EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON DIRECT SEEDED BORO RICE

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EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON DIRECT SEEDED BORO RICE

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This is to certify that the thesis entitled ***"EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON DIRECT SEEDED BORO RICE"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***IMRUL KAES,*** *Registration. No.* ***14-06328*** *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: June, 2015

Dhaka, Bangladesh

(Prof. Dr. Md. Abdullahil Baque)

Supervisor

Dedicated to

My

Beloved Parents

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EVALUATION OF HERBICIDAL EFFICACY AND RESIDUAL ACTIVITY ON DIRECT SEEDED BORO RICE

ABSTRACT

An experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka, from November 2014 to April 2015 to evaluate the different herbicidal efficacy on weed control and growth & yield of boro rice cv. BRRI dhan50. The experiment comprised nine treatments viz. Acetachlor + Bensulfuran (Pre-mix) @ 750 g ha^{-1}, Pyrazosulfuran-ethyl @ 150 g ha^{-1}, Bispyribac Sodium @ 150 g ha^{-1}, Pretilachlor @ 1 L ha^{-1}, Pretilachlor+ Triasulfuran@ (1 L + 10 g) ha^{-1}, Propyrisulfuran + Propanil @ (0.5 L + 1 kg) ha^{-1}, Propyrisulfuran + Propanil@ (0.38 L + 1.5 kg) ha^{-1}, Two hand weeding (20 and 40 DAS) and Weedy check.The experiment was laid out in randomized complete block design (RCBD) with three replications. Sixteen weed species belonging to seven families were observed in the experimental field. Weed population, weed dry weight and weed control efficiency were significantly influenced by herbicidal treatments. The highest weed population and dry weight were observed in unweededcontrol condition compared to other treatments. Application of Propyrisulfuran + Propanil (0.38 L + 1.5 kg) ha^{-1}showed the best performance to control all kind of weeds found in the field and its residual activity remained upto 45 days.Yield contributing characters and yield of BRRI dhan50 was significantly influenced by weed control treatments. The highest number of effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index were obtained from the application of Propyrisulfuran + Propanil (0.38 L + 1.5 kg) ha^{-1}. Weed control had pronounced influence on yield (5.50 t ha^{-1}) of BRRI dhan50 and 46.55% yield was lost in unweeded control condition. It can be concluded that application of Propyrisulfuran + Propanil (0.38 L + 1.5 kg) ha^{-1}may be used for the best performance of BRRI dhan50. However, in practical point of view the application of Propyrisulfuran+ Propanil (0.5 L + 1 kg) ha^{-1} may consider for producing second highest yield of BRRI dhan50.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important food crops (Singh & Khush 2000). Worldwide, rice is grown on 161million hectares, with an annual production of about 678.7 million tons of paddy (FAO, 2009). About 90% of the world's rice is grown and produced (143 million ha of area with a production of 612 million tons of paddy) in Asia (FAO, 2009). Bangladesh is a sub-tropical country with plenty of water and suitable climatic condition for rice production. In respect of area and production it ranks fourth among the rice producing countries of the world following China, India and Indonesia (FAO, 2009). The people of Bangladesh fully depend on rice as staple food and have tremendous influence on agrarian economy of Bangladesh. Here agriculture is characterized by rice based cropping systems. Rice is extensively grown here in aus, amanand boroseasons. About 77.07% of the cropped area of Bangladesh is used for rice production, with annual production of 33.54 million tons from 11.52 million ha of land (BBS, 2011).The average yield of rice in Bangladesh is 2.73 t ha^{-1} (BRRI, 2006), which is almost 50% of the average rice grain yield per ha worldwide.Among different groups of dry season rice, bororice covers about 43.6% of the total rice area and it contributes to 61.3% of the total rice production in Bangladesh (BBS, 2008). Amancovers the second largest area of 4.61 million hectares with a production of 17.72 million metric tons and the average yield is about 3.84 t ha^{-1} (BBS, 2008).

Weed is one of the most important agricultural pests. It is the most serious biotic constraint to higher yields (Datta & Bernasor 1973; Subhas & Jitendra 2001; Mandal *et al*., 2002).Weeds grow in each of the crop field throughout the world. Where there is cultivable land, there is weed. The prevailing climatic and edaphic conditions of Bangladesh are very much favorable for luxuriant growth of numerous species of weeds that strongly compete with rice plant. Weeds are selfgrown and appear simultaneously with crop plant creating severe competition for nutrient, space, moisture and solar energy resulting in low yield of crop. Grassy weeds were heavy competitors with rice crop and were followed by sedges and broad leaved weeds (Umapathy and Sivakumar, 2000). There is no doubt that maximum benefit from costly inputs like fertilizer and pesticides in rice can be fully derived when the crop is kept free from weed infestation. Weeds removed nutrients (N, P and K) eight times higher under direct seeded rice (DSR) compared to that of puddled transplanting (Singh *et al.*, 2002). Chauhan and Johnson (2010) stated that when direct seeded rice was grown together with either jungle rice or *Ludwigia* spp. shoot competition reduced the growth and yield of rice more than root competition and rice grain yield was highly correlated with above and below ground biomass of the weeds. The unit increase in intensity of monocots, dicots and weed dry weight causes decrease in direct seeded Pusa Basmati [1] rice grain yield by 2.18, 1.64 and 2.85 q ha^{-1}, respectively during wet season (Singh *et al.*, 2008). Production cost of rice increases due to increase in weed control cost. The losses due to infestation of weed is greater than the combined losses caused by insect pest and diseases in rice.Weed infestation in DSR fields remains the single largest constraint limiting their productivity. Yield loss due to weeds in direct seeded upland rice varied from 40 to 100% depending on the weed flora, their density and duration of competition (Choubey *etal*., 2001). A DSR crop generally lacks a "head start" over weeds due to dry tillage, absence of flooding and alternate wetting and drying conditions making it particularly vulnerable to weed competition during early part of its growth (Rao *et al*., 2007). As the weeds and rice emerge simultaneously in DSR, the proper time and method of weed control remains a complex phenomenon (Khaliq and Matloob, 2011). In Bangladesh, weed infestation reduced the grain yield by 70-80% in aus rice (early summer), 30-40% for transplanted amanrice (autumn) and 22-36% for modernbororice cultivars (winter rice) (BRRI, 2006; Mamun, 1990).

In Bangladesh, weeds are traditionally controlled by hand weeding. This method of weed control is very much laborious, time consuming, inefficient and costly (Ahmed *et al.,* 2005). Labor availability in agricultural operations has decreased in recent years due to migration of landless people towards the urban areas with a dream to earn more. High competitive ability of weeds exerts a serious negative effect on crop production. Poor weed control is one of the major factors for yield reduction in rice, the extent of which depends on type of weed flora and their intensity of infestation. DSR being a closely spaced crop, yield losses could even be caused by hoe weeding through crop injury and stand losses, while some grass weeds which have close resemblance to the rice crop may escape hand weeding. This necessitates the introduction of an alternative weed control method that may be more effective with less labor requirements. An effective early weed management tactic is imperative for any DSR production technology aiming at achieving higher productivity and profitability (Suria *et al*., 2011). Several pre-emergence herbicides applied either alone or supplemented with hand weeding have been reported to provide fairly adequate weed suppression in DSR (Pellerin and Webster, 2004; Baloch *et al*., 2005). Herbicides are used in modern agriculture offering the most effective means of reducing weed competition, crop losses and production losses in rice field (Soliman *et al.,* 1993and Min *et al*., 2001).Moreover, in Bangladesh during boroseason, uprooting of weeds at the critical period is difficult due to peak labor demand. In such situation, herbicides are promising alternatives in controlling weeds (Datta, 1980). Nowadays the use of herbicides is gaining popularity in rice fields due to their rapid effects and the lower costs compared with the traditional methods (Karim, 2008). However, crop injury may occur at higher dose of herbicide application. Major herbicides available for weed control in Bangladesh include Propanil, Butachlor, Acetachlor, Pretilachlor, Oxadiazon, Bensulfuran, Pyrosulfuran-ethyl, Propyrisulfuran, Bispyribac Sodium etc, but information regarding their effect is highly scarce. Herbicides are effective against weed species, but most of them are specific and are effective against narrow range of weed species (Mukerjee and Singh, 2005). Herbicides, when used at recommended rate, offer good weed suppression and increase rice grain yield (Adigun *et al.*, 2000). But the rate of herbicides also depends on the intensity of weed infestation, edaphic and other climatic factors. As a result, higher doses are applied sometimes to obtain better result.

The present study was, therefore, undertaken with a view to examining the following objectives:

- To find out the efficacy of herbicides for controlling weeds in direct seeded boro rice.
- To evaluate the performance of selected herbicides used at recommended rates on weed suppression and yield performance of direct seeded boro rice.
- To investigate the effects of herbicides at variable rates on weed suppression as well as growth and yield of direct seeded boro rice.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Weed is one of the serious problems in rice field. So, weed control is one of the important means for successful crop production. Weed control by herbicidal means is a common practice in many countries of the world due to its superiority over other methods. In Bangladesh there is scanty of research work in the field of weed control. Recently research work regarding weed control in rice has got due importance. In developed countries, herbicides are extensively used to control weeds in crop fields. However in Bangladesh, weeds in rice field are controlled manually and through different cultural practices. At present, many pre and post-emergence herbicides are available for controlling weeds. Some literatures pertinent to the efficacy of herbicides for toxicity on rice and controlling weeds in rice field with special reference to direct seeded bororice have been reviewed in this chapter.

2.1. Weed vegetation in direct seeded bororice

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

The most important species of weeds found by (Islam, 2014) were*Panicum repens, Leersia hexandra, Digitaria sanguinalis, Echinochloa crusgalli, Scirpus mucronatus, Parapholis incurva, Cynodon dactylon, Paspalum scrobbiculatum, Fimbristylis diphylla, Eclipta alba, Echinochloa colonum, Murdania nudiflora, Cyperus rotundus, Cyperus michelianus, Polygonum orientale, Monochoria hastate*. Zannat (2014) listed 18 commonly growing weed species in aromatic amanrice cv. Binadhan-9 and identified weed species like *Panicum repens, Oxalis corniculate, cyperus michelianus, Cyperus difformis, Fimbristylis diphylla, Leersia hexandra, Monochoria hastata, Scirpus mucronatus, Ludwigina prostrata, Echinochloa colonum, Cynodon dactylon, Polygonum orientale, Echinochloa crusgalli, Parapholis incurva and Eclipta alba*. Grasses were the dominant weed flora followed by broad leaved weeds and sedges in wet seeded rice. *Echinochloa* was the main grass weed in unweeded control whereas the lowest density was registered in graminicide applied plots (Prameela *et al*., 2014). Nath *et al*. (2014) revealed that the major weed species in direct seeded rice were *Echinochloa colona* L., *Echinochloa crusgalli* L., *Cyperus rotundus* L., *Cyperus difformis* L. *Caesuliaaxillaris* L. and *Commelina benghalensis L.* Grassesconstituted the highest percentage of weed population followed by broad leaves. *Echinochloa colonum, Digitaria marginata, Chloris barbata, Cynadon dactylon, Ageratum conyzoides, Commelina benghalensis, Spilanthus acmella, Mollugo disticha, Celosia argentia, Parthenium hysterophorus* and *Cyperus rotundus* were the most prominent weed population in aerobic rice cultivation (Madhukumar *et al*., 2013). Another study was stated that the major associated weeds in rice field were*Echinochloa colona, Cyperus difformis, Ammania baccifera, Ludwigia octovalvis* and *Monochoria vaginalis* (Pal *et al*., 2012). In transplanted rice; *Echinochloa glabrescence, Cyperus* sp., *Scripus roylei, Fimbristylis miliacea, Ludwigia parviflora, Linderniaverbenaefolia* and *Glinus oppositifolius* were most prominent (Jayadeva*et al*., 2009). Khandakar and Sato (1999) also observed that nine species of weeds belonging to nine families infested the transplant rice field. They observed that the relative density of each weed species increased with the increase with spacing.

The most important weed species throughout the growing season were *Fimbristylis miliacea, Scirpus mucronatus and Sphenocela zeylanica* having higher degree of infestation (Kabir *et al.*, 2008). On the other hand, Halder *et al.*

(2005) found the predominant weed species were *Echinochloa crusgalli, Cyperus iria, Fimbnstylis miliacea, Scripus maritimus, Monochoria vaginalis, Ludwigia parviflora* and *Ammania baccifera.* It was reported that rice field affected mostly with *Cyperus iria, Echinochloa crusgalli, E. colonum, Eclipta alba*and *Ludwigiaparviflora* (Stahyamoorthy *et al.,* 2004).

In Bangladesh, the major weeds are *Panicim repens, Digitaria sangui nails, Leersia hexandra, Cyperus difformis,Ludwigia hyssopifolia, Fimbristylis miliace, Rottboellia proteensa, Commeelinabenghalensis and Echinochloa crusgalli* (Hassnuzzaman *et al.,* 2008). But *Paspalumscrobiculatum, Echinochola crusgalli, Leersia hexandra L* and *Echinocholacolonum* were the most important weed species found in Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh (Rashid, 2011). Weed species commonly grown in Bororice like *Echinochloa crusgalli, Marsilea quadrifolia, Scirpus juncoides, Cyperus difformis, Monochoria vaginalis, Leersia hexandra, Lindernia anagalis and Fimbristylis miliaceae* (Jesmin, 2006).

2.2. Effect of Herbicides on weeds and rice

2.2.1 Growth and yield attributes affected by herbicidal application

The maximum grain yield, yield attributes and weed-control efficiency were recorded with the application of penoxulam @ 22.5 g ha^{-1}(8 days after sowing). The maximum reduction in grain yield over weed-free treatment was recorded in weedy check and the least reduction in penoxulam @ 22.5 g ha^{-1}. Application of penoxulam @ 22.5 g ha^{-1}being at par with weed-free treatment proved superior to the other weed-management practices for grain yield and yield attributes (Manzoor *et al.,* 2014). Rice yields in penoxsulam-treated plots were 30 to 56% higher than in the untreated controls. Yields with penoxsulam (all rates) were similar (P>0.05) to those obtained using molinate followed by ADW applications of bentazon or

MCPA. Although penoxsulam is an ALS inhibitor, it controlled *A. plantago-aquatica* resistant to metsulfuron and bensulfuron (Kogan *et al.,* 2011).

Again, the maximum number and length of tillers, length of panicle, leaf area of flag leaves, number and percentage of filled grains, grain and straw yield per hectare were found when normal dose of Rifit 500 EC was applied. Different doses of Machete 5G were also found effective in controlling weeds and increasing in yield (Hossain and Rahman, 2013). Prechlor @ 1.5 L ha^{-1} showed best performance with respect to most yield attributes, grain and straw yields and the lowest grain yield was obtained from Prechlor @ 0 L ha^{-1}. The interaction effects of variety and herbicide Prechlor had significant effect on all yield attributes except plant height, effective tillers $hill^{-1}$, panicle length, 1000-grain weight and harvest index. The highest grain yield was obtained from variety BRRI dhan41 with Prechlor @ 1.5 L ha^{-1}. The results suggest that farmers can be advised to use herbicide Prechlor @ 1.5 L ha^{-1} to boost up the production of BRRI dhan41 controlling weeds during aman season under the agro-climatic condition of the study area (Faruk *et al.,* 2013). The pre-emergent application of Bensulfuron methyl @ 60 g + pretilachlor @ 600 g a.i ha^{-1} recorded significantly higher productive tillers per hill, panicle weight, thousand grain weight, filled spikelets per panicle, weed control efficiency, grain yield, straw yield and lower total weed density and dry weight followed by two hand weeding at 20 and 40 DAS and oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray followed by 2, 4-DEE as post emergent spray @ 500 g a.i. ha^{-1} at 25 DAS which were on par with each other. Whereas, unweeded check registered significantly lower productive tillers per hill, panicle weight, thousand grain weight, filled spikelet's per panicle, grain yield, straw yield and higher total weed density and dry weight with a weed index of 91.7 percent (Madhukumar *et al*., 2013).

Remover 10 WP gave the lowest weed density, dry weed biomass and weed index, and the highest weed control efficiency. The yield and yield components of rice (e.g. No. of panicles m^{-2}, No. of grains per panicle, grain and straw yield) were greatly influenced by the treatments. Herbicide treatment Remover 10 WP produced similar yield to hand weeding, but the weeding cost of Remover 10 WP was almost one-sixth of hand weeding. Maximum marginal return rate with Remover 10 WP suggests that this treatment could be used as alternative tool when labor is a limiting factor in dry season rice cultivation (Mamun*et al.*, 2010). The highest number of productive tiller $hill^{-1}$ was obtained in the plots treated with Anilofos @ 0.3 kg a.i. ha^{-1}, Pretilachlor @ 0.4 kg a. i. ha^{-1} and Butanil @ 1.0 kg a.i. ha^{-1}. The number of filled grain per panicle was the highest with Anilofos @ 0.3 kg a.i. ha^{-1}, Pretilachlor @ 0.4 kg a. i. ha^{-1} and Butanil @ 1.0 kg a.i. ha^{-1}. The weed control treatments were equally effective in increasing grain yield (Tamiselvan and Bydhar, 2001). But no significant differences were found in grain yield, yield components, relative yield loss, harvest index, rice biomass, weed biomass, and herbicide efficacy between 'Hashemi' and 'Deylamani' as averaged across herbicide rates. At the same time, 'Hashemi' was significantly taller than 'Deylamani'. In contrast, 'Deylamani' produced greater leaf area compared to 'Hashemi'. Regardless of rice cultivar, the highest grain yield, tiller number per m^{-2}, grain number per panicle, rice biomass, leaf area index, and herbicide efficacy were observed in plots received recommended rate (2 L ha^{-1}) of Pretilachlor, while the highest weed biomass and relative yield loss were found in plots received no herbicide. The results suggest that rice grain yield significantly reduces when Pretilachlor is used at lower than recommended rates (Aminpanah *et al.*, 2013).

Butachlor gave the highest yield, which remained at per with Anilophos 5G 0.60 kg ha^{-1}, Anilophos + 2,4-D (Readmix) 0.40 + 0.53 kg ha^{-1}, Anilophos + 2,4-D significantly higher the number of panicles and an increased in weed control efficiency (Dhiman *et al.*, 1998). On the other hand, Butachlor @ 1 kg ha^{-1} or Pretilachlor @ 0.75 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 (Rajkhown *et al.*, 2001).

Acharya, S. S. and Bhattacharya, S. P. (2013), were conducted an experiment to evaluate the efficacy of sulfonylurea herbicide like pyrazosulfuron ethyl, benzothiadiazinone like bentazon alone and its combination with MCPA, clefoxydim and quinclorac were studied in comparison to traditional acetamides like butachlor and pretilachlor under field condition in transplanted boro rice. The herbicidal treatments were significantly superior to weedy check. There was 32.97% reduction in the grain yield of rice due to competition with weeds in the weedy plots. The pyrazosulfuron ethyl @ 30 g a.i. ha^{-1}applied as pre-emergence, with a weed control efficiency of 71.78%, was found to be the most effective in controlling predominant weeds, in comparison to acetamide and benzothiadiazinone herbicides. In terms of profitability, application of pyrazosulfuron ethyl @ 20 g a.i. ha^{-1}gave the highest gross and net return than other weed control treatments.

2.2.2. Herbicidal efficacy in controlling weed population

The lowest weed population was observed with the application of penoxsulam 25 g ha^{-1}at 30 and 90 DAS. The highest grain yield was recorded in weed free check treatment followed by two hand weeding treatment which was statistically at par with penoxsulam 25 g ha^{-1}, bispyribac sodium 25 g ha^{-1}and pyrazosulfuron ethyl 20 g ha^{-1}. All the weed control treatments caused significant reduction in uptake of nutrients by weeds over weedy check (Nath *et al.*, 2014). On the other hand, the highest broad leaved weed population was in metamifop sprayed plots. The lowest grass population was noticed in bispyribac sodium which was free of sedges also. At harvest stage of rice, in hand weeded plots the broad leaved weed *Lindernia crustacea* alone was present. The best herbicide treatment with low weed dry matter production was fenoxaprop- p- ethyl or cyhalofop-butyl with follow up spray of Almix. Bispyribac sodium registered the highest weed control efficiency next to hand weeding which was comparable to application of cyhalofop-butyl/fenoxaprop-p-ethyl/metamifop with follow up spray of Almix (Prameela *et al*., 2014). Total weed population and dry weight under bispyribac-sodium at 25 g ha^{-1}were at par with the higher doses of bispyribac-sodium at 35 and 50 g ha^{-1}during both the years of study. The weed control efficiency and weed index under bispyribac sodium at lower dose were also comparable with that of higher doses indicating the sufficiency of bispyribac-sodium at 25 g ha^{-1}for effective weed management in transplanted rice. The effect of bispyribac-sodium at 25 g ha^{-1}on producing tillers and panicles was also at par with that of higher doses and twice hand weeding and significantly superior to butachlor application. Post-emergence application of bispyribac sodium at 25 g ha^{-1}recorded a grain yield of 6.84 and 6.51 t ha^{-1}respectively which were at par with higher doses of bispyribac sodium, twice hand weeding and weed free and significantly higher than butachlor application. Higher net income and benefit-cost ratio were also associated with the application of bispyribac sodium at 25 g ha^{-1}(Veeraputhiran, R. and Balasubramanian, R. 2013).

The best herbicide for control of grass weeds was either fenoxaprop-p-ethyl @ 60 g a.i. ha^{-1} or cyhalofop butyl @ 80 g a.i. ha^{-1}, both applied at 20 DAS. Broad spectrum weed control can be made possible by spraying herbicide combinations that could give higher yield and B:C ratio (Jacob *et al*., 2014). But Set-off 20WG (Cinosulfuron) @ 20 g ha^{-1} resulted in > 85% control of *Monochoria vaginalis,Marselia creanata, Cyperus*spp*.*, *Fimbristylis miliacea* and *Scirpus juncodes*,but only 50-60% control of E. crusgalli in transplant rice (Burthun *et al.*, 1989). On the other hand, Flucetosulfuron10 WG at 25 g ha^{-1} applied at 2 days after transplanting can be used safely achieve broad spectrum weed control in transplanted rice. It also gave the maximum grain and straw yield of rice resulting in lowest weed index (Bhimwaland Pandey, 2014).

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

2.2.3. Weed density and crop yield affected by sequential application of herbicide

The sequential application of butachlor and anilophos fb bispyribac sodium, 2, 4-D and one hand weeding at 25 days was recorded significantly lower weed population and dry weight of weeds viz., monocots, dicots and sedges in equal manner which ultimately indicates that higher weed control efficiency over rest of the treatments except weed free check and hand weeding thrice. Further, grain and straw yield of rice was followed the same trend as well influenced by yield parameters like number of panicles m^{-2} and number of seeds $panicle^{-1}$. Ultimately sequential application butachlor and anilophos fb 2, 4-D and bispyribac sodium and one hand weeding at 25 days after sowing resulted higher grain yield and profitable under wet seeded rice production (Arjun *et al.*, 2014). On the other hand, sequential application of glyphosate in combination with bensulfuron methyl + pretilachlor is promising and effective in control of weeds as compared to single herbicide application in rice-based cropping system (Ramachandra*et al.*, 2014). With application of PT (prometryn+ thiobencarb) reduced to 0.16 kg + 1.6 kg a.i.ha^{-1}, sufficient herbicidal efficacy was obtained without injury to rice seedlings during the drained period after seeding. Effective control of weeds during the drained period using reduced rate of PT will ensure a sequential treatment of one-shot herbicide which can be applied after reflooding to provide good control of a range of weed species (Miura *et al.*, 2012). Herbicide application + hand weeding once had the highest grain yield while control treatment; because of the high unfilled grain per panicle and less panicle number per square meter had the lowest grain yield. Unfilled grain number per panicle had negative and significant correlation with grain yield. Panicle number per square meter had very high and positive correlation with grain and biological yield. As a result, panicle number per square meter is considered as the most important and the most effective trait in increasing grain yield (Pasha *et al.*, 2012).

2.2.4. Weed density and crop yield as affected by combined application of herbicide

The herbicidal combinations such as Propanil/Benthiocarb fb Bentazone/MCPA or Cyhalofopbutyl+Bensulfuron fb Bentazone/MCPA or Pendimethalin fb Cyhalofop-butyl+Bensulfuron fb Bentazone/MCPA or Pretilachlor+Pendimethalin fb Bentazone/MCPA could be the possible alternative options for effective and economic weed control in rice under aerobic system towards avoiding development of herbicide resistance in weed. Manual weeding is not at all cost-effective. The selected herbicide combinations could be used in rotation for sustainable weed management and to run the aerobic rice system as a profitable business venture (Suria *et al*., 2011). Combined application of Pretilachlor with safener @ 0.45 kg ha^{-1} on 3 DAS and conoweeding on 45 DAS recorded higher weed control efficiency of 86.7 percent which lead to highest grain yield of 6,216 kg ha^{-1} in direct seeded rice (Reddy, 2010). On the other hand, application of Pretilachlor with safener at 500 g a.i. ha^{-1} at 3 DAS/DAT and chlorimuron + metsulfuron at 4 g a.i. ha^{-1} at 21 DAS/DAT followed by hand-weeding at 35 DAS/DAT could effectively control all the weeds(Singh *et al.*, 2008). Pre-emergence application of Bensulfuron methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1}+Hand weeding at 40 DAT and Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac sodium @ 25 g a.i ha^{-1} recorded significantly higher grain and straw yield which remained at par with two hand weeding at 20 and 40 DAT. In terms of economics, highest net returns and B:C ratio were also high with the pre emergence application of Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10 kg granules ha^{-1}+ Bispyribac sodium @ 25 g a.i. ha^{-1} at 20DAT compared to that of two hand weeding and benefit cost ratio (Uma *et al.,* 2014). The highest grain yield was obtained from two hand weeding as a result of reduced dry weight of weeds and higher values of yield components. This was statistically at par with pre-emergence application of Pyrazosulfuron ethyl and ready mix Chlorimuron + Metsulfuron methyl. The highest net return and B:C was also obtained with two hand weeding followed by Pyrazosulfuron ethyl and Chlorimuron + Metsulfuron methyl application (Singh *et al.,* 2014).

Again, the herbicidal combination of Pretilachlor + Safener @ (0.4kg ha^{-1} and 0.6kg ha^{-1}), Butachlor + Safener @ (1.5kg ha^{-1}) and Anoliphos + Ethoxysulfuron @ (0.375 kg ha^{-1}+ 0.04 kg ha^{-1}) controlled the most dominant weeds (*Cyperus difformis* and *Fimbristylis miliacea*) and produced yields comparable to those of the hand weeded control in direct seeded rice (Moorthy *et al.,* 1999). Pertilachlor + Pertilachlor" treatment based on EWRC standard evaluation and also 3471 kg ha^{-1}grain yield had the best output in comparison other treatments Also "Thiobencarb + mixed of Bentazone and Propanil", "Oxadiargyl + mixed of Bentazone and Propanil" and " Butachlor + mixed of Bentazone and Propanil" treatments with 3454, 3390 and 3349 kg ha^{-1}yield respectively had acceptable yield in comparison to three time hand weeding check treatment with 3044 kg ha^{-1}yield (Abbassi *et al.,* 2012).

Herbicidal combination of almix + 2,4-DEE provided excellent control of weeds and their biomass production and significantly superior to all other treatments and was at par with almix. These treatments caused significant lower depletion on nutrients (N, P and K) by weeds. It aslo improved in all yield attributing characters and maximized grain yield and was at par with hand weeding (Mukherjee, 2006). On the other hand, application of almix 0.004 kg + butachlor 0.938 kg ha-

^{1}increased the grain yield by 45.1% over the unweeded check. There was a negative linear relationship between weed dry weight and grain yield (Patra *et al.*, 2006).

Application of anilofos 600 g GR with emulsifier recorded significantly minimum density of grasses, sedges and broad leaved weeds, and higher no. of effective tillers, maximum panicle length and weight, 1000-grain weight, grain and straw yields, harvest index, nutrient content and minimum weed index (Babul*et al.*, 2013). On the other hand, post emergence application of Ethoxysulfuron + Anilofis (@ 0.02 + 0.375 kg ha^{-1}) at 10 DAT was statistically at par with hand weeding at 29 and 40 DAT in controlling weeds of transplanted rice effectively and the grain yield were also comparable. Butachlor 1.0 kg ha^{-1} at 5 DAT + 2,4-D Na salt 0.4 kg ha^{-1} at 25 DAT, Pretilachlor 1.0 kg ha^{-1} at 5 DAT and Oxadiagyl 0.1 kg ha^{-1} at 5 DAT were also promising (Bhowmick *et al.,* 2002). Nandal and Singh (1994) compared the efficiency of 0.3-0.6 kg ha^{-1}Anoliphos with that of 0.5 kg ha^{-1} Oxadiazon, 1.0 kg ha^{-1} Butachlor and hand weeding (30 + 60) DAS for controlling weed flora in direct seeded puddled rice. Results indicated that panicle length and number of panicle were highest and weed dry weight was the lowest in the weeding treatment. But the efficacy of benzobicyclon mixtures and carfentrazone-ethyl mixtures was greater than that of pyrazosolfuron-ethyl + pyriminobac-methyl GR. The yield of rice increased in both benzobicyclon and carfentrazone-ethyl treatments when compared with pyrazosolfuron-ethyl + pyriminobacmethyl GR in direct seeded rice field (Park*et al.*, 2013). Ronstar 25 EC @ 1.0 kg ha^{-1} followed by 2,4-D at 1.5 kg ha^{-1} + 5% Jaggery (course brown suger) applied 30 days after sowing effectively controlled annual broadleaved weeds and grasses (Patanker *et al.,* 1992).

2.2.5. Weed density and crop yield as affected by individual application of herbicide

Bispyribac sodium suppressed both weed density and dry weight over control that was highest among all herbicides. Higher rice grain yield and maximum marginal rate of return was also associated with this herbicide in all rice cultivars. Despite of its effectiveness against weeds and scoring higher rice yields, manual weeding was uneconomical primarily due to higher costs involved. Post emergence application of bispyribac sodium appeared to be a viable strategy for weed control in direct seeded rice with higher economic returns (Khaliq *et al.,* 2012). Application of Acetochlor 50 EC @ 250 ml gave more than 80% weed control efficiency, lower number and dry weight of weeds which ultimately resulted in higher yield attributes and grain yield of transplanted rice that were comparable to the standard in both seasons (Mamun*et al.,* 2011) and Aimchlor 5G had significant effect on weed reduction and grain yield of rice. This was reflected in increased number of productive tillers and number of finally grain yield of rice. The other treatments produced similar effect (Kumar and Uthayakumar, 2005). Due to application of herbicides as pre-emergence supplemented with two hand weeding at 30 and 60 days after transplanting, the highest yield of rice was obtained with the application of Butachlor at 1.5 kg ha^{-1} supplemented with two hand weeding in transplant rice (Singh *et al.*, 2005). Again, 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 minimum weed density (16 g m^{-2}) as well as weed biomass (9.27 g m^{-2}) and the highest weed control efficiency (82.57%). Yield and yield components were also significantly influenced by different weed control treatments and water management. The highest grain yield was obtained under good water management in weed free treatment followed by Butachlor 5G @ 2 kg $ha^{-1}$and one hand weeding under same water management. Results revealed that integration of approaches, particularly Butachlor application along with one manual weeding accompanied by proper water management might be the best option to combat weed problems as well as to obtain satisfactory grain yield in transplanted amanrice (Kabir *et al.*, 2008). Meanwhile, Butachlor provided better weed control efficiency and contributed to better crop growth and grain yield compared to MCPA irrespective of concentration. It might be due to that pre-emergence application of Butachlor provided effective early season weed control, which MCPA could not since apply as post emergence. The highest grain yield of4.18 t ha^{-1} was contributed by weed free treatment, while the least (2.44 t ha^{-1}) was by weedy check. Among the herbicide treatments, the highest grain yield of 4.08 t ha^{-1} was obtained from Butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate. Results further revealed a positive relationship between butachlor rate and grain yield, although a declining trend was apparent at higher than the recommended rates, while a negative relationship was found in MCPA treatments (Bari, 2010). But Pyrazosulfuran-ethyl (PSE) 10% WP @ 16 g a.i. $ha^{-1}$was the best in reducing weed population and weed dry weight without showing any phytotoxic symptoms in rice. Though hand weeding twice at 20 and 40 DAT gave the maximum grain yield, benefit: cost ratio clearly showed that PSE 10% WP@ 15g a.i ha^{-1} is the right herbicide to replace the hand weeding treatment (Halder *et al.*, 2005). It was most effective in managing associated weed species and yielded maximum grain yield (3.3 t ha^{-1}) of rice with lower weed index (10.8%) at the rate of 42.0 g ha^{-1}applied at 3 DAT (Pal *et al*., 2012). The effects of herbicides (Butachlor, Thiobencarb, Pretilachlor + Fenclorim, Butachlor + 2,4-D + Bensulfuron) applied as seed treatments and weed control in wet sown rice resulted that, all treatments, except Bensulfuron ,reduced the crop stand. The same herbicides, when 15 poured directly into flooded fields several days after sowing did not reduce by all treatments, except Bensulfuron. Weed weights were generally less and crop yields were increased in herbicides treated plots compared with untreated plots (Mobbaynd and Moody, 1992). Application of pretilachlor at 1.5 kg ha^{-1}*fb* HW registered higher weed control efficiency and numerically lower weed dry matter at all the stages. Removal of nutrients by weeds was also significantly differed with different treatments. The analysis of terminal residues of pretilachlor in rice grain, straw and postharvest soil indicated that the residues were below detectable limit (Dharumarajan *et al.*, 2009).

Application of azimsulfuron @ 30 g a. i. ha^{-1}+0.2% nonionic surfactant applied at 19 DAT recorded higher mean rice grain and straw yield (Jayadeva*et al*., 2009). But Penoxsulam 24 SC applied at 8 DAT gave the maximum grain yield and straw yield of transplanted kharif rice resulting in lowest weed index (Pal *et al.*, 2009). On the other hand, Sunrice@ 150WG achieved highest grain yield which was higher than the yield obtained from control, one hand weeding, two hand weeding and Topstar@ 400SC treated plots, respectively. The interaction of BRRI dhan34 in combination with Sunrice@ 150WG produced the highest grain yield while lowest grain yield was obtained from BRRI dhan50 in control treatment. Sunrice@ 150WG achieved highest benefit cost ratio over the others and control achieved the lowest (Chowdhury *et al.*, 2014).

Zafar (1989) conducted an experiment to see the relative performance of Butachlor (Machete 60EC @ 1.2 kg a.i. ha^{-1}), Oxadiazon (Ronstar @ 0.54 kg a.i. ha^{-1}), Thiobencarb (Stam F 10G @ 1.43 kg a.i. ha^{-1}) And Endimethalin (Stam 33EC @ 1.43 kg a.i. ha^{-1}). All herbicides gave above 83% weed control. Tillering was not significantly changed by Oxadiazon but increased rice yield. Whereas Rangaraju (2002) studied the effects of herbicide application and application time of weed flora and dynamics in dry seeded rainfed rice. He observed that application of either Butachlor or Thiobencarb at 1.5 kg ha^{-1}effectively control the weeds.The new herbicide, IR 5878 at 150 g ha^{-1} recorded the highest WCE (5Y, 1%) followed by the traditional herbicides 2,4-DEE and anilofos at harvest. IR 5878 at 125 g ha^{-1} recorded the highest grain yield among all the treatments which was 42.2 % more than that recorded from the untreated control, the lowest recorder was closely followed by the treatment, anilofos resulting 40.1' % higher grain yield than the untreated control (Ghosh *et al.*, 2005). On the other hand, the application of 2,4-D either alone or combination with Anolifos (tank-mixed or applied in sequence) effectively controlled Cyanotis axillaris. The optimum treatment was 0.4 kg Anolofis ha^{-1} applied as pre-emergence and 0.6 kg 2,4-D ha^{-1} applied at 20 days after transplanting. Whole application of Anoliphos, Butachlor, Thiobencarb or Oxidiazon without 2,4-D resulted poor weed control. Rice grain yield was increased by all weed control treatments and highest with 2,4- D with or without Anoliphos (Brar *et al.*, 1997).

Pacanoski Z. & Glatkova G. (2009) were conducted an experiment to establish an appropriate weed management strategy for the effective control of weed flora in direct wet-seeded rice. Herbicide selectivity and influence on grain yield were also evaluated. The weed population in the trials was composed of 8 and 5 weed species in Kočani and Probištip locality, respectively. The most prevailing weeds in both localities were: *Cyperus rotundus, Echinochloa crusgalli* and *Heteranthealimosa*. The average weediness for both years was 456.8 weed stems per m^2 in Kočani locality and 589.0 weed stems per m^2 in Probištip locality. In both localities all herbicides controlled *Cyperus rotundus, Echinochloacrusgalli* and *Heteranthera limosa* excellently except Mefenacet 53 WP. All applied herbicides showed high selectivity to rice, no visual injuries were determined at any rates in any year and locality. Herbicidal treatments in both localities significantly increased rice grain yield in comparison with untreated control.

2.2.6. Toxicity of herbicide on rice

Singh and Singh (1998) conducted an experiment to assess the pyhtotoxic effects of Acetochlor on rice crops. They observed on leaf tip drying, yellowing of leaves, necrosis, epinasty and crop stand reduction were 4 recorded at 15 and 30 DAT. The observation were based on a “0 – 10” scale, where “0” denoted no phytotoxicity. No phytotoxic symptoms appeared on the crop. There was no reduction in the density of rice crop due to application of Acetochlor. On the other hand, Set-off (Chinosulfuron) @ 20g ha^{-1} resulted in 85% control of *Monochoria* *vaginalis, Marsilea crenata, Cyperus* spp., *Fimbristylismiliacea a*nd *Spirpus juncoides* but only 50-60% controlled of *Echinochloacrusgalli* in transplanted rice. Weed control was general, superior to that provided by 720g ha^{-1} of 2,4 D, Cinosulfuron with 0-3% phytotoxicity less damaging to rice when applied with 6-21 days after transplanting as assessed 45 days after transplanting (Burthan *et al.*, 1989). Again, Cinosulfuron was less damaging to rice and resulted in higher rice yields than unwedded control plots, comparable to that achieved by annual weeding better than that obtained after treatment with 2,4-D (Burthun *et al.,* 1989).

Ronstar had a phytotoxic effect on seedling maturity and yield reduction of pre-germinated bororice. Ronstar rates used were 1.0L ha^{-1} and 2.0L ha^{-1} applied at the same day of seedling three days before seedlings and three days after seedlings. Pre-germinated seeds of BRRI dhan29 were broadcasted at 70 kg ha^{-1} following all recommended cultural practices throughout the growth period. Ronstar applied at the same day of sowing, it reduced grain yield significantly irrespective of doses. The high grain yield (5.76 t ha^{-1}) was observed when 1.0 L ha^{-1} Ronstar was applied three days after sowing (BRRI, 1998). On the other hand, light transmission rate is not much affected by Ronstar 25EC application in transplant ausrice (Islam, 1997). Piperphose mixture with Sulfonylurea herbicide (Piperphose/set-off) resulted excellent weed control efficacy. Piperphose/set-off mixture @ 330/20 a.i. ha^{-1} gave better control of grasses, sedges and broad leaves weeds in transplant low land rice. This new herbicide mixture did not show any phytotoxicity to young rice plants (Cabanilla, 1993).Application of Anolofis, 2,4-D and Butachlor @ 0.6 kg ha^{-1} in transplant rice caused slight toxicity at 10 DAT in transplanted rice but the plant recovered within 40 days after application of herbicides (Pamplona and Evangelista, 1982). On the other hand, pre-emergence application of Thiobencarb @ 3.0 kg ha^{-1},Oxadiazon @ 1.1 kg ha^{-1} and Butachlor @ 2 kg ha^{-1} each followed by 2,4-D ethyl post emergence application gave about 80% weed control without injury to rice (Kuchania *et al.,* 1991). Combined herbicidal application of Butachlor + Thiobencarb, Pretilachlor + Fencolrim, Butachlor +2,4-D ethyl @ 0.04 kg ha^{-1} reduced the crop stand plant height due to some toxic effect of plants (Mobbayand and Moody, 1992). Though Propanil + triclopyr controlled weeds; the control level was significantly lower than the check Orizoplus in each respective application rate. There was no phytotoxic effect of the herbicides on rice, indicating that the hebicides are not injurious to rice crop (Bakare *et al.*, 2008). IR 5878 applied at higher doses caused stunted growth of paddy and these affected plants recovered within 21 days after application (Ghosh *et al.*, 2005). On the other hand, pre-emergence application of Oxadiazon caused slight crop injury but reduced weed population effectively and gave maximum profit as compared with of other herbicides (Dayanand, 1987). Another study was evaluated that Oxadiazon produced some moderate phytotoxicity in the rice plant within two weeks received toxicity after application. Oxadiazon at higher rate caused phytotoxicity to rice plant and as a result plants were shorter and flowering were delayed (Khemphel and Rangsit, 1986). Ell-Deek (1989) studied herbicidal efficacy in transplant rice and was found that the Oxadiazon @1.5 a.i. kg ha^{-1} applied 4 DAT eliminated the growth of barnyard grass (*Echinochola crusgalli*) and common weeds completely and gave excellent control of yellow nutsedge (*Cyperus rotundus*), Oxadiazon had no harmful effect on rice plant. Again, pre or post emergence application of Oxadiazon @0.75 and 1.0kg a.i. ha^{-1} gave good control of *Echinochloa crusgalli*. It caused temporary injury to rice but this did not reduce yield of rice (Richard *et al.*, 1983). The pre-emergence application of Oxadiazon (Ronstar) in ausrice field gave the highest yield than hand weeding. The use of herbicide was not toxic to rice (Ghobrial, 1979). IRRI (1975) evaluated the effect of liquid herbicide on direct seeded rice in the Philippines. It was observed that Oxadiazon @0.75 kg a.i. ha^{-1} was slightly phytotoxic to the rice plants but the plants recovered fully within days after application.

From these reviews it can be obviously said that the use of herbicides in controlling weed is effective and economic in rice production. The doses of different herbicides depends on the intensity of weed infestation, edaphic and other climatic factors. In this regard the present study will enrich the knowledge to evaluating the effect of herbicides on growth and yield of direct seeded bororice.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

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

3.1. Description of the experimental site

3.1.1. Location

The experimental site was situated in $23^0 74^/$ N latitude and 90^0 $35^/$ E longitudes with an elevation of 8.2 meter from sea level.

3.1.2. Soil

The soil of the experimental area belongs to the Modhupur Tract with Tejgaon soil series. The soil of the experimental area was silty and non calcareous dark grey. The selected plot was medium high land and its pH value was around 5.6. The morphological characters of soil of the experimental plots were:

3.1.3. Climate

The experimental area was under the sub-tropical climate. The total rainfall of the experimental site was 29 mm during the study period. The average monthly maximum and minimum temperature were 27.75^0C and 17.1^0C respectively during the experimental period. The Maximum and minimum temperature, humidity, rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) Dhaka and given in (Appendix I).

3.2. Details of the experiment

3.2.1. Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The total number of unit plots was 27. The net size of each plot was 12 m^2 (4m × 3m).

3.2.2. Treatments

T1: Acetachlor + Bensulfuran (Pre-mix) @ 750 g ha^{-1}

T2: Pyrazosulfuran-ethyl @ 150 g ha^{-1}

T3: Bispyribac Sodium @150 g ha^{-1}

T4: Protilachlor @ 1 L ha^{-1}

T5: Protilachlor + Triasulfuran @ (1 L + 10 g)ha^{-1}

T6: Propyrisulfuran + Propanil @ (0.5 L + 1 kg)ha^{-1}

T7: Propyrisulfuran + Propanil @ (0.38 L + 1.5 kg)ha^{-1}

T8: Hand weeding (20 and 40 DAS)

T9: Weedy Check

3.2.3. Description of the herbicides

3.2.3.1. Acetachlor

Acetachlor is a member of the class of herbicides known as chloroacetanilides. Its mode of action is elongase inhibition, and inhibition of geranylgeranyl pyrophosphate (GGPP) cyclisation enzymes, part of the gibberellin pathway. It is used to control weeds in rice, and is particularly useful as a replacement for atrazine in the case of some important weeds.

3.2.3.2. Bensulfuran

Bensufuran is an herbicide of the sulfonylurea class. It is used as selective pre- and post-emergence control of annual and perennial weeds and sedges in continuously flooded rice. Mode of action selective systemic herbicide, absorbed by the foliage and roots, with rapid translocation to the meristematic tissues. As a result inhibition of biosynthesis of the essential amino acids valine and isoleucine, hence stopping cell division and plant growth.

3.2.3.3. Pyrazosulfuran-ethyl

Pyrazosulfuron-ethyl, a new herbicide belonging to the sulfonylurea group, is used for weed control of annual and perennial broad-leaved weeds and sedges, pre- or post-emergence in wet-sown and transplanted rice crops growing in areas varying from acidic to alkaline soil. It is a systemic herbicide, absorbed by roots and/or leaves and translocated to the meristems. . As a result inhibition of biosynthesis of the essential amino acids valine and isoleucine, hence stopping cell division and plant growth.

3.2.3.4. Bispyribac Sodium

Bispyribac sodium belongs to the group pyrimidinyloxybenzoic. It is used for controlling of grasses, sedges and broad-leaved weeds in direct-seeded rice. Also used to stunt growth of weeds in non-crop situations.

3.2.3.5. Pretilachlor

Pretilachlor is a chloroacetanilide herbicide which is widely used in rice cultivation for the control of several grasses, broad–leaved weeds and sedges. It is selective herbicide and it is taken up readily by the hypocotyls, mesocotyls and coleoptiles, and, to a lesser extent, by the roots of germinating weeds.

3.2.3.6. Triasulfuron

Triasulfuron belongs to the group sulfonylurea; is a water dispersible granular, herbicide for the pre-plant, incorporated by sowing, control of annual grass and certain broadleaf weeds in rice field.

3.2.3.7. Propanil

Propanil is a selective contact herbicide with a short duration of activity. It is used as post-emergence herbicide in rice to control broad-leaved and grass weeds.

3.3. Varietal characteristics

BRRI dhan50 is an aromatic variety ofrice developed by Bangladesh Rice Research Institute (BRRI). It was released by National Seed Board in 2008. The variety can be cultivated all over the country except salt affected coastal area during boro season. The average plant height of this variety is 82 cm. The grain is long and narrow in size but anterior portion of the grain is somewhat inclined. This variety can be harvested within 152-155 days of cultivation. Its yield is about 6.0-6.5 t ha^{-1} with proper care and favorable condition.

3.4. Management practices

3.4.1. Seed collection

Seeds of BRRI dhan50 was collected from Bangladesh Agricultural Development Corporation (BADC), Gabtoli branch, Dhaka.

3.4.2. Herbicide collection

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

3.4.3. Preparation of land

The land was opened with a power tiller on 31 December, 2015. The field was thoroughly prepared with the help of country plough and ladder. Weeds and stubbles were removed from the field during land preparation. The land was finally prepared on 4 January, 2015 and the field layout was done on the next day.

3.4.4. Sowing of seeds

Direct sowing method was followed in this experiment and seeds were sown on 5 January, 2015. Before sowing, the seeds were soaked in water overnight and kept in a shaded condition covered with wet gunny bag and rice straw for germination. After 72 hours the seeds were uniformly germinated and then the pre germinated seeds were directly sown on each plot.

3.4.5. Fertilizer application

The field was fertilized with Urea, Triple super phosphate (TSP), Muriate of potash (MOP), Gypsum and Zinc sulphate @ 250, 120, 120, 100 and 10 kg ha^{-1} respectively. Except urea and half of the gypsum & zinc sulphate, the whole amount of other fertilizers were applied before final land preparation. $1/3^{rd}$ urea and rest half of the gypsum & zinc sulphate was top dressed at 10-15 DAS. The remaining 2/3rd of urea were top dressed in two equal installment at 25-30 DAS and 40-45 DAS.

3.4.6. Intercultural operation

The following intercultural operations were done for ensuring adequate growth and development of the crop.

3.4.7. Application of herbicides

All the plots except control and hand weeding plots were applied with herbicide at 20 days after sowing (DAS).

3.4.8. Irrigation

Crop was irrigated at 10, 20, 30, 40, 50 and 60 DAS for successful crop production.

3.4.9. Sampling, harvesting and processing

The crop was harvested at full maturity on 25 March, 2015. For weed character, 1 m^{-2} area was randomly selected and for plant and yield contributing character five sample hills were randomly selected and uprooted prior to harvesting from each unit plot except from two border rows. After sampling the plot was harvested by cutting at the base with sickle. The harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor. The harvested crop was threshed by pedal thresher and the fresh weight of grain and straw were recorded plot wise. The grains were cleaned and sun dried and straws were also sun dried properly.

3.5. Data collection

The following parameters were recorded from five sampled hills.

3.5.1.Weed characters

Total weed population m^{-2}

Weed dry weight (g m^{-2})

Weed control efficiency (%)

3.5.2.Plant characters

Plant height (cm)

Number of total tillers $hill^{-1}$

Number of effective tillers m^{-2}

Number of non-effective tillers m^{-2}

Length of panicle (cm)

Number of grains $panicle^{-1}$

Number of filled grains $panicle^{-1}$

Number of unfilled grain $panicle^{-1}$

1000-grain weight (gm)

Grain yield (t ha^{-1})

Straw yield (t ha^{-1})

Biological yield (t ha^{-1})

Harvest index (%)

3.6.Procedure of data collection

A brief outline of data collection procedure is given below:

3.6.1. Total weed population m^{-2}: Total number of different weed species in one square meter were counted individually before 3 days of spray and 7, 14, 21, 28, 45 days after spray.

3.6.2. Total weed dry weight (g m^{-2}): Weeds were harvested individually from each plot at 45 days after spray. Dry weight of individual weed species of each plotwas taken by drying them in electric oven (Perkin-Elmer Corporation, USA) at 60°C for 72 hoursfollowed by weighing by digital balance.

3.6.3. Weed control efficiency (WCE %): For measuring WCE, the following formula was used;

WCE= (DWC - DWT)/ DWC* 100

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

3.6.4. Plant height (cm): Plant height was measured from the base of the plant to the tip of the longest panicle. It was measured at 40, 60 DAS and during harvesting period.

3.6.5. Total number of tillers hill^{-1}: Tillers which had at least one visible leaf were counted. It was counted at 40 and 60 DAS and during harvesting period.

3.6.6. Number of effective tillers m^{-2}: The tillers which had at least one visible grain in the panicle were considered as productive tillers.

3.6.7. Number of non-effective tillers m^{-2}: The tillers which had no grain in the panicle were regarded as non-effective tillers.

3.6.8. Panicle length (cm): Measurement was taken from basal node of the rachis to the apex of each panicle.

3.6.9. Filled grains $panicle^{-1}$: Presence of any food material in the spikelet was considered as filled grain and total number of filled grains present on each panicle was counted.

3.6.10. Unfilled grain(s) $panicle^{-1}$: Absence of any food material in the spikelets was considered as empty spikelets and total number of empty spikelets on each panicle was counted.

3.6.11. 1000-grain weight (g): Weight of 1000 grains was determined from the dried seed sample taken from each unit plot and was expressed in gram by using an electrical balance.

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

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

3.6.14. Biological yield (t ha^{-1}): The biological yield was calculated with the following formula-

Biological yield = Grain yield + Straw yield.

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

Harvest index (%) = Grain yield / Biological Yield × 100

3.6.16. Statistical Analysis

Data recorded for different parameters were compiled and tabulated in proper form. Analysis of variance was done following Randomized Complete Block Design with the help of computer package program MSTAT-C. The mean differences among the treatments were tested with Duncan’s Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Effect of weed control treatments on weed parameters and crop characters obtained from the present study have been presented and discussed in this chapter. Weed species infested the experimental plot was shown in Table 1 and the results related to weed infestationwas presented in Tables 2-7. Data on dry weight of weed at 45 days after spray was presented in Table 8, weed control efficiency in Table 9 and data on different crop characters was presented in Table 10-13.

4.1. Infested weed species in the experimental field

Conditions favourable for growing bororice are also favorable for the exuberant growth of numerous kinds of weeds that compete with crop plants. These competitions of weeds are increases when the weed population increases.

Sixteen weed species infested the experimental field which belongs to eightfamilies. Among these species 5 belonged to Poaceae, 3 Cyperaceae & Compositae, 2 Amaranthaceae and 1 from each of Marsiliaceae, Cruciferae and Scrophulariaceae. Weeds grown in the experimental plot were grass, broad-leaved, sedge type. The most important weed in the experimental plots were grasses like, *Cynodon dactylon* (Bermuda grass), *Leersia hexandra* (rice cutgrass) and *Echinochloa crusgalli* (barnyard grass); sedges like, *Cyperus esculentus* (Yellow nutsegde), *Cyperus irria* L. (nut segde) and *Cyperus difformis* L. (umbrella sedge) and broad leaf weeds like *Marsilea quadrifoliata* (4-leaved water clover). The particulars of weeds Common name, English name, Scientific name, Family name and life cycle have been presented in Table 1.

Table 1. Infested weed species of the experimental field

Common Name	English name	Scientific name	Family name	Life cycle
Behua	Small leaved umbrella sedge	*Cyperus diformis*	Cyperaceae	Annual
Shusni shak	4-leaved water clover	*Marsilea quadrifolia*	Marsiliaceae	Annual
Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Perennial
Choto shama	Jungle rice	*Echinochloa colona*	Poaceae	Annual
Boro shama	Banyard grass	*Echinochloa crusgalli*	Poaceae	Annual
Anguli ghas	Crab grass	*Digitaria ciliaris*	Poaceae	Annual
Chanchi	Chanchi	*Alternanthera sessilis*	Amaranthaceae	Perennial
Durba	Burmuda grass	*Cynodon dactylon*	Poaceae	Perennial
Bon mula	Wild raddish	*Raphanus raphaistrum*	Cruciferae	Perennial
Khet papri	Khet papri	*Lindernia procumbens*	Scrophulariaceae	Annual
Keshuti	White eclipta	*Eclipta alba*	Compositae	Annual
Arail	Swamp rice	*Leersia hexandra*	Poaceae	Annual
Shetolumi	Shetolumi	*Gnaphaliwm luteoalbum*	Compositae	Annual
Boro chucha	Umbrella nutsedge	*Cyperus irria*	Cyperaceae	Perennial
Girakata	Girakata	*Spilanthes acmella*	Compositae	Annual
Halda mutha	Yellow nutsedge	*Cyperus esculentus*	Cyperaceae	Perennial

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

Weed population was significantly influenced by different weed control treatments as recorded at 3 days before spray, 7, 14, 21, 28 and 45 days after spray of the rice plot (Table 2-7).

4.2.1. Effect of different weed control treatments before 3 days of spray

The highest number (386.7) of *Cyperus diformis* was found in T_1 whereas the lowest number (131.7) was found in T_7 which was statistically similar with T_3 (151.7) and T_4 (178.3). The maximum number (10.33) of *Marsilea quadrifolia* was found in T_5 whereas the minimum number (2.33) was found in T_7 and moderate infestation was found in T_3 which was statistically similar with T_4, T_6 and T_8. Maximum infestation (22.67) of *Alternanthera philoxeroides* was found in control condition (T_9) whereas the least infestation (1.33) was found in T_7 which was statistically similar with T_3 (1.67). The highest number (3.67) of *Digitaria ciliaris* was found in T_2 whereas no *Digitaria ciliaris* was found in T_3, $T_4$and T_7. The maximum number (5.00) of *Alternanthera sessilis* was found in T_3 whereas no *Alternanthera sessilis* was found in all the plots except T_2. The highest number (3.67) of *Cynodon dactylon* was found in untreated plot whereas no *Cynodon dactylon* was found in T_7 and moderate infestation was found in T_1 which was statistically similar with T_3, T_4, $T_6$and T_8. The maximum number (5.33) of *Raphanus raphaistrum* was found in T_7 whereas no *Raphanus raphaistrum* was found in all the plots except T_2 and T_5. The highest infestation (11.67) of *Eclipta alba* was found in control condition whereas no *Eclipta alba* was found in all the plots except T_1, $T_2$and T_5. The highest number (1.00) of *Leersia hexandra* was found in T_6 whereas no *Leersia hexandra* was found in all the plots except $T_2$and T_5. The highest number (4.67) of *Gnaphaliwm luteoalbum* was found in T_8 whereas no *Gnaphaliwm luteoalbum* was found in T_3, T_4 andT_7. The highest infestation (1.33) of *Spilanthes acmella* was found in untreated plots which was statistically similar with T_2 whereas no *Spilanthes acmella* was found in T_3, T_4,

$T_7$and T_8. Partially similar weed species were found by Islam(2014) and Zannat (2014).

Table 2.Weed population in treatments before 3 days of spray

Treatments	No. of weed species m^{-2}					
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	386.7 a	7.67 b	11.00 cd	2.67 b	0.00 c	0.33 d
T_2	285.3 b	8.67 b	16.33 b	3.67 a	0.332 b	3.33 b
T_3	151.7 e	3.67 d	1.67 g	0.00 g	5.00 a	0.33 d
T_4	178.3 de	4.00 d	4.67 f	0.00 g	0.00 c	0.33 d
T_5	268.3 bc	10.33 a	12.33 c	1.67 c	0.00 c	1.00 c
T_6	218.0 cd	4.33 d	9.67d e	1.00 e	0.00 c	0.33 d
T_7	131.7 e	2.33 e	1.33 g	0.00 g	0.00 c	0.00 e
T_8	216.7 cd	4.00 d	9.00 e	0.33 f	0.00 c	0.33 d
T_9	235.0 bcd	6.33 c	22.67 a	1.33 d	0.00 c	3.67 a
SE	18.23	0.355	0.630	0.080	0.037	0.073
Level of significance	**	**	**	**	**	**
CV (%)	13.71	10.76	11.06	11.61	11.17	11.83

Table 2: Continued

Treatments	No. of weed species m^{-2}				
	Raphanus raphaistrum	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*
T_1	0.00 d	1.00 d	0.00 d	0.00 e	0.33 c
T_2	2.00 b	9.67 b	0.67 b	1.33 b	1.33 a
T_3	0.00 d	0.00 e	0.00 d	0.00 e	0.00 d
T_4	0.00 d	0.00 e	0.00 d	0.00 e	0.00 d
T_5	1.67 c	3.33 c	0.33 c	1.33 b	0.67 b
T_6	0.00 d	0.00 e	1.00 a	0.33 d	0.33 c
T_7	5.33 a	0.00 e	0.00 d	0.00 e	0.00 d
T_8	0.00 d	0.00 e	0.00 d	4.67 a	0.00 d
T_9	0.00 d	11.67 a	0.00 d	0.672 c	1.33 a
SE	0.088	0.214	0.018	0.052	0.018
Level of significance	**	**	**	**	**
CV (%)	15.00	12.97	10.34	9.95	5.18

Values followed by the different letter(s) are significantly different from each other by DMRT at 1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.2.2. Effect of different weed control treatments on weed population after 7 days of spray

Weeds are drastically reduced most of the field crops especially cereal crops including rice. Weed control strategy is very important to prevail the yield of rice. The strategies applied to the experimental plots have significant effect on controlling of weed. From Table 3, it was observed that maximum number of weeds was found in control condition (T_9) and minimum number of weeds was found in T_7 treatment at 7 days after spray for all the enlisted species. T_6 showed statistically similar results with T_7 to control *Alternanthera philoxeroides* and Spilanthes acmella. T_2, T_6 and T_8 also showed statistically insignificant results with T_7 to control *Digitaria ciliaris, Alternanthera sessilis, Leersia hexandra* and *Raphanus raphaistrum*. T_2, T_3 was showed slightly moderate effect and T_6 showed moderate effect to control *Cyperous diformis*. To control *Echinochloa colona*, *Gnaphaliwm luteoalbum* and *Cyperus irria* all the treatments are effective and statistically similar except T_4 and T_5. Number of *Cynodon dactylon* become zero in per meter square area after 7 days of spraying of T_7 that means T_7 was effective to control it and T_2, T_6 and T_8 showed better result to control *Cynodon dactylon* but effect was statistically similar. *Eclipta alba* was also become zero with the spraying of T_7 as well as number of *Eclipta alba* in per meter square area was gradually decreased with the spraying of T_6, T_8, T_2, T_3, T_1, T_4 and T_5 respectivly. From the above discussion spraying of T_7 after 7 days was effective to control all the listed weed species but most effective to control *Cynodon dactylon* and *Eclipta alba*. Hasanuzzaman *et al.* (2008) reported that all herbicidal treatments reduced weed population significantly compared with weedy check.

Table 3. Effect of different weed control treatmentson weed populationafter 7 days of spray

Treatments	No. of weed species m^{-2}						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Echinochloa colona*	*Digitaria ciliaris*	*Alternanthera sessilis*
T_1	146.3 c	6.33 d	9.00 c	1.00 d	0.00 c	2.33 cd	0.33 c
T_2	127.7 d	4.00 e	6.67 d	0.33 f	0.00 c	1.33 e	0.00 d
T_3	129.7 d	4.33 e	9.00 c	0.67 e	0.00 c	2.00 d	0.33 c
T_4	152.3 c	7.67 c	9.33 bc	1.33 c	0.00 c	2.67 bc	0.33 c
T_5	187.3 b	8.67 b	10.00 b	1.67 b	0.33 b	3.00 b	0.67 b
T6	44.67 e	3.67 e	1.33 f	0.00 g	0.00 c	1.00 e	0.00 d
T_7	25.67 f	2.33 f	1.00 f	0.00 g	0.00 c	1.00 e	0.00 d
T_8	122.7 d	4.00 e	4.00 e	0.33 f	0.00 c	1.33 e	0.00 d
T_9	257.0 a	10.33 a	16.00 a	2.67 a	3.33 a	5.33 a	1.33 a
SE	4.64	0.214	0.291	0.041	0.041	0.123	0.018
Level of significance	**	**	**	**	**	**	**
CV (%)	6.07	6.52	6.84	7.72	16.72	9.67	10.83

Table 3. Continued

Treatments	No. of weed species m^{-2}							
	Cynodon dactylon	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus irria*
T_1	0.67 d	0.33 c	2.67	6.00 d	0.67 c	0.00 c	1.33 d	0.33 b
T_2	0.33 e	0.00 d	0.00	3.33 f	0.33 d	0.00 c	0.33 e	0.00 c
T_3	0.67 d	0.33 c	0.00	4.00 e	0.67 c	0.00 c	0.33 e	0.00 c
T_4	1.67 c	1.67 b	0.00	7.00 c	0.67 c	0.33 b	3.67 c	0.33 b
T_5	3.67 b	1.67 b	0.00	9.67 b	1.33 b	0.33 b	5.00 b	0.33 b
T_6	0.33 e	0.00 d	0.00	1.00 h	0.00 e	0.00 c	0.00 f	0.00 c
T_7	0.00 f	0.00 d	0.00	0.00 i	0.00 e	0.00 c	0.00 f	0.00 c
T_8	0.33 e	0.00 d	0.00	2.67 g	0.00 e	0.00 c	0.33 e	0.00 c
T_9	5.33 a	6.67 a	0.00	11.00 a	2.33 a	4.67 a	7.67 a	1.00 a
SE	0.063	0.079		0.208	0.018	0.036	0.070	0.018
Level of significance	**	**	-	**	**	**	**	**
CV (%)	7.69	11.56		7.27	5.14	11.28	5.94	15.49

Values followed by the different letter(s) are significantly different from each other by DMRT at 1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.2.3. Effect of different weed control treatmentson weed populationafter 14 days of spray

Different herbicidal treatments showed significant influence on controlling the above mentioned weed species. From Table 4, it was assumed that massive infestation i.e. minimum controlling efficiency of weeds was found in control condition (T_9) and less infestation i.e. maximum controlling efficiency of weeds was found with T_7 treatment at 14 days after spray for all the enlisted species. $T_6$and T_8 was showed statistically similar results with T_7 to control *Marsilea quadrifolia*, *Alternanthera philoxeroides*, *Digitaria ciliaris*, *Alternanthera sessilis*, *Raphanus raphaistrum* and *Leersia hexandra*. T_6 was the second most effective herbicide while $T_2$and T_8 was showed moderate effect to control *Cyperous diformis* and *Eclipta alba*. To control *Echinochloa crusgalli* T_3 was the most important herbicide after T_7 while $T_2$and T_8 also performed moderately. *Echinochloa colona*, *Gnaphaliwm luteoalbum*, *Spilanthes acmella* and *Cyperus irria* were effectively controlled and statistically similar by all the treatments except T_4 and T_5. The second most important treatment to control *Cynodon dactylon* were T_2, T_3, $T_6$and T_8 whose effects were statistically similar. Improved moisture also improved herbicide activity, which resulted in reduced weed population and thus the reduced weed dry matter accumulation. The findings get support from the work published Kumar *et al*. (2004) and Singh and Tiwari (2005).

Table 4. Effect of different weed control treatmentson weed populationafter 14 days of spray

Treatments	No. of weed species m^{-2}						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Echinochloa colona*	*Digitaria ciliaris*	*Alternanthera sessilis*
T_1	110.0 cd	4.67 d	5.67 c	2.67 d	0.00 c	2.67 d	0.33 d
T_2	70.33 e	2.33 e	2.33 e	1.67 f	0.00 c	2.00 e	0.00 e
T_3	97.67 d	2.67 e	3.67 d	2.00 e	0.00 c	2.33 de	0.33 d
T_4	119.0 c	6.67 c	5.67 c	3.33 c	0.33 b	3.33 c	1.33 c
T_5	160.3 b	10.00 b	9.00 b	4.00 b	0.33 b	4.67 b	4.00 b
T_6	30.33 f	0.00 f	1.00 f	0.33 g	0.00 c	1.33 f	0.00 e
T_7	0.00 g	0.00 f	0.33 f	0.33 g	0.00 c	1.00 f	0.00 e
T_8	66.33 e	0.33 f	1.00 f	1.67 f	0.00 c	1.33 f	0.00 e
T_9	315.3 a	45.33 a	11.67 a	4.33 a	1.67 a	7.00 a	6.67 a
SE	4.50	0.465	0.296	0.077	0.026	0.210	0.058
Level of significance	**	**	**	**	**	**	**
CV (%)	7.24	10.07	11.45	6.01	20.72	12.77	24.18

Table 4. Continued

Treatments	No. of weed species m^{-2}							
	Cynodon dactylon	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus irria*
T_1	0.67 d	0.33 d	0.00 c	4.00 d	0.67 c	0.00 d	1.33 c	0.00 c
T_2	0.33 e	0.00 e	0.00 c	3.33 de	0.00 d	0.00 d	0.33 d	0.00 c
T_3	0.33 e	0.33 d	0.00 c	4.00 d	0.67 c	0.00 d	0.33 d	0.00 c
T_4	2.00 c	1.67 c	0.00 c	6.00 c	0.67 c	0.33 c	3.33 b	0.33 b
T_5	2.33 b	4.33 b	0.67 b	9.67 b	2.33 b	4.33 b	3.67 b	0.33 b
T_6	0.33 e	0.00 e	0.00 c	1.00 f	0.00 d	0.00 d	0.00 d	0.00 c
T_7	0.00 f	0.00 e	0.00 c	0.00 g	0.00 d	0.00 d	0.00 d	0.00 c
T_8	0.33 e	0.00 e	0.00 c	2.67 e	0.00 d	0.00 d	0.00 d	0.00 c
T_9	5.33 a	6.00 a	2.67 a	11.33a	2.67 a	4.67 a	7.67 a	1.00 a
SE	0.073	0.037	0.036	0.232	0.083	0.057	0.193	0.018
Level of significance	**	**	**	**	**	**	**	**
CV (%)	9.66	23.67	17.96	8.63	18.59	9.65	18.08	26.97

Values followed by the different letter(s) are significantly different from each other by DMRT at 1% (**) level of probability

T_1=Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1 L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) $ha^{-1,}$ T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.2.4. Effect of different weed control treatmentson weed populationafter 21 days of spray

Application of different herbicides significantly influenced on mitigating the weed species found in the experimental plots. From Table 5, it was observed that minimum weed control efficiency was found in control condition (T_9) and maximum weed control efficiency was found with T_7 treatment at 21 days after spraying for all the listed weed species. $T_6$and T_8 was showed statistically similar results with T_7 to control *Marsilea quadrifolia*, *Digitaria ciliaris* and *Leersia hexandra*. The second most effective herbicidal treatment was T_6 which was statistically similar with T_8 while T_2 showed moderate effect to control *Cyperous diformis*. In case of controlling *Alternanthera philoxeroides*, T_6 was statistically similar with T_7 while T_8 performed better and $T_2$and T_3 was moderately influenced to control of it. To control *Echinochloa crusgalli* T_6 was most effective as like as T_7 while $T_2$and T8 was better to control of it and action of T_3 was moderate. The better suppression of *Cynodon dactylon* after T_7 was observed in T_6 which was numerically similar with $T_2$and T_8 while it was moderately suppressed by $T_1$and T_3. *Alternanthera sessilis*, *Gnaphaliwm luteoalbum* and *Spilanthes acmella* were effectively controlled by all the treatments except $T_4$and T_5. All the treatments were singnificantly controlled *Lindernia procumbens*and*Cyperus esculentus* except T_5. *Raphanus raphaistrum*and*Cyperus irria* were effectively controlled by all the treatments except T_1, T_4 and T_5. Reduced weed growth under these treatments might be due to the better control of weeds. Bhattacharya *et al.* (2005) observed that both the weed density and dry weight of weeds were significantly reduced in different treatment plots as compared to unweeded check.

Table 5. Effect of different weed control treatmentson weed populationafter 21 days of spray

Treatments	No. of weed species m^{-2}						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	81.00 c	6.00 d	7.67 c	1.33 d	2.67 d	0.33 d	0.67 d
T_2	34.67 d	1.33 f	5.00 e	0.33 f	2.00 e	0.33 d	0.33 e
T_3	80.33 c	5.33 e	5.67 d	1.00 e	2.297 e	0.33 d	0.67 d
T_4	93.33 c	9.33 c	8.33 b	1.67 c	3.33 c	1.33 c	2.00 c
T_5	150.3 b	11.67 b	8.67 b	2.00 b	4.67 b	4.00 b	3.00 b
T_6	16.33 e	0.00 g	1.00 g	0.00 g	1.33 f	0.00 d	0.33 e
T_7	0.00 f	0.00 g	0.67 g	0.00 g	1.33 f	0.00 d	0.00 f
T_8	26.33 de	0.33 g	3.67 f	0.33 f	1.33 f	0.00 d	0.33 e
T_9	325.0 a	49.67 a	10.00 a	2.67 a	7.00 a	6.003 a	5.33 a
SE	5.35	0.192	0.193	0.036	0.100	0.111	0.048
Level of significance	**	**	**	**	**	**	**
CV (%)	10.33	3.59	5.92	6.38	6.01	14.01	6.05

Table 5. Continued

Treatments	No. of weed species m^{-2}							
	Raphanus raphaistrum	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
T_1	1.00 d	0.00 c	4.33 c	0.67 c	0.00 c	0.33 d	0.00 c	0.3367 c
T_2	0.00 e	0.00 c	2.67 e	0.33 d	0.00 c	0.00 d	0.00 c	0.00 d
T_3	0.00 e	0.00 c	3.33 d	0.67 c	0.00 c	0.33 d	0.00 c	0.00 d
T_4	1.33 c	0.00 c	7.67 b	0.67 c	0.33 b	3.67 c	0.00 c	0.43 b
T_5	2.00 b	2.67 b	9.67 a	2.33 b	0.33 b	5.00 b	1.67 b	0.43 b
T_6	0.00 e	0.00 c	1.00 f	0.00 e	0.00 c	0.00 d	0.00 c	0.00 d
T_7	0.00 e	0.00 c	0.00 g	0.00 e	0.00 c	0.00 d	0.00 c	0.00 d
T_8	0.00 e	0.00 c	1.00 f	0.00 e	0.00 c	0.00 d	0.00 c	0.00 d
T_9	9.67 a	12.67 a	10.00 a	2.67 a	4.33 a	8.33 a	3.00 a	0.80 a
SE	0.070	0.194	0.192	0.018	0.044	0.325	0.032	0.018
Level of significance	**	**	**	**	**	**	**	**
CV (%)	7.95	19.70	7.56	4.39	14.25	28.69	29.44	19.75

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) level of probability
T_1=Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1 L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.2.5. Effect of different weed control treatmentson weed populationafter 28 days of spray

The weed control treatment exerted significant effect on reducing the weed population found in the different experimental plots at 28 days after spraying. From Table 6, it was assumed that maximum number of weed species was found in control condition (T_9) whereas minimum number was found in T_7 treatment for all the enlisted weed species. Better result showed by T_2 in case of controlling *Marsilea quadrifolia* and *Leersia hexandra* while T_3 for *Raphanus raphaistrum*. $T_6$and T_8 was showed statistically similar results with T_7 for above mentioned three weed species along with *Echinochloa crusgalli* while it was moderately controlled by $T_2$and T_3. *Cyperous diformis* was also effectively controlled by T_6 which was statistically similar with T_7 while T_8 showed moderate effect to control. In case of controlling *Alternanthera philoxeroides*, T_6 followed by T_8 showed better performance while $T_2$and T_3 was moderately influenced to control of it. In case of suppressing of *Digitaria ciliaris*, T_6 showed better result while $T_2$and T_8 gave moderate action. Better controlling of *Cynodon dactylon* after T_7 was observed in T6 which was numerically similar with $T_2$and T_8 while it was moderately suppressed by $T_1$and T_3. All the treatments were effectively controlled *Spilanthes acmella* and *Gnaphaliwm luteoalbum* except $T_4$and T_5. *Alternanthera sessilis* and *Cyperus irria* were effectively controlled by all the treatments except T_1, $T_4$and T_5. *Lindernia procumbens* and*Cyperus esculentus* were singnificantly controlled by all the treatments except T_5. All herbicidal treatments reduced weed population significantly compared with weedy check that was reported by Hasanuzzaman *et al.* (2008).

Table 6. Effect of different weed control treatmentson weed populationafter 28 days of spray

Treatments	No. of weed species m^{-2}						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	66.00 d	9.67 d	7.67 d	1.00 d	2.33 d	0.33 d	0.67 d
T_2	36.33 e	3.00 e	5.00 e	0.33 e	1.33 e	0.00 e	0.33 e
T_3	62.33 d	8.67 d	5.33 e	0.33 e	2.00 d	0.00 e	0.67 d
T_4	80.67 c	11.00 c	8.33 c	1.33 c	2.67 c	1.00 c	2.00 c
T_5	139.0 b	14.33 b	9.33 b	2.00 b	3.33 b	1.33 b	2.33 b
T_6	1.00 g	0.00 f	1.00 g	0.00 f	0.67 f	0.00 e	0.33 e
T_7	0.00 g	0.00 f	0.33 h	0.00 f	0.33 g	0.00 e	0.00 f
T_8	11.67 f	0.00 f	3.67 f	0.00 f	1.33 e	0.00 e	0.33 e
T_9	313.7 a	38.67 a	10.67 a	2.67 a	7.00 a	6.67 a	5.33 a
SE	2.63	0.415	0.214	0.052	0.112	0.026	0.063
Level of significance	**	**	**	**	**	**	**
CV (%)	5.79	7.58	6.52	10.73	8.31	32.29	8.28

Table 6. Continued

Treatments	No. of weed species m^{-2}							
	Raphanus raphaistrum	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
T_1	1.00 d	0.00 c	4.33 d	0.67 c	0.00 c	0.33 d	0.00 c	0.33 b
T_2	0.00 f	0.00 c	2.67 e	0.33 d	0.00 c	0.00 d	0.00 c	0.00 c
T_3	0.33 e	0.00 c	4.33 d	0.67 c	0.00 c	0.33 d	0.00 c	0.00 c
T_4	2.00 c	0.00 c	5.33 c	0.67 c	0.00 c	3.33 c	0.00 c	0.33 b
T_5	3.67 b	2.67 b	7.67 b	2.33 b	0.33 b	3.67 b	1.00 b	0.33 b
T_6	0.00 f	0.00 c	1.00 f	0.00 e	0.00 c	0.00 d	0.00 c	0.00 c
T_7	0.00 f	0.00 c	0.00 g	0.00 e	0.00 c	0.00 d	0.00 c	0.00 c
T_8	0.00 f	0.00 c	1.00 f	0.00 e	0.00 c	0.00 d	0.00 c	0.00 c
T_9	7.33 a	7.67 a	9.00 a	2.67 a	2.00 a	5.00 a	1.67 a	1.00 a
SE	0.037	0.058	0.206	0.041	0.018	0.100	0.026	0.018
Level of significance	**	**	**	**	**	**	**	**
CV (%)	22.72	8.81	9.10	8.42	13.21	12.37	28.82	39.50

Values followed by the different letter(s) are significantly different from each other by DMRT at 1% (**) level of probability

T_1=Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1 L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.2.6. Effect of different weed control treatmentson weed populationafter 45 days of spray

The weed control treatment exerted significant effect on reducing the weed population found in the different experimental plots at 28 days after spray. From Table 7, it was observed that highest number of weed species was found in control condition (T_9) whereas lowest number was found in T_7 treatment for all the enlisted weed species. To control *Cyperous diformis, Marsilea quadrifolia, Raphanus raphaistrum* and *Leersia hexandra and Echinochloa crusgalli*, $T_6$and T_8 was showed statistically similar results with T_7. In case of controlling *Alternanthera philoxeroides*and*Digitaria ciliaris*, T_6 showed better performance after T_7 while T_8 was moderately influenced to control of it. Better controlling of *Cynodon dactylon* after T_7 was observed in T_6 which was statistically similar with T8 while it was moderately suppressed by T_1, $T_2$and T_3. After T_7, *Eclipta alba* was effectively suppressed by T_6 which was numerically similar with T_8 while it was moderately controlled by T_2. *Alternanthera sessilis* and *Cyperus irria* were effectively controlled by all the treatments except T_1, $T_4$and T_5. *Lindernia procumbens*&*Cyperus esculentus* were singnificantly controlled by all the treatments except T_5. Weed population was gradually decreased in the herbicide treated plots compared to control condition as reported by Bhattacharya *et al.* (2005).

Table 7. Effect of different weed control treatmentson weed populationafter 45 days of spray

Treatments	No. of weed species m^{-2}						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	56.33 d	9.00 d	8.33 d	1.00 d	2.67 c	0.33 c	0.67 d
T_2	30.33 e	2.67 e	5.33 f	0.33 e	2.00 e	0.00 d	0.67 d
T_3	55.67 d	8.33 d	7.67 e	0.33 e	2.33 d	0.00 d	0.67 d
T_4	74.00 c	10.33 c	9.33 c	1.33 c	3.33 b	1.00 b	1.67 c
T_5	126.3 b	12.67 b	10.67 b	2.00 b	3.33 b	1.00 b	2.33 b
T_6	1.00 f	0.00 f	1.00 h	0.00 f	1.33 f	0.00 d	0.33 e
T_7	0.00 f	0.00 f	0.33 i	0.00 f	0.33 g	0.00 d	0.00 f
T_8	3.33 f	0.00 f	3.67 g	0.00 f	2.00 e	0.00 d	0.33 e
T_9	295.7 a	35.67 a	11.67 a	2.67 a	3.67 a	6.67 a	5.33 a
SE	1.63	0.439	0.206	0.031	0.044	0.044	0.041
Level of significance	**	**	**	**	**	**	**
CV (%)	3.96	8.71	5.54	5.88	3.24	7.78	5.50

Table 7. Continued

Treatments	No. of weed species m^{-2}					
	Raphanus raphaistrum	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Cyperus esculentus*	*Cyperus irria*
T_1	1.00 d	0.00 c	4.33 d	0.67 b	0.00 c	0.33 b
T_2	0.00 f	0.00 c	2.67 e	0.33 c	0.00 c	0.00 c
T_3	0.33 e	0.00 c	4.33 d	0.67 b	0.00 c	0.00 c
T_4	1.67 c	0.00 c	5.33 c	0.67 b	0.00 c	0.33 b
T_5	2.33 b	2.67 b	7.67 b	1.67 a	1.00 b	0.33 b
T_6	0.00 f	0.00 c	1.00 f	0.00 d	0.00 c	0.00 c
T_7	0.00 f	0.00 c	0.00 g	0.00 d	0.00 c	0.00 c
T_8	0.00 f	0.00 c	1.00 f	0.00 d	0.00 c	0.00 c
T_9	4.67 a	6.67 a	9.00 a	1.67 a	1.67 a	1.00 a
SE	0.058	0.061	0.192	0.018	0.018	0.018
Level of significance	**	**	**	**	**	**
CV (%)	8.99	9.74	8.49	22.67	11.93	34.25

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.3. Effect of different weed control treatments on weed dry weightafter 45 days of spray

Due to spray of Propyrisulfuran + Propanil @ (0.38 L + 1.5 kg) ha^{-1}, after 45 days all kinds of weed species found in the experimental plots were zero except *Alternanthera philoxeroides*&*Digitaria ciliaris* as a result weed dry weight also become zero except these two species. On the other hand, with the increasing of time, all kinds of weed species were gradually increased hence, weed dry weight was also increased in untreated plots that means in control condition (T_9).

Dry weight of *Cyperus diformis* become zero in T_6 which was statistically similar with T_7 while T_8 showed the lower most weed dry weight and T_5 showed the maximum dry weight after T_9. In case of *Marsilea quadrifolia,* T_6 and T_8 showed statistically similar result with T_7 and the least dry weight was found in T_2 while T_5 showed the highest dry weight after T_9 which was statistically similar with T_1. For *Alternanthera philoxeroides*, *Echinochloa crusgalli* and *Eclipta alba,* T_6 showed statistically similar result with T_7 while maximum dry weight was found in T_5 after T_9. In case of *Digitaria ciliaris,* T_6 showed the second best result after T_7 and moderate dry weight was recorded from the plots where $T_2$and T_8 were practiced as well as these two treatments also showed statistically similar results while highest dry weight was found in T_5 after T_9. After T_7, T_2, T_3, $T_6$and T_8 were the best way to control *Cynodon dactylon* because due to spraying these four treatments dry weight of it was drastically reduced as compared to control condition. In case of *Leersia hexandra* and *Alternanthera sessilis,* $T_6$and T_8 showed statistically similar result with T_7 while maximum dry weight was found in T_5 after T_9. Dry weight become zero for all the treatments except T_1, $T_4$and T_5 in case of *Raphanus raphaistrum,* T_3, $T_4$and T_5 in case of *Spilanthes acmella,* T_5 in case of *Cyperus esculentus* and $T_4$and T_5 in case of *Cyperus irria.*Singh and Kumar (1999) also reported that the maximum weed dry weight was recorded in the unweeded control which was significantly higher compared to other weed control treatments.

Table 8. Effect of different weed control treatment on weed dry weightafter 45 days of spray

Treatment	Weed dry weight (g m^{-2})						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	4.16 d	1.65 b	2.53 cd	3.89 d	1.77 d	0.18 d	0.41 d
T_2	2.26 e	0.59 d	2.07 de	1.28 ef	0.90 e	0.00 e	0.10 e
T_3	3.89 d	1.21 c	2.48 ce	1.53 e	1.65 d	0.11 d	0.13 e
T_4	4.96 c	1.77 b	2.93 c	7.34 c	2.67 c	0.44 c	0.84 c
T_5	9.18 b	1.84 b	4.25 b	9.18 b	3.77 b	0.67 b	1.16 b
T_6	0.00 g	0.00 e	0.36 f	0.00 g	0.44 f	0.00 e	0.08 e
T_7	0.00 g	0.00 e	0.17 f	0.00 g	0.05 g	0.00 e	0.00 f
T_8	0.86 f	0.00 e	1.93 e	0.75 f	0.78 e	0.00 e	0.08 e
T_9	23.79 a	7.47 a	7.03 a	10.82 a	5.28 a	3.043 a	1.37 a
SE	0.201	0.101	0.178	0.193	0.080	0.026	0.018
Level of significance	**	**	**	**	**	**	**
CV (%)	6.40	10.91	11.77	8.68	7.25	8.14	7.74

Table 8. Continued

Treatment	Weed dry weight (g m^{-2})					
	Raphanus raphaistrum	*Eclipta alba*	*Leersia hexandra*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
T_1	0.210 c	1.53 d	0.77 b	0.04 d	0.00 c	0.04 d
T_2	0.00 e	0.88 f	0.46 c	0.00 d	0.00 c	0.00 d
T_3	0.00 e	1.39 e	0.65 b	0.12 c	0.00 c	0.00 d
T_4	0.29 b	1.67 c	0.78 b	1.63 b	0.00 c	0.10 c
T_5	0.08 d	1.85 b	2.39 a	1.66 b	1.06 b	0.44 b
T_6	0.00 e	0.03 h	0.00 d	0.00 d	0.00 c	0.00 d
T_7	0.00 e	0.00 h	0.00 d	0.00 d	0.00 c	0.00 d
T_8	0.00 e	0.17 g	0.00 d	0.00 d	0.00 c	0.00 d
T_9	1.64 a	2.68 a	2.55 a	3.81 a	1.81 a	0.63 a
SE	0.018	0.032	0.058	0.026	0.032	0.018
Level of significance	**	**	**	**	**	**
CV (%)	12.68	4.59	11.56	4.87	17.49	12.02

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.4. Effect of different weed control treatment on weed control efficiency (WCE) after 45 days of spray

Significant variation was found on weed control efficiency (%) due to different weed control treatment practiced in the experimental plot. From Table 9, it was assumed that, weed control efficiency of T_7 was best (100%) for all kinds of weed species found in the experimental plot except Alternanthera philoxeroides (97.58%) and Digitaria ciliaris (99.05%) while zero % was found in control condition (T_9). Efficiency of $T_6$and T_8 showed statistically similar result with T_7 to control *Cyperus diformis.* It means T_6, $T_7$and T_8 showed statistically best efficiency to control *Cyperus diformis* as well as T_1, $T_2$and T_3 also showed statistically similar results bellow the best results, that means, these three (T_1, T_2 and T_3) treatments showed moderate efficiency to control of it. In case of *Marsilea quadrifolia*, 100% efficiency was found in $T_6$and T_8 after T_7 which was statistically similar with T_2 while T_1, T_3, $T_4$and T_5 showed statistically moderate efficiency to control of it. Weed control efficiency of T_6 showed statistically similar result with T_7 for *Alternanthera philoxeroides* while T_1, T_2, $T_3$and T_8 showed statistically moderate efficiency to control of it. Efficiency of $T_6$and T_8 showed statistically similar result with T_7 to control *Echinochloa crusgalli* while moderate efficiency was showed by $T_2$and T_3. In case of *Digitaria ciliaris*, T_6 showed statistically similar result with T_7 as well as $T_2$and T_8 also showed statistically similar results bellow the best results that means, these two ($T_2$and T_8) treatments showed moderate efficiency to control of it. After T_7, 100% controlling efficiency of *Alternanthera sessilis* was observed in T_2, $T_6$and T_8 whereas $T_1$and T_3 also showed statistically similar result with T_7. That means, control efficiency of all treatments were statistically similar except $T_4$and T_5. Weed control Efficiency of T_2, $T_6$and T_8 showed statistically similar results with T_7 for *Cynodon dactylon* while least control efficiency was observed in T_5.

In case of *Raphanus raphaistrum,* 100% controlling efficiency was found in all the treatments except T_1, $T_4$and T_5 but T_5 showed statistically insignificant result with all the treatments excluding exceptions ($T_1$and T_4). T6 showed statistically similar efficiency with T_7 in controlling *Eclipta alba*while better performance was observed in T_8 and least control efficiency was found in T_5. After T_7, $T_6$and T_8 showed 100% weed control efficiency in case of *Leersia hexandra* while better efficiency was found in $T_2$and T_3 but T_5 showed the lowest control efficiency. 100% weed control efficiency was found in all the treatments except $T_4$and T_5 in case of *Spilanthes acmella* and only T_5 in case of *Cyperus esculentus.* In case of *Cyperus irria* 100% controlling efficiency was observed in all the treatments except T_1, $T_4$and T_5 but T_1 showed statistically similar result with all the treatments except T_5. That means, T_5 showed least efficiency to control of this species. From the above discussion, it can be concluded that, T_7 gave the best efficiency to control all the enlisted weed species while in maximum cases T_6 along with T_8 showed statistically moderate efficiency to control the weed species found in the experimental plots and T_5 showed the least efficiency to control these species after control condition. The lower weed control efficiency was due to poor control of weeds as a result recorded higher weed population and their dry weight. The results are in conformity with findings of Saha (2009) and Singh *et al.* (2005).

Table 9. Effect of different weed control treatment on weed control efficiencyafter 45 days of spray

Treatments	Weed control efficiency (%)						
	Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*
T_1	82.51 cd	77.91 c	64.01 bc	64.05 c	66.48 c	94.08 ab	70.07 c
T_2	90.50 bc	92.10 ab	70.55 b	88.17 b	82.95 b	100.0 a	92.70 ab
T_3	84.65 cd	83.80 bc	64.72 bc	85.86 b	68.75 c	96.39 a	90.51 b
T_4	79.15 d	76.31 c	58.32 c	32.16 d	49.43 d	85.54 bc	38.69 d
T_5	61.41 e	75.37 c	39.54 d	15.16 e	28.60 e	77.98 c	15.33 e
T_6	100.0 a	100.0 a	94.88 a	100.0 a	91.67 ab	100.0 a	94.16 ab
T_7	100.0 a	100.0 a	97.58 a	100.0 a	99.05 a	100.0 a	100.0 a
T_8	96.39 ab	100.0 a	72.55 b	93.07 ab	85.23 b	100.0 a	94.16 ab
T_9	0.000 f	0.00 d	0.00 e	0.00 f	0.00 f	0.00 d	0.00 f
SE	2.82	3.65	2.82	2.75	3.36	3.23	2.84
Level of significance	**	**	**	**	**	**	**
CV (%)	6.34	8.07	7.81	7.42	9.15	6.68	7.45

Table 9. Continued

Treatments	Weed control efficiency (%)					
	Raphanus raphaistrum	*Eclipta alba*	*Leersia hexandra*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
T_1	87.20 bc	42.91 de	69.80 c	98.95 a	100.0 a	93.65 ab
T_2	100.0 a	67.16 c	81.96 b	100.0 a	100.0 a	100.0 a
T_3	100.0 a	48.13 d	74.51 bc	96.85 a	100.0 a	100.0 a
T_4	82.32 c	37.69 e	69.41 c	57.22 b	100.0 a	84.13 b
T_5	95.12 ab	30.97 f	6.270 d	56.43 b	41.44 b	30.16 c
T_6	100.0 a	98.88 ab	100.0 a	100.0 a	100.0 a	100.0 a
T_7	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
T_8	100.0 a	93.66 b	100.0 a	100.0 a	100.0 a	100.0 a
T_9	0.00 d	0.00 g	0.00 d	0.00 c	0.00 c	0.00 d
SE	2.71	1.75	3.12	1.83	4.35	3.66
Level of significance	**	**	**	**	**	**
CV (%)	5.52	5.24	8.08	4.02	9.14	8.05

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1},T_4= Pretilachlor @ 1 L ha^{-1},T_5= Pretilachlor + Triasulfuran @ (1 L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1} ,T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5. Crop characters, yield contributing characteristics and yield

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

4.5.1. Plant height (cm) at harvest

Plant height was significantly influenced by weed control treatments (Figure 1). The highest plant height (67.87 cm) obtained from T_7 which was statistically identical with all the treatments except T_4 and T_5. The lowest plant height (60.11 cm) was obtained from unweeded control condition (T_9). Attalla and Kholosy (2002) reported that weed control treatments significantly enhanced plant height of rice. Weeding reduced crop-weed competition thus enhanced plant height significantly. Similar results were observed by Zannat (2014) and Islam (2014).

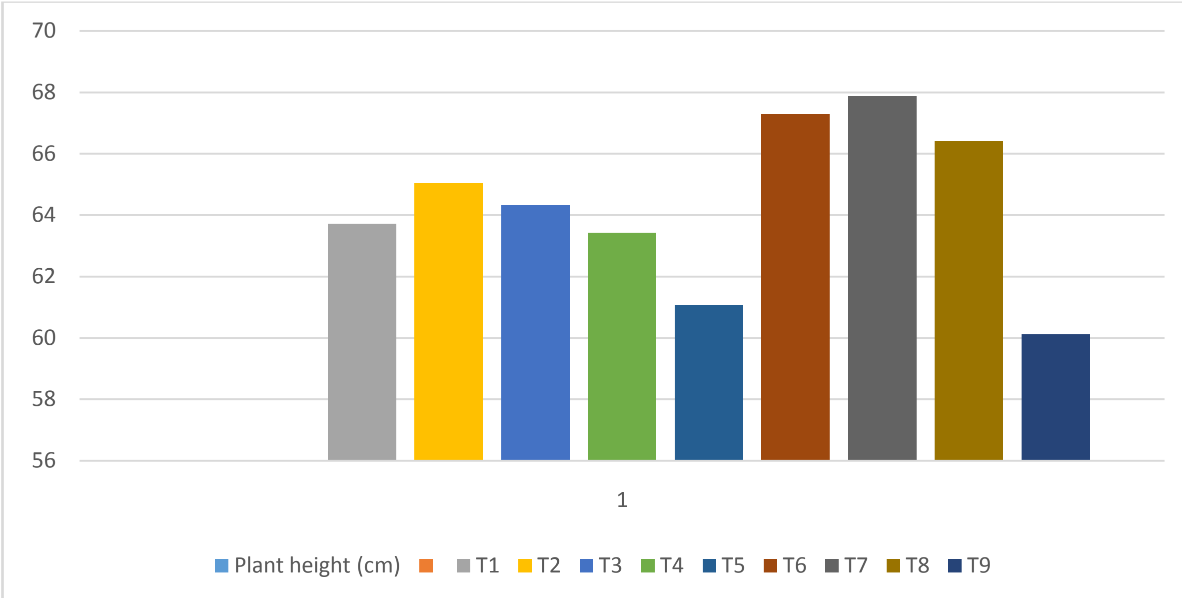

Fig. 1. Effect of different weed control treatments on plant height (SE value =1.28)

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5.2. Total number of tillers $hill^{-1}$

Number of total tillers $hill^{-1}$ was significantly influenced by different weed control treatments (Table 10). The highest number of tillers (9.10) was obtained in T_7 which was statistically identical with T_6. The lowest number of tillers (4.0) was obtained in control treatment which was statistically identical with T_5. The severe weed infestation might the main fact to fail to produce more tillers in those experimental plots. The similar result was found by Ahmed *et al*. (2005) reported the highest number of tillers m^{-2} (331) was recorded under continuous weeding followed by weed control at 30 DAT and herbicide.

4.5.3. Number of effective tillers $hill^{-1}$

The number of effective tillers $hill^{-1}$ was significantly influenced by different weed control treatments (Table 10). The highest number of effective tillers $hill^{-1}$ (8.17) was obtained from T_7 followed by T_6 (7.50) which was statistically identical with T_8 (7.10). The lowest one (2.66) was obtained in untreated plots. Weed control treatments reduced inter species competition between crop and weed thus facilited efficient utilization of resources viz. sunlight, nutrient, moisture and air to produce effective tillers. The contribution of weeding for higher number of effective tillers $hill^{-1}$ was strongly supported by Islam (2014), Khan (2013) and Rafiquddulla (1999). They reported that the maximum number of effective tillers $hill^{-1}$ observed under weed free treatment.

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

The number of non-effective tillers $hill^{-1}$ was statistically influenced by different weed control treatments (Table 10). The highest number of non-effective tillers $hill^{-1}$ (1.34) was observed in unweeded treatment which was statistically identical with all the treatments except T_7. The lowest number of non-effective tillers $hill^{-1}$ (0.930) was observed in T_7 which was statistically identical with $T_6$and T_8.

Table 10. Tillers as influenced by different weed control treatments

Treatments	Total no. of tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tiller (s) hill^{-1}
T_1	6.50 ef	5.26 e	1.24 a
T_2	7.63 cd	6.48 cd	1.15 ab
T_3	7.15 de	5.95 d	1.20 a
T_4	5.89 f	4.62 f	1.27 a
T_5	4.67 g	3.35 g	1.32 a
T_6	8.59 ab	7.50 b	1.09 ab
T_7	9.10 a	8.17 a	0.930 b
T_8	8.22 bc	7.10 bc	1.12 ab
T_9	4.00 g	2.66 h	1.34 a
SE	0.264	0.208	0.080
Level of significance	**	**	*
CV (%)	6.66	6.35	11.70

Values followed by the different letter(s) are significantly different from each other by DMRT at1%(**) and 5%(*) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5.5. Panicle length (cm)

Length of the panicle was statistically influenced by different weed control treatments (Table 11). The longest panicle was found in T_7 (19.63 cm) which was statistically similar with T_2, T_6 and T_8. The shortest panicle length was observed under unweeded control treatment (17.31 cm). Rafiquddaulla (1999) observed that maximum number of panicle length from the weed free condition which was similar to three hand weeding at 20, 40 and 60 DAT. The similar result was found by Khan (2013).

Table 11. Effect of weed control treatments on panicle length

Treatments	Panicle length (cm)
T_1	18.3 bc
T_2	18.69ab
T_3	18.37bc
T_4	18.15bc
T_5	17.81bc
T_6	19.57a
T_7	19.63a
T_8	18.77ab
T_9	17.31c
SE	0.347
Level of significance	**
CV (%)	3.25

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5.6. Total number of grains panicle^{-1}

Number of grains panicle-1 is one of the most important yield contributing character of rice. The influence of different weed control treatments was significant on the grains panicle^{-1} (Table 12). The highest number of grains panicle^{-1} (78.00) obtained from the plots treated with T_7 which was statistically identical with all the treatments except T_4 and T_5. The lowest number of grains panicle^{-1} (55.33) was obtained in the unweeded control treatment (T_9) which was statistically identical with T_1-T_5. Weeding reduce crop-weed competition and provides scope to the plants for efficient utilization of solar radiation and nutrients. This might be responsible to higher number of grains panicle^{-1}. Similar results were reported elsewhere (Islam, 2014; Zannat, 2014 and Khan, 2013). They reported that the highest number of grains was produced in the weed free condition in rice. Hasanuzzaman *et al.* (2008) and Salam *et al.*,(2010) who showed that application of herbicide contributed mainly increasing the number of grain panicle^{-1}. Singh *et al*. (1990) reported that weeding increase the number of grains panicle^{-1}.

4.5.7. Number of filledgrains panicle^{-1}

Total number of filled grains per panicle significantly influenced by different weed control treatments. The maximum number of filled grain per panicle (70.67) obtained from T_7 which was statistically similar with all the treatments applied except T_5. Minimum number of filled grain (50.33) was obtained from control condition (T_9) i.e. without any treatment.Madhukumar *et al*.(2013) also stated this kind of result.

4.5.8. Number of unfilled grain (s) panicle^{-1}

Different weed control treatments exerted significant influence on number of unfilled grains panicle^{-1} (Table 12). The highest number of unfilled grain panicle^{-1} (9.16) was found in T_7 which was statistically identical with T_6. The lowest number of sterile grains panicle^{-1} (5.00) was obtained from unweeded condition (T_9) which was statistically identical with T_4& T_5. Weed severity and environmental condition perhaps, the main reasons for such variation of the number of unfilled grains panicle^{-1}in different weed control treatments were observed. This result was also repoted by Madhukumar *et al*.(2013).

4.5.9. 1000-grain weight (gm)

Different weed control treatments exerted in significant influence on 1000 grain weight (Table 12). The highest 1000-grain weight (20.99 g) was found from T_7 which was statistically similar with T_6 (20.11 g). The lowest 1000-grain weight (17.42 g) obtained from unweeded control treatment (T_9) which was statistically identical with all the treatments except T_6 and T_7. The result was similar to the findings of Ganeshwor and Gadadhar (2000). They conducted a study during kharif season to evaluate the herbicides in controlling weeds and improving grain yield in rice. The highest 1000-grain weight (24.69 g) was found under weed control treatment. Khan (2013) found that the weeding regime had significant effect on all the parameters except 1000-grain weight, while Zannat (2014) and Rabbani (2012) obtained that no weeding reduced 1000-grain weight significantly.

Table 12. Effect of different weed control treatments on rice grain

Treatments	Total number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grain (s) panicle^{-1}	1000 grain weight (gm)
T_1	65.00 ac	58.33 ac	6.67 cd	17.85b
T_2	69.33 ac	59.33 ac	7.33 bc	18.38b
T_3	66.33 ac	59.00 ac	6.67 cd	18.17b
T_4	62.33 bc	57.00 ac	5.33 de	17.83b
T_5	61.00 bc	55.67 bc	5.33 de	17.77b
T_6	77.33 a	70.33 a	8.66 ab	20.11a
T_7	78.00 a	70.67 a	9.16 a	20.99a
T_8	74.67 ab	67.33 ab	7.33 c	18.59b
T_9	55.33 c	50.33 c	5.00 e	17.42b
SE	4.47	4.31	0.446	0.367
Level of significance	*	*	**	**
CV (%)	11.43	12.25	11.30	3.43

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) and 5% (*) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5.10. Grain yield (t ha^{-1})

The weed control treatment exerted significant effect on the grain yield of rice (Figure 2). Among the weed control treatments, the highest grain yield (5.50 t ha^{-1}) produced by T_7 which was statistically similar with T_6 (5.26 t ha^{-1}). The lowest grain yield (2.56 t ha^{-1}) was obtained from unweeded control treatment (T_9), which was significantly lower than the rest of the treatments.Highest grain yield ha^{-1} may be due to maximum control of weeds and minimum competition between weed and crop achieved by the application of herbicides that killed weeds initially and thus weeds failed to establish.The lowest grain yield ha^{-1} in the control treatment might be due to the poor performance of yield contributing characters like number of effective tillers hill^{-1}, grains panicle^{-1} and 1000-grain weight. Severe weed infestation occurred in the no weeding condition resulting reduced grain yield due to competition for moisture, space, light and nutrients between weeds and rice plant. Herbicide treatments contributed to higher yield performance compared to control in all the growing seasons (Bari, 2010). These findings are further supported with the work of Mamun *et al.* (2011) and Bhuiyan *et al.* (2011), who realized better yields in rice with herbicide use. Khan (2013) obtained the highest grain yield in weed free conditions and it produced 33.33% higher yield than no weeding. Zannat (2014) also mentioned no weeding treatment reduced 28.16% grain yield over three weeding in aromatic Amanrice Binadhan-9.

4.5.11. Straw yield (t ha^{-1})

Different weed control applications significantly affected the straw yield (Figure 2). The highest straw yield (6.27 t ha^{-1}) was found from T_7 which was statistically similar with T_6 (6.08 t ha^{-1}) and T_8 (5.81 t ha^{-1}). The lowest straw yield (3.48 t ha^{-1}) was obtained from control condition. The tallest plant and the highest number of total tillers hill^{-1} resulted the highest straw yield in different weed control condition. Rafiquddaulla (1999) observed that the maximum straw yield from the weed free condition which was similar to three hand weeding at 20, 40 and 60 DAT.

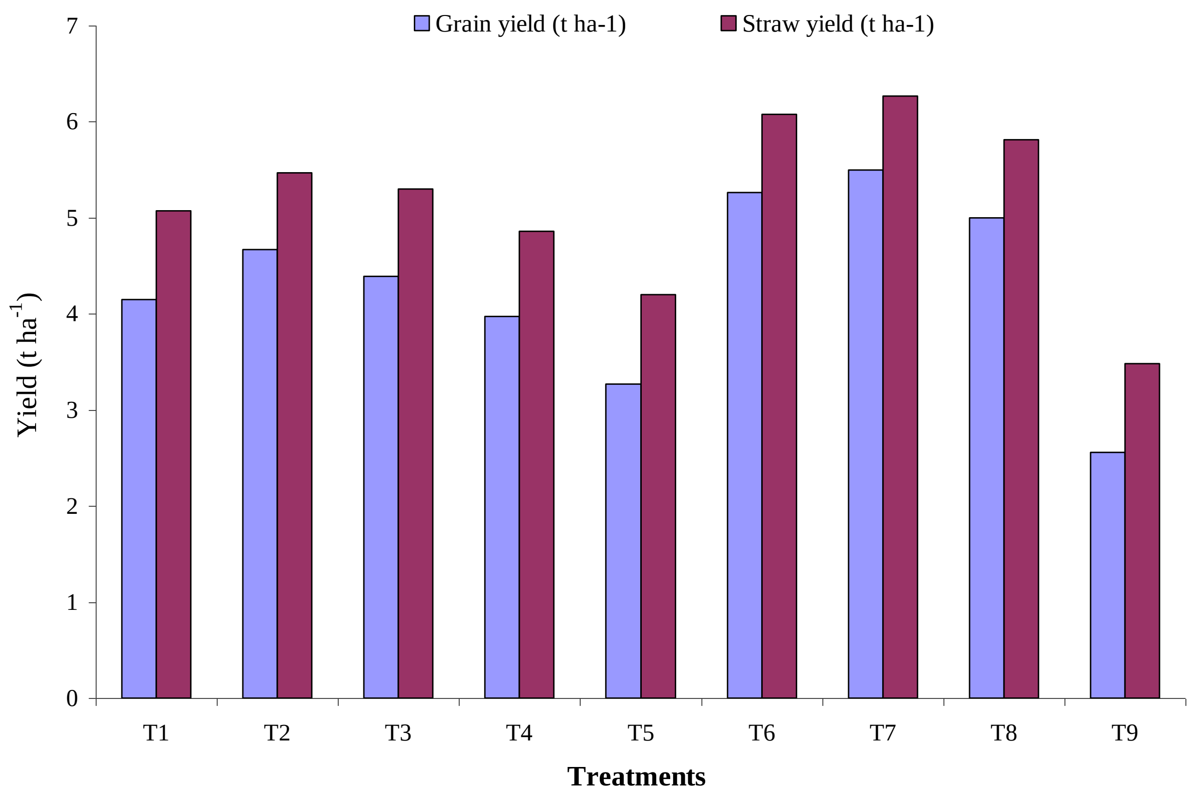

Fig.2:Effect of different weed control treatments on grain and straw yield (t ha^{-1})

(SE value 0.118 and 0.207 respectively)

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

4.5.12. Biological yield (t ha^{-1})

Different weed control treatments significantly affected the biological yield (Table 13). The highest biological yield (11.77 t ha^{-1}) was found from T_7 which was statistically identical with T_6(11.34 t ha^{-1}). The lowest biological yield (6.04 t ha^{-1}) was obtained from control condition (T_9). The biological yield is the combined of grain yield and straw yield. Variations of biological yield among the treatment were dependent upon the severity of weed infestation thus affected grain yield and straw yield.

4.5.13. Harvest index (%)

Harvest index was significantly influenced by different weed control treatment (Table 13). The highest harvest index (46.73%) was found in T_7 which was statistically identical with all the treatments except T_5 & T_9. The lowest harvest index (42.38%) was found from no weeding treatment (T_9). Similar results were obtained by Zannat (2014) and Islam (2014).

Table 13. Effect of different weed control treatments on biological yield and harvestindex

Treatments	Biological yield (t ha^{-1})	Harvest index (%)
T_1	9.22 ef	45.01 ac
T_2	10.14 cd	46.06 ab
T_3	9.69 de	45.31 ab
T_4	8.83 f	44.96 abc
T_5	7.47 g	43.78 bc
T_6	11.34 ab	46.38 ab
T_7	11.77 a	46.73 a
T_8	10.81 bc	46.25 ab
T_9	6.04 h	42.38 c
SE	0.228	0.852
Level of significance	**	*
CV (%)	4.17	3.27

Values followed by the different letter(s) are significantly different from each other by DMRT at1% (**) and 5% (*) level of probability

T_1= Acetachlor + Bensulfuran (Pre-mix @ 750 g ha^{-1}), T_2= Pyrazosulfuran-ethyl @ 150 g ha^{-1}, T_3 = Bispyribac Sodium @ 150 g ha^{-1}, T_4= Pretilachlor @ 1 L ha^{-1}, T_5= Pretilachlor + Triasulfuran @ (1L + 10 g) ha^{-1}, T_6= Propyrisulfuran + Propanil @ (0.5 L + 1 Kg) ha^{-1}, T_7= Propyrisulfuran + Propanil @ (0.38 L + 1.5 Kg) ha^{-1}, T_8= Hand weeding (20 and 40 DAS), T_9= Control.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Field Laboratory of Sher-E-Bangla Agricultural University, Dhaka, during the period from November 2014 to April 2015, in order to study the evaluation of herbicidal efficacy effect on BRRI dhan50. The experiment comprised of nine treatments viz. Acetachlor + Bensulfuran (Pre-mix) @ 750 g ha^{-1}, Pyrazosulfuran-ethyl @ 150 g ha^{-1}, Bispyribac Sodium @ 150 g ha^{-1}, Pretilachlor @ 1 L ha^{-1}, Pretilachlor + Triasulfuran @ (1 L + 10 g)ha^{-1}, Propyrisulfuran + Propanil @ (0.5 L + 1 kg)ha^{-1}, Propyrisulfuran + Propanil @ (0.38 L + 1.5 kg)ha^{-1}, Hand weeding (20 and 40 DAS) and Weedy Check . The experiment was laid out in randomized complete block design with three replications. The unit plot size was 12 m^2 (4.0 m × 3.0m).

Sixteen weed species infested the experimental field which belongs to eightfamilies. Among these species 5 belonged to Poaceae, 3 Cyperaceae and Compositae,2Amaranthaceae and 1 from each of Marsiliaceae, Cruciferae, Scrophulariaceaeof which *Echinochloa crusgalli*, *Cynodon dactylon*,*Eclipta alba* and *Cyperus difformis*were the most important weed species and the other dominant species were *Cryperus esculentus*, *Cyperus irria*, *Leersia hexandra*, *Marsilea quadrifoliata, Alternanthera philoxeroides, Digitaria ciliaris, Alternanthera sessilis*,*Spilanthes acmella*etc.

Among the different weed management treatments, herbicides and their combination were applied to the target plots. The data of weed parameters were collected at 3 days before spray, 7, 14, 21, 28 and 45 days after spraying (DAS). Weed parameters such as weed population (no. m^{-2}), weed dry weight (g m^{-2}) and weed control efficiency (%) were recorded. Crop characters such as plant height (cm), number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, number of sterile spikelets $panicle^{-1}$, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were recorded. Data were analysed using the Analysis of variance technique and mean differences were adjudged by Duncan Multiple Range Test (DMRT).

Weed population, weed dry weight and weed control efficiency was significantly influenced by different weed control treatments. The highest weed population, weed dry weight and the lowest weed control efficiency was observed in the unweeded control treatment. The lowest weed population, weed dry weight and the highest weed control efficiency was observed with the application ofPropyrisulfuran + Propanil @ (0.38 L + 1.5 kg) ha^{-1} (T_7).

All crop characters were significantly influenced by weed control treatment. T_7 gave statistically identical effects in respect of plant height, total number of tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, panicle length, total spikelets panicle^{-1}, grains panicle^{-1}, sterile spikelets panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were recorded. T_7 produced the highest grain yield (5.50 t ha^{-1}) and straw yield (6.27 t ha^{-1}) due to production of highest number of effective tillers hill^{-1} (8.17), the highest number of grains panicle^{-1} (78.00) and the highest 1000-grain weight (20.99). The lowest grain and straw yield were obtained from unweeded control condition (T_9). 46.55% yield was lost in unweeded control treatment over T_7. Propyrisulfuran + Propanil @ (0.5 L + 1 kg) ha^{-1} (T_6) followed byhand weeding (20 and 40 DAS) (T_8) also showed the better performance for weed control. Residual activity of the mixture of Propyrisulfuran + Propanil remained upto 45 days after spray compared to all other treatments applied to the experimental plots. Effectively controlling weeds in a crop production system can increase efficiency of production and use of resources. From the above present study it can be concluded that T_7 might be used to obtain the highest yield of BRRI dhan50. However, in practical point of view T_6 followed by T_8 may consider for producing second highest yield of BRRI dhan50. To draw a concrete conclusion further studies are needed at different AEZ.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November 2014 to March 2015

Month	*Air temperature (^0C)		*Relative humidity (%)	Total Rainfall (mm)
	Maximum	Minimum		
November, 2014	25.82	16.04	78	00
December, 2014	22.4	13.5	74	00
January, 2015	24.5	12.4	68	00
February, 2015	27.1	16.7	67	3
March, 2015	31.4	19.6	54	11
April,2015	35.3	22.4	51	15

* Monthly average

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

Appendix II. Analysis of variance (mean square) of the data for weed population (No.m^{-2}) at 3 days before spray

Source of variation	df	No. of weed species/m^2										
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*
Replication	2	1682.39	0.973	5.93	0.025	0.006	0.021	0.059	0.054	0.001	0.013	0.001
Treatment	8	17961.23**	21.626**	142.84**	5.105**	8.232**	5.908**	9.824**	63.214**	0.418**	6.823**	0.913**
Error	16	996.50	0.377	1.18	0.019	0.004	0.016	0.023	0.137	0.001	0.008	0.001

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

Source of variation	df	No. of weed species/m^2													
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Echinochloa colona*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus irria*
Replication	2	7.00	0.111	0.004	0.003	0.004	0.030	0.001	0.012	0.019	0.317	0.002	0.005	0.010	0.002
Treatment	8	14379.64**	21.626**	67.295**	2.341**	3.641**	5.664**	0.582**	10.168**	14.112**	42.380**	1.745**	7.076**	22.764**	0.333**
Error	16	64.75	0.138	0.254	0.005	0.005	0.046	0.001	0.012	0.019	0.130	0.001	0.004	0.015	0.001

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

Source of variation	df	No. of weed species/m^2														
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Echinochloa colona*	*Digitaria ciliaris*	*Alternanthera .sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus irria*
Replication	2	118.40	1.23	0.013	0.002	0.002	0.058	0.010	0.024	0.004	0.004	0.037	0.015	0.000	0.145	0.001
Treatment	8	25052.66**	621.66**	45.630**	6.315**	0.901**	11.188**	16.750**	8.866**	14.980**	2.377**	42.428**	3.167**	11.623 **	20.450**	0.342**
Error	16	60.87	0.65	0.263	0.018	0.002	0.133	0.010	0.016	0.004	0.004	0.162	0.021	0.010	0.112	0.001

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

Source of variation	df	No. of weed species/m^2														
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
Replication	2	45.44	0.11	0.111	0.006	0.073	0.041	0.005	0.008	0.138	0.111	0.002	0.001	0.154	0.003	0.001
Treatment	8	29884.52**	742.11**	33.776**	2.712**	10.780**	13.973**	9.309**	29.438**	53.067**	43.668**	3.010**	6.074**	27.534**	3.512**	0.255**
Error	16	85.94	0.11	0.111	0.004	0.030	0.037	0.007	0.015	0.113	0.111	0.001	0.006	0.317	0.003	0.001

Appendix VI. Analysis of variance (mean square) of the data for weed population (No.m^{-2}) at 28 days afterspray

Source of variation	df	No. of weed species/m^2														
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Gnaphaliwm luteoalbum*	*Spilenthus acmella*	*Cyperus esculentus*	*Cyperus irria*
Replication	2	28.77	0.97	0.121	0.013	0.068	0.001	0.013	0.004	0.013	0.128	0.003	0.002	0.058	0.001	0.001
Treatment	8	29174.52**	446.31**	39.131**	2.849**	11.921**	14.135**	8.658**	18.559**	20.279**	28.565**	3.010**	1.315**	11.988**	1.124**	0.333**
Error	16	20.90	0.51	0.138	0.008	0.038	0.002	0.012	0.004	0.010	0.128	0.005	0.001	0.030	0.002	0.001

Appendix VII. Analysis of variance (mean square) of the data for weed population (No.m^{-2}) at 45 days afterspray

Source of variation	df	No. of weed species/m^2												
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Lindernia procumbens*	*Eclipta alba*	*Leersia hexandra*	*Cyperus esculentus*	*Cyperus irria*
Replication	2	2.13	0.40	0.127	0.001	0.009	0.002	0.003	0.011	0.009	0.155	0.001	0.001	0.001
Treatment	8	26313.76**	378.54**	50.443**	2.849**	3.423**	14.099**	8.322**	7.509**	15.722**	28.565**	1.293**	1.124**	0.333**
Error	16	7.99	0.57	0.128	0.003	0.006	0.006	0.005	0.010	0.010	0.111	0.001	0.001	0.001

Appendix VIII. Analysis of variance (mean square) of the data for dry weight of weed

Source of variation	df	Dry weight (gm)												
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Eclipta alba*	*Leersia hexandra*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
Replication	2	0.08	0.018	0.197	0.106	0.013	0.002	0.004	0.001	0.002	0.010	0.003	0.004	0.001
Treatment	8	166.97**	16.274**	12.793**	52.658**	8.774**	2.908**	0.826**	0.854**	2.592**	2.862**	5.283**	1.307**	0.165**
Error	16	0.12	0.031	0.096	0.112	0.019	0.002	0.001	0.001	0.003	0.010	0.002	0.003	0.001

Appendix IX.Analysis of variance (mean square) of the data for weed control efficiency

Source of variation	df	No. of weed species/m^2												
		Cyperus diformis	*Marsilea quadrifolia*	*Alternanthera philoxeroides*	*Echinochloa crusgalli*	*Digitaria ciliaris*	*Alternanthera sessilis*	*Cynodon dactylon*	*Raphanus raphaistrum*	*Eclipta alba*	*Leersia hexandra*	*Spilanthes acmella*	*Cyperus esculentus*	*Cyperus irria*
Replication	2	20.94	43.29	30.08	36.36	37.80	11.44	12.46	41.89	27.38	45.37	45.48	45.46	65.33
Treatment	8	2955.55**	2916.34**	2588.60**	4497.56**	3147.17**	3139.98**	4402.93**	3174.15**	3608.32**	4401.69**	3639.42**	3988.42**	4151.71**
Error	16	23.95	40.04	23.78	22.77	33.85	31.31	24.33	21.96	9.14	29.20	10.02	56.70	40.08

Appendix X.Analysis of variance (mean square) of the data for yield and yield contributing characters of BRRI dhan50

Source of variation	df	Tiller length (cm)	Total no. of tillers hill^{-1}	No. effective tillers hill^{-1}	No. of non effective tiller(s) hill^{-1}	Panicle length (cm)	Total number of grains panicle^{-1}	Number of filled grainspanicle^{-1}	Number of unfilled grain(s)panicle^{-1}	1000 grain weight (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.746	0.130	0.122	0.005	0.907	171.81	173.44	0.231	1.982	0.041	0.146	0.175	1.529
Treatment	8	20.880**	9.217**	10.538**	0.050*	1.721**	182.20*	147.25*	6.459**	4.303**	2.706**	2.422**	10.244**	5.869*
Error	16	4.926	0.209	0.130	0.019	0.361	59.89	55.61	0.596	0.405	0.042	0.128	0.156	2.179

PLATES

T_7 treated plot

T_5 treated plot

T_1 treated plot

T_3 treated plot

Plate 1. 3 days before spray

T_4 treated plot

T_6 treated plot

T_7 treated plot

T_2 treated plot

Plate 2. 7 days after spray

T_7 treated plot

T_6 treated plot

Weedy check plot

T_4 treated plot

Plate 3. 14 days after spray

T_3 treated plot

T_2 treated plot

T_1 treated plot

Plate 4. 21 days after spray

T_4 treated plot

Weedy check plot

T_1 treated plot

T_5 treated plot

Plate 4. 28 days after spray

T_4 treated plot

T_5 treated plot

T_3 treated plot

T_2 treated plot

Plate 7. 45 days after spray