate for controlling weeds at 60 DAT (75.65%).

Bhuiyan and Ahmed (2010) conducted an experiment during dry season of 2007 in two different agroecological zones of Bangladesh and found that Mefenacet + bensulfuron methyl 53% WP @ 524, 594 and 657 g a.i. ha^{-1} had highest bioefficacy against broad spectrum of weeds and safety to crop.

James and Rahman (2009) suggested that Metolachlor was the most effective in controlling summer grass (*Digitaria sanguinalis*) and rough bristle grass (*Setaria verticillata*).

Jucai *et al.* (2002) revealed that Flumicloracpentyl at 50 g a.i. $ha-^{1}$ plus clethodim at 70 g a.i. $ha-^{1}$ suppressed both broadleaved weeds and grass weeds with an increased efficacy of more than 90% during field trials in Taigu, Shanxi province, China.

Norsworthy *et al.* (2009) carried out an experiments and concluded that herbicides imazethapyr and bispyribac controlled rice cutgrass 52 to 62% if it applied over the top of rice.

Julianoa *et al.* (2009) told that Barnyardgrass (*Echinochloa crus-galli*) showed resistency to both chloroacetamide (butachlor)- and acetanilide (propanil)-group herbicides in direct-seeded rice in the Philippines.

Datta and Lacsina (2009) found that the selective chemicals bentazon and fenoprop gave outstanding perennial sedge control in both transplanted and broadcest flooded rice.

Hasanuzzaman *et al.* (2008) conducted an experiment on transplanted Aman (monsoon) rice at the Sher-e-Bangla Agricultural University farm, Dhaka during June-November, 2005 and observed that Ronstar® 25EC @ 1.25 L ha-1 + IR5878® 50 WP @ 120 g ha-1 performed the most efficient which gave the lowest weed population.

Ronald and Nilda (2007) stated Propanil as a highly effective herbicide for controlling weeds on rice field and also revealed that the residual herbicides thiobencarb, molinate, and pendimethalin when mixed with propanil improved control of propanil resistant barnyardgrass.

Ishaya *et al.* (2007) told that pretilachlor+dimethametryne at 2.5 kg a.i./ha and piperophos+cinosulfuron at 1.5 kg ha^{-1} perfomed well as they effectively controlled weeds.

Talbert and Burgos (2007) stated that Clomazone as a standard herbicide for controlling annual grasses in rice, including barnyardgrass.

Hasanuzzaman *et al.* (2007) conducted an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka and revealed that among the pre-emergence herbicides, Sunrice 13.75 WG showed better performance to control weeds in transplanted *aus* rice field.

Samar *et al.* (2007) conducted an experiment and concluded that application of Pendimethalin (1000 g a.i. ha^{-1}) or Pretilachlor with Safener (500 g a.i. ha^{-1}) as pre-emergence applications followed by one hand-weeding were effective in controlling weeds, increasing grain yield of rice than the weed-free treatment.

Kalhirvelan and Vaiyapuri (2003) found that hand weeding recorded the lowest weed population (2.78 m^{-2}) and weed dry weight (155.70 kg ha^{-1}) and also stated that Pretilachlor and 2, 4-D at 300 + 300 g ha^{-1} caused the lowest weed density and weed dry weight.

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

Ilias and Kico (2002) conducted field experiments in Greece during 1997, 1998, and 1999 and revealed that red rice can be effectively controlled by applying the pre-emergence (alachlor, dimethenamid, metolachlor, or acetochlor) or post-emergence herbicides (paraquat, glyphosate, glufosinate, or quizalofopethyl).

Rangaraju (2002) in India determined the effect of herbicide application and application time on weed flora and weed dynamics of dry seeded rainfed rice and observed that application of Butachlor at 1.5 kg a.i. ha^{-1} effectively controlled the weeds.

Rajkhowa *et al.* (2001) reported that Butachlor 1.0 kg ha^{-1} applied three days after transplanting (DAT) significantly reduced weed infestation till 45 DAT and resulted in higher yield of rice over weedy check.

Gibson *et al.* (2001) conducted field experiments to determine the differences in competitive ability existed between two semi-dwarf cultivars of water seeded rice (Cultivars M202 and A301) by applying Molinate and propanil to control a mixed infestation of weeds and suggested that if more competitive cultivars were developed for water seeded rice then herbicide rates could be reduced and weed control could be improved.

Islam *et al.*, (2010) investigated that Pretilachlor (312.50-562.50 a.i. ha^{-1}) and one hand weeding reduced weed population and dry matter weight.

Jordan (1997) conducted a research from 1993 through 1995 to evaluate barnyardgrass control in rice field and evaluated that Propanil + molinate applied with quinclorac at 0.28 or 0.40 kg $ha-^{I}$ controlled barnyardgrass more effectively.

Savithri *et al.,* (1994) observed the efficiency of different pre-emergence herbicides in transplanted rice and they concluded that among the different herbicides, application of granular formulation of Butachlor @ 1.5 kg a.i. ha^{-1} six day after transplantation was found to be the most effective for controlling weeds in transplanted rice.

Singh and Singh (1994) observed that the best weed control was given by Oxadiazon 0.4 kg a.i. ha^{-1} which gave the highest grain yield also.

Moodya (1993) stated that herbicides as the most cost-effective weed control method in wet-seeded rice for weed control and also revealed that cultural practices need to be integrated with judicious herbicide use.

Biswas *et al.,* (1991) observed that the use of Oxadiazon at 0.5 kg a.i. ha^{-1} was more economic than hand weeding for effective weed management.

Chedzey and Findlay (1986) also reported that Acetochlor gave excellent residual control of grass and broadleaf weeds. The early post-emergence treatments of Harness with Gesapax and Gramoxone performed excellent control of weeds including *Cyperus esculentus.*

2.3 Effect on weed population and weed control efficiency

Weed control efficiency is an important measurement of controlling weeds in crop field. High weed control efficiency ensures proper crop growth and profitable weed control. Weed control efficiency varies with weed control methods.

Sharmin (2014) conducted an experiment at Agronomy field of Sher-e- Bangla Agricultural University, Dhaka, during August to December, 2013 in T. aman season to find out the performance of BRRI dhan56 and BRRI dhan57 under different weed control methods and told that two hand weeding at 20 and 40 DAT showed the highest wed control efficiency 89.90% at 30 DAT, 59.74% at 60 DAT 78.85% at 90 DAT.

Chowdhury (2012) also carried out a field experiment at Sher-e- Bangla Agricultural University Agronomy field during July to December, 2011 to evaluate the performance aromatic rice varieties under different weed control methods and revealed that application of Sunrice 150WG (Ethoxysulfuron 150 g kg^{-1}) @ 185 ml ha^{-1} as pre-emergence herbicide showed the highest weed control efficiency 95.28%

at 30 DAT and 78.95% at 60 DAT.

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy farm of Bangladesh Rice Research Institute, Gazipur, and stated that weed control efficiency ranged (WCE) from 42 to 84%. More than 80% WCE was obtained by Becolor 5G @ 30 kg ha^{-1}, Bouncer 10WP @ 150 g ha^{-1} and Becofit 500EC @ 1.20 L ha^{-1} respectively.

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

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

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

Gnanavel and Anbhazhagan (2010) carried out a field experiment during 2008- 09, and concluded that pre- emergence application of oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg+metsulfuron methyl @ 0.01 kg ha^{-1} recorded the highest WCE (90.12%) favoring higher grain yield of aromatic rice (5.32 t ha^{-1}).

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

Bhuiyan and Ahmed (2010) conducted an experiment during dry season of 2007 in two different agroecological zones of Bangladesh to evaluate the usefulness of Mefenacet + bensulfuron methyl 53% WP, for weed management in transplanted paddy and observed that pre-emergence application of Mefenacet + bensulfuron methyl 53%WP @ 594 g a.i. ha^{-1} led to higher weed control efficiency.

Bari (2010) conducted an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh (BSMRAU) during 2007-08 using eight herbicides, i.e. Oxadiazone, Butachlor, Pretilachlor and Anilphos from pre-emergence category, and MCPA, Ethoxysulfuran, Pyrazosulfuran Ethyl and Oxadiarzil from post-emergence category in transplanted wetland rice during *aman* (autumn), *aus* (summer) and *boro* (winter) seasons to study their effects on weed control and rice yield and found that pre-emergence herbicides butachlor provided better weed control efficiency.

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

From several field Experiments at BRRI farm, Bhanga, Faridpur (AEZ 12-Lower Ganges River Floodplain) and at Burichang of Comilla district (AEZ 19-Old Meghna Estuarine Floodplain) during dry season (*Boro*) 2007 to assess the effectiveness of different pre-emergence herbicide for weed management in direct wet seeded rice and its impact on phytotoxic effect, plant growth and yield of rice Bhuiyan *et al.* (2011) found that pre-emergence application of Sofit N 300EC @ 450 and 600 g a.i. ha^{-1} led to more than 80% weed control efficiency.

Jena *et al.* (2002) observed that application of Oxadiazon with hand weeding gave the highest weed control efficiency, grain and straw yield and harvest index also.

Sharma and Bhunia (1999) stated that Pendimethalin @ 1.5 kg ha^{-1} + one hand weeding resulted in the highest weed control efficiency than any other treatments.

Ahmed *et al.* (1999) compared Oxadiazon and Cinosulfuron with hand weeding control and observed that Oxadiazon and Cinsolfuron controlled weeds in rice effectively providing 91-92% and 90-92% weed control efficiency, respectively.

Chandra *et al.* (1998) observed that Oxadiazon 0.8 kg ha^{-1}, Butachlor 2.00 kg ha^{-1} and Thiobencarb 2.00 kg ha^{-1} provided 80.50, 78.30 and 35.10% weed control, respectively and also added that among the herbicides, Oxadiazon was the most effective herbicidal treatments.

Brar *et al.* (1997) told the efficacy of 0.5 kg Oxadiazon applied 5-15 days after transplanting compared to 0.3 kg Anilofos applied 3 days after transplanting (DAT) and hand weeding twice, for control of *Echinochloa crus- galli* in rice cv. PR-110 in sandy loam soil and observed that the best weed control and crop yield were achieved with Oxadiazon treatment applied 10 DAT.

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

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

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

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

2.4 Effect on growth characters

2.4.1 Tiller length (cm)

Sharmin (2014) showed that BRRI Dhan56 had the highest tiller length as two hand weeding was done in that field.

Chowdhury (2012) carried out a field experiment at Sher-e- Bangla Agricultural University Agronomy field during July to December, 2011 and observed that BRRI dhan37 scored the highest plant height from the field treated with pre-emergence herbicide Sunrice 150WG.

Hasanuzzaman *et al.* (2008) conducted an experiment on transplanted Aman (monsoon) rice at the Sher-e-Bangla Agricultural University farm, Dhaka during June-November, 2005 and observed that Ronstar® 25EC @ 1.25 L ha-1 + IR5878® 50 WP @ 120 g ha^{-1} showed the longest tiller length and gave the lowest weed population also.

2.4.2 Tillering pattern

Chowdhury (2012) told that effect of weed control treatments and variety significantly influenced the number of tillers $hill^{-1}$ at different DAT. He also showed that at 60 DAT, the highest number of tillers $hill^{-1}$ was recorded from the combinations of BRRI dhan34 and Sunrise 150WG, hence the lowest number of tillers $hill^{-1}$ was recorded from the treatment combinations associated with no weeding throughout the growing period.

2.5 Effect on yield contributing characters

2.5.1 Effective and non effective tillers $hill^{-1}$

Chowdhury (2012) told that weed controlled by Sunrise 150WG gave the highest effective tillers $hill^{-1}$ while non effective tillers $hill^{-1}$ were found from no weeding treatment.

Raju *et al.,* (2003) observed that use of weedicide (Safener and Butachlor) gave the highest tiller $hill^{-1}$ and control plot produced maximum non effective tiller.

2.5.2 Panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1}, filled grain percentage, 1000-grain weight

Chowdhury (2012) conducted a field experiment at Sher-e-Bangla Agricultural University Agronomy field during July to December, 2011 to evaluate the performance aromatic rice varieties under different weed control methods and observed that the highest panicle length, filled grains panicle^{-1} and 1000-grain weight was recorded from Sunrise 150WP treatment and no weeding treatment gave the highest unfilled grains panicle^{-1}, lowest panicle length, filled grains panicle^{-1} and 1000-grain weight.

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

Gnanasambandan and Murthy (2001) studied the efficiency of pre-emergence herbicide Butachlor @ 1250 g ha^{-1} which was applied at 4 days after transplanting and reported that treatments effectively controlled weed density and increased grain yield.

Jordan, (1997) conducted a research from 1993 through 1995 to evaluate barnyardgrass control, rice yield, and evaluated that Propanil+molinate applied with quinclorac at 0.28 or 0.40 kg ha^{-1} controlled barnyardgrass more effectively and provided higher yields than propanil at 3.4 kg ha^{-1} propanil+molinate at 5.6 kg ha^{-1} quinclorac at 0.17, 0.28, or 0.40 kg ha^{-1} or combinations of propanil and quinclorac.

2.5.3 Effect on grain yield, straw yield, biological yield, harvest index

Ahmed and Chauhan (2014) conducted a field study in the boro season of 2011-12 and aman season of 2012 at Jessore, Bangladesh, and suggested that oxadiargyl followed by ethoxysulfuron (4.13 t ha^{-1}) provided 62% higher yield in the boro season while oxadiargyl followed by one-time hand weeding (4.08 t ha^{-1}) provided 37% higher yield in *aman* season.

Chowdhury (2012) carried out an experiment at Sher-e- Bangla Agricultural University Agronomy field and scored the highest grain yield, straw yield, biological yield, harvest index from pre-emergence herbicide Sunrice 150WG treated plot.

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

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

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

Khaliq *et al.* (2011) reported that manual weeding scored highest paddy yield of 4.17 t ha^{-1} and also added that Bispyribac sodium gave 3.51 t ha^{-1} paddy yield appeared superior to penoxsulam.

Mamun *et al.* (2011) conducted field experiments at Bangladesh Rice Research Institute (BRRI), Gazipur during *boro*, 2009 and *aus*, 2010 to evaluate the performance of Bensulfuron methyl + Pretilachlor 6.6% GR for weed suppression and its impacts on transplanted rice and observed that application of Bensulfuron methyl + Pretilachlor 6.6% GR @ 652 g a.i. ha^{-1} resulted in higher yield attributes and grain yield of transplanted rice that were comparable to the standard in both seasons.

Shultana *et al.* (2011) conducted an experiment at Bangladesh Rice Research Institute, Gazipur, during winter season 2009 to evaluate the weed control efficiency of some pre-emergence herbicides in transplanted rice and found that among the evaluated herbicides, Rigid 50 EC (pretilachlor) @ 1L, Alert 18WP (bensulfuron + acetachlor) @ 400 g, Kildor 5G (butachlor) @ 25 kg, Bigboss 500EC (pretilachlor) @ 1L, Rifit 500EC (pretilachlor) @ 1L, Ravchlor 5G (butachlor) @ 25 kg, Succour 50EC (pretilachlor) @ 1L and Topstar 80WP (oxadiazon) @ 75 g ha^{-1} showed grain yields above 4.00 t ha^{-1} which were comparable to the standard check; however, weed free plots gave the highest grain yield as anticipated.

Bhuiyan and Ahmed (2010) conducted an experiment during dry season of 2007 in two different agroecological zones of Bangladesh to evaluate the usefulness of Mefenacet+bensulfuron methyl 53% WP, for weed management in transplanted paddy and observed that pre-emergence application of Mefenacet+bensulfuron methyl 53%WP @ 594 g a.i. ha^{-1} led to higher yield attributes and grain yield of rice that were comparable to the standards at both location.

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

Bari (2010) carried out an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh (BSMRAU) during 2007-2008 and revealed that 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.

Bhuiyan *et al.* (2010) conducted an experiment during *boro* 2006 at Gazipur and Comilla and stated that among different treatment, weed free plots produced highest grain yield followed by Oxadiargyl 400SC @ 75 g a.i. ha^{-1} which is comparable with other doses of Oxadiargyl 400SC in both locations.

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

Islam *et al.* (2010) revealed that BRRI dhan41 gave the highest grain yield (4.43 t ha^{-1}) with Rifit 25 EC @ 1.0 L ha^{-1}.

Salam *et al.* (2010) carried out a field experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, to evaluate the effect of herbicide on growth and yield in *boro* rice (Binadhan-5). The highest grain yield (7.15 t ha^{-1}) and straw yield (7.37 t ha^{-1}) were found due to application of Machete 5G @ 25 kg ha^{-1}.

Hasanuzzaman *et al.* (2008) observed that the yield and the yield contributing characters (plant height, number of effective tillers per hill, panicle length and no. of filled grains) were influenced by the effectiveness of the herbicidal treatments, while T_2 (Ronstar® 25EC @ 1.25 L ha-1 + IR5878® 50 WP @ 120 g ha-1), showed as highest yielding herbicidal treatment.

Kabir *et al.* (2008) stated that the highest grain yield (5.22 t ha^{-1}) was obtained under good water management in weed free treatment followed by Butachlor 5G @ 2 kg ha^{-1} and one hand weeding (4.96 t ha^{-1}) under same water management.

Jacob and Syriac (2005) showed that adoption of 20 x 10 cm spacing and pre-emergence application of Anilofos + 2, 4-D ethyl ester (0.40+0.53 kg a.i. ha^{-1}) at six days after transplanting supplemented with 2, 4-D Na salt (1.0 kg a.i. ha^{-1}) at 20 days after transplanting gave highest yield.

Chandra and Solanki (2003) observed that two hand weeding produced the highest grain yield (3.36 t ha^{-1}) and straw yield (6.53 t ha^{-1}) while Butachlor and Oxadiazon gave 2.0 kg ha^{-1} and 0.8 kg ha^{-1}, respectively.

Moorthy *et al.* (2002) revealed that application of Pretilachlor @ 625 g ha^{-1} and Butachlor 1600 @ g ha^{-1} on 2 days after sowing and the treatments gave effective weed control and produced the highest grain yield compared with twice hand weeding on 20 and 40 DAT.

Selvam *et al.* (2001) observed that among the herbicides, Pendimethalin recorded the highest grain yield (3773 kg ha^{-1}).

Tamilselvan and Budhar (2001) studied the effects of pre-emergence herbicides Pretilachlor 0.4 kg a.i. ha^{-1} on rice and stated that the weed control treatments was effective in increasing grain yield.

Gogoi *et al.* (2000) stated that different weed control practices significantly increased the rice yield over the control plot (unweeded) in transplanted rice and also observed that combined weed control treatment like Oxadiazon 2.0 L ha^{-1} + 1 hand weeding gave the highest grain yield.

Moorthy *et al.* (1999) studied that Pretilachlor + safener (0.4 kg ha^{-1} and 0.6 kg ha^{-1}, Butachlor + safener (1.5 kg ha^{-1}) and Anilofos + Ethoxysulfuron (0.37 + 0.04 kg ha^{-1}) produced the highest yields comparable to hand weeding.

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

Chandra *et al.* (1998) observed that Oxadiazon 0.8 kg $ha^{-1}$and Thiobencarb 2.00 kg ha^{-1} gave maximum grain yield.

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

BRRI (1998) evaluated a new pre-emergence herbicide Golteer 5G (Butachlor) at Gazipur in transplanted *aus* rice and results indicated that hand weeding produced a slightly higher grain yield than Golteer (Butachlor) treated plots.

Nandal *et al.* (1998) revealed the performance of herbicide in direct seeded puddled rice during kharif season and suggested that the highest grain yield was obtained from the Pretilachlor (1.0 kg ha^{-1}) + two hand weeding.

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

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

Chowdhury *et al.* (1995) found that Oxadiazon , 2.0 L ha^{-1} significantly increased the grain yield and straw yield.

BRRI (1990) revealed that the highest grain yield was obtained from Oxadiazon treated plot.

Purushotham *et al.* (1990) observed that Oxadiazon (0.5 kg a.i. ha^{-1}) produced the maximum grain and straw yields than two manual weeding at 25 and 45 DAT, respectively .

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 transplanted *Aus* rice.

MATERIALS AND METHODS

This chapter represents those materials and methods which were used in the field to conduct the experiment during the period from April to August, 2014. It represents a concise explanation about experimental period, site, soil and climatic condition, planting materials, crop growing method, experimental layout and design, treatments, fertilizer application, sowing, uprooting and transplanting of seedlings, application of herbicide, intercultural operations, data collection and statistical analysis presented under the following headings:

3.1 Location

The field experiment was carried out at the Agronomy field laboratory of Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh. The location of the experimental area has been shown in Appendix I.

3.2 Weather and Climate

The experimental location was under the subtropical climate and was characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). The detailed meteorological data in respect of air temperature, relative humidity and rainfall recorded by the Sher-e-Bangla Agricultural University mini weather station, Dhaka for the period of experimentation have been presented in Appendix II.

3.3 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcareous dark grey soil. The pH value of the soil was 5.6 and has organic matter 0.45%. The physical and chemical properties of soil of the experimental field have been shown in Appendix III.

3.4 Plant materials

Nerica (drought tolerant African variety) was used as plant materials for the present study. Seeds of the variety were collected from Bangladesh Agricultural Development Corporation (BADC). This variety is drought tolerant so now popularly being used in Bangladesh during *Aus* Season.

3.5 Treatments

The experiment consisted of single factor and total thirteen treatments, twelve different treatments and one weedy check as mentioned below:

Factor A: different herbicides

1) T_1 = Propyrisulfuron @ 500 ml ha^{-1}
2) T_2 = Propanil 60 WG @ 2000 g ha^{-1}
3) T_3 = Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}
4) T_4 = Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}
5) T_5 = Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}
6) T_6 = Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}
7) T_7 = Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}
8) T_8 = Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}
9) T_9 = Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}
10) T_{10} = Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}
11) T_{11} = Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}
12) T_{12} = Acetochlor 14% + Bensulfuron-methene 4% @ 742 g ha^{-1}
13) T_{13} = Weedy check

All herbicidal treatments were applied 15 days after transplanting (2-3 leaf stage). The paddy field was drained out before spray but maintained 1-2 cm water during spray. All inlets were closed, then after 24 hours of spray the trial plots were re-flooded to facilitate activity of systemic herbicide.

3.6 Description of herbicides

A short explanation of the herbicides used in the experiment is given in Table 1.

Table1. Short description of the herbicides used in the experiment

Trade name	Common name	Mode of action	Selectivity	Time of application
ZETA-ONE®	Propyrisulfuron	Contact	Sedges and broadleaf weeds in corn, sorghum and cereals	Post-emergence
Propanil 60WG	Propanil	Contact	Broadleaf and grass weeds in rice	Post-emergence
Acetochlor	Harness, Keystone, Sure Start and Surpass	Systemic (soil or foliage applied)	Corn (all types), cotton, green peas, maize, potatoes, rape, soybeans and sunflower	Pre- or early-post emergence (rice)
Londax	Bensulfuron-methene	Systemic	broad leaf weeds and sedges in rice crops	Pre- or early post-emergence

3.7 Layout and Design

The experiment was laid out in a single factor Randomized Complete Block Design (RCBD) with three replications that consisted of 13 treatments. The size of the individual plot was 5.0 m x 2 m (10 m^2) and the total numbers of plots were 39.

3.8 Sprouting of seeds

The collected seeds were healthy enough. The seeds were immersed in a bucket full of water and seed soaking was done for 24 hours and then seeds were taken out of water and afterwards kept tightly in gunny bags for 2-3 days for uniform sprouting.

3.9 Preparation of nursery seedbed and sowing of seeds

For preparing nursery seedbed a piece of medium high land was selected at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka. The land was puddle with power tiller and leveled with ladder. Then the sprouted seeds were sown uniformly in the seedbed on 8 April, 2014. Seedbed size was 10 m long and 1.5 m wide. Weeds were removed and irrigation was given as and when necessary. Seedbed was protected from bird by covering the whole seedbed with net.

3.10 Experimental land preparation

Tillage was done in the experimental field by a power tiller and the land was leveled by repeated laddering to make the soil ready for transplanting. The layout of the experimental plot was done immediately after final land preparation. The experimental field was then divided into unit plots and prepared before transplantation. Weeds and stubbles were removed physically from individual plots.

3.11 Fertilizer application

Before final land preparation, 65 kg/ha TSP, 72 Kg/ha MOP, 60 Kg/ha gypsum and 10 Kg/ha zinc sulphate were applied as basal dose and with the help of a spade thoroughly incorporated with soil. Urea super granule @ 155 kg/ha was applied in two instalments-12 and 35 days after transplanting (BRRI, 2000).

3.12 Uprooting and transplanting of seedling

The seedbeds were made wet by the application of water both in the morning and evening on the previous day before uprooting to minimize mechanical injury to the roots and kept on soft mud in shade before they were transplanted. 22 days old 2-3 Rice seedlings were transplanted in each hill on 30th April on the well puddled plots maintaining row to row distance 20 cm and hill to hill distance 20cm.

3.13 Intercultural operations

For ensuring the normal growth of the crop following intercultural operations were done:

3.13.1 Gap filling

The dead seedlings in some hills were replaced by healthy seedlings within 10 days of transplantation.

3.13.2 Plant protection measures

Insignificant infestations of insect-pests were seen during the growing period of Nerica rice. Such as at 20 DAT Rice hispa (*Dicladespa armigera*) was infested so Marshal 20 EC was applied @ 2 ml/L water and controlled successfully that's why the crop growth was normal.

3.13.3 Water Management

Irrigation water was applied frequently to keep the trial plot in moist condition so that systemic herbicide can work properly as well as drainage practice was also done during heavy rainfall.

3.14 General observations of the experimental field

During the growth stages of the crop regular observations were made. In general, the field looked very well with fine green plants which were vigorous and fresh in the treatment plots than that of weedy check plots.

3.15 Harvesting and post-harvest operations

When 80% to 90% of the grains become golden yellow in color then the maturity of crop was decided. It was 09 August, 2014 when harvesting operation was done from each experimental plot separately. Before harvesting five hills were selected randomly from each plot and cut at the ground level for collecting data on yield contributing characters. 1 m^2 area was harvested from the centre of each plot outside the sample area and cut at the ground level to determine grain and straw yield of individual treatment and converted into t ha^{-1}. The harvested crop of each plot was bundled individually, tagged appropriately and brought to the Sher-e-Bangla Agricultural University threshing floor. The bundles were dried in open sunlight, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded accurately after proper sun drying.

3.16 Application of herbicide

Herbicide treatments were applied on 15 May, 2014 at 15 days after transplanting (2-3 leaf stage) according to the following ways to conduct the experiment:

3.16.1 Preparation of spray solution before spray and tank mix

Plate 1. Preparation of spray solution before spray

3.16.2 Sprayer calibration for dose verification before spray

For dose verification, the sprayer was calibrated according to the following method-

Step-1: It was made sure that the sprayer was in good working condition (no leaks, no blocked nozzles, etc). Calibration was done on a surface similar to the field to be sprayed.

Step-2: The sprayer was placed on a level ground and put in 5 liters of clean water. The sprayer was placed on the marked ground to the same spot can be found later. The sprayer pumped to develop pressure. A constant nozzle height was maintained. A comfortable walking pace was maintained, which was maintained throughout the application, and later in actually spraying the field. After completing spraying the plot, the sprayer was placed on the ground in its outlined position and measures the water level.

Step-3: The application rate was determined by subtracting the volume of water remaining the sprayer from the amount started with. The amount of water in the tank before spraying was 5L and the amount after spraying is 4 L, then the amount of water used was 1 liters (Table 2).

Step-4: The step 2 was repeated few times to maintain spray volume 1 L through adjusting uniform walking pace and height of the spray nozzle.

The similar walking pace and height of nozzle were maintained during spraying herbicide in trial plot by a similar applicator to spray herbicide uniformly.

3.16.3 Description of equipment and operation

1. The sprayer is normally used in Sher-e-Bangla Agricultural University for Agronomic practices.
2. Plot size (5m x 2m), so 4 times needed to complete spray in one plot.
3. Test products were dissolved separately in separate pots containing clean water. After dissolved completely they were mixed in the tank properly and spray volume was adjusted to 5 L in the tank (Plate 1). After each spray, the sprayer was cleaned properly with clean water and prepared spray product following similar way.

Plate 2. Calibration before spray similar to the trial plot

Plate 3. During spray of Herbicide in the trial plot

Table 2. Volume of spray solutions and required time to spray per plots of transplanted *aus* rice.

Treatments	Volume of spray (L)	Remaining volume (L)	Volume used (L)	Time (sec)	Treatments	Volume of spray (L)	Remaining volume (L)	Volume used (L)	Time (sec)
R_1T_1	5	3.8	1.2	56	R_3T_7	5	3.8	1.1	54.5
R_2T_1	5	3.9	1.1	54	Average	5	3.8	1.2	56
R_3 T_1	5	3.7	1.15	55	R_1T_8	5	3.9	1.1	54
Average	5	3.8	1.2	57	R_2T_8	5	3.7	1.15	55
R_1T_2	5	3.8	1.2	56	R_3T_8	5	3.9	1.1	54
R_2T_2	5	3.9	1.2	56.5	Average	5	3.8	1.1	55
R_3T_2	5	3.9	1.1	55	R_1T_9	5	3.6	1.1	54.5
Average	5	3.8	1.2	56	R_2T_9	5	3.8	1.2	57
R_1T_3	5	3.7	1.15	57.5	R_3T_9	5	3.7	1.3	59
R_2T_3	5	3.9	1.1	55	Average	5	3.7	1.25	58
R_3T_3	5	3.9	1.1	54	R_1T_{10}	5	3.8	1.2	57
Average	5	3.8	1.1	56.5	R_2T_{10}	5	3.9	1.1	54
R_1T_4	5	3.9	1.1	55	R_3T_{10}	5	3.7	1.25	55.5
R_2T_4	5	3.8	1.2	56	Average	5	3.8	1.15	55
R_3T_4	5	3.6	1.15	55.5	R_1T_{11}	5	3.7	1.3	59
Average	5	3.7	1.1	54	R_2T_{11}	5	3.7	1.25	58
R_1T_5	5	3.8	1.2	56	R_3T_{11}	5	3.8	1.2	57
R_2T_5	5	3.7	1.15	55	Average	5	3.7	1.1	54
R_3T_5	5	3.7	1.3	57	R_1T_{12}	5	3.7	1.25	55.5
Average	5	3.7	1.1	55	R_2T_{12}	5	3.6	1.2	56
R_1T_6	5	3.7	1.2	56	R_3T_{12}	5	3.8	1.2	57
R_2T_6	5	3.8	1.2	57	Average	5	3.7	1.1	55
R_3T_6	5	3.9	1.1	55	R_1T_{13}	5	3.8	1.2	56
Average	5	3.8	1.2	56	R_2T_{13}	5	3.9	1.1	54
R_1T_7	5	3.9	1.1	54	R_3T_{13}	5	3.9	1.1	55
R_2T7	5	3.9	1.1	55	Average	5	3.8	1.1	55.5

3.16.4 Efficacy and residual activity assessments

1) Percentage of control (% coverage) and crop effect was estimated through visual estimation in relation to growth reduction and injury to weed species at 1, 3, 5, 7, 14, 21, 28 and 45 days after spray (Table 3, 4 and 5).
2) To evaluate the efficacy and residual activity, individual plants were counted and recorded for each species. Data were recorded based on 3 days before spray and 7, 14, 21, 28 and 45 days after spray. These assessments were made on randomly selected quadrants 3 from each plot by using their average values. Results were presented in Table 7-12.

Table 3. Scale evaluation of weed coverage (IRRI, 1965)

Scale evaluation on crop effect	
Value	**Crop effect**
1	No toxicity
2	Slightly toxicity
3	Moderate toxicity
4	Severe toxicity
5	Toxic (Plant Kill)

Table 4. Scale evaluation of weed coverage on 3 and 7 days after spray in transplanted *Aus* rice (IRRI, 1965)

Treatments	Herbicides	Value	Weed effect (3 DASP)	% Coverage	Value	Weed effect (7 DASP)	% Coverage
T_1	Propyrisulfuron @ 500 ml ha^{-1}	2	Very poor control	1-50	5	Medium control	80-87.5
T_2	Propanil 60 WG @ 2000 g ha^{-1}	7	Good control	93-96.5	8	Very Good control	96.5-99
T_3	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	6	Enough	87.5-93	8	Very Good control	96.5-99
T_4	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}	5	Medium control	80-87.5	8	Very Good control	96.5-99
T_5	Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	6	Enough	87.5-93	8	Very Good control	96.5-99
T_6	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}	3	Poor	50-70	8	Very Good control	96.5-99
T_7	Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	7	Good control	93-96.5	8	Very Good control	96.5-99
T_8	Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}	5	Medium control	80-87.5	8	Very Good control	96.5-99
T_9	Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-}	3	Poor	50-70	8	Very Good control	96.5-99
T_{10}	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}	2	Very poor control	1-50	8	Very Good control	96.5-99
T_{11}	Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	8	Very Good control	96.5-99	8	Very Good control	96.5-99
T_{12}	Acetochlor14%+Bensulfuron 4% @ 742 g ha^{-1}	1	No effect	0-1	3	Poor	50.0-70
T_{13}	Control(Weedy check)						

Table 5. Scale evaluation of herbicide on crop effect at 5 and 7 days after spray in transplanted *Aus* rice (IRRI, 1965)

Treatments	Herbicides	Value	Crop effect
T_1	Propyrisulfuron @ 500 ml ha^{-1}	1.11	No toxicity
T_2	Propanil 60 WG @ 2000 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover
T_3	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover
T_4	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}	1.11	No toxicity
T_5	Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover
T_6	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}	1.11	No toxicity
T_7	Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover
T_8	Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}	1.11	No toxicity
T_9	Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-}	1.11	No toxicity
T_{10}	Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}	1.11	No toxicity
T_{11}	Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover
T_{12}	Acetochlor 14% +Bensulfuron 4% @ 742 g ha^{-1}	1.3	Temporary slight yellowish of leaf tips which require 5-7 days to recover

3.17 Data Collection

3.17.1 Weed parameters

Weed density

Weed infestation data as well as density were recorded from each unit plot based on 3 days before spray and 7, 14, 21, 28 and 45 days after spray. These assessments were made on randomly selected plant quadrants of 1.0 m^2 at three different spots of 10 m^2 from each plot by using their average values. For collecting yield data the middle quadrant was remained undisturbed. The identified infesting weed species within the first and third quadrate were counted alternately at different dates.

Relative weed density (%)

By using the following formula, relative weed density was calculated as -

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

Fresh and dry weight of weeds

The fresh and dry matter weight of infested weeds were recorded at 45 DAT (days after spray).

3.17.2 Collection of data at harvest

The following parameters are considered as yield and yield contributing characters and experimental data were recorded from those parameters

Tiller length (cm)

By the help of a meter scale (100 cm), tiller length was measured from base of the plants to the apex of the panicle. The average length of the five hills was considered as the tiller length (cm) for each plot.

Total number of tillers hill^{-1}

The mean tillers of five hills were counted at harvest date and considered as total tillers hill^{-1}.

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

The tiller without any panicle or the panicles containing no grains as selected as non-bearing tillers.

Number of effective tillers hill^{-1}

From counted total number of tillers hill^{-1}effective and non-effective tillers hill^{-1} were grouped. At least one grain containing panicles were considered as bearing tillers.

Panicle length (cm)

From the first node to the end of the five panicles were measured by the meter scale (1 m) and then average lengths were expressed in cm.

Total grains panicle^{-1}

From randomly selected five panicles the total number of filled grains panicle^{-1} and unfilled grains panicle^{-1} considered as total grains panicle^{-1}.

Number of sterile grains panicle^{-1}

Grains having partial food material inside or lacking of any food material in the grains graded as sterile grains panicle^{-1} and presence of such grains on each panicle were counted.

Number of filled grains panicle^{-1}

Grains were counted from panicle considered as filled grain having presence of food materials inside the grain.

1000 grain weight (g)

From the seed stock obtained from 5 hills of each plot thousand cleaned dried grains were randomly collected and were dried by proper sunlight up to 14% moisture content and by using an electric balance weight were measured accurately.

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

For yield measurement, the crop from an area of 1.0 m^2 was harvested separately from each plot after that was bundled individually, tagged properly and brought to threshing floor. Grains were threshed and then cleaned by winnowing after the bundles were dried in open sunlight. After proper drying in sun the grain and straw weights for each plot were measured properly with the help of digital weight machine (kg) and converted to t ha^{-1}.

Biological yield (t ha^{-1})

By using the following formula Biological yield was calculated:

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

Harvest index (%)

Harvest index is the relationship between grain yield and biological yield (Gardner *et al.*, 1985). It was calculated as follows:

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

3.18 Statistical analysis

The data obtained for different parameters were analyzed statistically following the analysis of variance (ANOVA) technique for single factor Randomized Complete Block Design (RCBD) and means were adjusted by least significant difference test (LSD) at 5% level of significance using MSTAT-C software program.

RESULTS AND DISCUSSION

This chapter consists of presentation and discussion of the results achieved from the study to explore the efficacy of herbicide and its residual activity on growth and yield of transplanted *aus* rice (Nerica). The results of the weed parameters, yield contributing characters of the crop as influenced by different treatments of herbicide have been presented and discussed in this chapter through different headings.

4.1 Weed infestation scenario in the experimental plots

It is a common observation that the favorable conditions for growing transplanted *aus* rice (Nerica) are also positive for high-spirited growth of various kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed population increases and hinders with the crop growth and development resulting poor yield. The experimental crop field was infested by nineteen weed species belonging to nine families.

In this field trial, weed flora infested in the field were comprised of 66% *Marsilea quadrifolia*, 32% *Cyperus deformis* and 2% others such as *Cynodon dactylon, Cyperus esculentus, Cyperus irria, Echinochloa crussgalli, Leersia hexandra, Leptochloa chinensis, Monochoria vaginalis, Eclipta alba, Ludwigia hyssopifolia, Alternanthera philoxeroides, Alternanthera sessilis, Spilenthes acmella, Sagitaria guyanensis, Commelina benghalensis and Sphenoclea zeylanica*. Among the weed species seven were aquatic, five were grasses, four were sedges, two were broad leaves and one was fern (Table 2). But from another experiment on the same field Sharmin (2014) found that the most important weed species were *Cyperus michelianus*, *Cyperus esculentus, Alternanthera sessile*, *Elusine indica*, *Cyperus difformis* and *Fimbristylis miliaceae*. While Chowdhury (2012) reported that the weed flora in the experimental area comprised of sedges such as *Cyperus michelianus, Cyperus rotundus, Cyperus difformis, Cyperus esculentus,* the broadleafs; *Sphenoclea zeylanica, Ludwigia octovalvis, Eclipta alba,* the fern; *Marsilea quadrifolia,* the aquatics; *Alternanthera sessilis, Alternanthera philoxeroides, Sagittaria guyanensis* and *the grasses; Cynadon dactylon, Echinochloa crusgalli, Leersia hexandra, Leptochloa panacea* were dominated in the another field experiment at Sher-e- Bangla Agricultural University. Similar kinds of weed species in the transplanted rice field were also reported by several researchers (Mamun *et al.*, 2011; Bhuiyan *et al.*, 2011; Hasanuzzaman *et al.*, 2008; Bhuiyan and Ahmed, 2010). The present result varied slightly from those reports and this might be due to location and seasonal variation.

Table 6. Weed species found in the experimental plots in transplanted *Aus* rice.

SL No.	Local name	Common name	Scientific name	Family	Types
1	Sushni	European water clover	*Marsilea quadrifolia*	Marsileaceae	Fern
2	Behua	Small flower umbrella	*Cyperus difformis*	Cyperaceae	Sedge
3	Holdemutha	Yellow nutsedge	*Cyperus esculentus*	Cyperaceae	Sedge
4	Boro Chech	Mud sedge	*Cyperus irria*	Cyperaceae	Sedge
5	Joyna	Fringerush	*Fimbristylis miliaceae*	Cyperaceae	Sedge
6	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae	Grass
7	Boro Shama	Barnyard Grass	*Echinochloa crussgalli*	Poaceae	Grass
8	Pani long	Water primose	*Ludwigia hyssopifolia*	Poaceae	Aquatic
9	Arail	Rice grass	*Leersia hexandra*	Poaceae	Grass
10	Moyurleja	Red sprangletop	*Leptochloa chinensis*	Poaceae	Grass
11	Chapra	Indian goosegrass	*Eleusine indica*	Poaceae	Grass
12	Keshuti	Eclipta	*Eclipta alba*	Compositae	Broadleaf
13	Zira kata	Toothache plant	*Spilanthes acmella*	Compositae	Aquatic
14	Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Aquatic
15	Chanci	Sessile	*Alternanthera sessilis*	Amaranthaceae	Aquatic
16	Pani kochu	Monochoria	*Monochoria vaginalis*	Pontederiaceae	Aquatic
17	Chandmala	Duck weed	*Sagittaria guyanensis*	Genetiaceae	Aquatic
18	Kanai bashi	Spider wort	*Commelina benghalensis*	Commelinacea	Aquatic
19	Jhilmorich	Goose weed	*Sphenoclea zeylanica*	Sphenocleaceae	Broadleaf

4.2 Weed population (No. m^{-2}) before 3 days of spray

Weed population was significantly differed among the herbicidal treatments (Table 7). It was observed that population of *Marsilea quadrifolia* was the highest in T_6 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG 1000 g ha^{-1}) whereas the lowest (155.30) was recorded from T_{13} (weedy check). Maximum number of *Cyperus difformis* (452.70) was recorded from T_2 (Propanil 60 WG @ 2000 g ha^{-1}) whereas the lowest (119) was found from T_{10} (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}). The maximum infestation of *Cyperus esculentus* (7.66) was recorded from T_1 (Propyrisulfuron @ 500 ml ha^{-1}) which was statistically similar with T_3 whereas the minimum infestation (3) was found from T_{13} (weedy check) which was statistically similar with $T_{6,}$ T_7, T_{11} and T_{12} treatments. The highest infestation of *Cynodon dactylon* (4.66) was observed in T_5 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) which was statistically similar with $T_{1,}$ T_{11} and T_{13} whereas the lowest (2) was found from T_3 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) which was statistically similar with $T_{2,}$ T_6, T_9 and T_{10} treatments. It was observed that the maximum infestation of *Echinochloa crusgalli, Leersia hexandra, Alternanthera philoxeroides, Leptochloa chinensis* (4, 2.33, 4 and 3.33, respectively) was recorded from T_{13} (Weedy check) whereas T_4 showed statistically similar result with T_{13} in the infestation of *Echinochloa crusgalli*. $T_{5,}$ T_7, T_{11} and T_{12} treatments also showed statistically similar result with T_{13} in terms of the highest infestation of *Leptochloa chinensis* and *Leersia hexandra*. On the other hand, the lowest infestation of *Echinocola crusgalli* (1.33) was found from $T_{1,}$ T_6, T_7, and T_8 which was statistically similar with T_2, T_{11} and T_{12}. The lowest infestation of *Alternanthera philoxeroides* (1.00) was found from T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) and T_9 (Propyrisulfuron @ 250 ml ha^{-1} + Propanil 60 WG @1000 g ha^{-1}) which was statistically similar with all treatments except T_1, T_4 and T_7. The maximum infestation of *Eclipta alba* (8.00) was recorded from T_9 (Propyrisulfuron @ 250 ml ha^{-1} + Propanil 60 WG @1000 g ha^{-1}) whereas the lowest (2.00) was found from T_4 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @1500 g ha^{-1}) and T_{10} (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}) which was statistically similar with all treatments except $T_{2,}$ T_8 and T_{13}. The maximum population of *Alternanthera sessilis* (4) was observed in T_8 which was statistically similar with all treatments except T_2 and T_5 as these two treatments showed the

Table 7. Weed population (No. m^{-2}) before 3 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T_1	180.0 h	420.3 b	7.66 a	4.00 a-c	1.33 d	2.66 de	2.33 b	2.66 ab	2.33 b	2.33 a	2.33 ab	1.33 bc	2.33 a-c
T_2	226.7 f	452.7 a	5.00 bc	2.33 ef	2.00 b-d	5.00 bc	2.33 b	2.33 b	3.00 ab	1.33 a	2.66 ab	1.33 bc	2.00 bc
T_3	178.3 h	274.0 e	7.00 a	2.00 f	2.66 bc	2.66 de	1.33 bc	3.00 ab	4.66 a	3.33 a	1.66 b	1.00 c	1.66 bc
T^4	285.7 c	270.0 e	4.66 b-d	4.33 ab	3.00 ab	2.00 e	2.33 b	3.00 ab	2.33 b	1.66 a	3.66 a	1.33 bc	2.66 ab
T_5	200.7 g	222.7 f	5.33 b	4.66 a	1.33 d	3.33 c-e	1.66 bc	2.33 b	3.00 ab	2.66 a	3.00 ab	1.00 c	2.66 ab
T_6	343.3 a	155.0 h	4.33 b-e	2.66 d-f	1.33 d	3.33 c-e	1.33 bc	3.66 ab	4.33 ab	3.00 a	2.33 ab	1.33 bc	1.66 bc
T_7	265.3 d	416.0 b	4.33 b-e	3.00 c-f	1.33 d	4.00 cd	2.33 b	3.00 ab	3.33 ab	2.66 a	2.66 ab	2.00 ab	1.66 bc
T_8	266.3 d	161.7 g	4.66 b-d	3.33 b-e	1.33 d	4.00 cd	1.00 c	4.00 a	3.66 ab	3.33 a	2.66 ab	1.66 a-c	1.33 c
T_9	222.3 f	152.0 h	3.66 c-e	2.33 ef	1.66 cd	8.00 a	1.00 c	2.66 ab	3.00 ab	3.33 a	3.00 ab	1.00 c	1.33 c
T_{10}	253.7 e	119.0 j	3.33 de	2.33 ef	2.33 b-d	2.00 e	2.00 bc	3.33 ab	2.66 ab	1.66 a	2.33 ab	1.00 c	1.66 bc
T_{11}	321.3 b	145.3 i	3.33 de	4.33 ab	2.33 b-d	2.66 de	1.66 bc	3.00 ab	3.00 ab	1.66 a	1.66 b	1.66 a-c	2.66 ab
T_{12}	327.7 b	310.0 d	3.33 de	3.33 b-e	2.00 b-d	3.00 de	2.00 bc	3.00 ab	2.33 b	2.00 a	2.66 ab	1.66 a-c	1.66 bc
T_{13}	155.3 i	361.3 c	3.00 e	3.66 a-d	4.00 a	6.00 b	4.00 a	2.66 ab	3.00 ab	2.66 a	2.00 b	2.33 a	3.33 a
LSD $_{(0.05)}$	8.77	6.26	1.34	1.2	1.16	1.96	1.14	1.6	2.16	2.02^{NS}	1.63	0.9	1.23
CV(%)	2.1	1.4	17.44	21.99	33.73	31.16	34.94	31.96	40.98	49.34	38.63	37.54	35.7

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

Figures in a column having the same letter(s) do not differ significantly whereas figures having dissimilar letter(s) are significantly different at 5% level

minimum infestation (2.33). On the other hand, the highest infestation of *Monochoria vaginalis* (4.66) was found from T_3 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) which was statistically similar with all treatments except T_1, T_4 and T_{12} as these treatments showed the lowest infestation (2.33). There is no significant difference observed of *Ludwigia hyssopifolia* infestation among all treatments. On the contrary, the highest number of *Sagittaria guyanensis* (3.66) was found from T_4 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with all treatments except T_3, T_{11} and T_{13} whereas the lowest (1.66) was recorded from T_3 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) and T_{11} (Propyrisulfuron @ 130 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) which was statistically similar with T_{13} (weedy check). Similar kind of weed species in the transplanted *aus* rice field were also reported by Reza *et al.* (2010) and Salam *et al.* (2010).

4.3 Effect of herbicidal treatments on weed population (No. m^{-2}) after 7 days of spray

At 7 days after spraying the weed population was also significantly influenced by different weed control treatments as herbicidal treatments drastically reduced the weed population. From Table 8, it was observed that at 7 days after spraying the highest population of all weed species viz. *Marsilea quadrifolia, Cyperus difformis, Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli, Eclipta alba, Alternanthera philoxeroides, Alternanthera sessilis, Monochoria vaginalis, Sagittaria guyanensis, Leersia hexandra, Ludwigia hyssopifolia* and *Leptochloa chinensis* (476, 422.7, 4.0, 4.0, 4.33, 7.0, 5.0, 4.0, 4.0, 3.33, 2.66, 4.0 and 4.0, respectively) was recorded from T_{13} (Weedy check). In terms of the highest weed infestation treatment T_4 and T_5 was statistically similar with T_{13} for controlling *Cyperus esculentus*, *Cynodon dactylon* and *Leptochloa chinensis*. On the other hand, the lowest weed population was observed from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) for almost all the enlisted weed species viz. *Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli, Alternanthera philoxeroides, Alternanthera sessilis, Monochoria vaginalis, Leersia hexandra and Leptochloa chinensis* (1.66, 1.33, 1.66, 1.0, 1.0, 1.0, 1.0, 1.33, respectively). Treatment T_6, T_7, T_9 and T_{10} were statistically similar with T_8 to control *Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli, Alternanthera philoxeroides*

Table 8: Weed population (No. m^{-2}) after 7 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T_1	0.00 c	0.00 c	4.00 a	2.66 a-c	1.66 cd	0.00 b	2.33 bc	1.66 bc	1.66 bc	1.33 b	1.66 bc	1.66 bc	2.66 bc
T_2	0.00 c	0.00 c	3.33 ab	1.66 bc	2.33 b-d	0.00 b	2.66 b	1.66 bc	2.00 bc	0.00 c	1.33 bc	1.66 bc	2.33 b-d
T_3	0.00 c	0.00 c	4.00 a	1.33 c	3.00 b	0.00 b	1.66 c-e	2.33 b	2.67 b	0.00 c	1.33 bc	1.00 c	2.00 b-d
T^4	0.00 c	0.00 c	3.00 a-c	2.66 a-c	3.00 b	0.00 b	2.66 b	1.66 bc	1.66 bc	0.00 c	1.66 bc	2.00 bc	3.00 ab
T_5	0.00 c	0.00 c	3.33 ab	3.00 ab	1.33 d	0.00 b	2.00 b-d	1.66 bc	1.66 bc	0.00 c	1.66 bc	1.33 bc	3.00 ab
T_6	0.00 c	0.00 c	2.00 cd	1.33 c	1.66 cd	0.00 b	1.33 de	1.00 c	1.333 c	0.00 c	1.00 c	1.66 bc	2.00 b-d
T_7	0.00 c	0.00 c	2.33 b-d	1.33 c	2.00 b-d	0.00 b	1.66 c-e	1.33 bc	1.33 c	0.00 c	1.00 c	2.33 b	1.66 cd
T_8	0.00 c	0.00 c	1.66 d	1.33 c	1.66 cd	0.00 b	1.00 e	1.00 c	1.00 c	0.00 c	1.00 c	2.00 bc	1.33 d
T_9	0.00 c	0.00 c	2.66 b-d	1.66 bc	2.00 b-d	0.00 b	1.66 c-e	1.66 bc	1.66 bc	0.00 c	2.00 ab	1.33 bc	1.66 cd
T_{10}	0.00 c	0.00 c	2.66 b-d	1.66 bc	2.66 bc	0.00 b	2.33 bc	1.66 bc	1.66 bc	0.00 c	1.33 bc	1.00 c	2.00 b-d
T_{11}	0.00 c	0.00 c	2.66 b-d	3.00 ab	2.66 bc	0.00 b	2.00 b-d	2.00 bc	1.66 bc	0.00 c	1.33 bc	2.33 b	3.00 ab
T_{12}	277.7 b	303.0 b	2.66 b-d	2.33 bc	2.33 b-d	0.00 b	2.33 bc	2.00 bc	1.66 bc	0.00 c	1.66 bc	1.66 bc	2.00 b-d
T_{13}	476.0 a	422.7 a	3.33 ab	4.00 a	4.33 a	7.00 a	5.00 a	4.00 a	4.00 a	3.33 a	2.66 a	4.00 a	4.00 a
$LSD_{(0.05)}$	3.01	3.05	1.09	1.4	1.05	1.06	0.95	1.23	1.22	0.46	0.8	1.1	1.22
CV(%)	3.08	3.25	22.39	38.69	26.44	91.06	25.59	40.15	39.35	60.09	31.61	35.41	30.8

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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Alternanthera sessilis, Monochoria vaginalis and *Leptochloa chinensis.* All the treatments showed statistically similar result with T_8 in controlling *Leersia hexandra* except T_7 and T_{11}. *Marsilea quadrifolia, Cyperus difformis, Eclipta alba* and *Ludwigia hyssopifolia* were absent in all the treatments as the treatments sumlessfully controlled these weed species except T_{12} as it was found less effective in controlling weed species compared to other treatments. This result is found dissimilar with Jursik *et al.* (2013) who observed that the highest efficacy on *Chenopodium album*, *Amaranthus retroflexus*, *Echinochloa crus-galli* and *Solanum physalifolium* was recorded after application of acetochlor and irrigation. Chedzey and Findlay (1986) also reported that Acetochlor gave excellent residual control of annual grasses and certain broadleaf weeds. The early post-emergence treatments of Harness with Gesapax and Gramoxone gave commercially amleptable control of weeds including *Cyperus esculentus.*

4.4 Effect of herbicidal treatments on weed population (No. m^{-2}) after 14 days of spray

Significant variation was observed on weed population after 14 days of spray for different weed control treatments as herbicidal treatments considerably reduced weed population (Table 9). From the table it was found that after 14 days of spray *Marsilea quadrifolia, Cyperus difformis, Eclipta alba, Alternanthera sessilis, Monochoria vaginalis* and *Ludwigia hyssopifolia* were absent in all the treatments except T_{12} (Acetochlor 14% + Bensulfuron 4% @ 742 g ha^{-1}) and T_{13} (Weedy check). The maximum weed population for all weed species viz. *Marsilea quadrifolia, Cyperus difformis, Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli, Eclipta alba, Alternanthera philoxeroides, Alternanthera sessilis, Monochoria vaginalis, Sagittaria guyanensis, Leersia hexandra, Ludwigia hyssopifolia* and *Leptochloa chinensis* (796, 716.7, 3.66, 6.0, 5.0, 7.66, 4.0, 4.33, 4.66, 5.0, 3.0, 4.66 and 4.66, respectively) was recorded from T_{13} (Weedy check) whereas the minimum was observed from T_6 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG 1000 g ha^{-1}) and T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) to control *Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli* and *Leptochloa chinensis* (1.0, 1.66, 1.66, 1.33 and 1.66 respectively). Treatments T_3, T_4, T_5, T_7, T_9, T_{10} and T_{12} showed statistically similar result with T_8 to control *Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli* and *Leptochloa chinensis.* On the other

Table 9: Weed population (m^{-2}) after 14 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T_1	0.00 e	0.00 b	2.33 bc	3.33 bc	2.66 bc	0.00 b	2.33 bc	0.00 c	0.00 b	0.00 b	1.33 b	2.66 bc	2.66 b-d
T_2	51.33 b	0.00 b	2.66 b	2.33 b-d	2.33 bc	0.00 b	2.66 b	0.00 c	0.00 b	0.00 b	1.00 b	2.33 bc	3.00 bc
T_3	7.33 d	0.00 b	1.66 cd	2.33 b-d	3.00 b	0.00 b	1.66 cd	0.00 c	0.00 b	0.00 b	0.00 c	1.66 cd	2.00 cd
T^4	0.00 e	0.00 b	1.33 d	3.00 b-d	3.00 b	0.00 b	2.66 b	0.00 c	0.00 b	0.00 b	1.00 b	3.00 b	3.00 bc
T_5	0.00 e	0.00 b	1.33 d	3.00 b-d	2.33 bc	0.00 b	2.33 bc	0.00 c	0.00 b	0.00 b	1.00 b	1.66 cd	3.33 b
T_6	0.00 e	0.00 b	1.00 d	1.66 d	1.66 c	0.00 b	1.33 d	0.00 c	0.00 b	0.00 b	0.00 c	2.00 b-d	2.00 cd
T_7	0.00 e	0.00 b	1.00 d	2.00 cd	2.00 bc	0.00 b	2.00 b-d	0.00 c	0.00 b	0.00 b	0.00 c	2.66 bc	1.66 d
T_8	0.00 e	0.00 b	1.00 d	1.66 d	1.66 c	0.00 b	1.33 d	0.00 c	0.00 b	0.00 b	0.00 c	2.66 bc	1.66 d
T_9	0.00 e	0.00 b	1.33 d	2.66 b-d	2.00 bc	0.00 b	2.33 bc	0.00 c	0.00 b	0.00 b	1.33 b	1.66 cd	2.00 cd
T_{10}	0.00 e	0.00 b	1.33 d	2.33 b-d	3.00 b	0.00 b	2.66 b	0.00 c	0.00 b	0.00 b	0.00 c	1.00 d	2.00 cd
T_{11}	0.00 e	0.00 b	1.33 d	3.66 b	3.00 b	0.00 b	2.33 bc	0.00 c	0.00 b	0.00 b	0.00 c	2.00 b-d	3.00 bc
T_{12}	12.00 c	0.00 b	1.66 cd	3.00 b-d	2.33 bc	0.00 b	2.66 b	0.00 c	0.00 b	0.00 b	0.00 c	2.00 b-d	2.00 cd
T_{13}	796.0 a	716.7 a	3.66 a	6.00 a	5.00 a	7.66 a	4.00 a	4.33 a	4.66 a	5.00 a	3.00 a	4.66 a	4.66 a
$LSD_{(0.05)}$	3.39	2.57	0.72	1.54	1.32	0.78	0.97	0.27	0.27	0.46	0.59	1.13	1.24
CV(%)	3.02	2.77	25.87	32.16	29.99	67.1	24.82	39.03	44.61	72.11	52.81	29.17	29.19

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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hand the minimum weed population (1.0) was found from T_{10} (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}) which was statistically similar with T_3, T_5, T_6, T_9, T_{11} and T_{12} treatments. *Sagittaria guyanensis* was absent in all treatments except T_1, T_2, T_4, T_5 and T_9 as the treatments suppressed *Sagittaria guyanensis* sumlessfully. This result is dissimilar with the findings of Khaliq *et al.* (2012) who stated that Acetochlor, butachlor and pendimethalin were effective against jungle rice while ethoxysulfuron ethyl was most efficient in controlling purple nutsedge.

4.5 Effect of herbicidal treatments on weed population (No. m^{-2}) after 21 days of spray

The weed population varied significantly due to various herbicidal treatments since weeds were drastically reduced from the rice field after application of herbicide. From Table 10 it was observed that after 21 days of spray maximum weed population viz. *Marsilea quadrifolia*, *Cyperus difformis*, *Cyperus esculentus*, *Cynodon dactylon*, *Echinochloa crussgalli*, *Eclipta alba*, *Alternanthera philoxeroides*, *Alternanthera sessilis*, *Monochoria vaginalis* , *Ludwigia hyssopifolia*, *Sagittaria guyanensis*, *Leersia hexandra* and *Leptochloa chinensis* (860.3, 719.7, 4.0, 6.0, 5.0, 7.66, 5.00, 4.33, 4.66, 5.0, 3.0, 5.0 and 4.66, respectively) was observed from the control plot (T_{13}). On the other hand, minimum number (10) of *Marsilea quadrifolia* was found from T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with treatment T_6. The lowest weed population was recorded from T_6 and T_8 treatments to control *Cynodon dactylon, Echinochloa crussgalli* and *Alternanthera philoxeroides* which was statistically similar with all treatments except T_1 and T_{11} for controlling *Cynodon dactylon* and *Echinochloa crussgalli*. Treatment T_3, T_5 and T_6 also showed statistically similar result with T_6 and T_8 to control *Alternanthera philoxeroides.* The minimum number (4.66) of *Leersia hexandra* was found from T_{10} (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}) which was statistically similar with T_5, T_9, T_{11} and T_{12}. The lowest number (1.66) of *Leptochloa chinensis* was observed from T_7 and T_8 which was statistically similar with all treatments except T_2, T_4, T_5 and T_{11}. From the table it was clear that *Cyperus difformis, Cyperus esculentus, Eclipta alba, Alternanthera sessilis, Monochoria vaginalis, Ludwigia hyssopifolia* and *Sagittaria guyanensis* were totally absent from all treatments except T_{12} as the other treatments effectively suppressed these weed species. This result is resemblance with the

Table 10: Weed population (m^{-2}) after 21 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T1	16.00 ef	0.00 b	0.00 d	3.66 b	2.66 bc	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.66 b-d
T2	176.3 b	0.00 b	2.66 b	2.33 bc	2.33 bc	0.00 b	3.00 c-e	0.00 b	0.00 b	0.00 b	0.00 b	3.66 b	3.00 bc
T3	20.67 d	0.00 b	0.00 d	2.33 bc	3.00 b	0.00 b	2.66 d-f	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	2.00 cd
T4	20.00 de	0.00 b	0.00 d	3.00 bc	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.33 bc	3.00 bc
T5	20.67 d	0.00 b	0.00 d	3.00 bc	2.33 bc	0.00 b	2.66 d-f	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.33 b
T6	13.00 fg	0.00 b	0.00 d	1.66 c	1.66 c	0.00 b	2.00 f	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.00 cd
T7	15.00 f	0.00 b	1.00 c	2.00 c	2.00 bc	0.00 b	2.33 ef	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	1.66 d
T8	10.00 g	0.00 b	0.00 d	1.66 c	1.66 c	0.00 b	2.00 f	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	1.66 d
T9	15.67 f	0.00 b	0.00 d	2.66 bc	2.00 bc	0.00 b	3.00 c-e	0.00 b	0.00 b	0.00 b	0.00 b	1.66 ef	2.00 cd
T10	22.00 d	0.00 b	0.00 d	2.33 bc	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	1.33 f	2.00 cd
T11	16.00 ef	0.00 b	0.00 d	3.66 b	3.00 b	0.00 b	3.66 bc	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.00 bc
T12	31.67 c	0.00 b	0.00 d	3.00 bc	2.33 bc	0.00 b	4.00 b	0.00 b	0.00 b	0.00 b	0.00 b	2.00 d-f	2.00 cd
T13	860.3 a	719.7 a	4.00 a	6.00 a	5.00 a	7.66 a	5.00 a	4.33 a	4.66 a	5.00 a	3.00 a	5.00 a	4.66 a
LSD (0.05)	4.26	2.1	0.68	1.5	1.32	0.71	0.74	0.27	0.27	0.46	0.46	1.12	1.24
CV(%)	2.66	2.26	69.22	31.09	29.99	63.55	30.86	48.04	44.61	72.11	120.19	24.13	29.19

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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findings of Jordan (1997) who reported that two applicanons of propanil were more effective in controlling barnyardgrass (*Echinochloa crussgalli*) and other weed species than a single application.

4.6 Effect of herbicidal treatments on weed population (No. m^{-2}) after 28 days of spray

Weed control strategy is essential for the growth and yield of rice plant. The strategies have significant effect on weed control. Herbicidal treatments drastically reduced weed population (Table 11). After 28 days of spray the weed population was also significantly influenced by different weed control treatments. From the table it was seen that the highest weed population was found from T_{13} (Weedy check) for all weed species viz. *Marsilea quadrifolia*, *Cyperus difformis, Cyperus esculentus*, *Cynodon dactylon, Echinochloa crussgalli*, *Eclipta alba*, *Alternanthera philoxeroides, Alternanthera sessilis, Monochoria vaginalis, Ludwigia hyssopifolia, Sagittaria guyanensis*, *Leersia hexandra* and *Leptochloa chinensis* (821.0, 719.7, 4.0, 6.0, 5.0, 7.66, 5.0, 4.66, 4.66, 5.0, 3.0, 5.0 and 4.66, respectively) whereas the lowest was observed from T_6 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG 1000 g ha^{-1}) and T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) to suppress *Cynodon dactylon*, *Echinochloa crussgalli* and *Alternanthera philoxeroides* (1.66, 1.66 and 2.0, respectively) which was statistically similar with all treatments except $T_{1,}$ T_{11} and $T_{12.}$ In the experimental plots *Cyperus difformis*, *Cyperus esculentus, Eclipta alba*, *Alternanthera sessilis, Monochoria vaginalis*, *Ludwigia hyssopifolia* and *Sagittaria guyanensis* were absent from all treatments except T_{12}. On the other hand, the minimum number (1.33) of *Leersia hexandra* was found from T_{10} (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}) which was statistically similar with T_5, $T_{9,}$ T_{11} and T_{12} treatments. The lowest number of *Leptochloa chinensis* (1.66) was observed from T_7 (Propyrisulfuron @ 250 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) and T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with all treatments except T_2, $T_{4,}$ T_5 and $T_{11.}$ This result was harmony with the findings of Jordan (1997) who reported that Propanil + molinate applied with quinclorac at 0.28 or 0.40 kg ha^{-I} controlled barnyardgrass (*Echinochloa crussgalli*) more effectively. This findings was inconsistence with the result of Chowdhury (2012) who revealed that pre-emergence herbicide Sunrice 150WG controlled weeds very significantly.

Table 11: Weed population (m^{-2}) after 28 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T_1	20.00 ef	0.00 b	0.00 d	3.66 b	2.66 bc	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.66 b-d
T_2	181.0 b	0.00 b	2.00 b	2.33 bc	2.33 bc	0.00 b	3.00 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.66 b	3.00 bc
T_3	35.00 c	0.00 b	0.00 d	2.33 bc	3.00 b	0.00 b	2.66 b-d	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	2.00 cd
T_4	20.00 ef	0.00 b	0.00 d	3.00 bc	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.33 bc	3.00 bc
T_5	25.00 d	0.00 b	0.00 d	3.00 bc	2.33 bc	0.00 b	2.66 b-d	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.33 b
T_6	15.00 g	0.00 b	0.00 d	1.66 c	1.66 c	0.00 b	2.00 d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.00 cd
T_7	16.33 fg	0.00 b	1.00 c	2.00 c	2.00 bc	0.00 b	2.33 cd	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	1.66 d
T_8	13.00 g	0.00 b	0.00 d	1.66 c	1.66 c	0.00 b	2.00 d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	1.66 d
T_9	19.67 ef	0.00 b	0.00 d	2.66 bc	2.00 bc	0.00 b	3.00 b-d	0.00 b	0.00 b	0.00 b	0.00 b	1.66 ef	2.00 cd
T_{10}	23.33 de	0.00 b	0.00 d	2.33 bc	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	1.33 f	2.00 cd
T_{11}	22.00 de	0.00 b	0.00 d	3.66 b	3.00 b	0.00 b	3.66 a-c	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.00 bc
T_{12}	36.00 c	0.00 b	0.00 d	3.00 bc	2.33 bc	0.00 b	4.00 ab	0.00 b	0.00 b	0.00 b	0.00 b	2.00 d-f	2.00 cd
T_{13}	821.0 a	719.7 a	4.00 a	6.00 a	5.00 a	7.66 a	5.00 a	4.66 a	4.66 a	5.00 a	3.00 a	5.00 a	4.66 a
$LSD_{(0.05)}$	4.23	2.1	0.46	1.5	1.32	0.71	1.61	0.54	0.27	0.46	0.46	1.12	1.24
CV(%)	2.62	2.26	51.51	31.09	29.99	63.55	30.86	89.21	44.61	72.11	120.19	24.13	29.19

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

Figures in a column having the same letter(s) do not differ significantly whereas figures having dissimilar letter(s) are significantly different at 5% level

4.7 Effect of herbicidal treatments on weed population (No. m^{-2}) after 45 days of spray

Weed control treatments had significant influence on weed population after 45 days of spray as herbicidal treatments severely suppressed weed population. From Table 12 it was observed that after 45 days of spray the minimum number (17.0) of *Marsilea quadrifolia* was found from T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with T_6 and T_7. On the contrary, the maximum weed population was observed at treatment T_{13} (Weedy check) for not only the *Marsilea quadrifolia* but also almost all weed species, viz. *Cyperus difformis, Cyperus esculentus, Cynodon dactylon, Echinochloa crussgalli, Eclipta alba, Alternanthera philoxeroides, Alternanthera sessilis, Monochoria vaginalis, Ludwigia hyssopifolia, Sagittaria guyanensis, Leersia hexandra* and *Leptochloa chinensis* (856.7 719.7, 4.0, 5.33, 5.0, 7.66, 5.0, 4.33, 4.66, 5.0, 3.0, 5.0 and 4.66, respectively) whereas the minimum number of *Cyperus esculentus* was found from almost all treatments except $T_{2,}$ $T_{6,}$ T_7 and T_{12}. No *Cynodon dactylon* was found from treatments $T_{3,}$ T_4 and T_5 which was statistically similar with all treatments except T_1 and $T_{11.}$ The lowest number (1.66) of *Echinochloa crussgalli* was recorded from T_6 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG 1000 g ha^{-1}) and T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with $T_{3,}$ $T_{4,}$ T_{10} and T_{11}. The minimum number (1.33) of *Leersia hexandra* was found from T_{10} which was statistically similar with T_5, $T_{9,}$ T_{11} and T_{12} treatments. The lowest number of *Leptochloa chinensis* (1.66) was recorded from T_7 (Propyrisulfuron @ 250 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) and T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with all treatments except T_2, $T_{4,}$ T_5 and $T_{11.}$ From the table it was clear that weed population was totally absent from all treatments except T_{13} (Weedy check) to control *Cyperus difformis, Eclipta alba, Monochoria vaginalis Alternanthera sessilis, Ludwigia hyssopifolia* and *Sagittaria guyanensis* as the treatments suppressed these weed species sucessfully. This result was in agreement with the findings of Rajkhowa *et al.* (2001) who reported that Butachlor 1.0 kg ha^{-1} applied three days after transplanting (DAT) significantly reduced weed infestation till 45 DAT and resulted in higher yield of rice over weedy check. James and Rahman (2009); Rangaraju (2002) and Ali *et al.* (2010) also reported

Table 12: Weed population (m^{-2}) after 45 days of spray

Treatments	*Marsilea quadrifolia*	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
T_1	35.00 d	0.00 b	0.00 c	3.66 b	2.66 bc	0.00 b	0.00 c	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.66 b-d
T_2	184.0 b	0.00 b	2.00 b	2.33 bc	2.33 bc	0.00 b	3.00 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.66 b	3.00 bc
T_3	38.00 cd	0.00 b	0.00 c	0.00 c	3.00 b	0.00 b	2.66 b-d	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	2.00 cd
T^4	25.33 e	0.00 b	0.00 c	0.00 c	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	3.33 bc	3.00 bc
T_5	26.33 e	0.00 b	0.00 c	0.00 c	2.33 bc	0.00 b	2.66 b-d	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.33 b
T_6	19.33 gh	0.00 b	1.66 b	1.66 c	1.66 c	0.00 b	2.00 d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	2.00 cd
T_7	20.33 f-h	0.00 b	1.00 bc	2.00 c	2.00 bc	0.00 b	2.33 cd	0.00 b	0.00 b	0.00 b	0.00 b	2.66 b-e	1.66 d
T_8	17.00 h	0.00 b	0.00 c	1.66 c	1.66 c	0.00 b	2.00 d	0.00 b	0.00 b	0.00 b	0.00 b	3.00 b-d	1.66 d
T_9	23.67 ef	0.00 b	0.00 c	2.66 bc	2.00 bc	0.00 b	3.00 b-d	0.00 b	0.00 b	0.00 b	0.00 b	1.66 ef	2.00 cd
T_{10}	22.33 e-g	0.00 b	0.00 c	2.33 bc	3.00 b	0.00 b	3.33 b-d	0.00 b	0.00 b	0.00 b	0.00 b	1.33 f	2.00 cd
T_{11}	25.33 e	0.00 b	0.00 c	3.66 b	3.00 b	0.00 b	3.66 a-c	0.00 b	0.00 b	0.00 b	0.00 b	2.33 c-f	3.00 bc
T_{12}	40.00 c	0.00 b	1.66 b	3.00 bc	2.33 bc	0.00 b	4.00 ab	0.00 b	0.00 b	0.00 b	0.00 b	2.00 d-f	2.00 cd
T_{13}	856.7 a	719.7 a	4.00 a	5.33 a	5.00 a	7.66 a	5.00 a	4.33 a	4.66 a	5.00 a	3.00 a	5.00 a	4.66 a
LSD $_{(0.05)}$	4.27	2.1	1.44	1.62	1.32	0.71	1.61	0.38	0.27	0.46	0.46	1.12	1.24
CV(%)	2.48	2.26	107.59	34.26	29.99	63.55	30.86	53.02	44.61	72.11	120.19	24.13	29.19

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

Figures in a column having the same letter(s) do not differ significantly whereas figures having dissimilar letter(s) are significantly different at 5% level

same results while the similar finding was observed from Ikeda *et al.* (2011) who stated that Propyrisulfuron is used as a rice herbicide to control annual and perennial paddy weeds, including *Echinochloa* spp, sedges and broadleaf weeds.

4.8 Relative weed density (%)

For the existence weed competes not only with plants but also with other weed species. In this experiment, several weed species were found in the field at different dates (Table 13). Even though, incidence of weed in the crop field mainly depends on various environmental factors such as climatic, rainfall etc. and abiotic factors such as edaphic, topography of land etc. Before 3 days of spray aquatic and grass weeds conquered the field among them the aquatic weed *Cyperus difformis* recorded the highest RWD (48.51%) and the grass weed *Marsilea quadrifolia* showed the second highest RWD (45.25 %). After 7 days of spray *Marsilea quadrifolia* (grass) scored the highest RWD (42.24%), *Cyperus difformis* (aquatic) found the second highest RWD (40.67%), *Cyperus esculentus* (aquatic) recorded the third highest RWD (2.11%) and *Leptochloa chinensis* (1.72%) recorded the fourth highest dominating weeds in the field. Similarly grass weeds dominated the experimental plot at 14 DAS, 21 DAS, 28 DAS and 45 DAS. At 14 DAS, the dominated weed species were *Marsilea quadrifolia* (47.06% RWD), *Cyperus difformis* (38.91% RWD) and *Cynodon dactylon* (2.01% RWD). Similarly grass weeds dominated than aquatic and sedges at 21 DAS, in case of *Marsilea quadrifolia* (grass) was scored 56.04% RWD, *Cyperus difformis* (aquatic) was recorded 32.59% RWD and *Alternanthera philoxeroides* (sedge) was showed 1.83% RWD. Grass weeds again dominated the field at 28 DAS although another being present and the highest RWD (56.25 % and 32.45 %) was observed for *Marsilea quadrifolia* and *Cyperus difformis*, respectively. At 45 DAS the dominating scenario of weeds was almost similar for *Marsilea quadrifolia* (grass), *Cyperus esculentus* (aquatic), *Alternanthera philoxeroides* (Sedge) the RWD were recorded 57.83%, 31.21% and 1.75%, respectively. In this experiment grass, aquatic and sedge weeds dominated the crop field throughout the growing period. Aquatics and broadleaf's were prominent during the earlier and grasses were prominent both early and later period due to the reemergence capacity while among the weed species *Cynodon dactylon* (grass), *Leptochloa chinensis* (sedge), *Echinochloa crussgalli* (aquatic), *Alternanthera philoxeroides* (Sedge), *Leersia hexandra* (grass), specially the weeds of gramineae family were present in the field throughtout the growing period as they are less affected by the herbicidal treatments. This result is similar with the findings of Chowdhury (2012) but dissimilar with the findings of Hasanuzzaman *et al.* (2008) who observed that grasses and sedges were less dominating weed species. This might be due to seasonal and varietal difference.

Table 13. Relative density (%) of different weed species infested the experimental area

SL No.	Scientific name	Types	Relative density (%)					
			Before 3 DAS	After 7 DAS	After 14 DAS	After 21 DAS	After 28 DAS	After 45 DAS
1	*Marsilea quadrifolia*	Fern	45.25	42.24	47.06	56.04	56.25	57.83
2	*Cyperus difformis*	Sedge	48.51	40.67	38.91	32.59	32.45	31.21
3	*Cyperus esculentus*	Sedge	0.84	2.11	1.18	0.35	0.32	0.38
4	*Cynodon dactylon*	Grass	0.59	1.57	2.01	1.69	1.68	1.59
5	*Echinochloa crussgalli*	Grass	0.37	1.72	1.85	1.54	1.53	1.47
6	*Eclipta alba*	Broadleaf	0.68	0.5	0.49	0.39	0.39	0.38
7	*Alternanthera philoxeroides*	Aquatic	0.36	1.61	1.65	1.83	1.82	1.75
8	*Alternanthera sessilis*	Aquatic	0.54	1.33	0.29	0.20	0.21	0.25
9	*Monochoria vaginalis*	Aquatic	0.57	1.35	0.25	0.21	0.21	0.20
10	*Ludwigia hyssopifolia*	Aquatic	0.44	0.34	0.27	0.23	0.23	0.22
11	*Sagittaria guyanensis*	Aquatic	0.46	1.1	0.47	0.14	0.14	0.13
12	*Leersia hexandra*	Grass	0.26	1.35	1.63	1.63	1.62	1.56
13	*Leptochloa chinensis*	Grass	0.37	1.72	1.79	1.49	1.49	1.43

4.9 Crop growth parameter

4.9.1 Tiller length (cm)

Significant variation was observed for tiller length due to different herbicidal treatments. It was observed that treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) gave the highest tiller length (107.3cm) which was statistically similar with the treatment T_3 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}) and the lowest tiller length (78.10cm) was obtained from treatment T_{13} (Weedy check). This result was in agreement with Hasanuzzaman *et al.* (2008) who described that tiller length varied significantly due to the different herbicidal treatments.

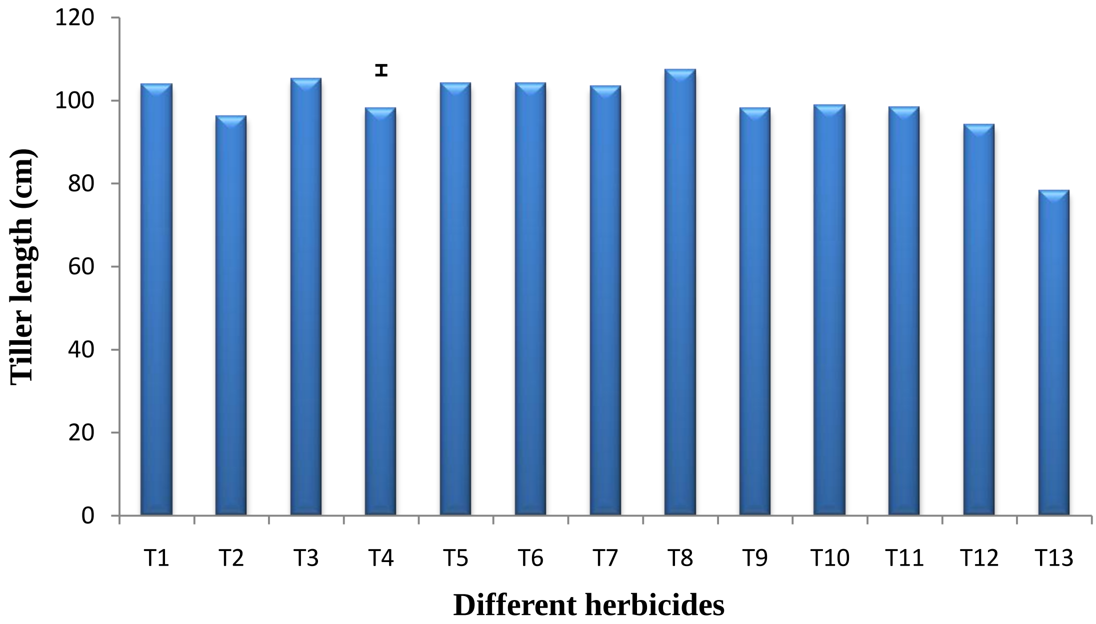

Figure 1. Effect of different herbicides on tiller length (cm) of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.9.2 Total number of tillers hill^{-1}

For different herbicidal treatments the total number of tillers hill^{-1} varied significantly. The total number of tillers hill^{-1} was found maximum (13.67) from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha-1) hence the minimum (6.33) number of tillers hill^{-1} was recorded in the weedy check plot treatment $T_{13.}$ Similar results were observed by Chowdhury (2012).

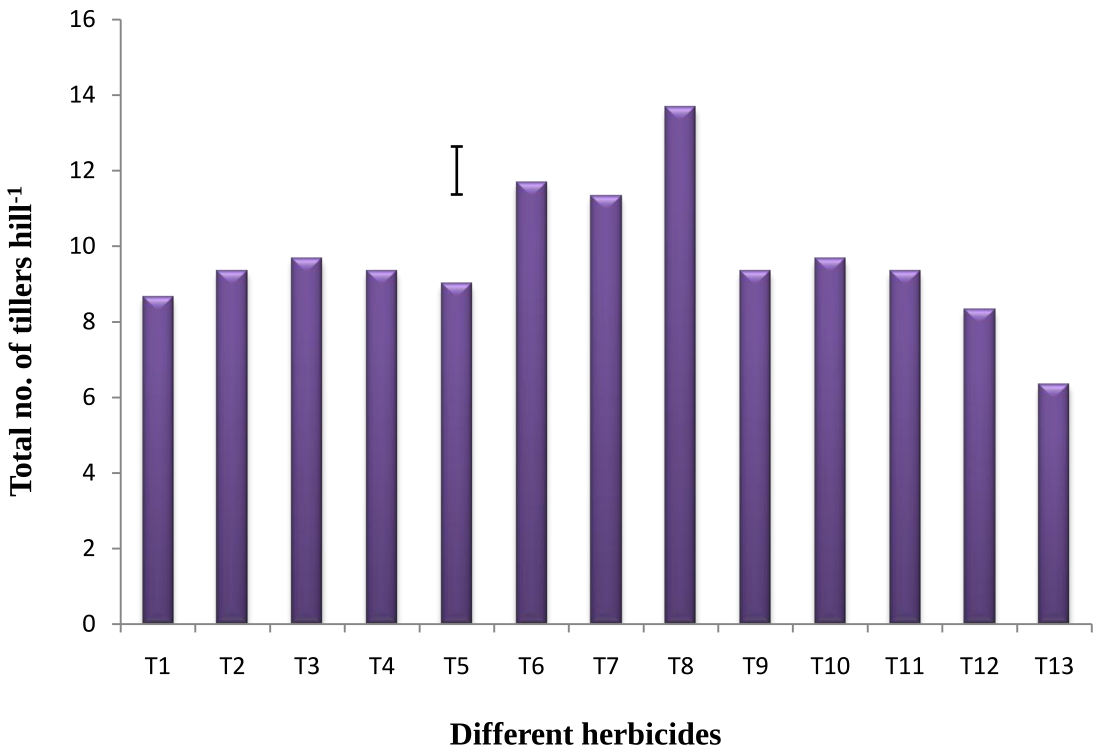

Figure 2. Effect of different herbicides on total number of tillers hill^{-1} of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10 Yield contributing characters

4.10.1 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} was affected significantly due to different herbicidal treatments. The least number of effective tillers hill^{-1} (3.0) was recorded from treatment T_{13} (Weedy check). On the other hand, the most number of effective tillers hill^{-1} (11.33) was scored from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}). Raju *et al.* (2003) observed that number of effective tillers hill^{-1} was differed due to different herbicidal treatments.

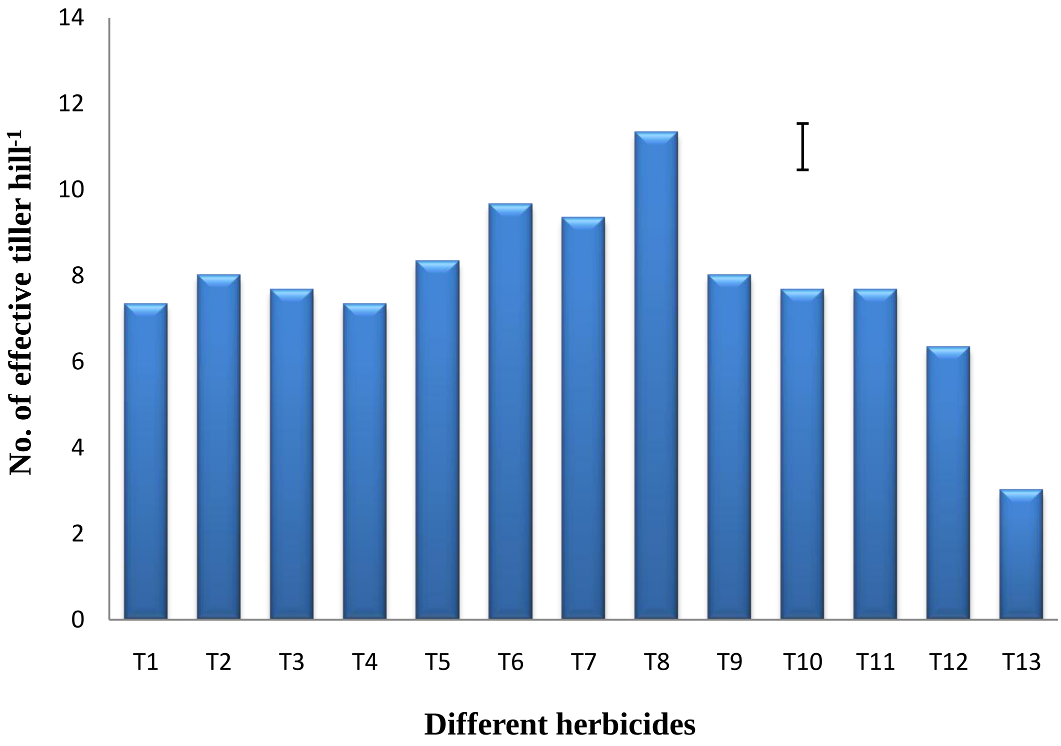

Figure 3. Effect of different herbicides on number of effective tillers hill^{-1} of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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

Different herbicidal treatments had significant influence on the number of non effective tillers hill^{-1}. It was observed that the highest number of non-effective tillers hill^{-1} (3.33) was recorded from treatment T_{13} (Weedy check) which was statistically similar with treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}), on the contrary, no significant difference was observed in case of the lowest number of non-effective tillers hill^{-1} which was almost statistically similar for all treatments except treatment T_{13} (Weedy check). Similar findings were reported from Chowdhury (2012).

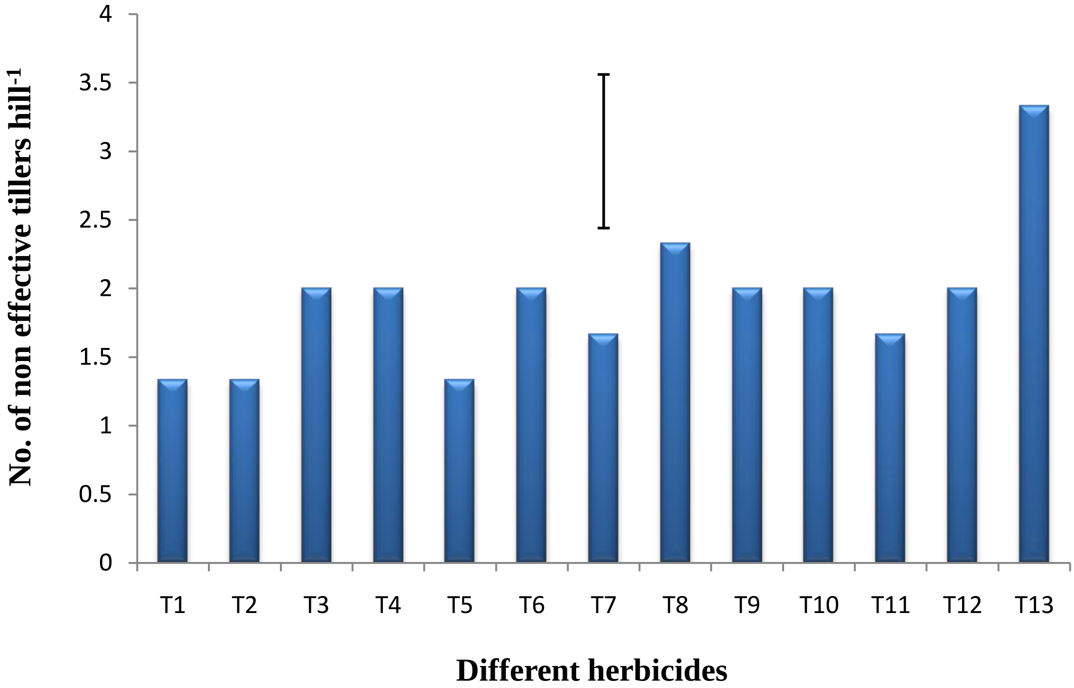

Figure 4. Effect of different herbicides on number of non-effective tillers hill^{-1} of transplanted *aus* vrice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10.3 Panicle length (cm)

Panicle length (cm) varied significantly due to the different herbicidal treatments. Among the treatments treatment, T_6 (Propyrisulfuron @ 500 ml ha^{-1} + Propanil 60 WG 1000 g ha^{-1}) was scored maximum panicle length (24.37 cm) which was statistically similar with T_2, T_3, T_7, and T_{10} treatments. The minimum panicle length (18.20 cm) was recorded from weedy check treatment T_{13} which was similar statistically with treatment T_{12} (Acetochlor 14% Bensulfuron 4% @ 742 g ha^{-1}). These results were in similar to the findings of Mahajan *et al.* (2003) who observed that application of Pretilachlor alone or in combination with Safener and hand weeding resulted the highest panicle length.

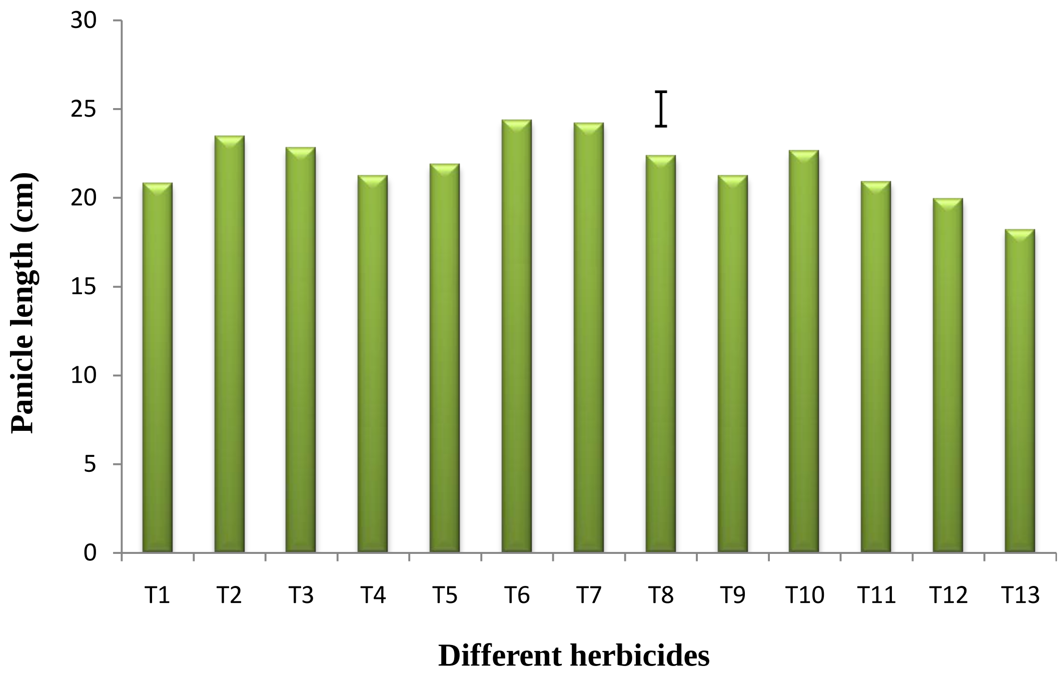

Figure 5. Effect of different herbicides on panicle length (cm) of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10.4 Total number of grains panicle^{-1}

Significant variation was observed in total number of grains panicle^{-1} due to the effect of different herbicidal treatments. The highest number of grains panicle^{-1} (69.00) was found from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically identical with T_6 and T_7 treatments. The lowest number of grains panicle^{-1} (54.67) was found from treatment T_{13} (Weedy check) which was statistically similar with T_{11} and T_{12} treatments. Similar findings were reported by Jordan (1997) who showed that application of propanil and molinate applied with quinclorac produced the highest number of grains panicle^{-1}.

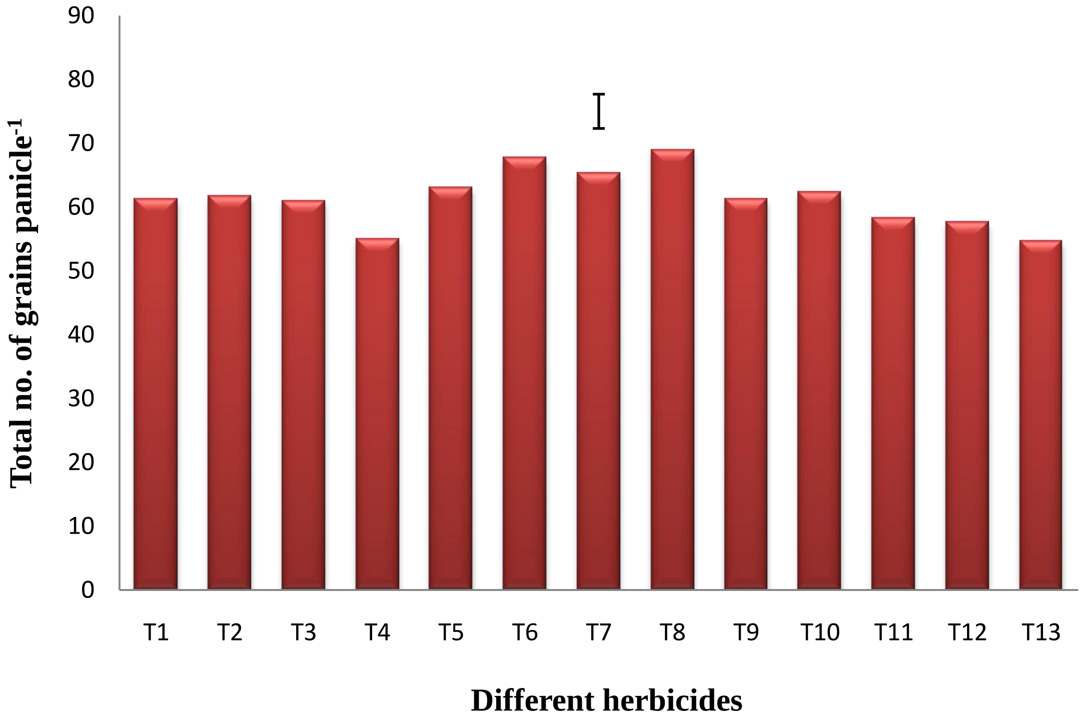

Figure 6. Effect of different herbicides on total number of grains panicle^{-1} of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10.5 Total number of sterile grains panicle^{-1}

The total number of sterile grains panicle^{-1} was significantly influenced by the effect of different herbicidal treatments. The maximum number of sterile grains panicle^{-1} (14.33) was obtained from weedy check treatment $T_{13.}$ The minimum number of sterile grains panicle^{-1} (4.66) was observed from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically resemblance with $T_{1,}$ T_6, $T_{7,}$ and T_{11} treatments. Similar findings were observed by Chowdhury (2012) who revealed that no weeding produced higher unfilled grain than Sunrise 150WG.

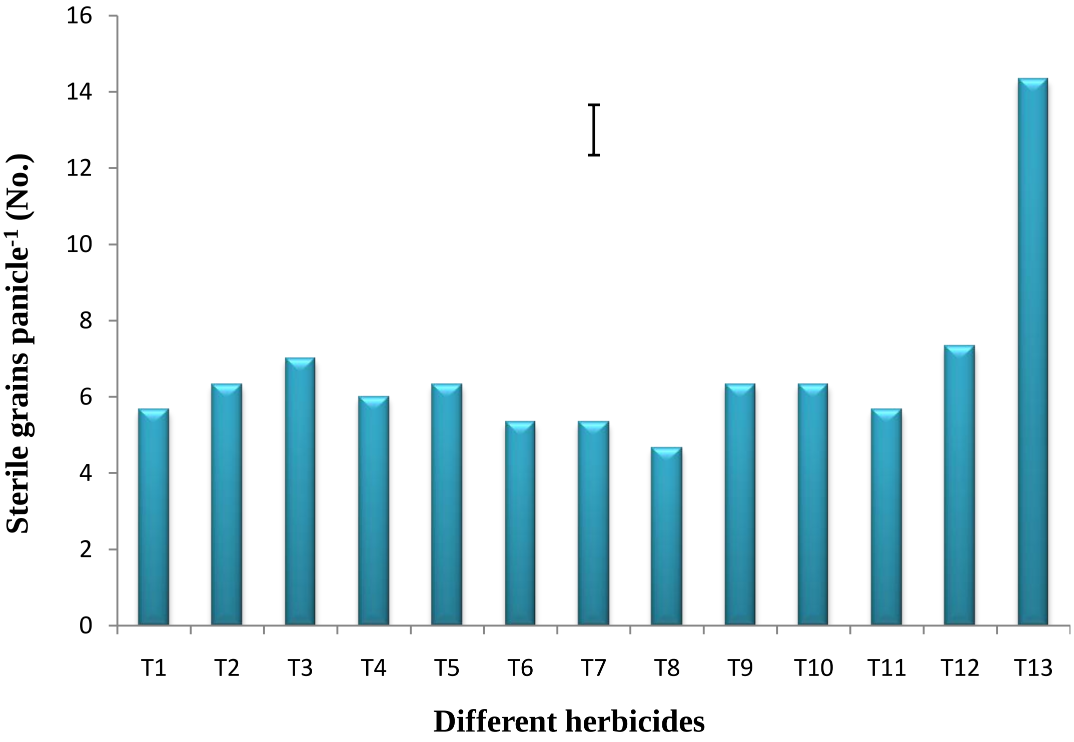

Figure 7. Effect of different herbicides on number of sterile grains panicle^{-1} of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10.6 Filled grain panicle^{-1}

The influence of different herbicidal treatments was affected significantly in terms of filled grain panicle^{-1}. It was observed that treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha-1) gave the most filled grain panicle^{-1} (64.33) which was statistically similar with T_6, T_7, and T_9 treatments hence the least filled grain panicle^{-1} (40.33) was obtained from treatment T_{13} (Weedy check). Gnanasambandan and Murthy (2001) also found the highest filled grain by the application of pre emergence herbicide Butachlor.

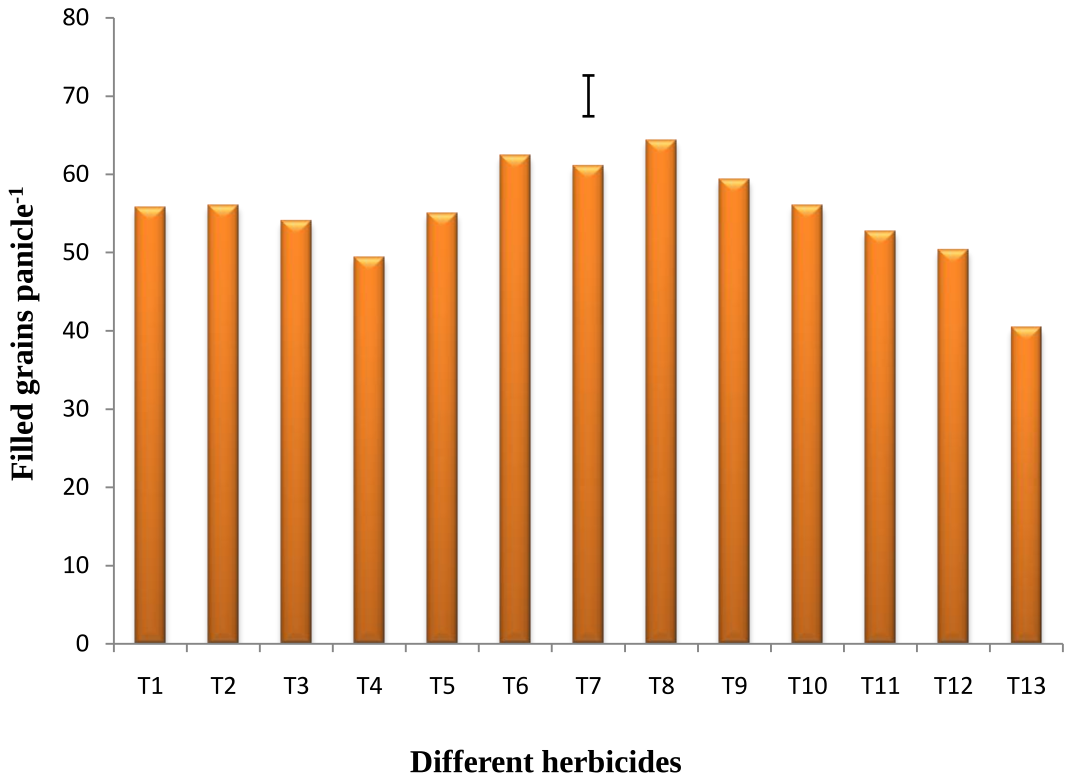

Figure 8. Effect of different herbicides on filled grains panicle^{-1} of transplanted *aus* rice (Nerica). Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.10.7 1000 grain weight

The weight of 1000 grains was significantly influenced by the different herbicidal treatments. The 1000 grain weight was the highest (24.33 g) in case of treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) and T_2, T_4, T_5, T_6, T_7 and T_{10} treatments which was statistically similar with T_2, T_3, T_7, and T_{10} treatments. On the other hand the lowest 1000 grain weight was (22.33 g) observed from treatment T_{13} (Weedy check) which was statistically identical with all the treatments except T_2, T_3 and T_{10} treatments. The highest 1000 grain weight was recorded from Sunrise 150WP treatment reported by Chowdhury (2012).

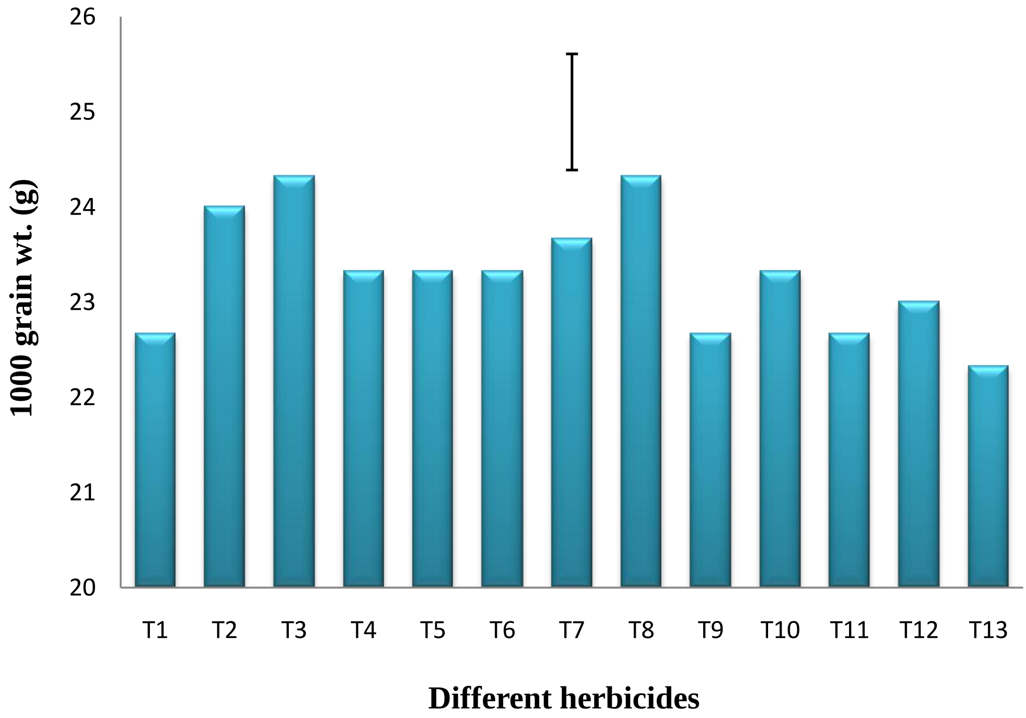

Figure 9. Effect of different herbicides on 1000 grain wt. (g) of transplanted *aus* rice (Nerica). Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check

4.11 Yield

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

For different herbicidal treatments grain yield varied significantly. It was observed that treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) showed maximum grain yield (3.81 t ha^{-1}) and treatment T_{13} (Weedy check) recorded minimum grain yield (0.85 t ha^{-1}). This result was similar with the findings of Ahmed and Chauhan (2014) who found that oxadiargyl followed by ethoxysulfuron provided higher yield than unweeded treatment.

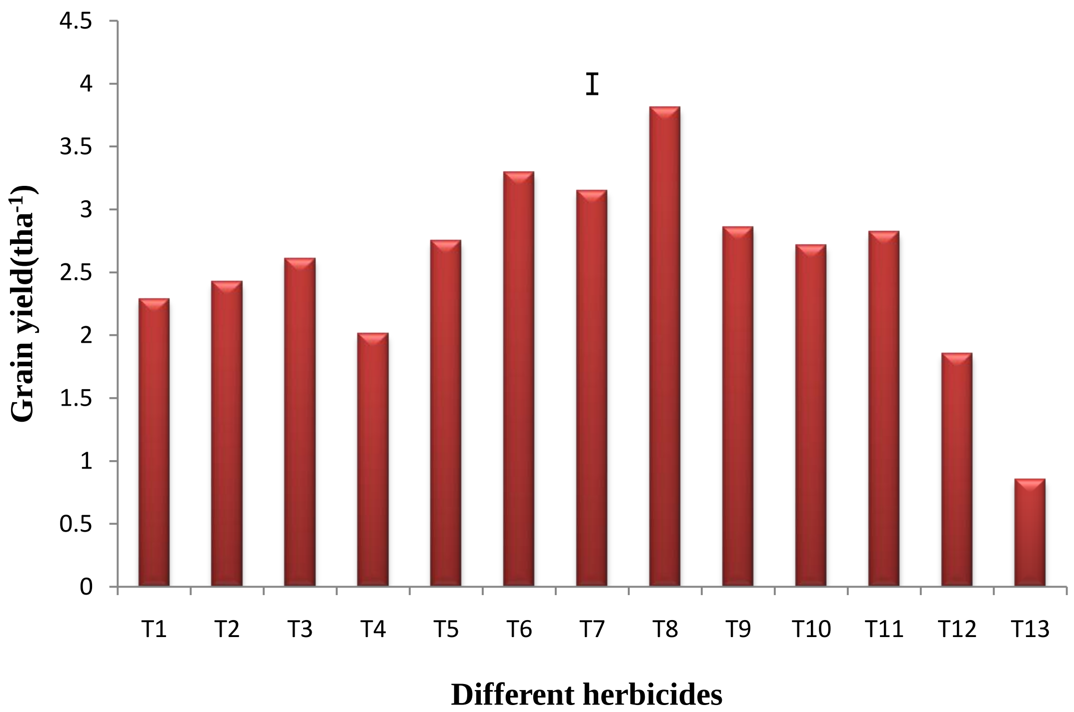

Figure 10. Effect of different herbicides on grain yield (t ha^{-1}) of transplanted *aus* rice (Nerica). Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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

Significant variation was observed for straw yield due to different herbicidal treatments. The highest straw yield (4.25 t ha^{-1}) was recorded from treatment T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) which was statistically similar with T_6 and T_7 treatments. The lowest straw yield (1.42 t ha^{-1}) was found from weedy check treatment $T_{13.}$ Chowdhury *et al.* (1995) found that Oxadiazon significantly increased the straw yield.

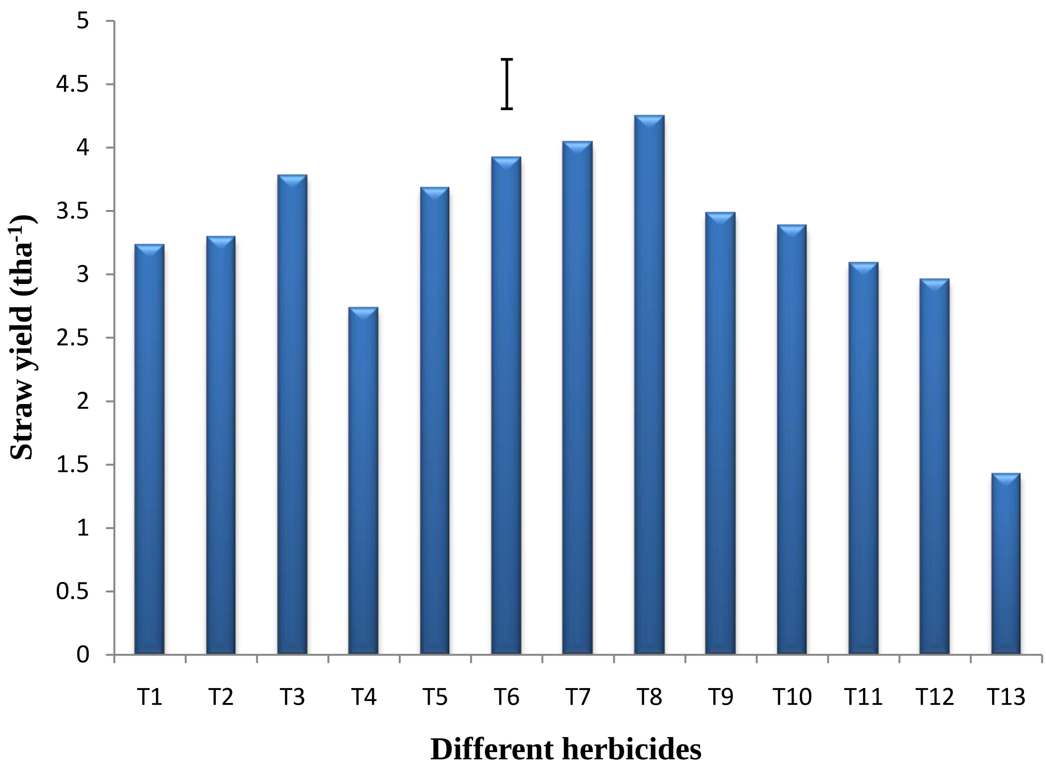

Figure 11. Effect of different herbicides on straw yield (t ha^{-1}) of transplanted *aus* rice (Nerica). Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

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

Different herbicidal treatments had significant influence on the biological yield(t ha^{-1}) also. Weeds controlled by T_8 (Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) showed the maximum biological yield (8.06 t ha^{-1}) on the other hand weedy check (treatment T_{13}) showed the minimum biological yield (2.27 t ha^{-1}). Similar results were found from Hasanuzzaman *et al.* (2008) who observed that the (Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}) as the highest yielding herbicidal treatment.

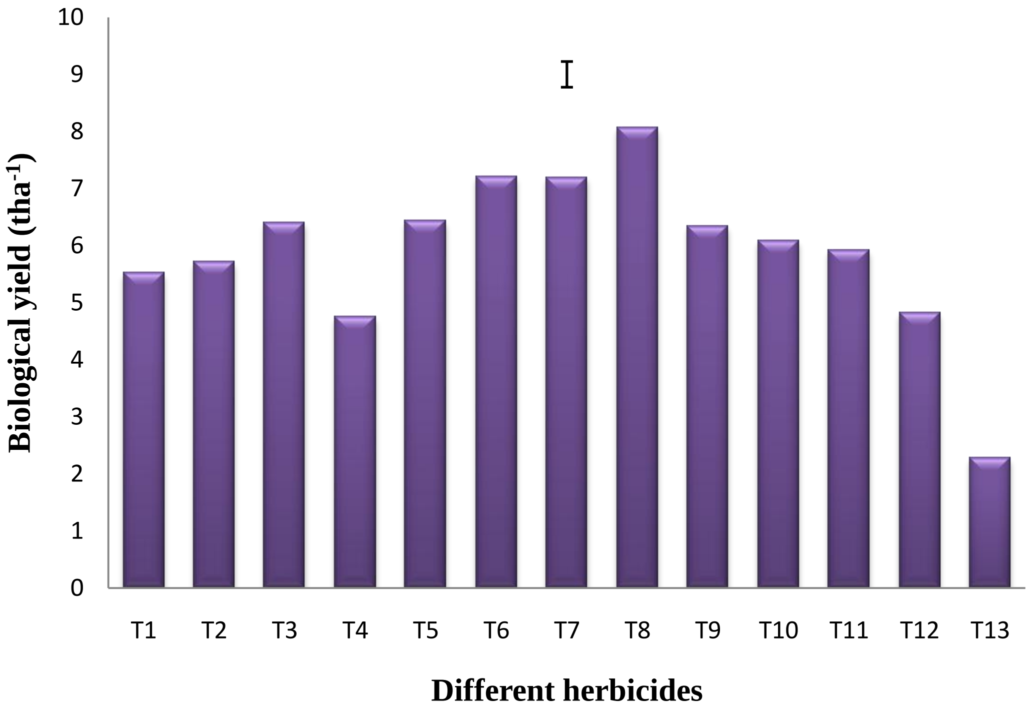

Figure 12. Effect of different herbicides on biological yield (t ha^{-1}) of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

4.11.4 Harvest Index (%)

Harvest index was also varied significantly due to application of different herbicidal treatments. From T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}) the highest harvest index (48.0 %) was obtained which was statistically resemblance with $T_{6,}$ T_8 and T_9 treatments, hence from treatment T_{13} (Weedy check) the lowest harvest index (37.53 %) was observed which was statistically similar with treatment T_{12}. The finding of Chowdhury (2012) was similar with this result who found that the lowest harvest index was observed from control plot than Sunrice 150WG treated plot.

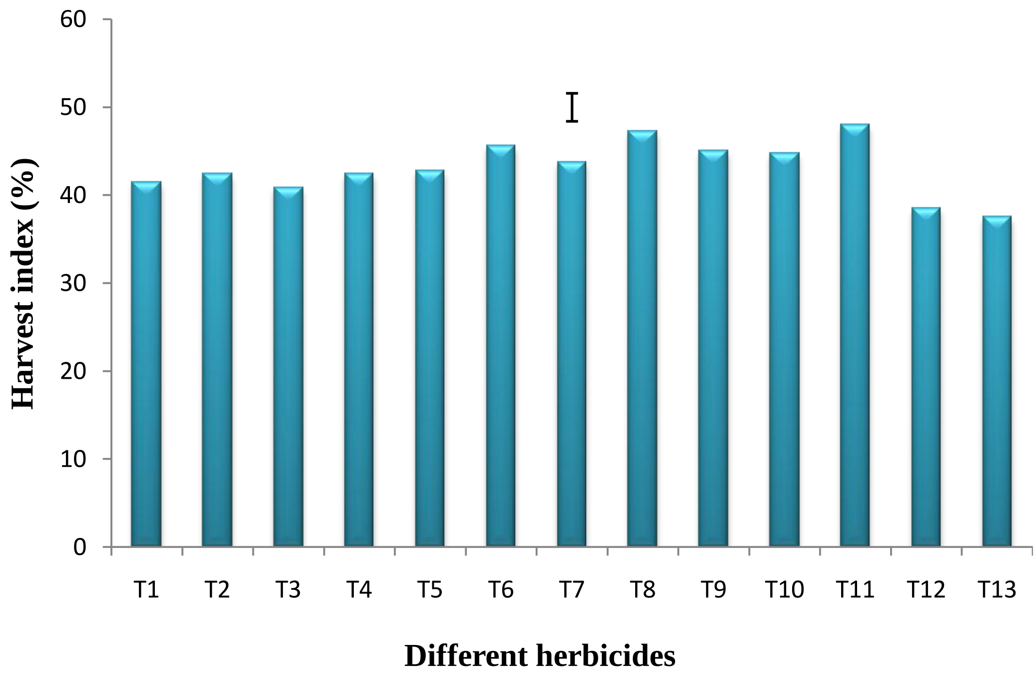

Figure 13. Effect of different herbicides on harvest index (%) of transplanted *aus* rice. Vertical bar represents the LSD value at p=0.05

T_1 (Propyrisulfuron @ 500 ml ha^{-1}), T_2 (Propanil 60 WG @ 2000 g ha^{-1}), T_3 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_4 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @1500 g ha^{-1}), T_5 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_6 (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG 1000 g ha^{-1}), T_7 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_8 (Propyrisulfuron @ 380 ml ha^{-1}+Propanil 60 WG @ 1500 g ha^{-1}), T_9 (Propyrisulfuron @ 250 ml ha^{-1}+Propanil 60 WG @1000 g ha^{-1}), T_{10} (Propyrisulfuron @ 500 ml ha^{-1}+Propanil 60 WG @ 667 g ha^{-1}), T_{11} (Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1}), T_{12} (Acetochlor 14%+Bensulfuron 4% @ 742 g ha^{-1}), T_{13} (Weedy check)

SUMMARY AND CONCLUSION

The present field trial was conducted at the Agronomy research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from April to August, 2014 with a view to evaluating the efficacy of herbicide to control weeds in addition to realize its residual activity on growth and yield of transplanted *Aus* rice, (Nerica).

The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. The size of the individual plot was 5.0 m x 2.0 m and total numbers of plots were 39. The experiment was consisted of 13 treatments as T_1(Propyrisulfuran @ 500 ml ha-^{1}), T_2(Propanil 60 WG @ 2000 g ha-^{1}), T_3(Propyrisulfuran @ 500 ml ha-^{1} + Propanil 60 WG @ 2000 g ha-^{1}), T_4(Propyrisulfuran @ 500 ml ha-^{1} + Propanil 60 WG @1500 g ha-^{1}), T_5(Propyrisulfuran @ 380 ml ha-^{1} + Propanil 60 WG @ 2000 g ha-^{1}), T_6(Propyrisulfuran @ 500 ml ha-^{1} + Propanil 60 WG @ 1000 g ha-^{1}), T_7(Propyrisulfuran @ 250 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}), T_8(Propyrisulfuran @380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}), T_9(Propyrisulfuran @ 250 ml ha^{-1} + Propanil 60 WG @1000 g ha^{-1}), T_{10}(Propyrisulfuran @500 ml ha^{-1} + Propanil 60 WG @ 667 g ha^{-1}), T_{11}(Propyrisulfuran @ 130 ml ha^{-1} + Propanil 60 WG @ 2000 g ha^{-1}, T_{12} (Acetochlor 14% + Bensulfuron-methene 4% @ 742 g ha^{-1}) and T_{13}(Weedy check).

The data on weed parameters were collected based on 3 days before spray and 7, 14, 21, 28 and 45 DAS (Days after spraying). Weed parameters such as total weed population (no. m^{-2}) and relative weed density (RWD %) were examined. At harvest, tiller length (cm), total tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, total grains $panicle^{-1}$, filled grains $panicle^{-1}$, 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.

Nineteen weed species belonging to nine families infested the experimental crop field. The most important weeds of the experimental plots were *Marsilea quadrifolia, Cyperus deformis, Cynodon dactylon, Cyperus esculentus, Echinochloa crussgalli* respectively. Weed population and relative weed density were significantly influenced by the weed control treatments. The highest weed population (m^{-2}) was observed in the control plot (T_{13}) and the lowest weed population (m^{-2}) was found from the treatment T_8 (Propyrisulfuran @380 ml ha^{-1} + Propanil 60 WG@1500 g ha^{-1}) throughout the growing period. In terms of Relative Weed Density (RWD), the *Marsilea quadrifolia* and *Cyperus difformis* was dominant throughout the growing period (45.25 and 48.51%, 42.24 and 40.67%, 47.06 and 38.91%, 56.04 and 32.59%, 56.25 and 32.45%, 57.83 and 31.21% RWD at before 3 days of spray, 7, 14, 21, 28 and 45 days of spray, respectively). Aquatics and broadleaf's were prominent during the earlier and grasses were prominent both early and later period due to the reemergence capacity while among the weed species *Cynodon dactylon* (grass), *Leptochloa chinensis* (sedge), *Echinochloa crussgalli* (aquatic), *Alternanthera philoxeroides* (Sedge), *Leersia hexandra* (grass), specially the weeds of gramineae family were present in the field throughtout the growing period as they are less affected by the herbicidal treatments.

Weed control treatments had significant effect on the yield and yield contributing characters viz. the highest tiller length (cm), total tillers $hill^{-1}$, effective tillers $hill^{-1}$, total grains $panicle^{-1}$, filled 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 from treatment T_8 (Propyrisulfuran @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}). On the contrary, the lowest tiller length (cm), total tillers $hill^{-1}$, effective tillers $hill^{-1}$, total grains $panicle^{-1}$, filled 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 (%) **w**as found for treatment T_{13} (Control).

The presence of butterfly and birds were observed frequently in the trial plots for searching their prey before and after spray of herbicide. Suggesting that prey-predator relationship was not affected by herbicide application.

Considering rapid and residual activity as well as selectivity which is a common desire of the farmers, finally it can be said that treatment T_8 (Propyrisulfuran @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) performed better than any other treatment under the present study.

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

1. Grass and sedge weeds dominated in the study area throughout the growing period.
2. Weeds of Poaceae family are less affected by the applied herbicidal treatments.
3. Among the herbicidal treatments T_8 (Propyrisulfuran @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1}) is the best treatment in case of controlling weed population for higher yield of transplanted *aus* rice (Nerica).

On the basis of the results of the present study certain recommendations might be suggested for future consideration:

i. Further research should be conducted by employing treatments T_6, T_7, T_8, T_9 and T_{10} in large scale and also in *aman* (upcoming) and *boro* season to explore the detail scenario of the efficacy and residual activity.

ii. It is worth to incorporate new herbicide which has good effect in controlling weeds under Poaceae family in combination with propyrisulfuran.

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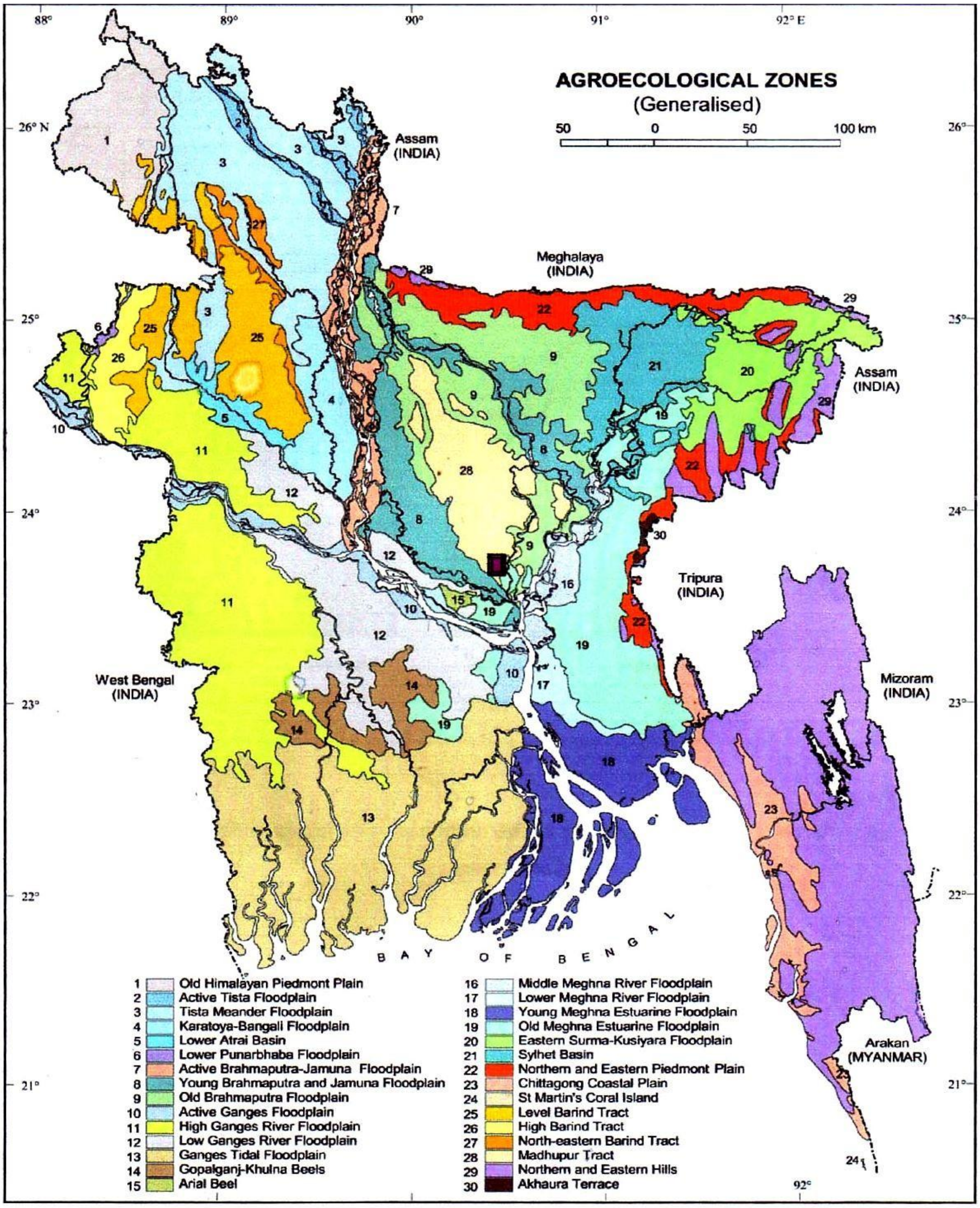
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period of April to August, 2014

Month	Air temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
April, 2014	39.4	19.4	80.2	39.2	65.60
May, 2014	38.2	19.3	89.2	40	202
June, 2014	37.2	17.4	88.4	46.3	282.7
July, 2014	35.6	18.2	88.2	55.4	107.8
August, 14	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 (mean square) of the data for weed population (No. m^{-2}) before 3 days of spray

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	11.872	94.231	6.641	4.179	1.256	6.333	0.103	4.487	6.949	0.333	5.026	0.179	1.564
Treatment	12	11079.7*	41629.256*	6.064*	2.397*	1.991*	8.842*	1.880*	0.692*	1.585*	1.521^NS	0.923*	0.521*	1.158*
Error	24	27.094	13.814	0.641	0.513	0.479	1.361	0.464	0.904	1.643	1.444	0.942	0.291	0.536

***** significant at 5% level, ^NS Non significant

Appendix V. Anaysis of variance (mean square) of the data for weed population (No. m^{-2}) after 7 days of spray

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	6.949	6.949	0.949	3.000	4.333	0.231	0.179	1.256	4.000	0.077	1.256	0.538	1.333
Treatment	12	64995.359*	57487.256*	1.466*	2.201*	1.915*	11.692*	2.863*	1.701*	1.701*	2.974*	0.645*	1.812*	1.637*
Error	24	3.199	3.282	0.421	0.694	0.389	0.397	0.318	0.534	0.528	0.077	0.229	0.427	0.528

***** significant at 5% level, ^NS Non significant

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

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	5.026	2.333	1.103	1.615	1.615	0.077	0.641	0.026	0.026	0.077	0.179	0.231	2.077
Treatment	12	144667.778*	118525.641*	1.833*	3.812*	2.269*	13.581*	1.444*	4.397*	5.026*	5.769*	2.444*	2.415*	2.197*
Error	24	4.053	2.333	0.186	0.838	0.615	0.216	0.335	0.026	0.026	0.077	0.124	0.453	0.459

***** significant at 5% level, NS Non significant

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

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	1.256	1.564	0.332	1.103	1.615	0.179	0.333	0.026	0.026	0.077	0.077	0.308	2.077
Treatment	12	164372.645*	119520.026*	4.897*	3.919*	2.269*	13.500*	2.077*	4.333*	5.026*	5.769*	2.077*	2.632*	2.197*
Error	24	6.395	1.564	0.167	0.797	0.615	0.179	0.917	0.026	0.026	0.077	0.077	0.447	0.549

***** significant at 5% level, NS Non significant

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

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	3.179	1.564	0.077	1.103	1.615	0.179	0.333	0.103	0.026	0.077	0.077	0.308	2.077
Treatment	12	148285.991*	119520.026*	4.308*	3.919*	2.269*	13.50*	2.077*	5.026*	5.026*	5.769*	2.077*	2.632*	2.197*
Error	24	6.318	1.564	0.077	0.797	0.615	0.179	0.917	0.103	0.026	0.077	0.077	0.447	0.549

***** significant at 5% level, NS Non significant

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

Source of variance	df	Mean square values												
		Marsilea quadrifolia	*Cyperus difformis*	*Cyperus esculentus*	*Cynodon dactylon*	*Echinochloa crussgalli*	*Eclipta alba*	*Alternanthera philoxeroides*	*Alternanthera sessilis*	*Monochoria vaginalis*	*Ludwigia hyssopifolia*	*Sagittaria guyanensis*	*Leersia hexandra*	*Leptochloa chinensis*
Replication	2	2.333	1.564	1.256	0.795	1.615	0.179	0.333	0.026	0.026	0.077	0.077	0.308	2.077
Treatment	12	159840.688*	119520.026*	4.585*	2.979*	2.269*	13.500*	2.077*	4.521*	5.026*	5.769*	2.077*	2.632*	2.197*
Error	24	6.444	1.564	0.731	0.934	0.615	0.179	0.917	0.053	0.026	0.077	0.077	0.447	0.549

***** significant at 5% level, NS Non significant

Appendix X. Analysis of variance (mean square) of the data for tiller length, total tiller hill^{-1}, no. of effective tiller hill^{-1}, no. of non effective tiller hill^{-1}, panicle length, total no. of grains panicle^{-1}, no. of sterile grains panicle^{-1}, filled grain panicle^{-1}, 1000 grain weight, grain yield t ha^{-1}, straw yield t ha^{-1}, biological yield t ha^{-1}, harvest index

Source of variance	df	Mean square values												
		Tiller length (cm)	Total no. of tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Total no. of grains panicle^{-1}	No. of sterile grains panicle^{-1}	Filled grain Panicle^{-1}	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.438	0.103	0.333	0.077	3.666	140.795	0.333	140.333	0.308	0.152	0.138	0.334	19.397
Treatment	12	167.798*	9.389*	11.090*	0.842*	8.972*	56.453*	17.444*	118.355*	1.248*	1.617*	1.569*	6.174*	28.875*
Error	24	1.946	0.575	0.417	0.438	1.337	10.184	0.611	9.611	0.53	0.009	0.009	0.074	3.567

***** significant at 5% level, ^{NS} Non significant

LIST OF PLATES

Plate 4: Field condition before 3 days of spray at 14 DAT

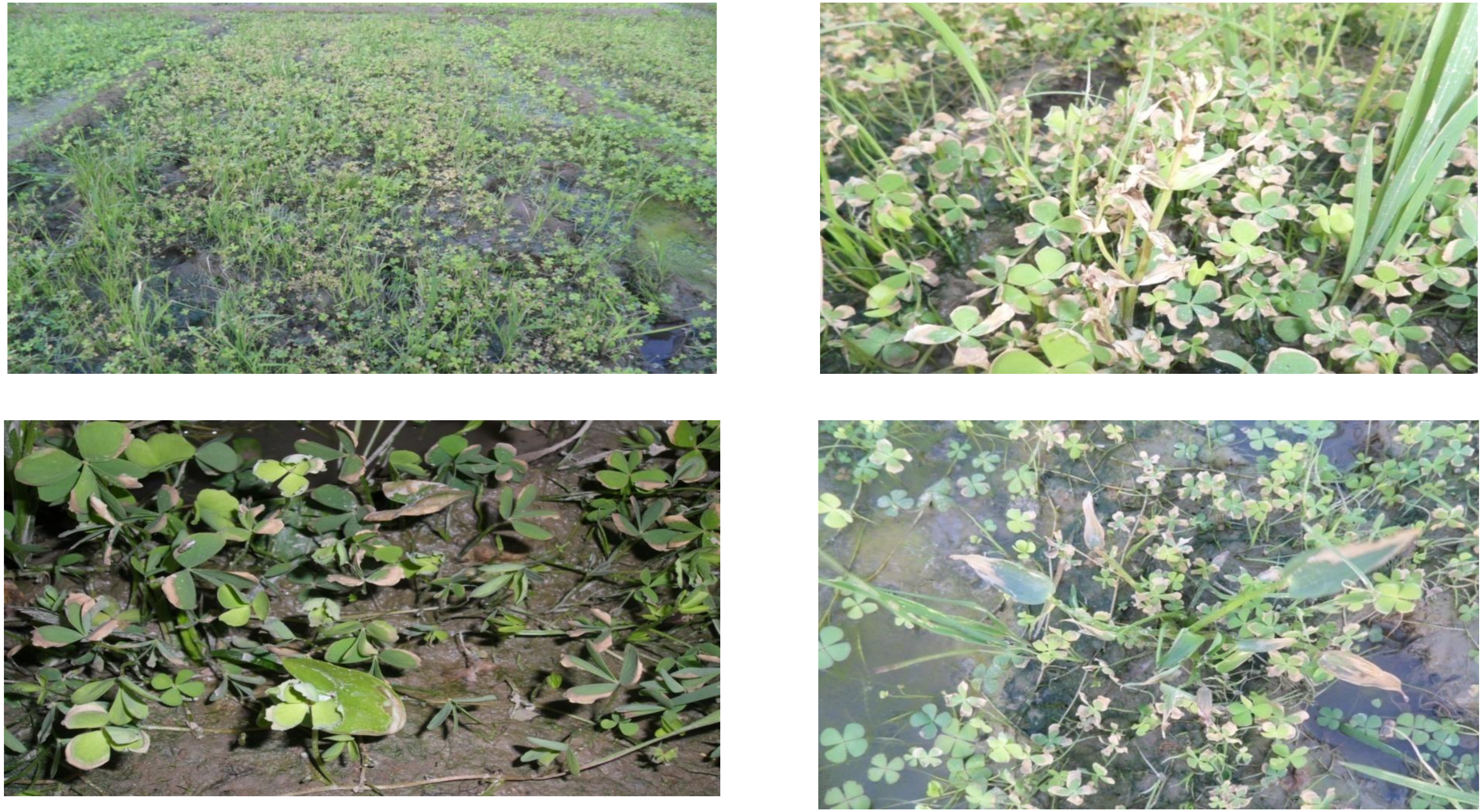
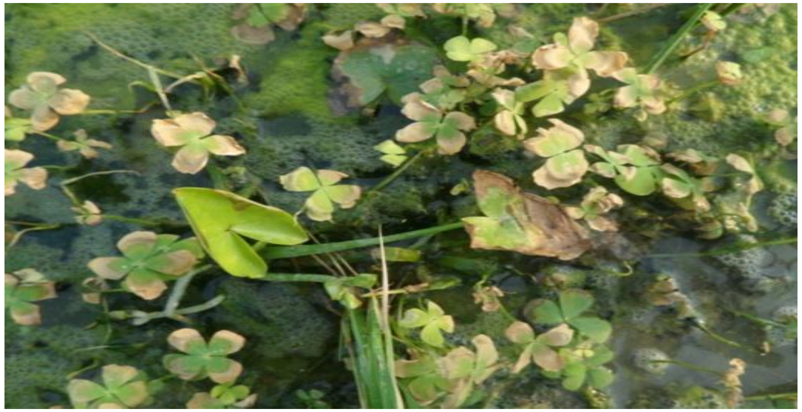


Plate 5: Field view of herbicide efficacy and selectivity 1 days after spray in transplanted *aus* rice



Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Weeds of herbicide treated plots

Plates 6: Field view of herbicide efficacy and selectivity 3 days after spray in transplanted *aus* rice

Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Plates 7: Field view of herbicide efficacy and selectivity 5 days after spray in transplanted *aus* rice

Weeds of herbicide treated plots

Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Plates 8: Field view of herbicide efficacy and selectivity 7 days after spray in transplanted *aus* rice

Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Plates 9: Field view of herbicide efficacy and selectivity 14 days after spray in transplanted *aus* rice

Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Plates 10: Field view of herbicide efficacy and selectivity 21 days after spray in transplanted *aus* rice

Weeds of weedy check (T_{13}) plots

Weeds of herbicide treated plots

Plates 11: Field view of herbicide efficacy and selectivity 28 days after spray in transplanted *aus* rice

Weeds of herbicide treated plots

Weeds of weedy check (T_{13}) plots

Plates 12: Field view of herbicide efficacy and selectivity 45 days after spray in transplanted *aus* rice

Dragon fly in weedy check plot (T_{13})

1 DASP-Rice hispa (*Dicladispa armigera*)

1 DASP-Dragon fly on herbicide treated plot

5 DASP- Birds in searching of organism

Plates 13: Field view of herbicidal effect on non-target organism in transplanted *aus* rice field