WEED CONTROL EFFICIENCY OF METSULFURON METHYL 20% IN AUS RICE

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CERTIFICATE

This is to certify that the thesis entitled '**Weed Control Efficiency of Metsulfuron Methyl 20% in Aus Rice**' submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the results of a piece of bona fide research work carried out by **NUSRAT GULTEKIN**, Registration No. **13-05304** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

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Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of March to July, 2018 to assess the weed control efficiency of Metsulfuron Methyl 20% in aus rice. BRRI dhan48 was used as the test crop in this experiment. The experiment consisted of two factors: Factor A: Doses of Metsulphuron Methyl 20% (4 doses) as - D_0 = Control i.e. no weedicide, D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}, D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1} and D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}; Factor B: Time of application (4 times) as - T_1 = Application at 12 DAT, T_2 = Application at 15 DAT, T_3 = Application at 20 DAT and T_4 = Application at 25 DAT. The two factors experiment was laid out in split-plot design with three replications. Data were recorded on weed control efficiency, yield contributing characters and yield of BRRI dhan48 and statistically significant variation was observed for different doses of Metsulphuron Methyl 20%, time of application and their combined effect. In considering the different doses of Metsulphuron Methyl 20%, the highest weed control efficiency (77.14%) was observed from D_3 and the lowest (23.40%) from D_1. The longest plant (95.90 cm), the maximum number of effective tillers $hill^{-1}$ (11.08), the longest panicle (21.31 cm), the maximum number of filled grains $panicle^{-1}$ (81.98) and the highest grain yield (5.08 t ha^{-1}) was recorded from D_3. For time of application, the highest weed control efficiency (67.09%) was found from T_3 and the lowest (15.56%) from T_2. The longest plant (96.11 cm), the maximum number of effective tillers $hill^{-1}$ (11.73), the longest panicle (20.63 cm), the maximum number of filled grains $panicle^{-1}$ (80.38) and the highest grain yield (4.81 t ha^{-1}) was observed from T_3,. Considering combined effect of different doses of Metsulphuron Methyl 20% and time of application, the interaction of D_3T_3 (Metsulphuron Methyl 20% @ 60 g ha^{-1} × application at 20 DAT) gave highest grain yield (5.49 t ha^{-1}). This may be attributed to the longest plant (99.81 cm), maximum number of effective tillers $hill^{-1}$ (12.53), the longest panicle (22.80 cm), maximum number of filled grains $panicle^{-1}$ (85.27) and heaviest 1000-seed weight (24.86 g) as well as highest weed control efficiency (92.15%) was found in this interaction treatment D_3T_3. Considering all Metsulphuron Methyl 20% @ 60 g ha^{-1} and application at 20 DAT showed the best performance when considered the weed control efficiency, yield contributing characters and yield of BRRI dhan48.

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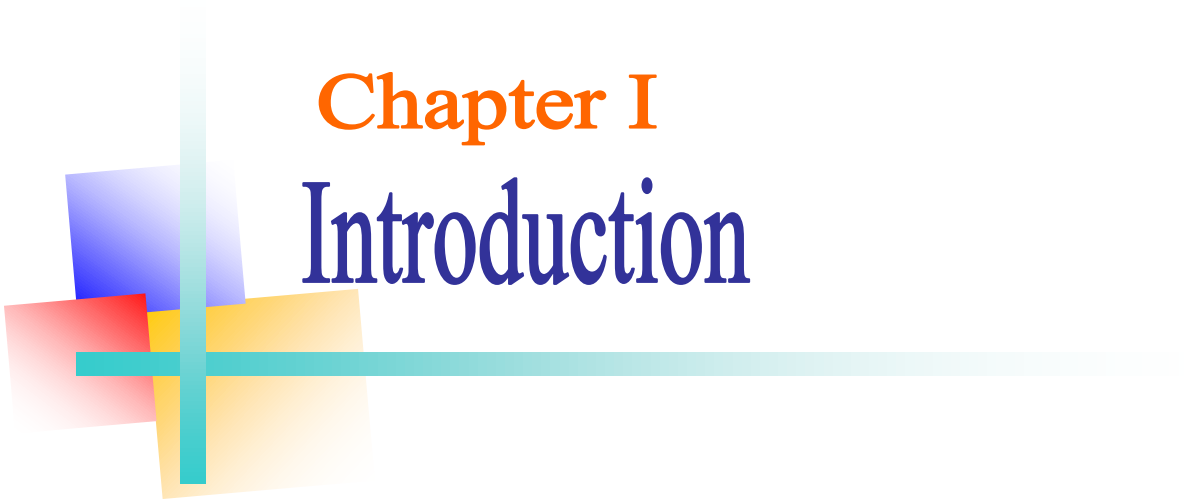
SOME COMMONLY USED ABBREVIATIONS

Full Word	Abbreviation
Agro-Ecological Zone	AEZ
and others	*et al.*
Bangladesh Rice Research Institute	BRRI
Bangladesh Bureau of Statistics	BBS
Co-efficient of variation	cv
Days After Transplanting	DAT
Etcetera	etc
Food and Agriculture Organization	FAO
Journal	J.
Least Significance Difference	LSD
Muriate of Potash	MoP
Non significant	NS
Sher-e-Bangla Agricultural University	SAU
Soil Resources Development Institute	SRDI
Triple Superphosphate	TSP
viz.	Namely



Chapter I
Introduction

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Poaceae, is the principal staple food for more than 50% of the world's population (Jahan *et al.,* 2017) and about 156 million in Bangladeshi people (Liu *et al*., 2017; Shelley *et al*., 2016). It is one of the world's most essential cereal food crop growing in at least 114 countries under diverse condition (Anis *et al*., 2016). Rice contributes on an average 20% of apparent total calorie intake of the world and also 30% of the Asian populations (Hien *et al.*, 2006). Bangladesh have the highest per capita consumption of rice is about 170 kg annually and its food security and economy largely depend on good harvests year after year (BBS, 2019). Bangladesh ranks the 4th largest country of the world in both area and production and the 6th in the production of per hectare yield of rice (Sarkar *et al*., 2016).

The population in Bangladesh will swell progressively to 223 million by the year of 2030 which will demand additional more than 48 million tons of food grains (Bhuiyan *et al*., 2014). So, a continuous increase of rice production and the highest priority has been given for this (Bhuiyan, 2004). Yearly increment of rice production in Bangladesh needs to be sustained to feed ever increasing population although there are very little scope to increase rice area (Sarkar *et al*., 2016) rather agricultural land is declining @ 0.7% per annum (BBS, 2019). There are two general ways to increase rice production either to increase productivity through improving management practices or to increase cropping intensity. Rice production has to be increased at least 60% by 2020 to meet up food requirement of increasing population (Masum, 2009). The average rice yield in Bangladesh is about 3.12 t ha^{-1} which is very low compared to other rice growing countries of the world, like 6.30 t ha^{-1} in China, 6.60 t ha^{-1} in Japan and 6.30 t ha^{-1} in South Korea (FAO, 2018). However, the low yield is not an indication of low yielding potentiality of rice is but may be attributed to a

number of biotic and abiotic factors (Singh *et al*., 2018; Mahbub *et al*., 2017; Ahmed *et al*., 2014).

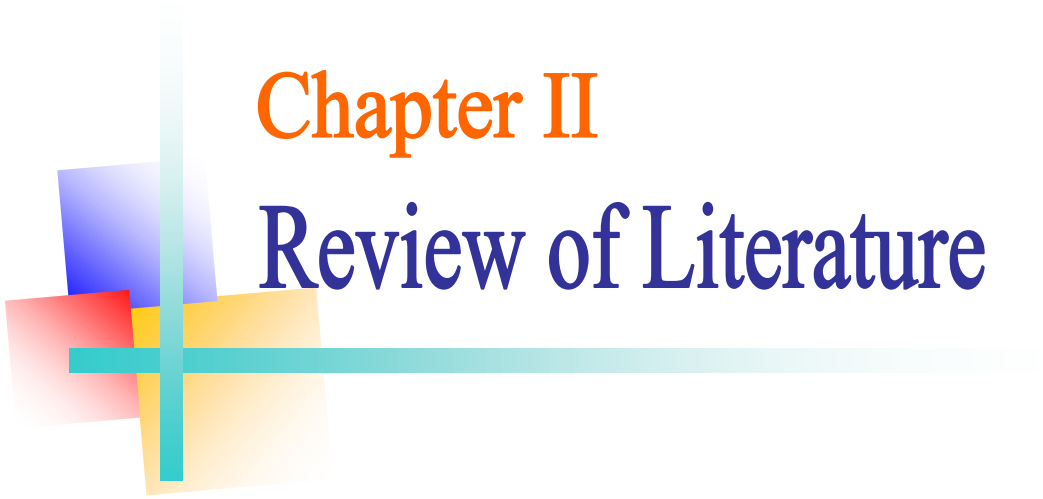
Among the different biotic and abiotic factors weed management play an important roles on the growth, yield attributes and yield of rice. Weeds are the most competitors in their early growth stages than at later stages and hence the growth of crops was suffered and finally reduced the grain yield (Kalaisudarson and Srinivasaperumal, 2019). Thus, the best weed management needs to be resorted to reduce weed infestation and maximum rice yield (Zaman *et al*., 2013). Commonly, weed controls used are water management, mechanically hand weeding and chemical herbicides weeding (Juraimi *et al*., 2013). The traditional method of weed control practice in Asia countries is hand manual weeding by hoe and hand pulling. Usually, hand weeding is conducted in two or three times during the planting season (Rao and Ladh, 2013). Manual weeding, although effective, is becoming difficult due to labor scarcity, cost increase and depend on weather conditions. Moreover, it is incomplete and impractical due to escape or regeneration of perennial weeds having many flushes. Delayed weeding cause crop loss and decreased production.

Weed infestation is one of the major threats to crop growth and yield and weed control is the method of limiting weed infestation so that crops can be grown profitably. At present situation of unavailability of labors and high cost, manual weed control is becoming not possible. Hence, chemical weed control appears to provide a great promise in dealing with effective, timely and economic weed suppression (Wibawa *et al*., 2010). Move of action of this herbicide is able to stop the plant cell division by blocking the action of the enzyme AcetoLactate Synthase (ALS) and AcetoHydroxy Synthase (AHAS) to inhibit the conversion of α-ketoglutarate to 2 acetohydroxybutyrate and pyruvate into 2-acetolactate resulting acid chain branches amino valine, leucine, and isoleucine are not generated. Without these essential amino acids, the protein cannot be formed and lead to the plant die (Antralinaa *et al*., 2015). Thus herbicide usage seems

indispensable for weed management (Sheeja *et al*., 2013). It offers selective and economical control of weeds since the beginning, giving the crop an advantage of good start and competitive superiority (Saha, 2005).

Metsulfuron methyl is commonly known as “Jump” in Bangladesh is a systemic and selective herbicide; it can be used as pre and post-emergence for control the broad leaf and sedges (Mahbub *et al*., 2017; Roshid, 2006). It has been recently used in Bangladesh for controlling post emergence weeds in rice field. It absorbed mainly by the shoots of germinating plants. It can effectively control most important perennial and annual species of broad leaf weeds, grasses and sedges in rice (Mahbub *et al*., 2017). This herbicide are very much effective for grasses and less effective against sedges and for broad-leaved weeds (Singh *et al*., 2009). Metsulfuron-methyl 20% WDG @ 80 g ha^{-1} 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 rice (Mamun *et al*., 2012). Weed control using herbicides containing Bispyribac sodium and 2.4 D + Methyl metsulfuron showed similar results as manual weed control on rice (Antralina *et al*., 2015). The different study revealed that the efficiency of different herbicides depends on the doses and time of application (Naik *et al*., 2018; Mishra *et al*., 2018; Maheswari *et al*., 2015; Mahajan and Chauhan, 2008). Considering the above mentioned situation and facts this experiment was undertaken with fulfilling the following objectives:

- To select optimum dose of Metsulfuron Methyl 20% on weed suppression in Aus rice.
- To select appropriate time of application of Metsulfuron Methyl 20% on weed suppression in Aus rice, and
- To observe the interaction of different doses and time of application of Metsulfuron Methyl 20% on weed control and to achieve higher yield of Aus rice.



Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Rice is a principal source of food for more than half of the world's population. The crop suffers from various biotic and abiotic constraints. Weed competition is one of the prime yield limiting biotic constraints in rice and they compete with crops for water, light, nutrients and space. There are several methods of weed control and now a day use of herbicides is gaining popularity in rice culture due to their rapid effects and less cost involvement. The use of herbicides offers selective control of weeds right from beginning, giving crop and advantage of good start and competitive superiority over weed. There are a number herbicides are available in the market and it is necessary to test the efficiency of these herbicides with different doses and times of application. The research work so far done in these aspects is not adequate and conclusive. However, some of the important and informative works and research findings related to doses and times of application of different herbicides on rice so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of herbicides on weed control efficiency, yield attributes and yield of rice

Kumar *et al*. (2020) observed that the lowest weed population and weed dry weight in weed free situation which were significantly superior over rest of the herbicidal treatments. The highest weed control efficiency (100%) was recorded under the treatment weed free which was followed by Pyrazosulfuron fb one hand weeding (85.96%), Pyrazosulfuron fb Bispyribac (84.77%), Bispyribac sodium (83.09%). The maximum mean grain yield of aerobic rice (4.00 t ha^{-1}) was recorded by weed free which was statistically similar to the herbicide Pyrazosulfuron fb one hand weeding (3.92 t ha^{-1}) and followed by Pyrazosulfuron fb Bispyribac (3.88 t ha^{-1}), Bispyribac sodium (3.83 t ha^{-1}), Pyrazosulfuron + Ethoxysulfuron (3.62 t ha^{-1}), Bispyribac sodium + Pyrazosulfuron (3.61 t ha^{-1}) and Halosulfuron + Azimsulfuron (3.50 t ha^{-1}) and

the lowest mean grain yield of (1.90 t ha^{-1}) was obtained from weedy check plots.

Ravikiran *et al*. (2019) observed that among the weed management methods, penoxsulam @ 20, 25 and 30 g ha^{-1} followed by (fb) either hand weeding (HW) or metsulfuron methyl + chlorimuron ethyl effectively controlled weeds and recorded lower total weed dry weight and higher weed control efficiency at 60 DAS. Penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS registered the highest grain yield (3.23 t ha^{-1}).

Kalaisudarson and Srinivasaperumal (2019) reported that application of pre-emergence herbicide bensulfuron methyl + pretilachlor 0.66 kg ha^{-1} on 3 DAT followed by post emergence herbicide bispyribac sodium 0.02 kg ha^{-1} on 30 DAT is considered to be judicious recommendation to rice farmers in view of inadequate labour and higher weeding cost in transplanted rice.

Singh *et al*. (2018) reported that herbicidal treatments the highest growth yield attributes, yield and low weed population of rice and pendimethalin (38.7% CS) fb bispyribac-sodium was significantly superior and the other herbicides that they used and recorded the maximum plant height (101.82 cm) and the highest grain yield of 4.84 t ha^{-1} from this treatment in transplanted rice.

Mahbub *et al*. (2017) reported that Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 15, 20 and 25 g ha^{-1} were applied and Pyrazosulfuran ethyl @ 125 g ha^{-1}, weed free and unweeded control were used for comparison. The results revealed that the major weed flora associated with the transplanted rice was mainly comprised of two grasses, two sedges and three broadleaves in Aman, and two grasses, two sedge and two broad leaves in Boro, 2014-15. The most dominant weeds were *Cyperus difformis*, *Echinochloa crus-galli*, *Scirpus maritimus* and *Monochoria vaginalis* in both the growing seasons. Application of Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 20 g ha^{-1} was most effective to suppress weed density and dry masses in both the seasons resulting

increased grain yield more than 30% as compared to unweeded control. Therefore, Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 20 g ha^{-1} should apply at one to two leaf stage of weed may be recommended for effectively control weed in transplanted rice.

Kishore *et al.* (2016) observed that both chemical and mechanical methods of weed control were superior over weedy check. The lowest weed density, dry weight, and highest WCE (weed control efficiency), maximum length of panicle, number of panicle (m^{-2}), and 1000-grain weight and grain yield of 30.40 and 32.60 q ha^{-1} were recorded with two HW (hand weeding) which was at par with Butachlor @ 1.0 kg ha^{-1} fb one HW over rest of the weed management practices.

Antralinaa *et al.* (2015) aimed to study the effect of difference weed control methods on rice yield. The results showed that weed control using herbicides containing Bispyribac sodium and 2, 4 D + Methyl metsulfuron showed similar results as manual weed control on rice yield.

Kashid *et al*. (2015) observed that the pre-emergence application of oxyfluorfen 0.150 kg/ha and post-emergence application metsulfuron-methyl + chlorimuron-ethyl 0.004 kg ha^{-1} as weed control measure in direct-seeded rice gave the higher weed control efficiency (91.08%) as well as highest yield contributing characters and yield of rice.

Chowdhury *et al.* (2015) reported that Sunrice® 150WG as pre-emergence herbicide controlled weeds very successfully which performed better in response of yield contributing characters of rice. Application of Sunrice® 150WG achieved highest grain yield which was 50.73%, 32.07%, 11.95% and 5.25% higher than the yield obtained from control, one HW, two HW and Topstar® 400SC treated plots, respectively.

Ahmed *et al.* (2014) applied pre-emergence herbicide Pretilachlor @ 75%, 100%, 125%, 150%, 175% and 200% of the recommended dose under two water management regime in Boro rice cv. BRRIdhan28 and observed that at 60 DAT,

the highest weed control efficiency of 65.75% was found in the treatment receiving Pretilachlor @ 125% of the recommended dose under continuous flooding and the least (54.76%) was found in the treatment receiving 75% of the recommended dose under field capacity in Boro rice cv. BRRIdhan28.

Menon *et al*. (2014) observed that cyhalofop-butyl + chlorimuronethyl + metsulfuron-methyl, fenoxaprop-p-ethyl + chlorimuron-ethyl + metsulfuron-methyl and bispyribac-sodium were best treatments with a lower weed biomass as well as high grain yield and B:C ratio. Maximum weed control efficiency of 97.1% was obtained in hand weeded plots followed by bispyribac-sodium (93.6%). The highest grain yield of 6.13 t ha^{-1} was recorded in hand weeded plot which was at par with cyhalofop-butyl + chlorimuron-ethyl + metsulfuron-methyl and fenoxaprop + chlorimuron ethyl+ metsulfuron-methyl (5.8 t ha^{-1}).

Mamun *et al*. (2012) evaluate the performance of Metsulfuron-methyl 20% WDG for weed suppression and reported that application of Metsulfuron-methyl 20% WDG @ 80 g ha^{-1} 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 rice.

Pasha *et al.* (2012) Reported that herbicide application + hand weeding once had the highest weed control efficiency and the highest grain yield (4584 kg ha^{-1}), while control treatment because of the high unfilled grain $panicle^{-1}$ and less panicle number m^{-2} and also the lowest grain yield (2505 kg ha^{-1}).

Walia *et al*. (2011) observed that weeds in direct-seeded rice (DSR) can be controlled effectively with integration of post-emergence seedlings (25-30 DAS) application of bispyribac 25 g ha^{-1} or azimsulfuron 20 g ha^{-1} with pre-emergence application of pendimethalin 0.75 kg ha^{-1}. Application of pendimethalin alone was found inadequate for controlling complex weed flora of DSR. Integration of pre-emergence application of pendimethalin 0.75 kg ha^{-1} with post-emergence application of bispyribac 25 g ha^{-1} or azimsulfuron 20 g ha^{-1} produced 61.7 and

42.1% higher yield, respectively compare with the alone application of pendimethalin 0.75 kg ha^{-1}.

Saha and Rao (2010) observed that the herbicidal treatments were significantly superior to weedy check. There was more than 44% reduction in the grain yield of rice due to competition with weeds in the weedy plots. The highest grain yield (4.96 t ha^{-1}) and N-use efficiency (62.0) were obtained in weed-free check. Among the tested herbicides, metsulfuron methyl 8 g ha^{-1} applied 10 days after transplanting was found to be the most effective herbicide (weed control efficiency 87.9%) in controlling the pre-dominant weeds, and thereby realizing an increase of 72% yield over weedy check. It was comparable with weed free check. The N-use efficiency (59.8) was also higher in metsulfuron methyl (8 g ha^{-1}), followed by tank-mix application of metsulfuron methyl + chlorimuron ethyl at 4 + 6 g ha^{-1} (57.9) and chlorimuron ethyl at 8 g ha^{-1} (55.8).

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

Mahajan *et al*. (2009) reported that sequential spray of pre-emergence application of pendimethalin (1 kg ha^{-1}) followed by bispyribac sodium (30 g ha^{-1}) at 15 days after sowing was found best for the control of weeds.

Bhagat *et al*. (2008) stated that Pendimethalin 1.5 kg ha^{-1} (pre-emergence) followed by one hand weeding 30 DAS and *Sesbania aculeate* 2, 4-D resulted in significantly lower dry weight of weight of weeds consequently resulting in superior yield and yield attributes.

Rajkhowa *et al*. (2007) carried out a field investigation with herbicides, viz. butachlor, oxadiargyl, pyrazosulfuron ethyl, pretilachlor, chlorimuron + metsulfuron methyl, fenoxaprop-p-ethyl applied alone or followed by paddy

weeder to test their efficiency in controlling weeds in transplanted summer rice. All the weed-control treatments increased the grain yield of rice significantly over unweeded check and decreased the population and dry weight of weeds significantly. Uncontrolled growth of weeds caused 49% reduction in crop yield. Treatment of pretilachlor 0.75 kg ha^{-1} (pre-emergence) + paddy weeder, resulted in the highest grain yield and maximum weed-control efficiency (88%).

Mukherjee *et al.* (2007) conducted an experiment on the transplanted rice, with Butachlor 1 kg ha^{-1} at three days after transplanting-DAT + almix 20 WP 4 g ha^{-1} at 20 DAT registered higher weed control efficiency and grain yield (3.17 and 3.5 t ha^{-1}) comparable with season long weed control weed-free condition.

Rahman *et al.* (2007) worked for an economic study of different levels of herbicide used and hand weeding method in controlling weeds in transplanted *Aman* rice. The highest grain yield (5.35 t ha^{-1}) was obtained with the application of Rifit 500 EC at 1 litre ha^{-1}, which was similar to hand weeding (5.16 t ha^{-1}). The application of Rifit 500EC at 1.1 litre ha^{-1} maximized the profit and its benefit-cost ratio was the highest (1.55) among the treatments.

Rao *et al*. (2007) reported that herbicides that are found effective in DSR are pyrazosulfuron and oxadiragyl as pre-emergence and azimsulfuron, penoxsulam, cyhalopfop-butyl, and ethoxysulfuron as post-emergence.

Khan and Ashraf (2006) conducted an experiment to evaluate the effects of herbicides on weed control and paddy yield in rice. The treatment were Ronstar @ 2.0 t ha^{-1}; Machete @ 1.5 t ha^{-1} and Saturn @ 3.2 t ha^{-1}. They found that Ronstar gives the highest grain yield (5.56 t ha^{-1}) than weedy plot (3.67 t ha^{-1}).

Mahadi *et al*. (2006) conducted an experiment in Nigeria to evaluate the performance of weeding and some herbicides. The treatments were two hand weeding and Butachlor @ 21 a.i ha^{-1} cinosulfuron @ 0.06 kg a.i ha^{-1}. All the treatments increase plant vigor, plant height, plant dry matter and rice grain yield.

Bali *et al*. (2006) carried out an experiment with different herbicide combinations, viz. anilophos + ethoxy sulfuron (0.312 + 0.015 kg ha^{-1}) applied 10 days after transplanting (DAT) or metsulfuron-methyl + chlonimuron ethyl + butachlor (0.004 + 0.938 kg ha^{-1} applied 3 DAT) or butachlor followed by (fb) metsulfuron-methyl + chlonimuron ethyl (0.938 + 0.004 kg ha^{-1} applied 3 DAT fb 21 DAT) with a mean grain yield of 48.1, 44.3 and 45.6 q ha^{-1}, respectively, remained at par with 2 hand weedings (20 and 40 DAT). However, through improvement in weed-control efficiency corresponding mean values being 69.6, 60.8 and 61.5%, enhanced the grain yield significantly by 67.6, 54.4 and 58.9%, respectively, over control treatment i.e. no weeding.

Subramanian *et al.* (2006) studied the effect of integrated weed management practices on weed control and yield of wet seeded rice. The combination of pre-emergence herbicides + one hand weeding at 125 DAT will reduced weed density, dry weight and higher weed control efficiency, resulting in highest yield attributes as well as higher grain yield (58.73 t ha^{-1}) .

Singh *et al*. (2005) reported that the application of herbicides as pre-emergence supplemented with two weeding at 30 and 60 days after sowing under all rice, the highest weed dry matter reduction was achieved. The highest yield (4.23 t ha^{-1}) was obtained with the application of butachlor @ 1.5 kg ha^{-1} supplemented with two hand weeding in rice.

Ranjit and Suwanketnikom (2005) reported that both Anilofos and Bispyribac-sodium reduced narrow leaf and broad leaf weeds compared with the unweeded control. Promising grain yield could be achieved with the Anilofos or Bispyribac-sodium with additional physical or mechanical control methods in dry seeded rice.

Amarjit *et al*. (2005) stated that hand weeding recorded the lowest weed count and weed dry weight and the highest values of panicle m^{-2}, panicle weight and grains $panicle^{-1}$ and grain yield. Maximum yield and its attributes were obtained

with the application of anilophos + ethoxysulfuron (0.312 + 0.015 kg ha^{-1}) at 10 DAT, thereby realized an increase of 67.3% yield over weedy check but was at per with hand weeding treatment.

Rangaraju (2002) in India determined the effect of herbicide application and application time on weed flora and weed dynamics of dry seeded rainfed rice and observed that application of either Butachlor or Thiobencarb @ 1.5 kg ha^{-1} effectively controlled the weeds and also produced the highest yield contributing characters and yield of rice.

Nair *et al.* (2002) observed that application of herbicide Butachlor @ 1.25 kg ha^{-1} along with one hand weeding at 40 DAT gave the significantly higher weed control efficiency, the longest plant, maximum number of effective tillers $hill^{-1}$, the highest panicle m^{-2}, the longest panicle, the maximum number of grains $panicle^{-1}$ and the highest 1000 grain weight and which ultimately increased the grain yield of rice.

Pathak *et al.* (2001) conducted an experiment without seed soaking and application of recommended 16.6 kg K ha^{-1}; modified practice: seed soaking in 40% KCl solution, application of 49.8 kg K ha^{-1}; 50 ppm paraquate spraying at tillering stage); water management practices (rainfed, intermittent irrigation at 3 and 6 days); weed control measures (weedy control and application of 2 kg butachlor ha^{-1}). The modified seed treatment significantly increased the number of effective tillers and root volume compared with normal practice, although there was no significant difference in yield. In the weed control treatment, butachlor significantly increased the number of effective tillers, number of grain $panicles^{-1}$ and grain yield than the weedy control. Applying butachlor increased yield by 23% compared to the weedy control.

Laxminaryan and Mishra (2001) also observed that both hand weeding and Anilofos @ 0.04 kg ha^{-1} reduced weed competition compared to the weedy control both hand weeding resulted in longest plant, maximum number of effective tillers $hill^{-1}$, longest panicle, highest dry matter content in plant and

ultimately the highest yield of rice compared to Anilofos in Transplant rice cv. P-33.

2.2 Effect of time of application of herbicides on weed control efficiency, yield attributes and yield of rice

Rahman *et al*. (2019) Recorded the lowest weed density and dry matter was found with seeding of rice seed at 5 cm and application of Pendimethalin at 1 DAS followed by one hand weeding at 20 DAS plus application of Pendimethalin again just after weeding gave the lowest weed density and matter and resulted in highest rice yield among the treatment combinations. Sowing at 5 cm depth and pre-emergence application of Pendimethalin followed by a hand weeding at 20 DAS fb Pendimethalin application could be considered as the best way to control weeds in dry direct seeded rice.

Naik *et al*. (2018) the lower weed density and weed dry weight, higher weed control efficiency, yield attributes, maximum grain yield (5637.00 kg ha^{-1}), straw yield (6599.00 kg ha^{-1}) and harvest index (46.60%) were recorded under two hand weeding, which was at par with post emergence application of bispyribac sodium 20 g a.i. ha^{-1} in combination with hand weeding at 40 DAT.

Mishra *et al*. (2018) reported that application of pendimethalin + pyrazosulfuron ethyl @ 920 g ha^{-1} as pre emergence at 1 to 2 DAS with manual weeding at 20 DAS fb halosulfuron @ 35 g ha^{-1} as post emergence at 35 DAS was found to be effective in controlling weeds and enhancing the weed control efficiency. The growth, yield attributing characters like productive panicle m^{-2}, grains $panicle^{-1}$ and 1000 grain weight and grain yield of direct seeded rice was remarkably enhanced in pendimethalin + pyrazosulfuron ethyl @ 920 g ha^{-1} as pre emergence at 1 to 2 DAS with manual weeding at 20 DAS fb halosulfuron @ 35 g ha^{-1} as post emergence at 35 DAS without any crop injury.

Hemalatha *et al*. (2018) found that superior performance of rice in terms of yield attributes and yield was observed with pre-emergence application of pendimethalin @ 0.75 kg a.i ha^{-1} at 3-5 DAS *fb* post-emergence application of metsulfuron methyl + chlorimuron ethyl @ 4 g a.i ha^{-1} at 20-25 DAS which was comparable with weed free check i.e. control. Maximum grain yield, net returns

and B:C ratio were also associated with pre-emergence application of pendimethalin @ 0.75 kg a.i ha^{-1} at 3-5 DAS *fb* post-emergence application of metsulfuron methyl + chlorimuron ethyl @ 4 g a.i ha^{-1} at 20-25 DAS.

Samant (2017) observed that pre emergence application of bensulfuron methyl at 60 g ha^{-1} + Pretilachlor at 600 g ha^{-1} at 3 DAT recorded weed dry weight (7.27, 19.69 and 27.47 g m^{-2}) and the weed control efficiency (73.13, 33.61 and 43.92%) at 30, 60 and 90 DAT respectively, which were higher than farmers practices of one hand weeding. The improved technology also produced grain yield (48.63 q ha^{-1}) which was 19.7% higher than local check with harvest index, Effective of tillers, spikelet fertility 46.5, 79.4 and 92.7% respectively. The same also recorded higher gross return of Rs. 77024.98 ha^{-1} with a benefit cost ratio of 1.90 and additional net return of Rs.11321.08 ha^{-1} as compared to local check. Thus, pre-emergence application of bensulfuron methyl 60 g ha^{-1} + pretilachlor 600 g ha^{-1} at 3 DAT was very effective in reducing the weed biomass in transplanting rice with higher grain yield and net realization.

Maheswari *et al*. (2015) observed among different weed management treatments the reveal that the orthosulfamuron @ 120 g ha^{-1} pre-emergence as sand mix application (SMA) at 3-5 DAT fb orthosulfamuron @120 g ha^{-1} as post-emergence at 25-30 DAT is the effective and economical in managing weeds in rice grown under transplanted conditions without any crop injury as an alternative to manual weeding.

Yakadri (2015) noticed the higher weed control efficiency was with pyrazosulfuron ethyl 20 g ha^{-1} as pre emergence (PE) at 3 days after transplanting-DAT followed by manual weeding at 25 DAT, hand weeding twice at 25 and 45 DAT and pretilachlor @ 750 g ha^{-1} as pre emergence at 3 DAT followed metsulfuron methyl + chlorimuron ethyl @ 4 g ha^{-1} as post emergence at 25 DAT. Significantly higher grain yield was obtained with either hand weeding twice at 25 and 45 DAT (6929 kg ha^{-1}) or pyrazosulfuron ethyl @ 20 g a.i. ha^{-1} at 3 DAT followed by manual weeding at 25 DAT (6868 kg ha^{-1}) or

pretilachlor @ 750 g a.i. ha^{-1} as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i.ha^{-1} as post-emergence-PoE at 25 DAT (6677 kg ha^{-1}) or bispyribac sodium @ 20 g a.i. ha^{-1}+ metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. ha^{-1} as PoE at 25 DAT (6381 kg ha^{-1}).

Mahajan and Chauhan (2008) recorded that maximum weed control efficiency (90%) was attained with penoxsulam (25 g ha^{-1}) applied at 12 DAT followed by the hand weeding treatment (76%) and the plots treated with penoxsulam applied at 12 DAT resulted in highest grain yield (7.95 t ha^{-1}) and this treatment increased yield to about 104% and 13% more than weedy check and butachlor (1500 g ha^{-1}) treatments, respectively. Penoxsulam applied at 12 DAT was superior in terms of increasing grain yield and reducing weed dry matter when compared to its application at 3 DAT.

Gopinath and Kundu (2008) reported a weed population of 272 m^{-2} in the weedy check plots and the field was dominated by (*Echinochloa colona*), *Paspalum notatum*, *Ageratum conyzoides*, and *Oxalis latifolia*. Hand weeding (20 and 40 days after sowing) being at par with application of metsulfuron-methyl + chlorimuron-ethyl 4 g ha^{-1} 7 days after sowing + hand weeding (40 days after sowing) resulted in significantly lower density of grass weeds compared with other treatments. The highest weed control efficiency (90.6%) was achieved with hand weeding twice, followed by metsulfuron-methyl + chlorimuron-ethyl applied 7 or 15 days after sowing + hand weeding (88.7-89.8%). The grain yield decreased by 79.7% due to season-long weed-crop competition. Hand weeding (20 and 40 days after sowing) recorded the highest grain yield (2439 kg ha^{-1}) and was significantly superior to all other treatments except sequential application of butachlor 2000 g ha^{-2} days after sowing and metsulfuron-methyl + chlorimuron-ethyl 4 g ha^{-1} 21 days after sowing, and metsulfuron-methyl + chlorimuron-ethyl applied 7 days after sowing + hand weeding.

Singh (2005) conducted an experiment at Bihar, India to assess the effectiveness of Beushening (a kind of mechanical weed control) in controlling weeds as well

as to make a comparison between Beushening and chemical weed control. It was found that standard practice of Beushening along with one hand weeding (HW) 40 days after sowing (DAS) was better in controlling weeds than other chemical treatments with or without one HW 40 DAS and both practices of Beushening as effective as two HWs (25 and 40 DAS) in terms of grain yield.

Kumar and Uthayakumar (2005) conducted an experiment with one hand weeding at 25 DAT, Butachlor @ 1 kg ha^{-1} at 8 DAT, 2, 4-D @ 0.5 kg ha^{-1} at 25 DAT, two hand weeding at 25 and 50 DAT and unweeded control. Among the treatments Butachlor @ 1 kg ha^{-1} at 8 DAT had significant effect on weed population and also gave the highest yield contributing characters and grain yield of rice.

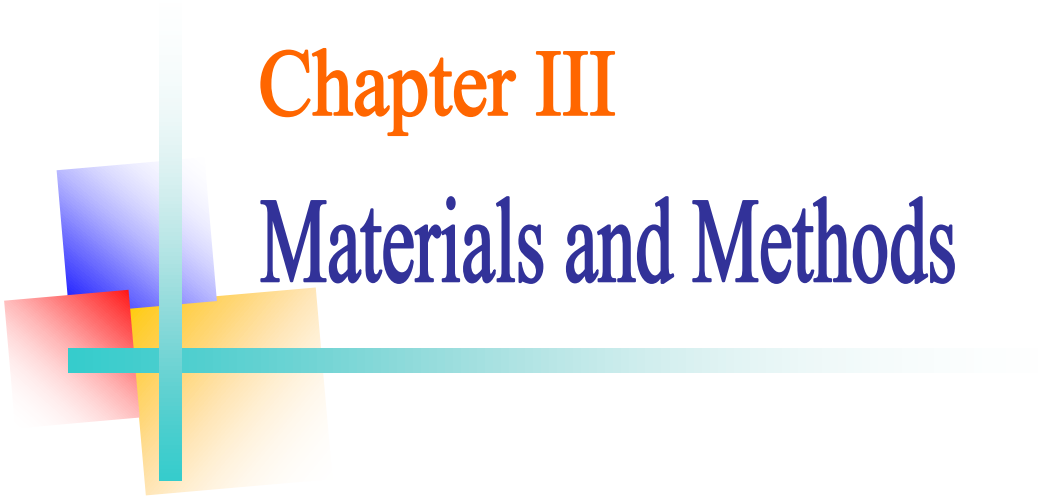
Bhowmick *et al.* (2002) observed that two hand weeding on 26 40 days after transplanting-DAT in transplanted rice showed the highest weed control efficiency and proved at par with the herbicide combination of Ethoxysulfuron + Anilophos application at 26 and 40 DAT.

Bhowmick *et al.* (2000) observed that post emergence application of Ethoxysulfuron + Anilofos (0.02 + 0.375 kg ha^{-1}) at 10 DAT was statistically similar with hand weeding at 20 and 40 DAT in controlling weeds of transplanted rice effectively and the grain yields were also comparable. Butachlor 1 kg ha^{-1} at 5 DAT + 2, 4-D Na salt 0.4 kg ha^{-1} at 25 DAT, Pretilachlor 0.04 kg ha^{-1} at 5 DAT and Oxadiagyl 0.1 kg ha^{-1} at 5 DAT were also promising. They also recorded the highest weed density in the weedy plots at 60 DAT.

The above cited reviews revealed that different levels of herbicides and their time of application played a significant role on weed control efficiency, optimum growth, yield attributes and yield of rice but there were no definite conclusion in this aspects under the agro climatic condition of Bangladesh.

Chapter III

Materials and Methods



CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to assess the weed control efficiency of Metsulfuron Methyl 20% in aus rice. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental site, experimental treatment and design, growing of crops, data collection and analysis procedure that was followed for this experiment has been presented below under the following headings:

3.1 Description of the site of experiment

3.1.1 Period of the experiment

The experiment was conducted during the period of March to July, 2018.

3.1.2 Location of the experiment

The present experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Characteristics of experimental soil

The soil of the experimental field belonged to "The Modhupur Tract", AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area having available irrigation and drainage system and situated above flood level. The soil having a texture of sandy loam organic matter 1.15% and composed of 26% sand, 43% silt and 31% clay. Details morphological, physical and chemical properties of the experimental field soil are presented in Appendix II.

3.1.4 Climatic condition of the experimental site

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon, pre-monsoon period or hot season and the monsoon period. The monthly average temperature, humidity and rainfall during the crop

growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III. In relation to the temperature of the study period the maximum temperature (35.1^0C) was recorded in the month of July 2018, while the minimum temperature (19.5^0C) in the month of March 2018. The highest humidity (81%) was recorded in the month of June, 2018, whereas the highest rainfall (298 mm) was recorded in the month of July, 2018 and highest sunshine hour (7.8 hour) was recorded in May, 2018.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan48 was used as the test crop in this experiment.

3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Doses of Metsulphuron Methyl 20% (4 doses) as

i. D_0 = Control i.e. no weedicide or no hand weeding
ii. D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}
iii. D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}
iv. D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

Factor B: Time of application (4 times) as

i. T_1 = Application at 12 DAT
ii. T_2 = Application at 15 DAT
iii. T_3 = Application at 20 DAT
iv. T_4 = Application at 25 DAT

There were total 16 (4×4) combination as a whole viz., D_0T_1, D_0T_2, D_0T_3, D_0T_4, D_1T_1, D_1T_2, D_1T_3, D_1T_4, D_2T_1, D_2T_2, D_2T_3, D_2T_4, D_3T_1, D_3T_2, D_3T_3 and D_3T_4.

3.2.3 Experimental design and layout

The two factors experiment was laid out in split-plot design with three replications. An area of 697.5 m^2 (31.0 m × 22.5 m) was divided into 3 blocks. The four doses of Metsulphuron Methyl 20% were assigned in the main plot and four Time of application in the sub-plot. The size of the each unit plot was 3.0 m × 2.0 m. The space between two blocks, main and two plots and sub plots were 1.0 m, 0.75 m and 0.5 m, respectively. Each plot and sub-plot were separated by raised border. The layout of the experiment presented in Figure 1.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds of BRRI dhan48 was collected from BRRI (Bangladesh Rice Research Institute), Joydevpur, Gazipur just 20 days ahead of the sowing of seeds in seed bed. For seedlings clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in the seed bed in 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible at 9th March, 2018. Irrigation was gently provided to the bed when needed. No fertilizer was used in the nursery bed.

3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 23th March 2018 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design at 29th March, 2018. Organic and inorganic manures as indicated 3.3.4 were mixed with the soil of each unit plot.

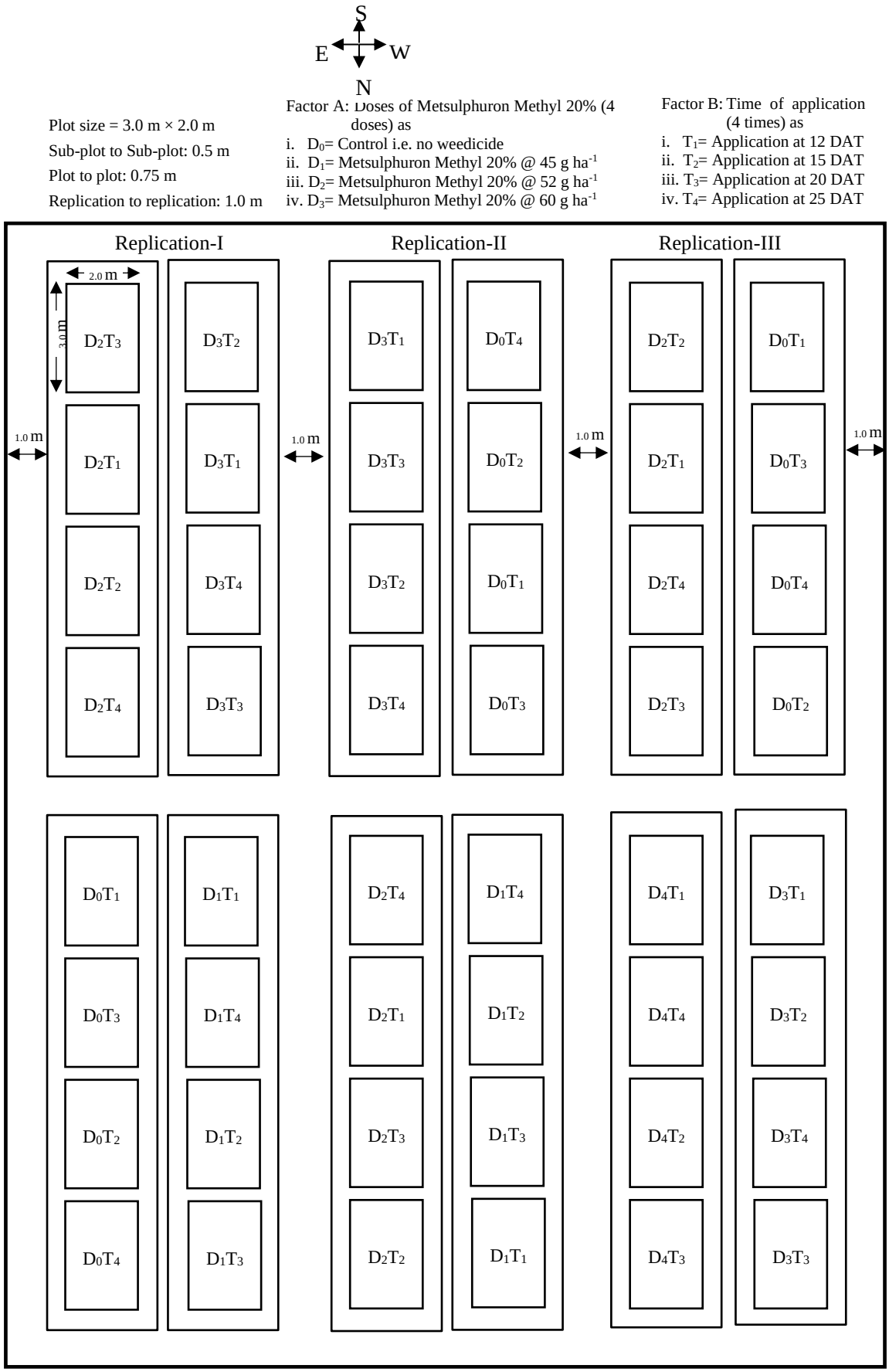


Figure 1. Layout of the experimental plot

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively. Urea, TSP, MoP, Gypsum, zinc sulphate and borax were applied @ 80, 60, 90, 12, 4 and 3 kg ha^{-1} (BRRI, 2018). Vermocompost were applied @ 5 ton ha^{-1} in each plot. The entire amount of Vermocompost, TSP, MoP, gypsum, zinc sulphate and borax were applied during final land preparation. Urea was applied in three equal installments as top dressing at early and maximum tillering and also panicle initiation stages.

3.3.5 Transplanting of seedling

Seedlings were carefully uprooted from the nursery bed and transplanted on 29th March, 2018 in well puddled plot with spacing of 25 cm × 15 cm. Two seedlings was transplanted in each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water upto 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.3.6.2 Application of weedicide

Weedicide Metsulphuron Methyl 20% were applied as per the treatment maintaining doses and time of application.

3.3.6.3 Insect and pest control

Furadan were applied at 15 DAT in the plot. Leaf roller (*Chaphalocrosis medinalis*) was found and used Malathion @ 1.12 L ha^{-1} at 25 DAT using sprayer but no diseases infection was observed in the field.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity based on variety when 80-90% of the grains were turned into straw color. The harvested crop was bundled separately, properly tagged and brought to threshing floor. The grains were dried, cleaned and weighed for individual plot. The weight was adjusted to 14% moisture content. Yields of rice grain and straw were recorded from each plot. Before harvest 5 hills from each plot were collected from the inner rows from which plant height and yield attributes data were collected.

3.5 Data recording

A. Weed related data

i. Weed population (no. m^{-2})
ii. Dry weight of weeds (g m^{-2})
iii. Weed control efficiency (%)

B. Plant and yield attributes data

i. Plant height (cm)
ii. Effective tillers $hill^{-1}$ (no.)
iii. Non-effective tillers $hill^{-1}$ (no.)
iv. Total tillers $hill^{-1}$ (no.)
v. Panicle length (cm)
vi. Filled grains $panicle^{-1}$ (no.)
vii. Unfilled grains $panicle^{-1}$ (no.)
viii. Total grains $panicle^{-1}$ (no.)
ix. Weight of 1000-grains (g)

C. Yield and harvest index data

i. Grain yield (t ha^{-1})
ii. Straw yield (t ha^{-1})

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

iv. Harvest index (%)

3.5.1 Weed population (no. m^{-2})

From the 1 m^2 area of every plot, the total weeds were uprooted and counted at 45 days after transplanting and recorded.

3.5.2 Dry weight of weeds (g m^{-2})

At first weeds were collected from 1 m^2, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

3.5.3 Weed control efficiency (%)

Weed control efficiency were computed by simple calculation from the weight recorded using the following formula:

$$\text{Weed control efficiency (\%)} = \frac{\text{Dry weight of weeds in control plot} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times 100$$

3.5.4 Plant height (cm)

The height of plant was measured in centimeter (cm) from the ground level to the tip of the plant during harvesting time. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.5 Effective tillers $hill^{-1}$ (no.)

The total number of effective tillers $hill^{-1}$ was counted as the number of panicle bearing tillers during harvesting. Data on effective tillers $hill^{-1}$ were counted from 5 selected hills and average value was recorded.

3.5.6 Non-effective tillers $hill^{-1}$ (no.)

The total number of non-effective tillers hill^{-1} was counted as the number of non-panicle bearing tillers during harvesting. Data on non-effective tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

3.5.7 Total tillers hill^{-1} (no.)

Number of total tillers hill^{1} was recorded by adding effective and non-effective tillers during harvesting time as the average of randomly selected 5 plants from the inner rows of each plot.

3.5.8 Panicle length (cm)

The length of panicle was measured with a meter scale from 10 selected panicle and the average length was recorded as per panicle in cm.

3.5.9 Filled grains panicle^{-1} (no.)

The total numbers of filled grains were collected randomly from selected 10 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

3.5.10 Unfilled grains panicle^{-1} (no.)

The total numbers of unfilled grains was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.5.11 Total grains panicle^{-1} (no.)

The total numbers of grains was calculated by adding filled and unfilled grain selected 5 plants of a plot and average numbers of grains panicle^{-1} was recorded.

3.5.12 Weight of 1000-grains (g)

One thousand grains were counted randomly from the total cleaned harvested grains and then weighed in grams and recorded.

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

Grains obtained from each unit plot were sun-dried and weighed carefully. Dry weight of grains of each plot were taken and converted to ton hectare^{-1} (t ha^{-1}).

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

Straw obtained from each unit plot were sun-dried and weighed carefully. Dry weight of straw of each plot were taken and converted to ton $hectare^{-1}$ (t ha^{-1}).

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

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

Biological yield = Grain yield + Straw yield.

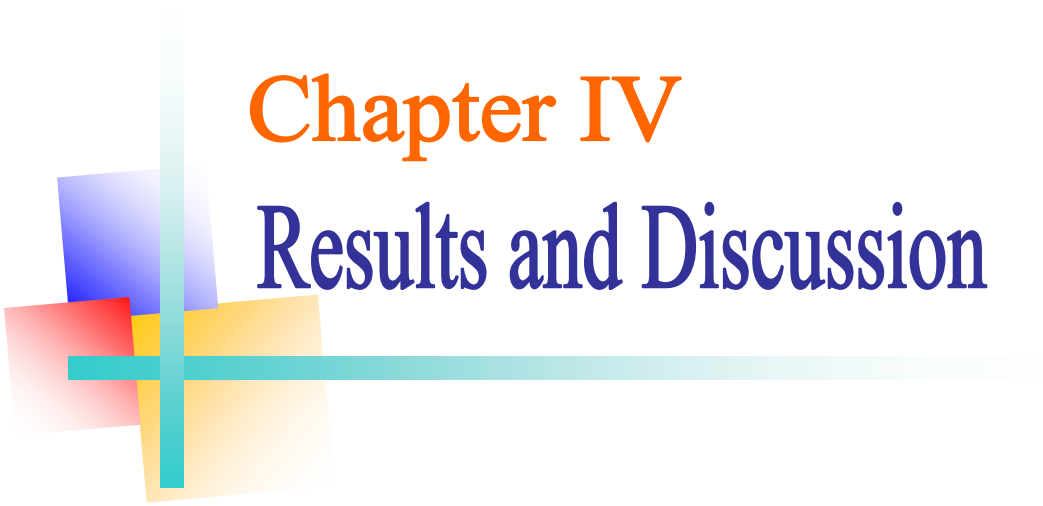
3.5.16 Harvest index (%)

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (total dry weight)}} \times 100$$

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out effect and the significance of the difference for different levels of Metsulphuron Methyl and time of application on weed control efficiency, yield contributing characters and yield of BRRI dhan48. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment and treatment combinations of means under the experiment was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to assess the weed control efficiency of Metsulfuron Methyl 20% in aus rice. Analyses of variance (ANOVA) of the data on weed control efficiency, yield contributing characters and yield of BRRI dhan48 are presented in Appendix IV-VII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Weed control efficiency

4.1.1 Available weeds in experimental plot

During the study period several types of weeds were observed in the experimental plot and they were presented in Table 1 with their local name, common name, scientific name, family, life cycle and type.

There were 18 major weed species that were found in the experimental plot. Among them 07 species belongs to Cyperaceae, 03 were Gramineae, 02 were Poaceae, 02 were Pontederiaceae and 01 were the family of Amaranthaceae, Commelinaceae, Commelinaceae and Marsileace, respectively. Weeds that found in the plot were 03 broadleaf, 04 were grass, 04 were herbs and 07 were sedge. Based on life cycle 08 weeds were annual and 10 in perennial types. The recorded weeds were *Panicum repens* (Bullet Grass), *Leersia hexandra* (Southern cutgrass), *Cyperus difformis* (Small flowered umbrella plant), *Eleocharis acutangula* (Acute spikerush), *Echinochloa crussgalli* (Burnyard grass), *Scirpus juncoides Roxb.I* (Grass Weed), *Cynodon dactylon* (Bermuda grass), *Fimbristylis miliaceae* (Hoorahgrass), *Eichhornia crassipes* (Water hyacinth), *Commelina benghalensis* (Spider Wort), *Jussiaea repens* (Creeping Water Primrose), *Alternanthera philoxeroides* (Alligator Weed), *Cyperus iria* (Umbrella Sedge), *Cyperus rotundus* (Nut Sedge), *Monochoria vaginalis L. solms*, (Pickerel Weed), *Ludwigia hyssopifolia* (Water primrose), *Cyperus*

difformis (Small-flowered nut sedge) and *Marsilea crenata* (4 leaved water clover).

Table 1. Different weed that was observed in the experimental plot

SL. No.	Local name	Common name	Scientific name	Family	Life cycle	Type
01.	Angta	Bullet Grass	*Panicum repens*	Gramineae	Perennial	Grass
02.	Arail	Southern cutgrass	*Leersia hexandra*	Poaceae	Annual	Grass
03.	Behua	Small flowered Umbrella Plant	*Cyperus difformis*	Cyperaceae	Perennial	Sedge
04.	Boro cheich	Acute spikerush	*Eleocharis acutangula*	Cyperaceae	Perennial	Sedge
05.	Boro shama	Burnyard grass	*Echinochloa crussgalli*	Gramineae	Annual	Grass
06.	Chechra	Grass Weed	*Scirpus juncoides Roxb.*	Cyperaceae	Annual	Sedge
07.	Durba	Bermuda grass	*Cynodon dactylon*	Gramineae	Perennial	Grass
08.	Joina	Hoorahgrass	*Fimbristylis miliaceae*	Cyperaceae	Annual	Sedge
09.	Kachuripana	Water hyacinth	*Eichhornia crassipes*	Pontederiaceae	Perennial	Broadleaf
10.	Kanaibashi	Spider Wort	*Commelina benghalensis*	Commelinaceae	Perennial	Herb
11.	Keshordarn	Creeping Water Primrose	*Jussiaea repens*	Onagraceae	Perennial	Herb
12.	Malancha	Alligator Weed	*Alternanthera philoxeroides*	Amaranthaceae	Perennial	Herb
13.	Mati cheich	Umbrella Sedge	*Cyperus iria*	Cyperaceae	Perennial	Sedge
14.	Mutha	Nut Sedge	*Cyperus rotundus*	Cyperaceae	Annual	Sedge
15.	Panee kachu	Pickerel Weed	*Monochoria vaginalis L. solms*	Pontederiaceae	Perennial	Broadleaf
16.	Pani long	Water primrose	*Ludwigia hyssopifolia*	Poaceae	Annual	Herb
17.	Sabuj Nakphulee	Small-flowered nut sedge	*Cyperus difformis*	Cyperaceae	Annual	Sedge
18	Shushni shak	4 leaved water clover	*Marsilea crenata*	Marsileace	Annual	Broadleaf

4.1.2 Number of weed population at 45 DAT

Number of weed population that were recorded at 45 DAT from 1 m^2 land showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 2). The highest weed population (14.08 no. m^{-2}) was found from D_0 (Control i.e. no weedicide) which was followed (10.58 no. m^{-2}) by D_1 (Metsulphuron Methyl 20% @ 45 g ha^{-1}), while the lowest (5.25 no. m^{-2}) was observed from D_3 (Metsulphuron Methyl 20% @ 60 g ha^{-1}) which was followed (8.25 no. m^{-2}) by D_2 (Metsulphuron Methyl 20% @ 52 g ha^{-1}).

Different time of application showed statistically significant differences in terms of number of weed population that were recorded at 45 DAT from 1 m^2 land (Table 2). The highest weed population (12.17 no. m^{-2}) was recorded from T_1 (Application at 12 DAT) which was followed (10.00 and 9.17 no. m^{-2}, respectively) by T_2 (Application at 15 DAT) and T_4 (Application at 25 DAT) and they were statistically similar, whereas the lowest (6.83 no. m^{-2}) was observed from T_3 (Application at 20 DAT).

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of number of weed population that were recorded at 45 DAT from 1 m^2 land (Table 3). The highest weed population (18.00 no. m^{-2}) was found from D_0T_1 (Control i.e. no weedicide and application at 12 DAT), while the lowest (3.67 no. m^{-2}) was recorded from D_3T_3 (Metsulphuron Methyl 20% @ 60 g ha^{-1} and application at 20 DAT) treatment combination.

4.1.3 Dry weight of weeds at 45 DAT

Different doses of Metsulphuron Methyl 20% showed statistically significant differences in terms of dry weight of weeds that were recorded at 45 DAT from 1 m^2 land (Table 2). The highest dry weight (20.30 g m^{-2}) was recorded from D_0 which was followed (15.55 g m^{-2}) by D_1 and the lowest dry weight (4.64 g m^{-2}) was found from D_3 which was followed (8.03 g m^{-2}) by D_2.

Table 2. Effect of different levels of Metsulphuron Methyl and time of application on weed population, dry weight of weeds and weed control efficiency for BRRI dhan48 in Aus rice

Treatments	Weed population at 45 DAT (no. m^{-2})	Dry weight of weeds at 45 DAT (g m^{-2})	Weed control efficiency (%)
Doses of Metsulphuron Methyl 20%			
D_0	14.08 a	20.30 a	--
D_1	10.58 b	15.55 b	23.40
D_2	8.25 c	8.03 c	60.44
D_3	5.25 d	4.64 d	77.14
Sx	0.228	0.273	--
CV(%)	14.48	6.29	--
Time of Application			
T_1	12.17 a	16.71 a	--
T_2	10.00 b	14.11 b	15.56
T_3	6.83 c	5.50 d	67.09
T_4	9.17 b	12.21 c	26.93
Sx	0.399	0.220	--
CV(%)	8.29	7.80	--

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Table 3. Combined effect of different levels of Metsulphuron Methyl and time of application on weed population, dry weight of weeds and weed control efficiency for BRRI dhan48 in Aus rice

Treatments	Weed population at 45 DAT (no. m^{-2})	Dry weight of weeds at 45 DAT (g m^{-2})	Weed control efficiency (%)
D_0T_1	18.00 a	26.50 a	-
D_0T_2	14.67 b	23.70 b	10.57
D_0T_3	10.67 d	10.35 fg	60.94
D_0T_4	13.00 c	20.67 c	22.00
D_1T_1	13.33 c	22.33 b	15.74
D_1T_2	10.67 d	17.83 d	32.72
D_1T_3	7.67 fg	6.53 h	75.36
D_1T_4	10.67 d	15.50 e	41.51
D_2T_1	10.00 de	11.33 f	57.25
D_2T_2	9.00 ef	8.97 g	66.15
D_2T_3	5.33 h	3.03 ij	88.57
D_2T_4	8.67 e-g	8.80 g	66.79
D_3T_1	7.33 g	6.67 h	74.83
D_3T_2	5.67 h	5.93 h	77.62
D_3T_3	3.67 i	2.08 j	92.15
D_3T_4	4.33 hi	3.87 i	85.40
Sx	0.456	0.546	--
CV(%)	8.29	7.80	--

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Dry weight of weeds that were recorded at 45 DAT from 1 m^2 land showed statistically significant differences due to different time of application (Table 2). The highest dry weight (16.71 g m^{-2}) was found from T_1 which was followed (14.11 g m^{-2}) by T_2, while the lowest (5.50 g m^{-2}) was recorded from T_3 which was followed (12.21 g m^{-2}) by T_4.

Statistically significant variation was recorded in terms of dry weight of weeds that were recorded at 45 DAT from 1 m^2 land due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 3). The highest dry weight (26.50 g m^{-2}) was observed from D_0T_1, whereas the lowest (2.08 g m^{-2}) was attained from D_3T_3 treatment combination.

4.1.4 Weed control efficiency

Weed control efficiency were estimated for different doses of Metsulphuron Methyl 20% (Table 2). The highest weed control efficiency (77.14%) was observed from D_3 and the lowest (23.40%) was recorded from D_1. Kashid *et al*. (2015) observed that application metsulfuron-methyl + chlorimuron-ethyl 0.004 kg ha^{-1} as weed control measure in direct-seeded rice gave the higher weed control efficiency (91.08%).

Due to different time of application weed control efficiency also estimated and presented in Table 2. The highest weed control efficiency (67.09%) was found from T_3, while the lowest (15.56%) was recorded from T_2. Mahajan and Chauhan (2008) recorded maximum weed control efficiency (90%) was attained with penoxsulam (25 g ha^{-1}) applied at 12 DAT.

Weed control efficiency also estimated for the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 3). The highest weed control efficiency (92.15%) was observed from D_3T_3 and the lowest (10.57%) was recorded from D_0T_2 treatment combination.

4.2 Plant characters, yield attributes and yield of rice

4.2.1 Plant height

Plant height of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 4). The longest plant (95.90 cm) was recorded from D_3 which was followed (92.89 and 91.14 cm, respectively) by D_2 and D_1 and they were statistically similar, while the shortest plant (88.53 cm) was found from D_0.

Statistically significant variation was recorded in terms of plant height of BRRI dhan48 due to different time of application (Table 4). The longest plant (96.11 cm) was observed from T_3 which was statistically similar (92.86 cm) to T_4 and followed (91.92 cm) by T_2, whereas the shortest plant (87.58 cm) from T_1. Gopinath and Kundu (2008) also reported the similar findings with 4 g ha^{-1} 7 DAS.

Plant height of BRRI dhan48 varied significantly due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 5). The longest plant (99.81 cm) was found from D_3T_3 which was statistically at par with combination of D_3T_2, D_2T_3, D_3T_4 and D_4T_4 (97.53, 96.81, 94.90 and 93.80 cm, respectively) and the shortest plant (83.63 cm) was recorded from D_0T_1 treatment combination which was statistically similar with D_0T_2, D_1T_1 and D_2T_1 interactions.

4.2.2 Effective tillers $hill^{-1}$

Effective tillers $hill^{-1}$ of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 4). The maximum number of effective tillers $hill^{-1}$ (11.08) was observed from D_3 which was followed (10.22) by D_2 and the minimum number (8.82) was recorded from D_0 which was followed (9.70) by D_1. The result revealed that D_3 doses produces 25.62, 14.23 and 8.42% higher tiller than D_0, D_1 and D_2, respectively. Mamun *et al*. (2012) reported that application of Metsulfuron-methyl 20% WDG @ 80 g ha^{-1} gave higher yield attributes.

Table 4. Effect of different levels of Metsulphuron Methyl and time of application on plant height, effective, non-effective and total tillers hill^{-1} of BRRI dhan48 in Aus rice

Treatments	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)
Doses of Metsulphuron Methyl 20%				
D_0	88.53 c	8.82 d	4.73 a	13.55 c
D_1	91.14 b	9.70 c	4.25 b	13.95 b
D_2	92.89 b	10.22 b	3.88 c	14.10 b
D_3	95.90 a	11.08 a	3.50 d	14.58 a
Sx	0.990	0.124	0.068	0.128
CV(%)	4.05	7.46	5.24	3.84
Time of Application				
T_1	87.58 c	8.78 c	4.82 a	13.60 b
T_2	91.92 b	9.33 b	4.52 b	13.85 b
T_3	96.11 a	11.73 a	3.08 d	14.82 a
T_4	92.86 ab	9.97 b	3.95 c	13.92 b
Sx	1.077	0.214	0.062	0.156
CV(%)	3.72	4.30	5.75	3.16

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Table 5. Combined effect of different levels of Metsulphuron Methyl and time of application on plant height, effective, non-effective and total tillers hill^{-1} of BRRI dhan48 in Aus rice

Treatments	Plant height (cm)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)
D_0T_1	83.63 g	7.80 i	5.67 a	13.47 de
D_0T_2	87.29 e-g	7.93 hi	5.00 b	12.93 e
D_0T_3	92.30 b-f	10.87 cd	3.67 f	14.53 ab
D_0T_4	90.90 b-f	8.67 gh	4.60 b-d	13.27 de
D_1T_1	86.82 fg	8.60 gh	4.87 bc	13.47 de
D_1T_2	90.39 c-f	9.07 fg	4.53 c-e	13.60 c-e
D_1T_3	95.50 a-c	11.53 bc	3.13 g	14.67 ab
D_1T_4	91.85 b-f	9.60 ef	4.47 c-e	14.07 b-d
D_2T_1	88.50 d-g	9.00 fg	4.60 b-d	13.60 c-e
D_2T_2	92.45 b-f	9.53 f	4.40 de	13.93 b-d
D_2T_3	96.81 a-c	12.00 ab	2.93 gh	14.93 a
D_2T_4	93.80 a-e	10.33 de	3.60 f	13.93 b-d
D_3T_1	91.37 b-f	9.73 ef	4.13 e	13.87 b-d
D_3T_2	97.53 ab	10.80 cd	4.13 e	14.93 a
D_3T_3	99.81 a	12.53 a	2.60 h	15.13 a
D_3T_4	94.90 a-d	11.27 bc	3.13 g	14.40 a-c
Sx	1.979	0.247	0.136	0.256
CV(%)	3.72	4.30	5.75	3.16

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Different time of application showed statistically significant differences in terms of effective tillers hill^{-1} of BRRI dhan48 (Table 4). The maximum number of effective tillers hill^{-1} (11.73) was found from T_3 which was followed (9.97 and 9.33, respectively) by T_4 and T_2 and they were statistically similar, whereas the minimum number (8.78) from T_1. The results indicated that T_3 time of herbicide application was superior by producing effective tillers hill^{-1} than earlier and later of herbicidal application. Yakadri (2015) also reported the similar findings with 20 g ha^{-1} as pre emergence (PE) at 3 days after transplanting-DAT.

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of effective tillers hill^{-1} of BRRI dhan48 (Table 5). The maximum number of effective tillers hill^{-1} (12.53) was observed from D_3T_3 which was statistically similar with D_2T_3 interaction (12.00), while the minimum number (7.80) was found from D_0T_1 treatment combination which was at par with D_0T_2 combination.

4.2.3 Non-effective tillers hill^{-1}

Different doses of Metsulphuron Methyl 20% showed statistically significant differences in terms of non-effective tillers hill^{-1} of BRRI dhan48 (Table 4). The minimum number of non-effective tillers hill^{-1} (3.50) was found from D_3 which was followed (3.88) by D_2, whereas the maximum number (4.73) was observed from D_0 which was followed (4.25) by D_1.

Non-effective tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different time of application (Table 4). The minimum number of non-effective tillers hill^{-1} (3.08) was recorded from T_3 which was followed (3.95) by T_4, while the maximum number (4.82) was observed from T_1 which was followed (4.52) by T_2.

Statistically significant variation was observed in terms of non-effective tillers hill^{-1} of BRRI dhan48 due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 5). The minimum

number of non-effective tillers hill^{-1} (2.60) was found from D_3T_3 and the maximum number (5.67) was recorded from D_0T_1 treatment combination.

4.2.4 Total tillers hill^{-1}

Total tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 4). The maximum number of total tillers hill^{-1} (14.58) was recorded from D_3 which was followed (14.10 and 13.95, respectively) by D_2 and D_1 and they were statistically similar, while the minimum number (13.55) was found from D_0.

Statistically significant variation was recorded in terms of total tillers hill^{-1} of BRRI dhan48 due to different time of application (Table 4). The maximum number of total tillers hill^{-1} (14.82) was found from T_3 which was followed (13.92 and 13.85, respectively) by T_4 and T_2 and they were statistically similar, whereas the minimum number (13.60) was recorded from T_1. Gopinath and Kundu (2008) also reported the similar findings with 4 g ha^{-1} 7 days after sowing.

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of total tillers hill^{-1} of BRRI dhan48 (Table 5). The maximum number of total tillers hill^{-1} (15.13) was found from D_3T_3 which was similar with D_3T_2, D_2T_3, D_1T_3 and D_3T_4 combination, while the minimum number (12.93) was recorded from D_0T_2 treatment combination which was at par with D_0T_1, D_0T_4, D_1T_1, D_1T_2 and D_2T_1 combination.

4.2.5 Panicle length

Different doses of Metsulphuron Methyl 20% varied significantly differences in terms of panicle length of BRRI dhan48 (Figure 2). The figure indicates that panicle length increased gradually with the higher doses. The longest panicle (21.31 cm) was recorded from D_3 which was followed (21.31 and 19.41 cm, respectively) by D_2 and D_1 and they were statistically similar, whereas the shortest panicle (18.62 cm) from D_0. Saha and Rao (2010) observed similar

findings with the application of metsulfuron methyl 8 g ha^{-1} applied 10 days after transplanting.

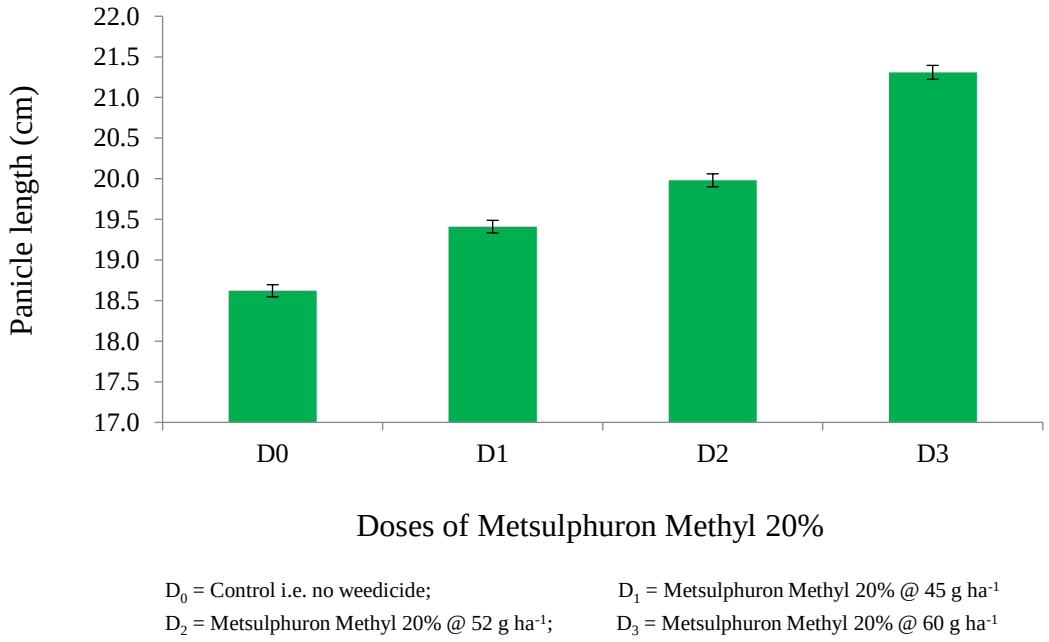


Figure 2. Effect of doses of Metsulphuron Methyl 20% on panicle length of BRRI dhan48. Sx = 0.358.

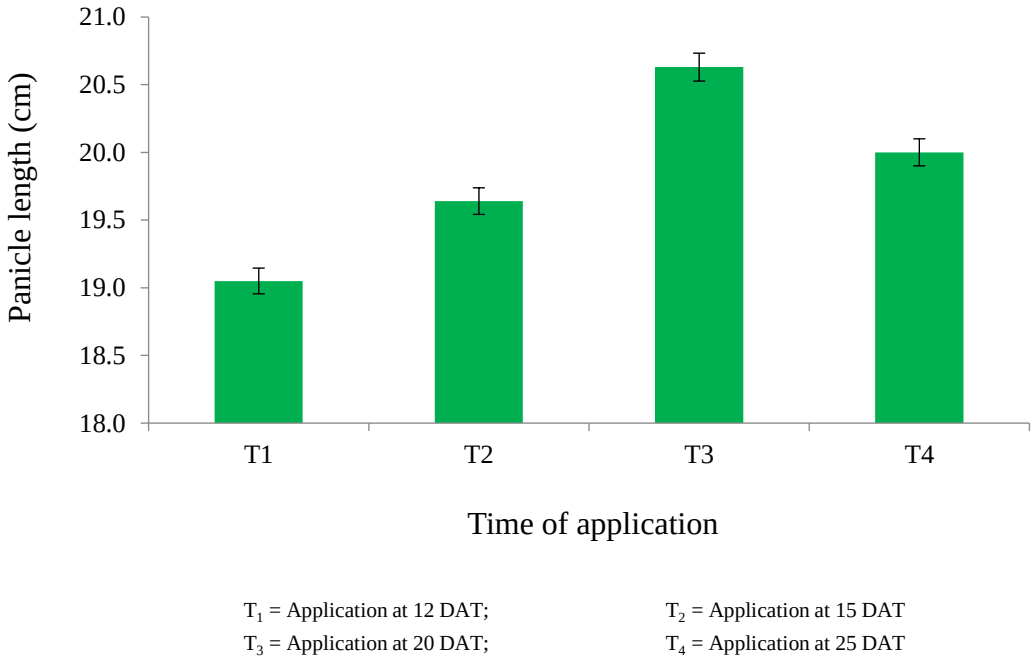


Figure 3. Effect of time of application of Metsulphuron Methyl 20% on panicle length of BRRI dhan48. Sx =0.210.

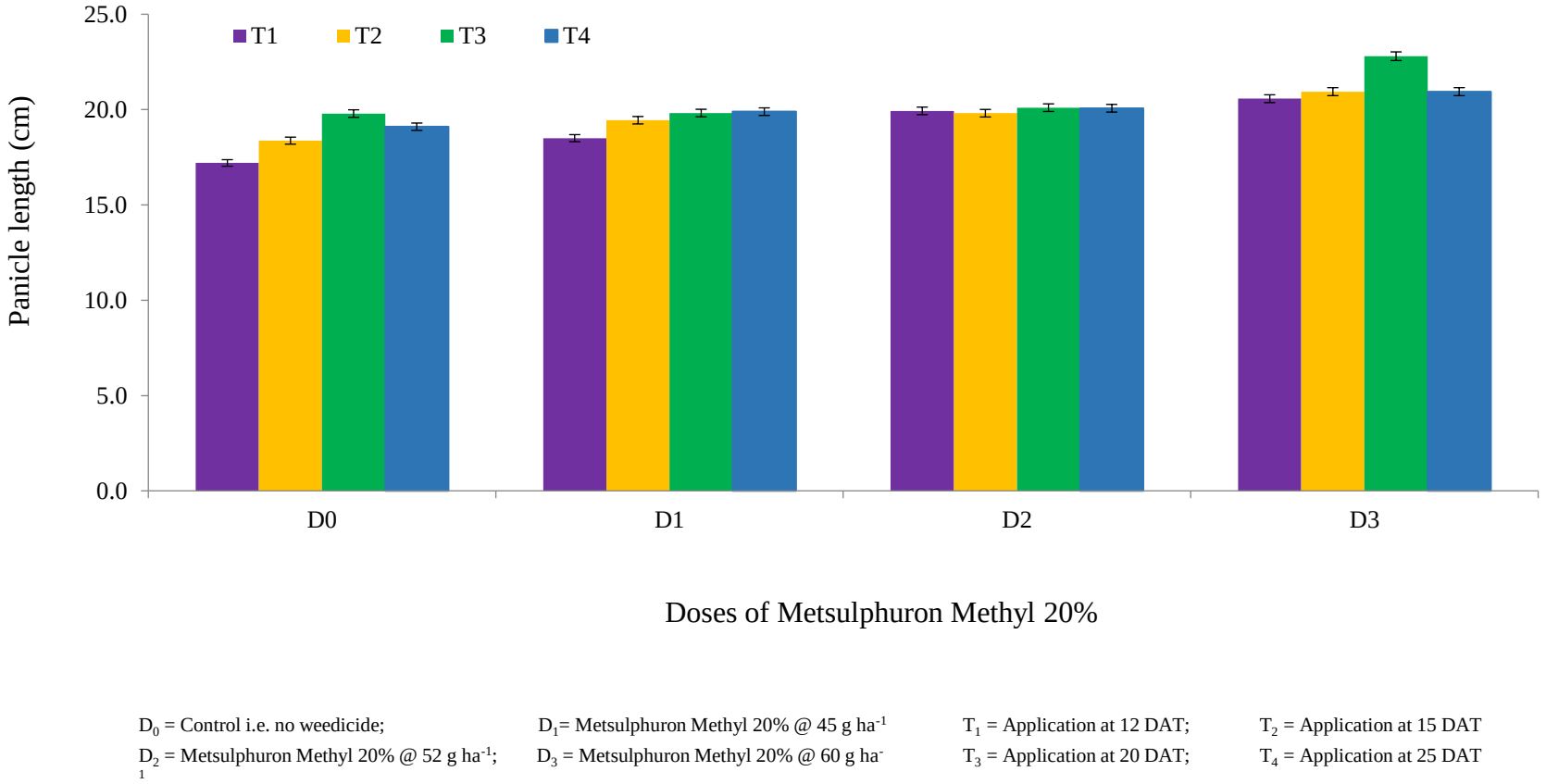
Panicle length of BRRI dhan48 showed statistically significant differences in terms of different time of application (Figure 3). The figure shows that T_3 was superior in producing higher panicle length than earlier and later application of herbicide Metsulphuron Methyl 20%. The longest panicle (20.63 cm) was observed from T_3 which was statistically similar (20.00 cm) to T_4 and followed (19.64 cm) by T_2, while the shortest panicle (19.05 cm) was recorded from T_1. Yakadri (2015) also reported the similar findings with 20 g ha^{-1} as pre emergence (PE) at 3 days after transplanting-DAT.

Statistically significant variation was observed in terms of panicle length of BRRI dhan48 due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Figure 4). The figure shows that the longest panicle (22.80 cm) was observed from D_3T_3 and the shortest panicle (17.20 cm) was found from D_0T_1 treatment combination.

4.2.6 Filled grains panicle^{-1}

Filled grains panicle^{-1} of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 6). The maximum number of filled grains panicle^{-1} (81.98) was found from D_3 which was followed (77.77) by D_2, while the minimum number (70.53) was observed from D_0 which was followed (73.93) by D_1. Kashid *et al*. (2015) observed that application metsulfuron-methyl + chlorimuron-ethyl 0.004 kg ha^{-1} as weed control measure in direct-seeded rice gave the highest yield contributing characters.

Different time of application showed statistically significant differences in terms of filled grains panicle^{-1} of BRRI dhan48 (Table 6). The maximum number of filled grains panicle^{-1} (80.38) was recorded from T_3 which was statistically similar (78.67) to T_4 and followed (74.88) by T_2, whereas the minimum number (70.28) was observed from T_1. Saha and Rao (2010) also recorded similar observation with the application of metsulfuron methyl 8 g ha^{-1} applied 10 days after transplanting.



D_0 = Control i.e. no weedicide; D_1= Metsulphuron Methyl 20% @ 45 g ha^{-1} T_1 = Application at 12 DAT; T_2 = Application at 15 DAT

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}; D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1} T_3 = Application at 20 DAT; T_4 = Application at 25 DAT

Figure 4. Combined effect of doses of Metsulphuron Methyl 20% and time of application on panicle length of BRRI dhan48. Sx = 0.716.

Table 6. Effect of different levels of Metsulphuron Methyl and time of application on filled and unfilled grains panicle^{-1}, sterility and weight of 1000-grains of BRRI dhan48 in Aus rice

Treatments	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Sterility (%)	Weight of 1000-grains (g)
Doses of Metsulphuron Methyl 20%				
D_0	70.53 d	17.10 a	19.63 a	23.38
D_1	73.93 c	15.95 b	17.83 b	24.02
D_2	77.77 b	14.85 c	16.10 c	24.18
D_3	81.98 a	13.65 d	14.31 d	24.44
Sx	0.970	0.181	0.272	0.331
CV(%)	4.43	8.11	10.46	7.53
Time of Application				
T_1	70.28 c	17.62 a	20.19 a	23.23
T_2	74.88 b	15.87 b	17.56 b	24.09
T_3	80.38 a	13.72 c	14.64 c	24.50
T_4	78.67 a	14.35 c	15.48 c	24.20
Sx	0.973	0.360	0.512	0.522
CV(%)	4.42	4.07	5.56	4.78

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of filled grains panicle^{-1} of BRRI dhan48 (Table 7). The maximum number of filled grains panicle^{-1} (85.27) was found from D_3T_3 which was statistically similar with D_3T_4, D_2T_3, D_2T_4 and D_3T_2 combinations (83.73, 82.27, 80.27 and 80.27, respectively) while the minimum number (63.07) was recorded from D_0T_1 treatment combination.

4.2.7 Unfilled grains panicle^{-1}

Statistically significant variation was found in terms of unfilled grains panicle^{-1} of BRRI dhan48 due to different doses of Metsulphuron Methyl 20% (Table 6). The minimum number of unfilled grains panicle^{-1} (13.65) was observed from D_3 which was followed (14.85) by D_2 and the maximum number (17.10) was obtained from D_0 which was followed (15.95) by D_1.

Different time of application showed statistically significant differences in terms of unfilled grains panicle^{-1} of BRRI dhan48 (Table 6). The minimum number of unfilled grains panicle^{-1} (13.72) was found from T_3 which was statistically similar (14.35) to T_4 and followed (15.87) by T_2, whereas the maximum number (17.62) was recorded from T_1.

Unfilled grains panicle^{-1} of BRRI dhan48 varied significantly due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 7). The minimum number of unfilled grains panicle^{-1} (11.93) was recorded from D_3T_3, while the maximum number (19.27) from D_0T_1 treatment combination.

4.2.8 Total grains panicle^{-1}

Total grains panicle^{-1} of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Figure 5). It can be inferred from the figure that total grains panicle^{-1} increased sharply with increases of herbicidal dose from D_0 to D_3 doses. However, the maximum number of total grains panicle^{-1} (95.63) was found from D_3 which was followed

(792.62 and 89.88, respectively) by D_2 and D_1 and they were statistically similar, whereas the minimum number (87.63) was attained from D_0.

Table 7. Combined effect of different levels of Metsulphuron Methyl and time of application on filled and unfilled grains panicle^{-1}, sterility and weight of 1000-grains of BRRI dhan48 in Aus rice

Treatments	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain sterility (%)	Weight of 1000-grains (g)
D_0T_1	63.07 h	19.27 a	23.43 a	22.75
D_0T_2	70.27 fg	17.40 b	19.91 c	23.25
D_0T_3	75.27 d-f	15.73 c	17.32 e-g	23.80
D_0T_4	73.53 ef	16.00 c	17.86 d-f	23.70
D_1T_1	67.13 gh	18.53 a	21.65 b	23.15
D_1T_2	72.73 e-g	16.27 c	18.28 c-e	24.20
D_1T_3	78.73 b-e	14.47 d-f	15.53 hi	24.60
D_1T_4	77.13 c-e	14.53 d-f	15.86 g-i	24.15
D_2T_1	72.27 e-g	17.40 b	19.43 cd	23.25
D_2T_2	76.27 c-f	15.53 cd	16.92 e-h	24.35
D_2T_3	82.27 a-c	12.73 gh	13.41 jk	24.75
D_2T_4	80.27 a-d	13.73 fg	14.63 ij	24.36
D_3T_1	78.67 b-e	15.27 c-e	16.24 f-i	23.75
D_3T_2	80.27 a-d	14.27 ef	15.12 ij	24.56
D_3T_3	85.27 a	11.93 h	12.30 k	24.86
D_3T_4	83.73 ab	13.13 g	13.57 jk	24.60
Sx	1.940	0.362	0.545	0.662
CV(%)	4.42	4.07	5.56	4.78

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

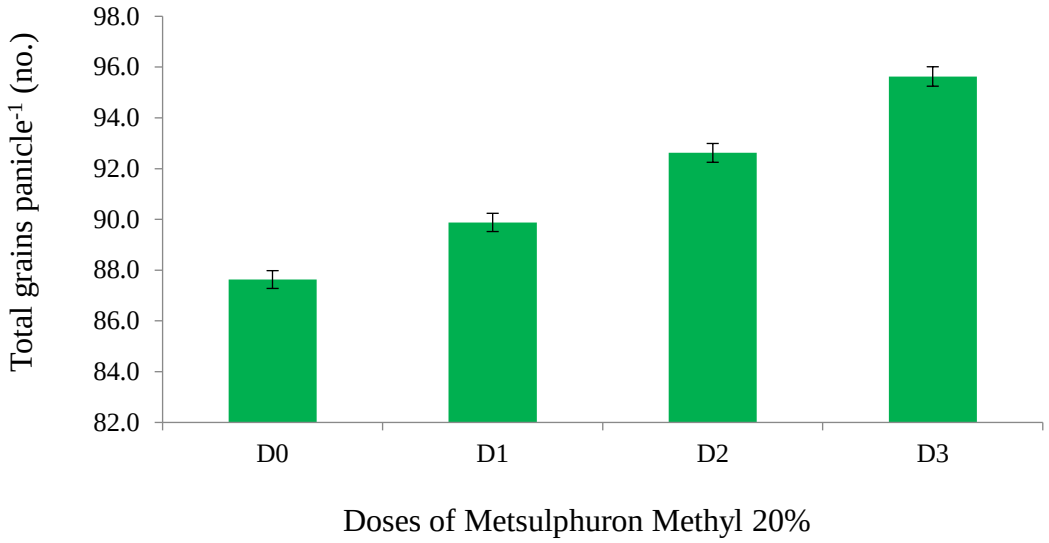
D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

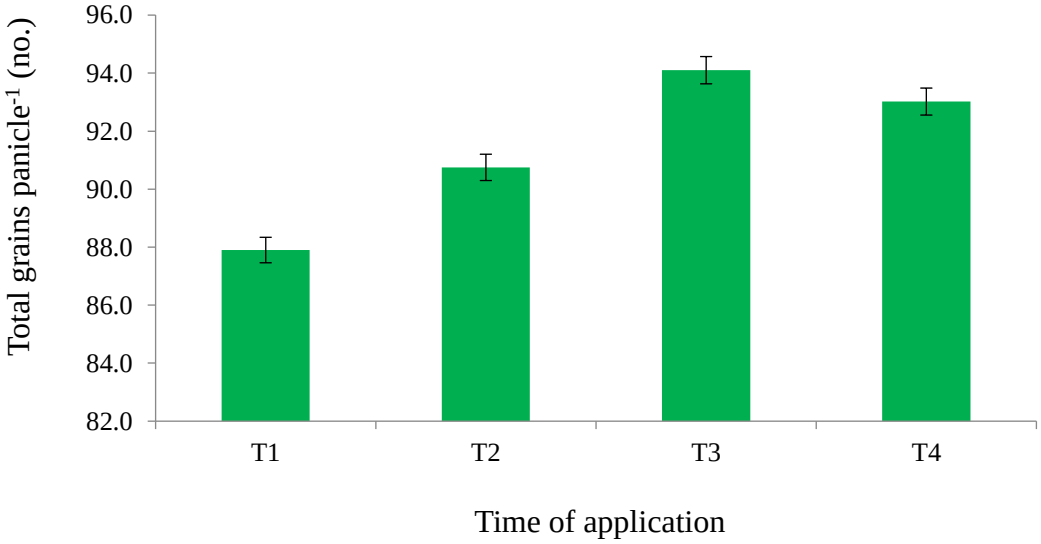
T_3 = Application at 20 DAT

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1} T_4 = Application at 25 DAT



D_0 = Control i.e. no weedicide; D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}
D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}; D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

Figure 5. Effect of doses of Metsulphuron Methyl 20% on total grains $panicle^{-1}$ of BRRI dhan48. Sx = 0.958.



T_1 = Application at 12 DAT; T_2: Application at 15 DAT;
T_3= Application at 20 DAT; T_4: Application at 25 DAT

Figure 6. Effect of time of application of Metsulphuron Methyl 20% on total grains $panicle^{-1}$ of BRRI dhan48. Sx =0.724.

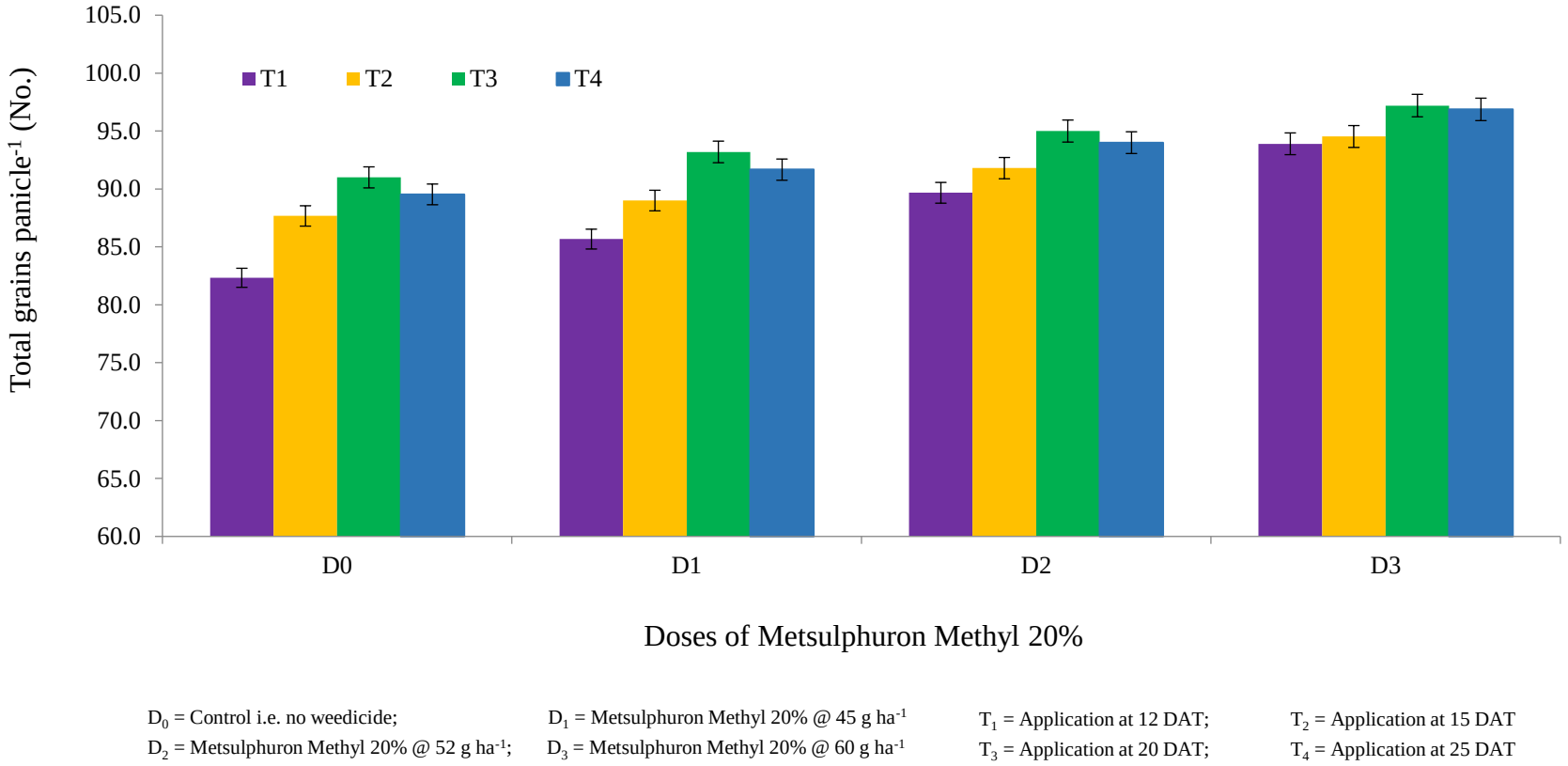
Different time of application showed statistically significant differences in terms of total grains panicle^{-1} of BRRI dhan48 (Figure 6). The figure shows that T_3 time of herbicide application was the best (among the doses) in producing total grains panicle^{-1} in rice. It can also show that the maximum number of total grains panicle^{-1} (94.10) was found from T_3 which was statistically similar (93.02) to T_4 and followed (90.75) by T_2, while the minimum number (87.90) was observed from T_1. Gopinath and Kundu (2008) also reported the similar findings with 4 g ha^{-1} 7 days after sowing.

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of total grains panicle^{-1} of BRRI dhan48 (Figure 7). The indicates that irrespective of herbicidal doses total grains panicle^{-1} increased with the time of application and T_3 application time showed highest total grains panicle^{-1} for all doses. The maximum number of total grains panicle^{-1} (97.20) was found from D_3T_3 and the minimum number (82.33) was observed from D_0T_1 treatment combination.

4.2.9 Sterility

Different doses of Metsulphuron Methyl 20% showed statistically significant differences in terms of grain sterility of BRRI dhan48 (Table 6). The lowest grain sterility (14.31%) was recorded from D_3 which was followed (16.10%) by D_2, while the highest grain sterility (19.63%) was found from D_0 which was followed (17.83%) by D_1.

Grain sterility of BRRI dhan48 showed statistically significant differences due to different time of application (Table 6). The lowest grain sterility (14.64%) was observed from T_3 which was statistically similar (15.48%) to T_4 and followed (17.56%) by T_2, whereas the highest grain sterility (20.19%) was recorded from T_1.



D_0 = Control i.e. no weedicide; D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1} T_1 = Application at 12 DAT; T_2 = Application at 15 DAT

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}; D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1} T_3 = Application at 20 DAT; T_4 = Application at 25 DAT

Figure 7. Combined effect of doses of Metsulphuron Methyl 20% and time of application on total grains $panicle^{-1}$ of BRRI dhan48. Sx = 1.917.

Statistically significant variation was observed due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application in terms of grain sterility of BRRI dhan48 (Table 7). The lowest grain sterility (12.30%) was attained from D_3T_3, while the highest (23.43%) was observed from D_0T_1 treatment combination.

4.2.10 Weight of 1000-grains

Weight of 1000-grains of BRRI dhan48 showed statistically non-significant differences due to different doses of Metsulphuron Methyl 20% (Table 6). Numerically, the highest weight of 1000-grains (24.44 g) was found from D_3 and the lowest weight (23.38 g) was observed from D_0.

Different time of application showed statistically non-significant differences in terms of weight of 1000-grains of BRRI dhan48 (Table 6). However, numerically the highest weight of 1000-grains (24.50 g) was recorded from T_3, while the lowest weight (23.23 g) was observed from T_1.

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of weight of 1000-grains of BRRI dhan48 (Table 7). But numerically, the highest weight of 1000-grains (24.86 g) was found from D_3T_3, whereas the lowest weight (22.75 g) from D_0T_1 treatment combination.

4.2.11 Grain yield

Statistically significant variation was observed in terms of grain yield of BRRI dhan48 due to different doses of Metsulphuron Methyl 20% (Table 8). The data revealed that D_3 doses out yielded over D_0, D_1 and D_2 by producing 43.91, 24.82 and 14.16%, respectively higher yield. The highest grain yield (5.08 t ha^{-1}) was recorded from D_3 which was followed (4.45 t ha^{-1}) by D_2, whereas the lowest grain yield (3.53 t ha^{-1}) was found from D_0 which was followed (4.07 t ha^{-1}) by D_1. Kashid *et al*. (2015) observed that application metsulfuron-methyl +

chlorimuron-ethyl 0.004 kg ha^{-1} as weed control measure in direct-seeded rice gave the highest yield contributing characters and yield of rice.

Table 8. Effect of different levels of Metsulphuron Methyl and time of application on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Doses of Metsulphuron Methyl 20%				
D_0	3.53 d	4.45 d	7.98 d	44.11 c
D_1	4.07 c	4.85 c	8.92 c	45.49 b
D_2	4.45 b	5.19 b	9.64 b	46.08 a
D_3	5.08 a	5.75 a	10.83 a	46.83 a
Sx	0.067	0.070	0.104	0.430
CV(%)	7.39	2.72	3.57	3.66
Time of Application				
T_1	3.55 c	4.42 c	7.97 c	44.48 b
T_2	4.10 b	4.99 b	9.08 b	44.98 b
T_3	4.81 a	5.39 a	10.20 a	47.05 a
T_4	4.66 a	5.45 a	10.11 a	45.99 a
Sx	0.091	0.040	0.096	0.482
CV(%)	5.40	4.81	3.87	3.26

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Different time of application showed statistically significant differences in terms of grain yield of BRRI dhan48 (Table 8). The data presented in table indicated that time treatment T_3 showed its superiority by producing 1.26, 0.71 and 0.15 t ha^{-1} higher yield than T_1, T_2 and T_4 times, respectively. However, T_3 and T_4 time was statistically similar in producing higher yield. The highest grain yield (4.81 t ha^{-1}) was observed from T_3 which was statistically similar (4.66 t ha^{-1}) to T_4 and followed (4.10 t ha^{-1}) by T_2, while the lowest grain yield (3.55 t ha^{-1}) was found from T_1. Saha and Rao (2010) recorded the highest grain yield (4.96 t ha^{-1}) among the tested herbicides, metsulfuron methyl 8 g ha^{-1} applied 10 days after transplanting which was at par with D_0T_2.

Grain yield of BRRI dhan48 varied significantly due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 9). The highest grain yield (5.49 t ha^{-1}) was observed from D_3T_3 which was statistically at par with D_3T_4 and the lowest grain yield (2.85 t ha^{-1}) was found from D_0T_1 treatment combination.

4.2.12 Straw yield

Different doses of Metsulphuron Methyl 20% showed statistically significant differences in terms of straw yield of BRRI dhan48 (Table 8). The highest straw yield (5.75 t ha^{-1}) was found from D_3 which was followed (5.19 t ha^{-1}) by D_2, while the lowest straw yield (4.45 t ha^{-1}) was recorded from D_0 which was followed (4.85 t ha^{-1}) by D_1.

Straw yield of BRRI dhan48 showed statistically significant differences due to different time of application (Table 8). The highest straw yield (5.45 t ha^{-1}) was recorded from T_4 which was statistically similar (5.39 t ha^{-1}) to T_3 and followed (4.99 t ha^{-1}) by T_2 and the lowest straw yield (4.42 t ha^{-1}) was found from T_1.

Table 9. Combined effect of different levels of Metsulphuron Methyl and time of application on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
D_0T_1	2.85 f	3.73 e	6.58 i	43.34 e
D_0T_2	3.23 ef	4.13 e	7.36 h	43.85 de
D_0T_3	4.09 cd	4.96 cd	9.05 ef	45.19 a-e
D_0T_4	3.93 cd	4.99 cd	8.92 fg	44.07 de
D_1T_1	3.27 e	4.00 e	7.27 h	44.93 b-e
D_1T_2	3.94 cd	4.98 cd	8.92 fg	44.17 de
D_1T_3	4.78 b	5.34 bc	10.12 cd	47.26 a-c
D_1T_4	4.27 c	5.09 cd	9.36 ef	45.59 a-e
D_2T_1	3.73 d	4.65 d	8.38 g	44.52 c-e
D_2T_2	4.22 c	5.05 cd	9.27 ef	45.50 a-e
D_2T_3	4.87 b	5.33 bc	10.20 b-d	47.77 ab
D_2T_4	4.97 b	5.72 ab	10.69 bc	46.50 a-d
D_3T_1	4.36 c	5.29 bc	9.65 de	45.15 a-e
D_3T_2	5.00 b	5.78 a	10.78 b	46.38 a-d
D_3T_3	5.49 a	5.94 a	11.43 a	47.97 a
D_3T_4	5.48 a	5.98 a	11.46 a	47.80 ab
Sx	0.133	0.141	0.209	0.859
CV(%)	5.40	4.81	3.87	3.26

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

D_0 = Control i.e. no weedicide

D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}

D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1}

D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}

T_1 = Application at 12 DAT

T_2 = Application at 15 DAT

T_3 = Application at 20 DAT

T_4 = Application at 25 DAT

Statistically significant variation was observed in terms of straw yield of BRRI dhan48 due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 9). The highest straw yield (5.98 t ha^{-1}) was observed from D_3T_4 which was statistically similar with D_3T_3 (5.94 t ha^{-1}), D_3T_2 (5.78 t ha^{-1}) and D_2T_4 (5.72 t ha^{-1}) combinations, whereas the lowest straw yield (3.73 t ha^{-1}) was found from D_0T_1 treatment combination which was statistically at par with D_0T_2 and D_1T_1.

4.2.13 Biological yield

Biological yield of BRRI dhan48 showed statistically significant differences due to different doses of Metsulphuron Methyl 20% (Table 8). The highest biological yield (10.83 t ha^{-1}) was found from D_3 which was followed (9.64 t ha^{-1}) by D_2, whereas the lowest biological yield (7.98 t ha^{-1}) was observed from D_0 which was followed (8.92 t ha^{-1}) by D_1.

Different time of application showed statistically significant differences in terms of biological yield of BRRI dhan48 (Table 8). The highest biological yield (10.20 t ha^{-1}) was recorded from T_3 which was statistically similar (10.11 t ha^{-1}) to T_4 and followed (9.08 t ha^{-1}) by T_2, while the lowest biological yield (7.97 t ha^{-1}) was observed from T_1. Saha and Rao (2010) also recorded similar observation with the application of metsulfuron methyl 8 g ha^{-1} applied 10 days after transplanting.

Combined effect of different doses of Metsulphuron Methyl 20% and time of application varied significantly in terms of biological yield of BRRI dhan48 (Table 9). The highest biological yield (11.46 t ha^{-1}) was found from D_3T_4 which was at par with D_3T_3 combination and the lowest biological yield (6.58 t ha^{-1}) was recorded from D_0T_1 treatment combination.

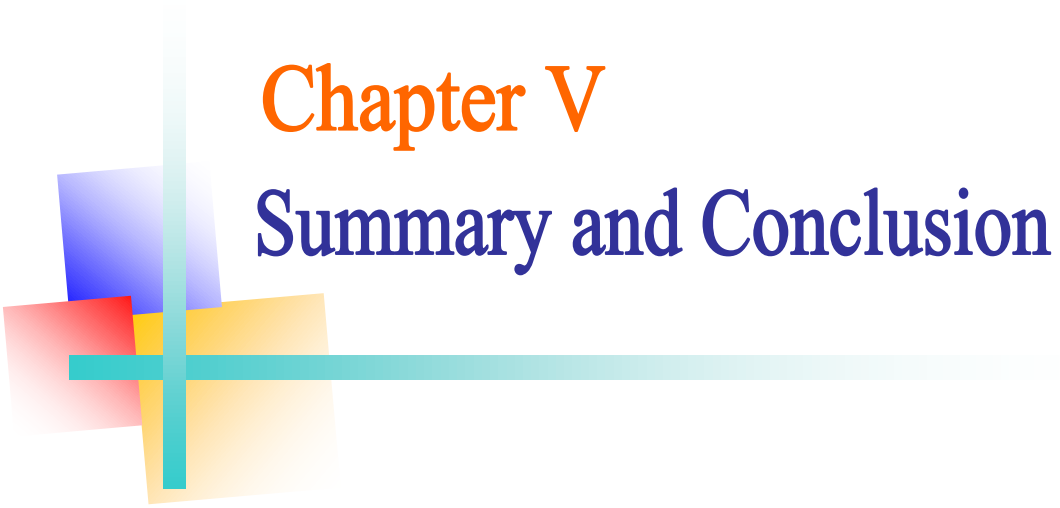
4.2.14 Harvest index

Statistically significant variation was observed in terms of harvest index of BRRI dhan48 due to different doses of Metsulphuron Methyl 20% (Table 8).

The highest harvest index (46.83%) was recorded from D_3 which was statistically similar (46.08%) to D_2 and followed (45.49%) by D_1, while the lowest harvest index (44.11%) was observed from D_0.

Different time of application showed statistically significant differences in terms of harvest index of BRRI dhan48 (Table 8). The highest harvest index (47.05%) was observed from T_3 which was statistically similar (45.99%) to T_4, whereas the lowest harvest index (44.48%) was found from T_1 which was statistically similar (44.98%) to T_2.

Harvest index of BRRI dhan48 varied significantly due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application (Table 9). The highest harvest index (47.97%) was recorded from D_3T_3 which was statistically similar with D_3T_4, D_3T_2, D_3T_1, D_2T_4, D_2T_3, D_2T_2, D_1T_4, D_1T_3 and D_0T_3, while the lowest harvest index (43.34%) was found from D_0T_1 treatment combination which was similar to D_0T_2, D_0T_3, D_0T_4, D_1T_1, D_1T_2, D_1T_4, D_2T_1 and D_2T_2 combination.



Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of March to July, 2018 to assess the weed control efficiency of Metsulfuron Methyl 20% in aus rice. BRRI dhan48 was used as the test crop in this experiment. The experiment consisted of two factors: Factor A: Doses of Metsulphuron Methyl 20% (4 doses) as - D_0 = Control i.e. no weedicide, D_1 = Metsulphuron Methyl 20% @ 45 g ha^{-1}, D_2 = Metsulphuron Methyl 20% @ 52 g ha^{-1} and D_3 = Metsulphuron Methyl 20% @ 60 g ha^{-1}; Factor B: Time of application (4 times) as - T_1 = Application at 12 DAT, T_2 = Application at 15 DAT, T_3 = Application at 20 DAT and T_4 = Application at 25 DAT. The two factors experiment was laid out in split-plot design with three replications. Data were recorded on weed control efficiency, yield contributing characters and yield of BRRI dhan48 and statistically significant variation was observed for different doses of Metsulphuron Methyl 20%, time of application and their combined effect.

The results revealed that there were 18 weed species that were found in the experimental plot. Among them 07 species belongs to Cyperaceae, 03 were Gramineae, 02 were Poaceae, 02 were Pontederiaceae and 01 were the family of Amaranthaceae, Commelinaceae, Commelinaceae and Marsileace, respectively. Weeds that found in the plot were 03 broadleaf, 04 were grass, 04 were herbs and 07 were sedge. 08 weeds were annual and 10 in perennial as life cycle.

Considering the different doses of Metsulphuron Methyl 20%, the highest weed population (14.08 no. m^{-2}) was found from D_0, while the lowest (5.25 no. m^{-2}) from D_3. The highest dry weight (20.30 g m^{-2}) was recorded from D_0 and the lowest dry weight (4.64 g m^{-2}) was found from D_3. The highest weed control efficiency (77.14%) was observed from D_3 and the lowest (23.40%) from D_1.

The longest plant (95.90 cm) was recorded from D_3, while the shortest plant (88.53 cm) from D_0. The maximum number of effective tillers hill^{-1} (11.08) from D_3 and the minimum number (8.82) from D_0. The minimum number of non-effective tillers hill^{-1} (3.50) was found from D_3, whereas the maximum number (4.73) from D_0. The maximum number of total tillers hill^{-1} (14.58) was recorded from D_3, while the minimum number (13.55) from D_0. The longest panicle (21.31 cm) was recorded from D_3, whereas the shortest panicle (18.62 cm) from D_0. The maximum number of filled grains panicle^{-1} (81.98) was found from D_3, while the minimum number (70.53) from D_0. The minimum number of unfilled grains panicle^{-1} (13.65) was observed from D_3 and the maximum number (17.10) from D_0. The maximum number of total grains panicle^{-1} (95.63) was found from D_3, whereas the minimum number (87.63) from D_0. The lowest grain sterility (14.31%) was recorded from D_3, while the highest grain sterility (19.63%) was found from D_0. The highest weight of 1000-grains (24.44 g) was found from D_3 and the lowest weight (23.38 g) from D_0. The highest grain yield (5.08 t ha^{-1}) was recorded from D_3, whereas the lowest grain yield (3.53 t ha^{-1}) was found from D_0. The highest straw yield (5.75 t ha^{-1}) was found from D_3, while the lowest straw yield (4.45 t ha^{-1}) from D_0. The highest biological yield (10.83 t ha^{-1}) was found from D_3, whereas the lowest biological yield (7.98 t ha^{-1}) was observed from D_0. The highest harvest index (46.83%) was recorded from D_3, while the lowest (44.11%) from D_0.

For time of application of herbicide, the highest weed population (12.17 no. m^{-2}) was recorded from T_1, whereas the lowest (6.83 no. m^{-2}) from T_3. The highest dry weight (16.71 g m^{-2}) was found from T_1, while the lowest (5.50 g m^{-2}) from T_3. The highest weed control efficiency (67.09%) was found from T_3 and the lowest (15.56%) from T_2.

The tallest plant (96.11 cm) was observed from T_3, whereas the shortest plant (87.58 cm) from T_1. The maximum number of effective tillers hill^{-1} (11.73) was found from T_3, whereas the minimum number (8.78) from T_1. The minimum

number of non-effective tillers hill^{-1} (3.08) was recorded from T_3, while the maximum number (4.82) from T_1. The maximum number of total tillers hill^{-1} (14.82) was found from T_3, whereas the minimum number (13.60) from T_1. The longest panicle (20.63 cm) was observed from T_3 while the shortest panicle (19.05 cm) from T_1. The maximum number of filled grains panicle^{-1} (80.38) was recorded from T_3, whereas the minimum number (70.28) from T_1. The minimum number of unfilled grains panicle^{-1} (13.72) was found from T_3, whereas the maximum number (17.62) from T_1. The maximum number of total grains panicle^{-1} (94.10) was found from T_3, while the minimum number (87.90) from T_1. The lowest grain sterility (14.64%) was observed from T_3, whereas the highest grain sterility (20.19%) from T_1. The highest weight of 1000-grains (24.50 g) was recorded from T_3, while the lowest weight (23.23 g) from T_1. The highest grain yield (4.81 t ha^{-1}) was observed from T_3, while the lowest grain yield (3.55 t ha^{-1}) from T_1. The highest straw yield (5.45 t ha^{-1}) was recorded from T_4 and the lowest straw yield (4.42 t ha^{-1}) from T_1. The highest biological yield (10.20 t ha^{-1}) was recorded from T_3, while the lowest biological yield (7.97 t ha^{-1}) from T_1. The highest harvest index (47.05%) was observed from T_3, whereas the lowest (44.48%) from T_1.

Due to the combined effect of different doses of Metsulphuron Methyl 20% and time of application, the highest weed population (18.00 no. m^{-2}) was found from D_0T_1, while the lowest (3.67 no. m^{-2}) was recorded from D_3T_3 treatment combination. The highest dry weight (26.50 g m^{-2}) was observed from D_0T_1, whereas the lowest (2.08 g m^{-2}) was attained from D_3T_3 treatment combination. The highest weed control efficiency (92.15%) was observed from D_3T_3 and the lowest (10.57%) from D_0T_2 treatment combination.

The longest plant (99.81 cm) was found from D_3T_3 and the shortest plant (83.63 cm) from D_0T_1 treatment combination. The maximum number of effective tillers hill^{-1} (12.53) was observed from D_3T_3, while the minimum number (7.80) from D_0T_1 treatment combination. The minimum number of non-effective tillers hill^{-1}

(2.60) was found from D_3T_3 and the maximum number (5.67) from D_0T_1 treatment combination. The maximum number of total tillers hill^{-1} (15.13) was found from D_3T_3, while the minimum number (12.93) from D_0T_2 treatment combination. The longest panicle (22.80 cm) was observed from D_3T_3 and the shortest panicle (17.20 cm) from D_0T_1. The maximum number of filled grains panicle^{-1} (85.27) was found from D_3T_3, while the minimum number (63.07) from D_0T_1 treatment combination. The minimum number of unfilled grains panicle^{-1} (11.93) was recorded from D_3T_3, while the maximum number (19.27) from D_0T_1. The maximum number of total grains panicle^{-1} (97.20) was found from D_3T_3 and the minimum number (82.33) from D_0T_1. The lowest grain sterility (12.30%) was attained from D_3T_3, while the highest (23.43%) from D_0T_1 combination. The highest weight of 1000-grains (24.86 g) was found from D_3T_3, whereas the lowest weight (22.75 g) from D_0T_1. The highest grain yield (5.49 t ha^{-1}) was observed from D_3T_3 and the lowest grain yield (2.85 t ha^{-1}) from D_0T_1 treatment combination. The highest straw yield (5.98 t ha^{-1}) was observed from D_3T_4, whereas the lowest straw yield (3.73 t ha^{-1}) from D_0T_1. The highest biological yield (11.46 t ha^{-1}) was found from D_3T_4 and the lowest biological yield (6.58 t ha^{-1}) from D_0T_1 combination. The highest harvest index (47.97%) was recorded from D_3T_3, while the lowest harvest index (43.34%) from D_0T_1 treatment combination.

Conclusion:

It was revealed that Metsulphuron Methyl 20% @ 60 g ha^{-1} and its application at 20 DAT showed best performance when considered the weed control efficiency, yield contributing characters and yield of BRRI dhan48.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. For regional adaptability, such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh;
2. Other management practices may be included for further study, and

3. Other herbicides and weed control methods may be used for further study to specify the specific combination.

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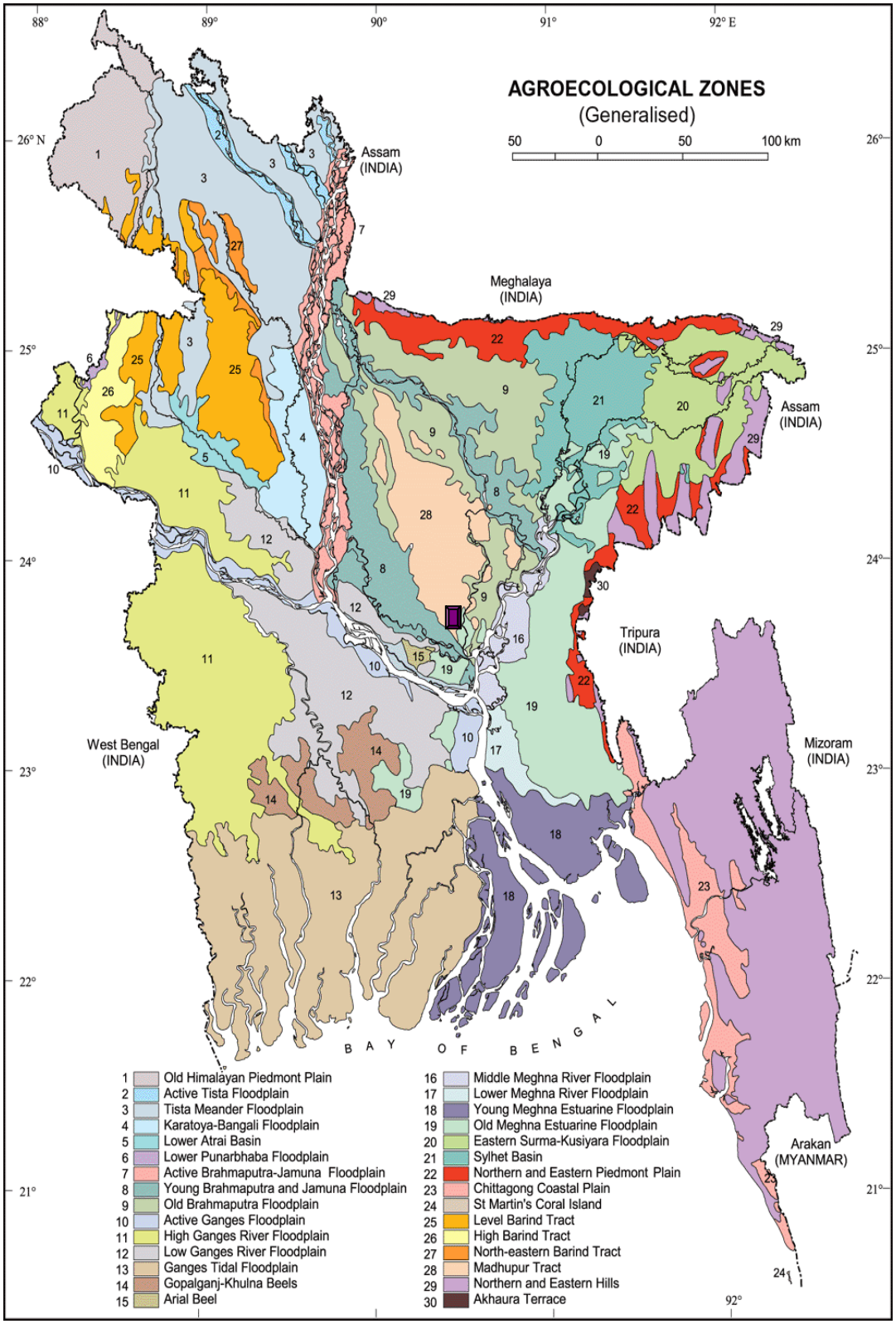
Appendices

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Soil characteristics of experimental field as per the Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	26
% Silt	43
% clay	31
Textural class	Sandy loam
pH	5.9
Catayan exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix III. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from March to July 2018

Month (2018)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
March	28.1	19.5	68	00	6.8
April	33.4	23.2	67	78	6.9
May	34.7	25.9	70	185	7.8
June	32.4	25.5	81	228	5.7
July	35.1	22.4	67	298	5.9

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1212

Appendix IV. Analysis of variance of the data on weed population and dry weight of weeds of BRRI dhan48 in Aus rice as influenced by different levels of Metsulphuron Methyl and time of application

Treatments	Degrees of freedom	Mean square	
		Weed population at 45 DAT (no. m^{-2})	Dry weight of weeds at 45 DAT (g m^{-2})
Replication	2	0.771	0.008
Metsulphuron Methyl (A)	3	58.306**	275.411**
Error I	6	1.910	0.582
Time of Application (B)	3	167.194**	605.743**
Interaction (A×B)	9	2.157**	18.847**
Error II	24	0.625	0.895

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on plant height, effective, non-effective, total tillers hill^{-1} and panicle length of BRRI dhan48 in Aus rice as influenced by different levels of Metsulphuron Methyl and time of application

Treatments	Degrees of freedom	Mean square				
		Plant height (cm)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)	Panicle length (cm)
Replication	2	0.322	0.001	0.011	0.013	0.246
Metsulphuron Methyl (A)	3	148.340**	19.687**	6.972**	3.392**	5.236**
Error I	6	13.917	0.551	0.046	0.291	0.531
Time of Application (B)	3	114.995**	10.810**	3.321**	2.188**	15.472**
Interaction (A×B)	9	36.967*	0.438*	0.130*	0.522*	5.365*
Error II	24	11.748	0.183	0.055	0.197	1.538

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of the data on filled, unfilled and total grains panicle^{-1}, sterility and weight of 1000-grains of BRRI dhan48 in Aus rice as influenced by different levels of Metsulphuron Methyl and time of application

Treatments	Degrees of freedom	Mean square				
		Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Total tillers hill^{-1} (no.)	Sterility (%)	Weight of 1000-grains (g)
Replication	2	9.001	0.277	6.626	0.622	0.975
Metsulphuron Methyl (A)	3	240.961**	36.268**	90.277**	73.345**	3.609
Error I	6	11.357	1.558	6.286	3.148	3.268
Time of Application (B)	3	292.261**	26.228**	143.530**	62.657**	2.474
Interaction (A×B)	9	49.116*	1.049*	36.846*	5.668*	0.057
Error II	24	11.288	0.392	11.020	0.890	1.316

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of the data on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus rice as influenced by different levels of Metsulphuron Methyl and time of application

Treatments	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.032	0.001	0.047	0.621
Metsulphuron Methyl (A)	3	3.948**	2.709**	13.087**	15.503*
Error I	6	0.100	0.019	0.111	2.793
Time of Application (B)	3	5.153**	3.604**	17.368**	15.800**
Interaction (A×B)	9	0.205*	0.138*	0.311*	8.637*
Error II	24	0.053	0.059	0.130	2.213

LIST OF PLATES

Plate 1. a. Field view of the experimental plot at tillering stage

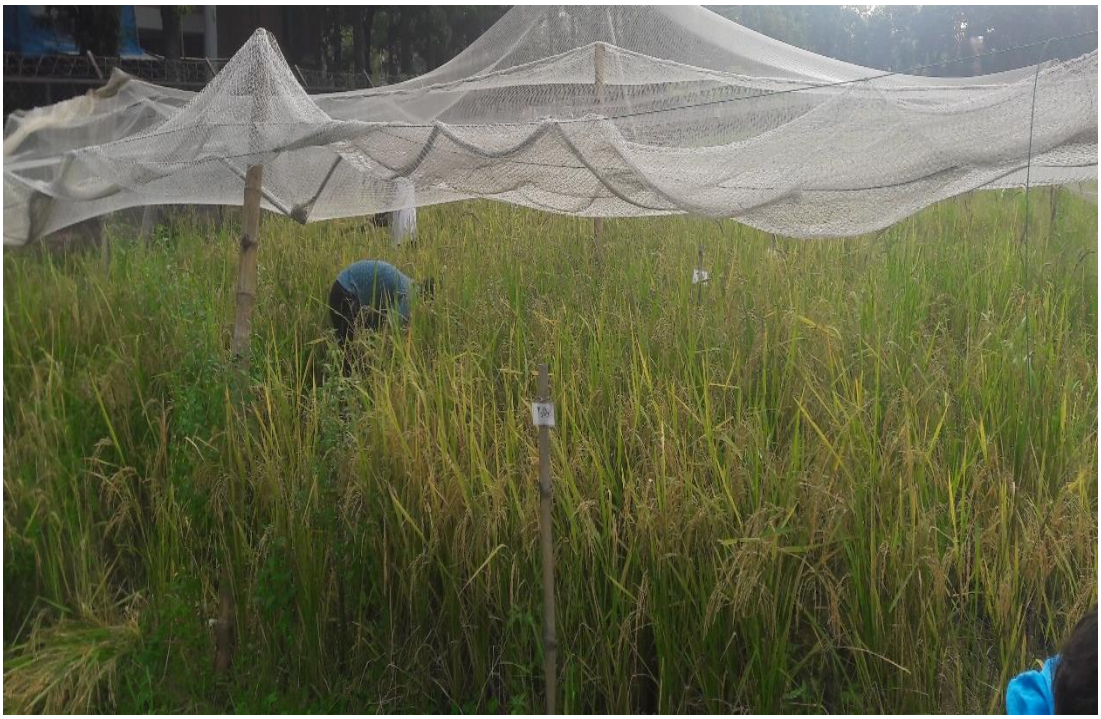


Plate 1. b. Field view of the experimental plot at maturity stage

Arail (*Leersia hexandra*)

Behua (*Cyperus difformis*)

Boro shama (*Echinochloa crussgalli*)

Durba (*Cynodon dactylon*)

Joina (*Fimbristylis miliaceae*)

Kanaibashi (*Commelina benghalensis*)

Malancha (*Alternanthera philoxeroides*)

Mutha (*Cyperus rotundus*)

Pani long (*Ludwigia hyssopifolia*)

Plate 2. Major weeds in the experimental plot