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Performance of Metsulfuron Methyl 10% + Chlorimuron Ethyl 2% WP Against Annual Weed Inhibition in Transplanted Rice

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Abstract: Weed infestation is one of the major threats to crop growth and yield. Weed control is the method of limiting weed infestation so that crops can be grown profitably. Metsulfuron methyl + Chlorimuron ethyl is a new post-emergence herbicide in Bangladesh. Field trials were conducted at Bangladesh Rice Research Institute (BRRI), Gazipur during Aman, 2014 and Boro, 2014-15 to evaluate the efficacy of Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP on weed suppression and performance of transplanted rice. 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. Visual observation indicated that this herbicide possesses high selectivity and not toxic to rice plants. 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, 2014 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.

Keywords: Metsulfuron methyl + Chlorimuron ethyl, transplanted rice, weed density, weed control efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world's population, especially in Bangladesh. Rice is grown in 10.417 million hectares of land with a production of 28.91 million tons [1] in Bangladesh. The average yield of rice in Bangladesh is 4.5 tha^{-1} [2]. Rice production needs to be increased by 50% or more above the current production level to meet the rising food demand [3, 4]. The present nutritional situation of developing countries like Bangladesh is a matter of great concern since the most of the people are suffering from malnutrition [5, 6, 7] and it is great source to nutritional calories, providing 35-80% of total calorie uptake [8]. Weed infestation and interference is a serious problem in rice fields that significantly decreases yield. In Bangladesh weed infestation reduces rice grain yield by 70-80% in Aus rice, 30-40% in transplanted aman rice and 22-36% for modern boro rice cultivars [9, 10]. According to [11, 12] the losses due to infestation of weeds are greater than the combined losses caused by insect, pest and diseases in rice. Weeds not only cause huge reductions in rice yields but also increase cost of cultivation, reduce input efficiency, interfere with agricultural operations, impair quality, act as alternate hosts for several insect pests, diseases, they affect aesthetic look of the ecosystem as well as native biodiversity, affect human and cattle health. Weeds compete for nutrient, space, sunlight and consume the available moisture with crop plant resulting in crop yield reduction. Weed management in rice production is a major constraint and is expensive. Since hand weeding and other weed control methods are difficult, chemicals are the obvious and cost efficient weed control practices [13]. Chemical weed control has become popular in Bangladesh mainly due to scarcity of labour during peak growing season, and lower weeding cost. In Bangladesh the annual consumption of herbicides grew over 3420 metric tons in 2014 [14] compared to only 108 tons during 1986-87 [15], and the growth is almost exponential. In Bangladesh the traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Mechanical and cultural weed control in transplanted rice is an expensive method. Especially at the time of peak period of labor crisis sometimes weeding becomes late causing drastic losses in grain yield. Nowadays use of herbicides is gaining popularity in rice culture due to their rapid effects and less cost involvement compared to traditional methods. Quite a lot of pre and post emergence herbicides such as butachlor, pretilachlor, oxadiazone, pyrazosulfuron ethyl, ethoxysulfuron alone or supplemented with one hand weeding have been found to be useful for weed management in transplanted paddy. Use of single herbicide might be effective for only sedges or only grass or broad leaf weeds. Metsulfuron methyl + Chlorimuron ethyl has been recently developed for selective post emergence control of weeds in rice field. It can effectively control most important annual species of broad leaf weeds, grasses and sedges in transplanted rice. Furthermore such type of herbicide is almost new perception in Bangladesh for control of weeds. So to give farmers a wider choice of effective herbicide there is a need to develop environmental friendly molecules of newer chemistries with different mode of action. The present experiment was, therefore, planned to evaluate the efficacy of Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP for weed suppression, to find out an appropriate dose of the herbicide and its impacts on transplanted rice cultivation.

MATERIALS AND METHODS

The experiments were conducted at the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh situated at $23^0$59´33´´ N and $90^0$24´19´´ E at an elevation of 8.4 m from the mean sea level, and is characterized by sub-tropical climate during Aman, 2014 and Boro, 2014-2015 seasons to evaluate the efficacy of Metsulfuron methyl + Chlorimuronethyl for weed suppression and to find out an appropriate dose of this herbicide by with its impacts on transplanted rice. The soil of the experimental site was non-calcareous dark grey flood plain [16] with pH around 6.2 and low in organic matter (1.2%). The experiment was carried out with six (6) treatments viz. i) T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 15 g ha^{-1} (1.8 g a.i. ha^{-1}), ii) T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 20 g ha^{-1} (2.4 g a.i. ha^{-1}), iii) T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 25 g ha^{-1} (3 g a.i. ha^{-1}), iv) T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1} (12.5 g a.i. ha^{-1}), v) T_5= Weed free by hand weeding and vi) T_6= Control (Unwedded). All treatments were laid out in a randomized complete block design with three replications. Twenty five days of BRRI dhan49 for Aman, 2014 and thirty five days old seedlings of BRRI dhan28 for Boro, 2014-2015 were transplanted at 20 x 20 cm spacing with 2 seedlings $hill^{-1}$. Fertilizer was applied following BRRI recommended dose Aman: N:P:K:S= 69:10:41:11 kg ha^{-1} and Boro; N:P:K:S= 120:19:60:24 kg ha^{-1} [17]. Herbicides were sprayed at 1 to 2 leaf stage of weed (7 DAT in Aman, 2014 and 10 DAT in Boro, 2014-2015) with the help of a knapsack sprayer. In weed free treatment, the plots were kept weed free up to 50 DAT by hand weeding and check herbicide was Pyrazosulfuran ethyl which commercian name is Manage 10 WP. Metsulfuron methyl + Chlorimuron ethyl herbicide is innovative in Bangladesh and its phytotoxicity needs to be evaluated on rice crop. The commercial name of Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP is Almix. The phytotoxicity of the herbicide to rice plants was determined by visual observations (yellowing leaves, burring leaf tips, stunting growth etc). The degree of toxicity on rice plant was measured by the following scale used by [18].

1. No toxicity
2. Slightly toxicity
3. Moderate toxicity
4. Severe toxicity
5. Toxic (plant kill)

The rating of toxicity was done within 7 days after application of herbicides. It was observed three times at 3, 5 and 7 days after application of herbicide and the mean rate was calculated from 10 sample plants of a unit plot.

Data on weed density and dry weight were taken from each plot on 40 DAT. The weeds were identified species-wise. Dry weights of weeds were taken by drying them in electric oven at 60^0 C for 72 hours followed by weighing by digital balance. Relative weed density (RWD), relative weed biomass (RWB) and weed control efficiency (WCE) of different weed control treatments were calculated with the following formulas [19]:

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

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

$$\text{SDR (\%)} = \frac{\text{RWD (\%)} + \text{RWB (\%)}}{2}$$

$$\text{WCE (\%)} = \frac{\text{(Dry weight of weeds in weedy check plots - Dry weight of weeds in treated plots)}}{\text{Dry weight of weeds in weedy check plots}} \times 100$$

Data on panicle m^{-2}, grains panicle^{-1}, sterility and grain yield were collected. Yield attributes data were analyzed with analysis of variance and also graphical presentation by using STAR 2.0.1 software**.**

RESULTS AND DISCUSSION

Phytotoxicity of herbicides on rice plant

The degree of toxicity of the herbicide to rice plants and the symptoms produced on plant are presented in Table 1. It is observed that Metsulfuronmethyl 10% + Chlorimuron ethyl 2% WP @ 15 g ha^{-1} showed no toxicity and Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 20 g ha^{-1} showed very slight yellowing of leaves while Metsulfuron methyl 10% + Chlorimuron ethyl 2% WP @ 25 g ha^{-1}showed temporary yellowing of leaves. It is observed that phytotoxicity symptoms were not more prominent for using this herbicide. Phytotoxicity of rice plant by combined herbicide is less which is similar to the findings of [20].

Table-1: Rating of herbicide toxicity on rice plant under different treatments

Treatments	Rating		Symptom observed in rice field
	Aman,2014	Boro,2014-15	
Metsulfuron Methyl 10% + Chlorimuron Ethyl 2% wp @ 15 gha^{-1} (1.8 g a.i. ha^{-1})	1.11	1.10	No toxicity
Metsulfuron Methyl 10% + Chlorimuron Ethyl 2% wp @ 20 gha^{-1} (2.4 g a.i. ha^{-1})	1.15	1.17	Sometimes slight yellowing of leaves
Metsulfuron Methyl 10% + Chlorimuron Ethyl 2% wp @ 25 gha^{-1} (3 g a.i. ha^{-1})	1.80	1.85	Slight yellowing of leaves which required 5-7 days to recover
Pyrazosulfuran ethyl @125 gha^{-1} (12.5 g a.i. ha^{-1})	1.10	1.12	No toxicity

Weed infestation

Aman season, 2014

In this experiment the rice field was infested with different types of weeds. The relative density of these weed species was also different (Table 2). Seven different weed species were observed in unweeded (control) plot where most dominating weeds were sedges. Among the infesting different categories of weeds, two were grasses, two sedges and three broadleaves. The weed species were belonging to the families of Poaceae, Cyperaceae, Pontederiaceae, Marsileaceae and Sphenocleaceae. The broad leaved were: *Monochoria vaginalis*, *Marsilea minuta* and *Sphenoclea zeylanica*; grasses were: *Echinochloa crus-galli*, *Cynodon dactylon*; and sedges were *Cyperus difformis*and *Scirpus maritimus.* Among the weed species maximum relative weed density (RWD) was observed for *Cyperus difformis* (31.67%) followed by *Echinochloa crus-galli* (29.58%) and similarly highest relative weed biomass (RWB) observed for *Cyperus difformis* (33.64%) followed by *Echinochloa crus-galli* (33.38%). Among the weeds *Sphenoclea zeylanica* was the minor weed with 4.21% RWD and 2.63% RWB. In this study it was also observed that broad leaf were less dominating weed species. Bhuiyan [20] found that efficacy of combined herbicide reduce the weed infestation.

Boro season, 2014-15

The number of infesting weed species was slightly different in Boro season than Aman season. These weed flora were ecologically categorized into two broad leaved species, two sedge and two grasses (Table 3). The major weed was *Cyperus difformis* which relative weed density (RWD) and relative weed biomass (RWB) was 32.94% and 35.68%, respectively. The second top weed was *Echinochloa crus-galli* which RWD was 30.71% and relative weed biomass (RWB) was 33.57%. So in Boro season broad leaf weeds were less dominating than Aman season. Combination of Trisulfuron + Pretilachlor effectively control *Echinochola* and *Cyperus* sp. which found by [21].

Table-2: Weed composition, Relative weed density (RWD) and Relative weed biomass (RWB) in the untreated control plots in Aman season, 2014 at BRRI, Gazipur

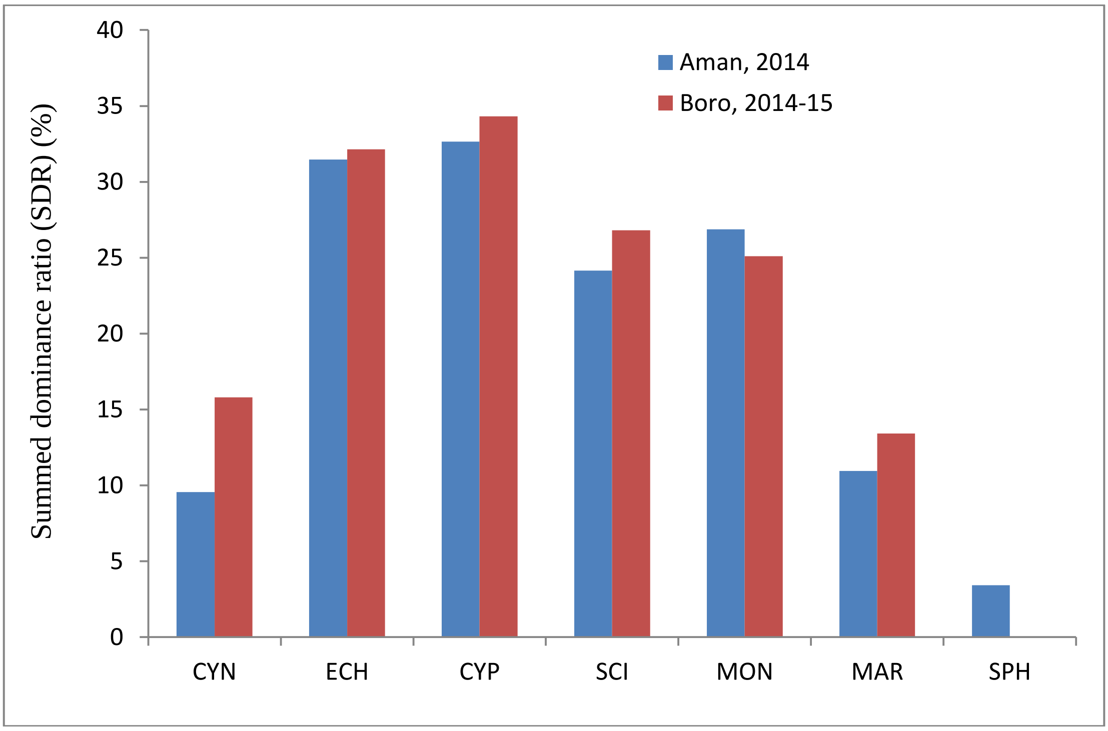
Name of Weed Species	Family	Class	RWD (%)	RWB (%)
Cynodon dactylon	Poaceae	Grass	8.67	10.51
Echinochloa crus-galli	Poaceae	Grass	29.58	33.38
Cyperus difformis	Cyperaceae	Sedge	31.67	33.64
Scirpus maritimus	Cyperaceae	Sedge	23.54	24.79
Monochoria vaginalis	Pontederiaceae	Broad leaf	24.59	29.17
Marsilea minuta	Marsileaceae	Broad leaf	10.47	11.46
Sphenoclea zeylanica	Sphenocleaceae	Broad leaf	4.21	2.63

Table-3: Weed composition, Relative weed density (RWD) and Relative weed biomass (RWB) in the untreated control plots in Boro season, 2014-15 at BRRI, Gazipur

Name of Weed Species	Family	Class	RWD (%)	RWB (%)
Cynodon dactylon	Poaceae	Grass	13.42	18.21
Echinochloa crus-galli	Poaceae	Grass	30.71	33.57
Cyperus difformis	Cyperaceae	Sedge	32.94	35.68
Scirpus maritimus	Cyperaceae	Sedge	27.06	26.54
Monochoria vaginalis	Pontederiaceae	Broad leaf	20.83	29.38
Marsilea minuta	Marsileaceae	Broad leaf	12.59	14.26

Weed ranking

The summed dominance ratio (SDR) is an important pointer of showing ranking of weeds. The most dominant weeds in Aman season, 2014 were *Cyperus difformis*, *Echinochloa crus-galli*, *Scirpus maritimus and Monochoria vaginalis* (Figure 1). *Cyperus difformis*, *Echinochloa crus-galli*, *Scirpus maritimus and Monochoria vaginalis* were also the most dominant weeds in Boro saeson, 2014-15. Mamun [22] showed that SDR of a weed against same herbicide is more or less similar in different seasons.



CYN=*Cynodon dactylon*, ECH= *Echinochloa crus-galli*, CYP=*Cyperus difformis*, SCI=*Scirpus maritimus*, MON= *Monochoria vaginalis*, MAR=*Marsilea minuta*, SPH=*Sphenoclea zeylanica*

Fig-1: Summed dominance ratio (SDR) of infesting weeds

Weed control efficiency (WCE)

Metsulfuron methyl + Chlorimuron ethyl exhibited by lower weed biomass as well as higher weed control efficiency in all the growing seasons. Weed control efficiency improved with increases of herbicide dose irrespective of weed species. Treatment, T_1 controls all the weeds less than 80% whereas T_2, T_3 and T_4 (check) control *Echinochloa crus-galli*, *Cyperus difformis*, *Scripus maritimus* and *Monochoria vaginalis* more than 80% in Aman season (Table 4). The trend of weed control efficiency in Boro, 2014-15 was almost similar as Aman, 2014. All treatment controls most of the weeds more than 80% except T_1. Treatment, $T_{2,}$ T_3 and T_4 controls *Echinochloa crus-galli*, *Cyperus difformis*, *Scripus maritimus* and *Monochoria vaginalis* more than 80% (Table 5). It was evident from the study that the post emergence herbicide Metsulfuron methyl + Chlorimuron ethyl @ 20 g ha^{-1} and 25 g ha^{-1} was effective for controlling weed than other doses of that herbicide. [23] reported that the mixture of herbicides gave 80% control of annual weeds.

Table-4: Effect of Metsulfuron methyl + Chlorimuron ethyl on weed control efficiency in transplanted rice in Aman season, 2014 at BRRI, Gazipur

Name of weeds	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodondactylon	42.95	51.32	52.26	46.89
Echinochloa crus-galli	65.83	82.18	84.06	84.61
Cyperusdifformis	67.42	84.29	85.67	80.45
Scripusmaritimus	73.39	83.45	86.32	80.89
Monochoriavaginalis	70.46	80.71	81.95	80.34
Marsileaminuta	54.10	63.84	69.17	67.10
Sphenocleazeylanica	60.16	75.43	68.74	71.90

T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 15 gha^{-1}, T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1}, T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1} and T_4= Pyrazosulfuran ethyl @ 125gha^{-1}

Table-5: Effect of Metsulfuronmethyl + Chlorimuron ethyl on weed control efficiency in transplanted rice in Boro season, 2014-15 at BRRI, Gazipur

Name of weeds	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodondactylon	39.54	45.39	48.36	50.82
Echinochloa crus-galli	65.73	84.68	85.38	82.18
Cyperusdifformis	71.49	82.65	85.48	84.60
Scripusmaritimus	69.28	83.95	84.62	82.94
Monochoriavaginalis	62.13	80.26	81.53	80.42
Marsileaminuta	48.12	59.76	63.35	57.06

T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 15 gha^{-1}, T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1}, T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1} and T_4= Pyrazosulfuran ethyl @ 125gha^{-1}

Yield and yield attributes

Grain yield is the function of an interaction among various yield components, which are affected differentially by the growing conditions and crop management practices. From Table 6 it was found that all the treatments significantly increased rice grain yield over unweeded control plot. In Aman season, 2014, the highest grain yield (5.18 tha^{-1}) was recorded in the weed free treatment which was statistically similar to treatments T_2 and T_4 producing grain yields of 5.10 and 4.99 tha^{-1}, respectively. Minimum grain yield (3.21 t ha^{-1}) was found in weedy check plots as compared to weed free treatment due to high weed density which resulted less number of panicle m^{-2}, grains panicle^{-1} and high sterility. Treatment wise boxplot of yield attributes in Aman season, 2014 confirm that most of the yield contributing characters are showed similar range in T_2, T_4 (check) and T_5 (weed free) treatments; whereas T_6 was outside of the normal range and its data was also in disperse condition than other treatments due to severe weed infestation (Figure 2).

Similar trend of results was observed during the Boro, 2014-15 where unweeded control (T_6) produced minimum number of panicles m^{-2}, grains panicle^{-1} and high sterility which resulting lowest grain yield (3.37 tha^{-1}). The minimum number of panicles m^{-2} in the control plot was the result of higher competition for nutrient, air space, light and water between crop plants and weeds. Hasanuzzaman [24] reported similar results. Maximum grain yield of 5.81 t ha^{-1} that was recorded with T_2 treatment could be due to lower weed-crop competition at crop growth stages. In Boro season, 2014-15; T_2, T_4 (check) and T_5 (weed free) treatments are in similar range in boxplot of yield attributes (Figure 3). Metsulfuron methyl + Chlorimuron ethyl @ 15, 20, 25 gha^{-1} gave effective control of grass, sedge and broad leaf weeds lead to increased grain yield. Herbicide treatments contributed to higher yield performance compared to control in all the growing seasons [12].

Table-6: Effect of Metsulfuron methyl + Chlorimuron ethyl on yield of transplanted rice at BRRI, Gazipur

Treatments	Panicles m^{-2}		Grains panicle^{-1}		Sterility (%)		Grain yield (t ha^{-1})	
	Aman, 2014	Boro, 2014-15	Aman, 2014	Boro, 2014-15	Aman, 2014	Boro, 2014-15	Aman, 2014	Boro, 2014-15
T_1	224	265	104	115	17.67	16.03	4.87	5.46
T_2	232	283	107	115	16.53	14.67	5.10	5.81
T_3	219	260	97	112	18.03	16.50	4.78	5.11
T_4	237	283	103	114	17.27	15.27	4.99	5.69
T_5	236	287	107	117	16.23	14.60	5.18	5.75
T_6	186	214	78	93	19.77	19.07	3.21	3.37
CV (%)	5.96	3.64	2.69	3.83	4.38	4.07	2.27	2.11
$LSD_{0.05}$	19.12	17.59	4.87	7.76	1.40	1.18	0.19	0.20

T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 15 gha^{-1}, T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1}, T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1} and T_4= Pyrazosulfuran ethyl @ 125gha^{-1} T_5= Weed free and T_6= Unweed (control)

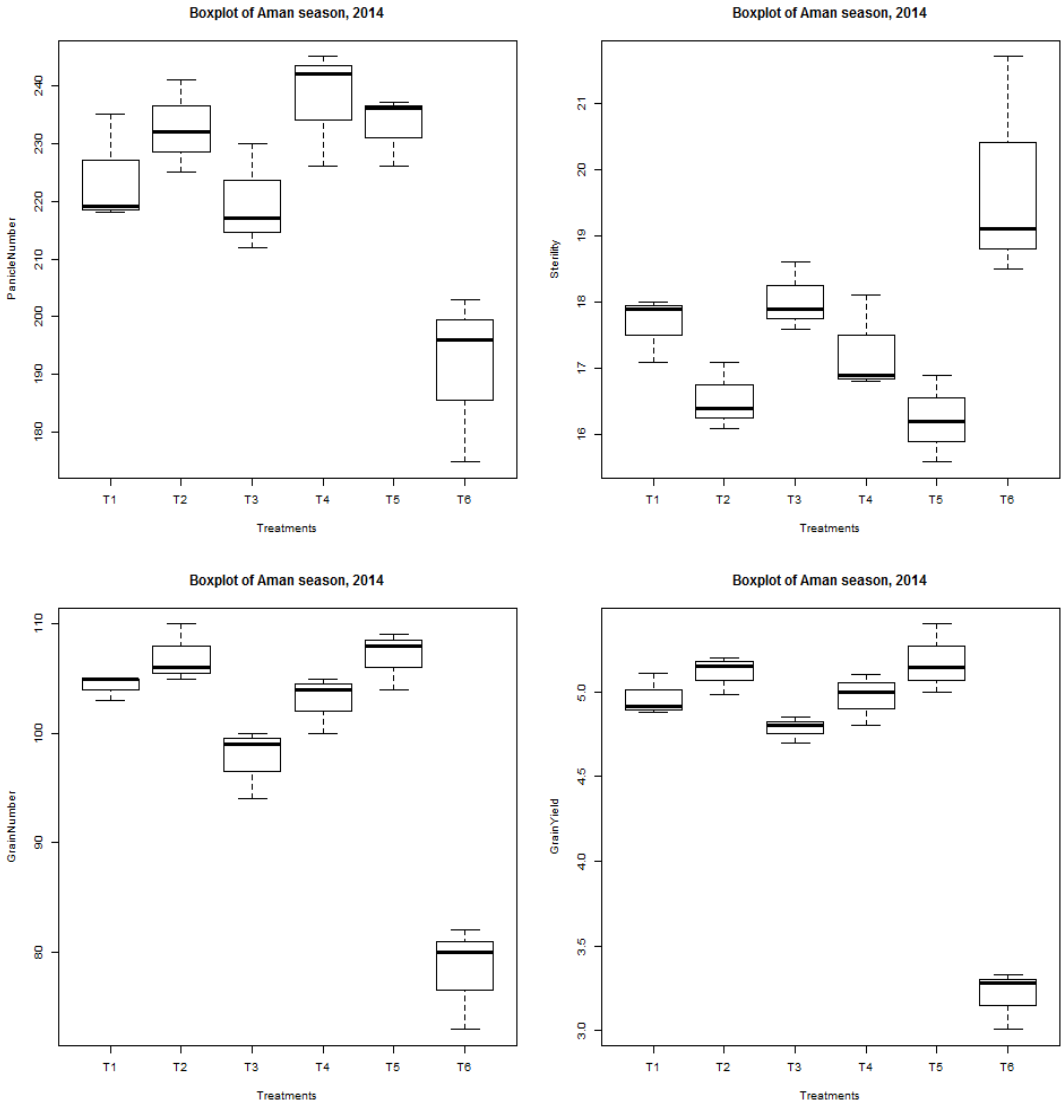


Fig- 2: Boxplot of yield attributes in Aman season, 2014 at BRRI, Gazipur

T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 15 gha^{-1}, T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1}, T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1}, T_4= Pyrazosulfuran ethyl @ 125 gha^{-1} and T_5= Weed free and T_6= Unweed (control)

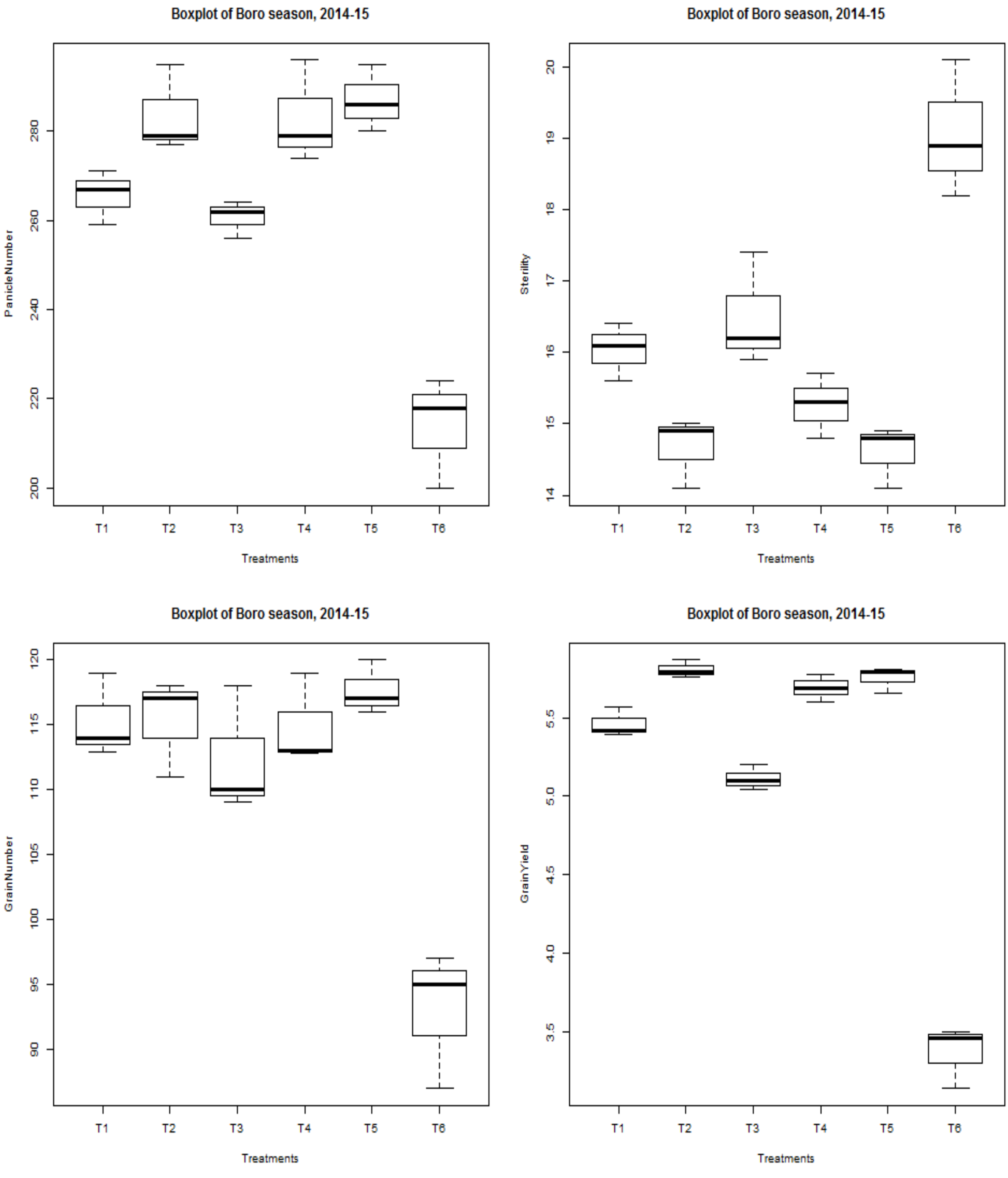


Fig-3: Boxplot of yield attributes in Boro season, 2014-15 at BRRI, Gazipur

T_1= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 15 gha^{-1}, T_2= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1}, T_3= Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1}, T_4= Pyrazosulfuran ethyl @ 125 gha^{-1} and T_5= Weed free and T_6= Unweed (control)

CONCLUSION

Based on the results, yield and yield attributing parameters and weed dynamics were greatly influenced by different weed management practice. Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 25 gha^{-1} showed a good weed control efficiency but slightly phytotoxity found in this dose. So it may be suggested from this experiment that Metsulfuron methyl 10% + Chlorimuron ethyl 2% wp @ 20 gha^{-1} applied at 1 to 2 leaf stage of weed may be used for effective weed control option instead of hand weeding at peak period of labor for less weed infestation in transplanted rice.

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