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SENSITIVITY OF ANNUAL WEEDS AGAINST METOLACHLOR+ BENSULFURON-METHYL HERBICIDE IN TRANSPLANTED RICE

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Abstract

Field trials were conducted at Bangladesh Rice Research Institute (BRRI), Gazipur during *aman*, 2014 and *boro*, 2014-15 to evaluate the efficacy of metolachlor + bensulfuron methyl 20% WP on weed suppression of transplanted rice. Metolachlor + bensulfuron methyl 20% WP @ 150, 190 and 230 g ha^{-1} were applied and pyrazosulfuran ethyl @ 125 g ha^{-1}, weed free and unweeded control were the treatment variables. Visual observations 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 broadleaf in *aman* and two grasses, two sedges and two broadleaf in *boro* season. The most dominant weeds were *Cyperus difformis, Echinochloa crus-galli, Scirpus maritimus and Monochoria vaginalis* in both the growing seasons. Application of metolachlor + bensulfuron methyl 20% WP @ 190 g ha^{-1} was most effective to suppress weeds in both the seasons resulting in increased grain yield more than 40% as compared to unweeded control. Therefore, metolachlor + bensulfuron methyl 20% WP@ 190 g ha^{-1}applied at one to two leaf stage of weed effectively controls the weed infestation in transplanted rice.

Introduction

Rice is a staple food of Bangladesh. About 160 million peoples in Bangladesh depend on rice as main food and about 75 percent of agricultural land use to grow rice. The average yield of rice in Bangladesh is 4.5 t ha^{-1} (BRRI, 2016). Bangladesh needs to feed 215.4 million people in 2050 (Kabir *et al*., 2015). In Bangladesh weed infestation reduces rice grain yield by 70-80% in *aus* rice, 30-40% in transplanted *aman* rice, 22-36% for modern *boro* rice cultivars and 80-82% in direct wet seeded rice (Bhuiyan, 2016; BRRI, 2006; Mamun, 1990). According to Willocquet *et al*., (1998) and Bari, (2010) that Yield losses due to the infestation of weeds are greater than the combined losses caused by insect, and diseases in rice. Weeds not only cause huge reductions in rice yields but also increase the cost of cultivation, reduce input efficiency, interfere with agricultural operations, impair quality, act as alternate hosts for several insect pests, diseases, they affect the aesthetic look of the ecosystem as well as native biodiversity, affect human and cattle health (Bhuiyan *et al*., 2017). Weeds compete for nutrient, space, sunlight and moisture with rice resulting in crop yield loss (Sunyob *et al*., 2015). Weed management in rice production is a major constraint and expensive. Since hand weeding and other weed control methods are labour intensive and complicated, chemicals are the obvious and cost-efficient weed control practices. Chemical weed control has become popular in Bangladesh mainly due to the scarcity of labour during peak growing season, and lower weeding cost. Now a days the use of herbicides is gaining popularity in rice weed control due to their rapid effects and less cost involvement compared to traditional methods of weeding. 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 broadleaf weeds. Metolachlor + bensulfuran methyl has been recently developed for post emergence control of weeds in the rice field. So, there is a need to develop environment friendly molecules of newer chemistries with a different mode of action. The present study was, therefore, planned to evaluate the efficacy of metolachlor + bensulfuran methyl for rice weed suppression and find out an appropriate dose of the herbicide and its impacts on transplanted rice.

Materials and Methods

The experiments were conducted at the Bangladesh Rice Research Institute, Gazipur, 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. The soil of the experimental site was non-calcareous dark grey floodplain with pH around 6.2 and low in organic matter (1.2%). The experiment was carried out with six (6) treatments viz. T_1= Metolachlor + bensulfuran methyl 20% WP@ 150gha^{-1} (7.5 g a.i. ha^{-1}), T_2= Metolachlor + bensulfuran methyl 20% WP @ 190 g ha^{-1}(9.5 g a.i. ha^{-1}), T_3= Metolachlor + bensulfuran methyl 20% WP @ 230 gha^{-1}(11.5 g a.i. ha^{-1}), T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1}(12.5 g a.i. ha^{-1}), T_5= Weed free by hand weeding, and T_6=Control (Unweeded). All treatments were laid out in a randomized complete block design with three replications. Twenty-five days of BRRI dhan49 for *aman*, and thirty-five days old seedlings of BRRI dhan28 for *boro* were transplanted at 20 x 20 cm spacing with 2 seedlings hill^{-1}. Fertilizers were applied as *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} (BRRI, 2013). All herbicides were sprayed at 1 to 2 leaf stage of weed (7 DAT in *aman* and 12DAT in *boro*) with the help of a knapsack sprayer. In weed free treatment, the plots were kept weed free up to 50 DAT by hand weeding. Metolachlor + bensulfuran methyl herbicide is innovative in Bangladesh and its phytotoxicity needs to be evaluated on rice crop. 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 IRRI (1965).

Rating	Visual Symptom	Effect
1	No effect	No toxicity
2	Yellowing leaves	Slightly toxicity
3	Yellowing leaves and stunting	Moderate toxicity
4	Burning leaves and leaf tips	Toxicity
5	Burning plant, plant kill	Highly toxicity

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), The sum dominance ratio (SDR) and weed control efficiency (WCE) of different weed control treatments were calculated with the following formulas (Janiya and Moody, 1989; Rao ,1985):

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

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

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

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

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

Results and Discussion

Phytotoxicity of herbicides on rice plant

The degree of toxicity of the herbicide to rice plants and the symptoms produced on the plant are presented in Table 1. It is observed that metolachlor + Bensulfuran methyl 20% WP@ 150 g ha^{-1} showed no toxicity, and metolachlor + bensulfuran methyl 20% WP@ 190 g ha^{-1} showed slight yellowing of leaves while metolachlor + bensulfuran methyl 20% WP@ 230 g ha^{-1} showed temporary yellowing of leaves. Results showed that phytotoxicity symptoms were not more prominent for using this herbicide. Phytotoxicity of rice plant found by combined herbicide is less which is like the findings of Bhuiyan *et al.* (2010).

Table 1. Rating of herbicide toxicity on rice plant under different treatments in field condition

Treatments	Rating		Symptom observed in rice field
	Aman	Boro	
Metolachlor + bensulfuranmethyl 20% wp @ 150 gha^{-1} (7.5 g a.i. ha^{-1})	1.10	1.10	No toxicity
Metolachlor + bensulfuran methyl 20% wp @ 190 gha^{-1} (9.5 g a.i. ha^{-1})	1.14	1.17	Sometimes slight yellowing of leaves
Metolachlor + bensulfuran methyl 20% wp @ 230 gha^{-1}(11.5 g a.i. ha^{-1})	1.90	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})	1.12	1.10	No toxicity

Weed infestation

Aman season

The experimental field was infested with eight different types of weed species belonging to different families of Poaceae, Cyperaceae, Pontederiaceae, Marsileaceae, Sphenocleaceae and Asteraceae. The relative density of these weed species was also different (Table 2).Among the infesting weeds, twowere grasses, two sedges, and four broadleaf. The weed species belonging to the families of broadleaf were: *Monochoria vaginalis, Marsilea minuta*, *Sphenoclea zeylanica*and *Eclipta alba*; 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* (31.24%) followed by *Echinochloa* *crus-galli* (30.40%) but the highest relative weed biomass (RWB) observed for *E. crus-galli* (33.75%) followed by *C. difformis* (33%). *Eclipta alba*was the minor weed with 3 and 4 RWD and RWB, respectively. It was also observed that broad leaved were less dominating weed species. Priya *et al*., 2017 revealed that application of herbicide combination, bispyribac sodium + metamifop 14% SE at 70 g ha^{-1} recorded significantly lower total weed density and and higher weed control efficiency.

Boro season

The number of infesting weed species was slightly different in *boro* than *aman*. These weed flora were ecologically categorized into two broad leaved species, two sedge and two grasses (Table 3). The major weed was *C. difformis* which (RWD) and (RWB) was 32.50% and 34.07%, respectively. The second top weed was *E. crus-galli* which RWD was 31.48% and (RWB) was 33.76%. So, in *boro*season broadleaf weeds were less dominating than *aman* season. Combination of Trisulfuron + Pretilachlor effectively control *Echinochola* sp. and *Cyperus* sp. which found by Puniya *et al.*, 2007.

Table 2. Weed composition, relative weed density (RWD), and relative weed biomass (RWB) in *aman*, at Gazipur

Name	Family	Type	RWD (%)	RWB (%)
Cynodon dactylon	Poaceae	Grass	7.65	9.63
Echinochloa crus-galli	Poaceae	Grass	30.40	32.75
Cyperus difformis	Cyperaceae	Sedge	31.24	32.45
Scirpus maritimus	Cyperaceae	Sedge	24.76	23.92
Monochoria vaginalis	Pontederiaceae	Broadleaf	22.28	27.29
Marsilea minuta	Marsileaceae	Broadleaf	11.47	12.64
Sphenoclea zeylanica	Sphenocleaceae	Broadleaf	3.81	2.58
Eclipta alba	Asteraceae	Broadleaf	2.84	3.45

Table 3. Weed composition, relative weed density (RWD), and relative weed biomass (RWB) in *boro*, at BRRI, Gazipur

Name	Family	Type	RWD (%)	RWB (%)
Cynodon dactylon	Poaceae	Grass	10.76	9.21
Echinochloa crus-galli	Poaceae	Grass	31.48	33.76
Cyperus difformis	Cyperaceae	Sedge	32.50	34.07
Scirpus maritimus	Cyperaceae	Sedge	28.16	27.63
Monochoria vaginalis	Pontederiaceae	Broadleaf	21.42	26.74
Marsilea minuta	Marsileaceae	Broadleaf	10.90	12.65

Weed ranking

The summed dominance ratio (SDR) is more informative than any single measure in reflecting the contribution of a species in the community. The most dominant weeds in *aman* seasonwere *C. difformis, E. crus-galli, S. maritimus and M. vaginalis* (Fig. 1). *Cyperus difformis, Echinochloa crus-galli, Scirpus maritimus and Monochoria vaginalis* were also the most dominant weeds in *boro* season. Mamun *et al.*, 2011 showed that SDR of a weed against the same herbicide is similar in different seasons.

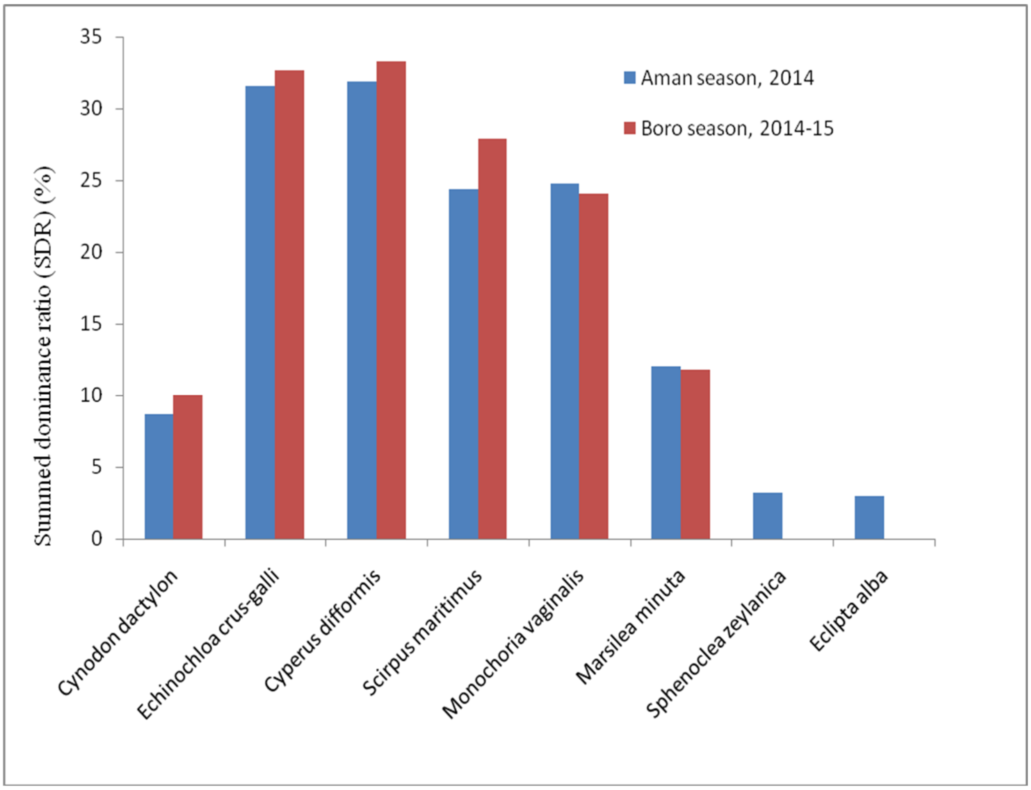

Fig.1. Summed dominance ratio (SDR) of weed species in transplanted rice

Weed control efficiency (WCE)

Lower weed biomass as well as higher weed control efficiency in all the growing seasons exhibited by Metolachlor + bensulfuran methyl. Weed control efficiency improved with increases of herbicide dose irrespective of weed species. Treatment, T_1 controls all the weeds less than 80% due to a lower dose of application, whereas T_2, T_3 and T_4 (check) control *E. crus-galli*, *C. difformis, S. maritimus* and *M. vaginalis* more than 80% in *aman* season (Table 4). The trend of weed control efficiency in Boro, 2014-15 was almost similar to Aman, 2014. Treatment $T_{2,}$ T_3 and T_4controls *E. crus-galli, C. difformis, S. maritimus* and *M. vaginalis* more than 80% (Table 5) in *boro* season. It was evident from the study that the post emergence herbicide Metolachlor + Bensulfuran Methyl @ 190 gha^{-1} and 230 g ha^{-1} was effective for controlling weed than other doses of that herbicide. Lodhi *et al.*, 2017 reported that application of Bensulfuron methyl + Pretilachlor Control weeds more than 80% in transplanted rice in India.

Table 4. Effect of Metolachlor + Bensulfuran methylon weed control efficiency in transplanted rice in *aman* at BRRI, Gazipur

Name of weeds	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodon dactylon	40.54	52.30	51.26	45.80
Echinochloa crus-galli	62.74	81.36	83.25	84.61
Cyperus difformis	68.52	83.20	85.67	81.54
Scripus maritimus	72.49	82.36	86.32	83.72
Monochoria vaginalis	68.43	80.71	80.87	80.59
Marsilea minuta	51.30	62.80	64.38	69.26
Sphenoclea zeylanica	62.14	75.33	68.49	72.65

Eclipta alba	52.62	60.45	62.92	62.75

T_1= Metolachlor + bensulfuran methyl 20% WP @ 150 g ha^{-1}, T_2= Metolachlor + bensulfuran methyl 20% WP @ 190 g ha^{-1}, T_3= Metolachlor + bensulfuran methyl 20% WP @ 230 g ha^{-1} and T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1}

Table 5. Effect of Metolachlor + Bensulfuran Methylon weed control efficiency in transplanted rice in Boro, 2014-15 at BRRI, Gazipur

Name of weeds	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodon dactylon	37.94	46.39	48.36	52.45
Echinochloa crus-galli	66.34	83.68	84.09	83.35
Cyperus difformis	70.45	81.60	85.20	85.60
Scripus maritimus	68.25	83.35	84.25	83.68
Monochoria vaginalis	63.16	80.65	81.85	83.40
Marsilea minuta	45.10	57.70	65.50	59.30

T_1= Metolachlor + bensulfuran Methyl 20% wp @ 150 g ha^{-1}, T_2= Metolachlor + bensulfuran Methyl 20% wp @ 190 g ha^{-1}, T_3= Metolachlor + bensulfuran Methyl 20% wp @ 230 g ha^{-1} and T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1}

Yield and yield attributes

From Table 6 it was found that all the treatments significantly increased rice grain yields over unweeded condition. In *aman* season, the highest grain yield (5.18 t ha^{-1}) was recorded in the weed free treatment which was statistically similar to treatments T_2 and T_4 (5.05 and 4.98 t ha^{-1}, respectively). Minimum grain yield (3.21 t ha^{-1}) was found from BRRI dhan49 in weedy check plots as compared to weed-free treatment due to high weed density which resulted from a smaller number of panicle m^2, grains panicle^{-1} and high sterility. Treatment wise box plot of yield attributes in *aman* season confirm that most of the yield contributing parameters 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 dispersing condition than other treatments due to severe weed infestation (Fig. 2).

The similar trend of results was observed during the *boro* season where unweeded control (T_6) produced the minimum number of panicles m^{-2}, grains panicle^{-1} and high sterility which resulting the lowest (3.37 t ha^{-1}) grain yield of BRRI dhan28. The minimum number of panicles m^{-2} in the control plot was the result of higher competition for nutrient, space, light and water between crop plants and weeds. Maximum grain yield of 5.71 t ha^{-1} that was recorded with T_2treatment could be due to lower weed-crop competition at crop growth stages. In Boro season, T_2, T_4 (check) and T_5 (weed-free) treatments are in similar range in boxplot of yield attributes (Fig. 3). Metolachlor + bensulfuran methyl @ 150, 190, 230 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 (Bari, 2010).

Table 6. Effect of Metolachlor + bensulfuran methyl on the yield attributes and yield of transplanted rice at BRRI, Gazipur

Treatments	Panicles m^{-2}		Grains panicle^{-1}		Sterility (%)		Grain yield (t ha^{-1})	
	BRRI dhan49	BRRI dhan28	BRRI dhan49	BRRI dhan28	BRRI dhan49	BRRI dhan28	BRRI dhan49	BRRI dhan28
T_1	222	264	105	114	17.43	16.03	4.93	5.44
T_2	228	281	105	114	16.60	14.87	5.05	5.71
T_3	216	258	98	111	18.13	16.33	4.72	5.07
T_4	237	283	103	114	17.27	15.27	4.98	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 (%)	8.57	3.12	3.08	4.57	4.24	4.20	2.73	2.45
LSD (0.05)	11.08	14.99	5.57	9.21	1.45	1.22	0.23	0.23

T_1= Metolachlor + Bensulfuran Methyl 20% wp @ 150 gha^{-1}, T_2= Metolachlor + Bensulfuran Methyl 20% wp @ 190 gha^{-1}, T_3= Metolachlor + Bensulfuran Methyl 20% wp @ 230 gha^{-1}, T_4= Pyrazosulfuran ethyl @ 125gha^{-1}, T_5= Weed free and T_6= Unweeded (control)

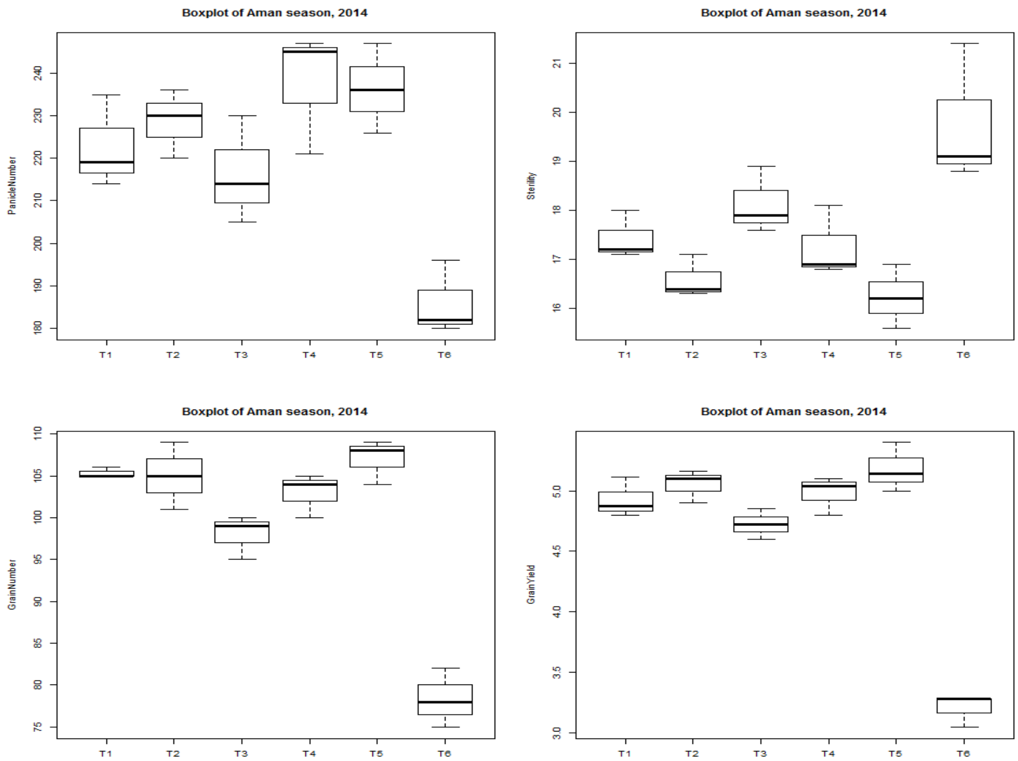

Fig. 2. Box plot of yield attributes in BRRI dhan49 at BRRI, Gazipur

T_1= Metolachlor + Bensulfuran Methyl 20% wp @ 150 g ha^{-1}, T_2= Metolachlor + Bensulfuran Methyl 20% wp @ 190 g ha^{-1}, T_3= Metolachlor + Bensulfuran Methyl 20% wp @ 230 g ha^{-1}, T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1}, T_5= Weed free and T_6= Unweed (control)

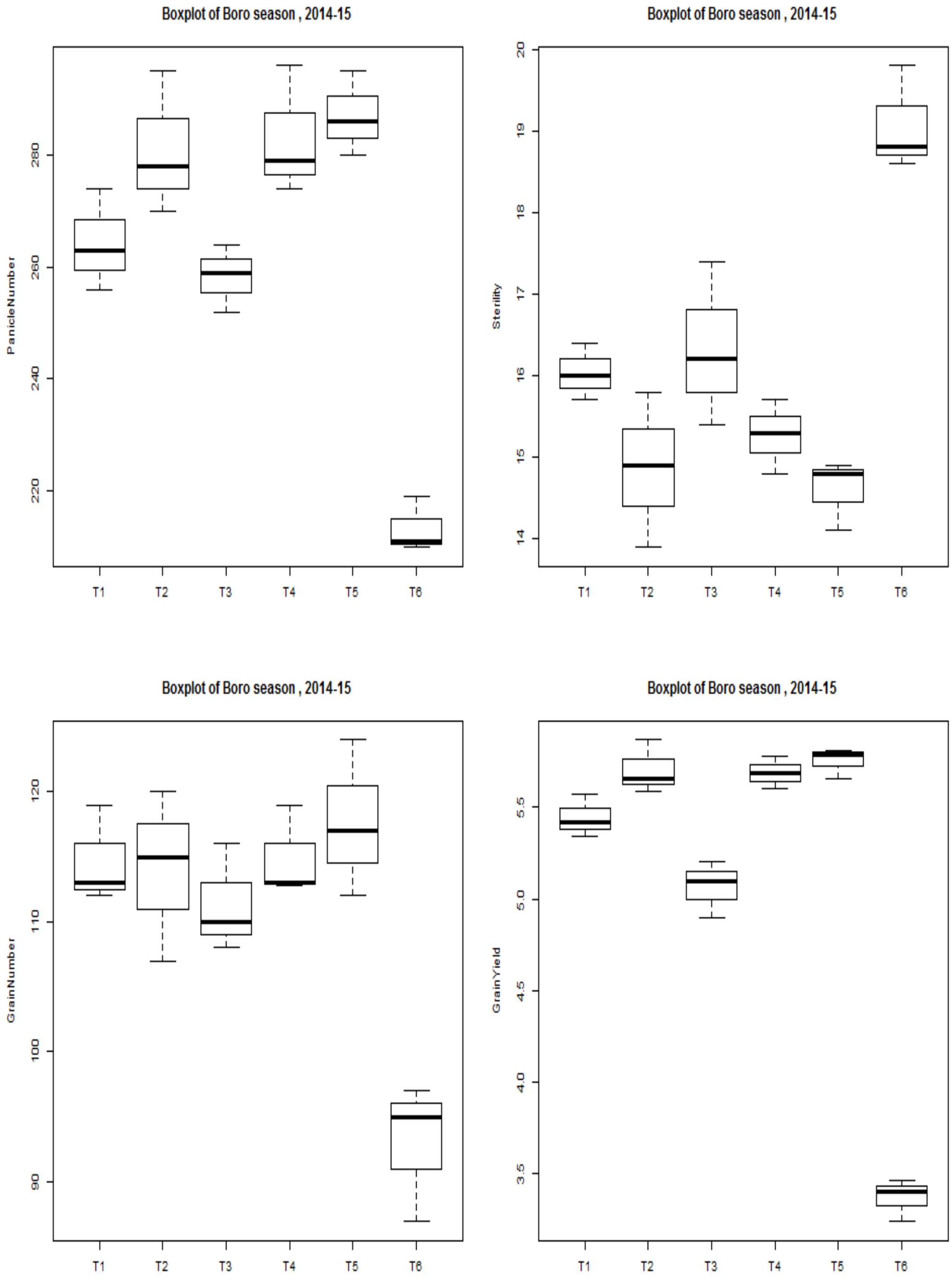

Fig. 3. Box plot of yield attributes in BRRI dhan28 at BRRI, Gazipur

T_1= Metolachlor + Bensulfuran Methyl 20% wp @ 150 g ha^{-1}, T_2= Metolachlor + Bensulfuran Methyl 20% wp @ 190 g ha^{-1}, T_3= Metolachlor + Bensulfuran Methyl 20% wp @ 230 g ha^{-1}, T_4= Pyrazosulfuran ethyl @ 125 g ha^{-1}, T_5= Weed free and T_6= Unweed (control)

Conclusion

Results reveal that yield and yield attributes, and weed dynamics were greatly influenced by different weed management practices. Metolachlor + bensulfuran methyl 20% WP @ 230 g ha^{-1} showed better weed control efficiency although it has slight phytotoxicity. On the other hand, Metolachlor + Bensulfuran methyl 20% WP @ 190 g ha^{-1} applied at 1 to 2 leaf stage would be more effective for controlling annual weeds in transplanted rice.

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