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Sensitivity of Annual Weeds against Sulfentrazone 48 SC herbicide in Rice Cultivation

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ABSTRACT

Herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low cost involvement in comparison to the traditional methods of hand weeding. Sulfentrazoneis a new pre-planting 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 Sulfentrazone 48 SC on weed suppression and performance of transplanted rice. Treatments were Sulfentrazone 48 SC @ 150, 200 and 250 ml ha^{-1}, pretilachlor 500 EC @ 1000 ml ha^{-1}, weed free and unweeded control. Visual assessment 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 four broadleaves in Aman 2014 and two grasses, two sedge and two broadleaves 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 Sulfentrazone 48 SC @ 200 ml ha^{-1} was most effective to suppress weed density and dry masses in both the seasons resulting increased grain yield more than 50% as compared to unweeded control. Therefore, Sulfentrazone 48 SC @ 200 ml ha^{-1} should apply two or three days before plantingfor effectively control weeds in rice.

Key words: Sulfentrazone, transplanted rice, weed density, weed control efficiency

INTRODUCTION

Among the cereals, rice (*Oryza sativa* L.) is the most important and extensively grown in tropical and subtropical regions of the world, and staple food for more than 60 per cent of the world population. The average yield of rice in Bangladesh is 4.5 t ha^{-1} (BRRI, 2016). Rice production needs to be increased by 50% or more above the current production level to meet the rising food demand (Sunyob *et al*., 2015). Weed infestation and interference is a serious problem in rice fields that significantly decreases yield of rice. In Bangladesh weed infestation reduces rice grain yield by 70-80% in Aus, 30-40% in transplanted Aman and 22-36% in modern Boro rice cultivars (BRRI, 2006; Mamun, 1990). Losses due to infestation of weeds are greater than the combined losses caused by insect, pest and diseases in rice (Willocquet *et al*., 1998 and Bari, 2010). 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, human and cattle health. Weed competes for nutrient, space, sunlight and consume the available moisture with crop plant resulting in crop yield reduction (Sunyob *et al*., 2015). Weed infestation in rice cultivation is a major constraint and expensive as well. Since hand weeding including all other weed controlling methods still are not easy so that uses of chemicals are the obvious and cost efficient (Jayadeva, 2010). Now-a-days chemical control of weed has become popular in Bangladesh due to scarcity of labour during peak growing season, and lower cost involvement. In Bangladesh, the annual consumption of herbicides grew over 3,420 metric tons in 2014 (BCPA, 2016) compared to only 108 metric tons during 1986-87 (BBS, 1991), and the growth is almost

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exponential. The traditional methods of weed control practices in Bangladesh are 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 peak period of labour crisis sometimes weeding becomes late resulting drastic yield loss. Abundant use of pre and post emergence herbicides such as butachlor, pretilachlor, oxadiazone, pyrazosulfuron ethyl, ethoxysulfuron alone or supplemented with one hand weeding found effective for weed management in transplanted rice (Bhuiyan, 2016). Sulfentrazone has been recently released for pre planting weed control in rice field in Bangladesh. It belongs to Triazolinones chemical group. Mode of action is the destruction of cell membranes by inhibiting the enzyme Protox and consequently the destruction of cell membranes. The chemical formula of sulfentrazone is 4′-dichloro-5′-(4-difluoromethyl-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl) methane sulfonanilide; N-[2,4-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl] phenyl] methane sulfonamide. It is a selective herbicide, absorbed mainly by the shoots of germinating plants. It can effectively control most important perennial and annual species of Broadleaf weeds, grasses and sedges in transplanted rice. Furthermore this type of herbicide is almost new adding up in Bangladesh for control of weeds before planting. Therefore, to provide a wider choice of effective herbicide for farmers there is a crucial need to develop environmental friendly molecules of newer chemistries with different mode of action. Considering the situation, the present study was undertaken to evaluate the efficacy of sulfentrazone for annual weed suppression and to find out an appropriate dose and its impacts on transplanted rice.

MATERIALS AND METHODS

The experiment wasconducted at Bangladesh Rice Research Institute, Gazipur, situated at 23°59´33´´ N and 90°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 sulfentrazone for weed suppression and to find out an appropriate dose of this herbicide and its impacts on transplanted rice. The commercial name of sulfentrazone is Authority 48 SC. The soil of the experimental field was non-calcareous dark grey flood plain (FAO, 2004) with pH around 6.2 and low in organic matter (1.2%). The experiment was carried out with six treatments. Table 1 presents details of experimental treatments and table 2 presents details of herbicides. All treatments were laid out in a randomized complete block design with three replications. Twenty-five-day-old seedlings of BRRI dhan49 for T. Aman 2014 and 35-day-old seedlings of BRRI dhan28 for Boro 2014-2015 were transplanted. Two/three seedlings per hill were transplanted maintaining 20 × 20 cm spacing. The field was fertilized following BRRI recommendation (T. 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). Herbicides were sprayed three days before transplanting with the help of a knapsack sprayer. In weed free treatment, the plots were kept weed free up to 45 DAT by hand weeding and check herbicide was Pretilachlor (commercial name is Rifit 500 EC). Authority 48 SC (Sulfentrazone) herbicide is new in Bangladesh and its phytotoxicity needs to be evaluated on rice crop. The phytotoxicity of the herbicide onrice 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	Symptom
1	No toxicity
2	Slightly toxicity
3	Moderate toxicity
4	Severe toxicity
5	Toxic (plant killed)

Table 1. Weed management treatments of the experimental plots.

Label	Treatment	Rate of application	Application time of herbicide / Operation of hand weeding
T_1	Authority 48 SC (Sulfentrazone) + 1 HW on 45 DAT	150 ml ha^{-1}	3 days before transplanting
T_2	Authority 48 SC (Sulfentrazone) + 1 HW on 45 DAT	200 ml ha^{-1}	3 days before transplanting
T_3	Authority 48 SC (Sulfentrazone) + 1 HW on 45 DAT	250 ml ha^{-1}	3 days before transplanting
T_4	Rifit 500 EC (Pretilachlor)	1000 ml ha^{-1}	3 days after transplanting
T_5	Weed free by three hand weeding	-	15, 30 and 45 days after transplanting
T_6	Unweeded (Control)	-	No weeding

DAT= Days after transplanting.

Table 2. Details of herbicide.

Trade name	Active ingredients (a. i.) rate	Name of active ingredient	Chemical name	Chemical family
Authority 48 SC	75 ml ai ha^{-1}	Sulfentrazone	2′, 4′-dichloro-5′-(4-difluoromethy l-4, 5-dihydro-3-methyl-5-oxo-1H-1, 2, 4-triazol-1-yl) methane sulfonanilide; N-[2, 4-dichloro-5-[4-(difluoromethyl)-4, 5-dihydro-3-methy l-5-oxo-1H-1, 2, 4-triazol-1-yl]phenyl] methane sulfonamide	Triazolinones
Authority 48 SC	96 ml ai ha^{-1}	Sulfentrazone	do	do
Authority 48 SC	120 ml ai ha^{-1}	Sulfentrazone	do	do
Rifit 500 EC	500 ml ai ha^{-1}	Pretilachlor	2-chloro-2′,6′-diethyl-N-(2-propoxyethyl) acetanilide	Chloroacetamide

The rating of toxicity was done within 15 days after application of herbicides. It was observed four times- at 6, 9, 12 and 15 days after application 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°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 (Tabib *et al.*, 2013 and 2014):

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

$$\text{RWD (\%)} = \frac{\text{RWD (\%)} + \text{RWB (\%)}}{2} \times 100$$

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

Data on panicle m^{-2}, grains $panicle^{-1}$, 1000 grain weight (TGW), sterility (%) and grain yield were collected according to the standard protocol. Analysis of Variance of the measured parameters were analyzed and graphical presentation were done by using STAR 2.0.1 software.

RESULTS AND DISCUSSION

Phytotoxicity of herbicides on rice plant

Table 3 presents the degree of toxicity of the herbicide to rice plants and the symptoms produced on plant are. It is observed that Authority 48 SC @ 150 ml ha^{-1} showed no toxicity and Authority 48 SC @ 200 ml ha^{-1} showed very slight yellowing of leaves while Authority 48 SC @ 250 ml ha^{-1} showed moderate yellowing of leaves. Phytotoxicity symptoms observed not more prominent for using this herbicide. Phytotoxicity of rice plant by combined herbicide resulted less which is similar to the findings of Bhuiyan *et al*., 2010.

Weed infestation during T. Aman season 2014

The rice field was infested with different types of weeds. The relative density of these weed species was also dissimilar (Table 4). Eight different weeds species were observed in unweeded (control) plot where most dominating weeds were sedges and broadleaves. Among the infestation of different categories of weeds, two were grasses, two sedges and four broadleaves. The weed species were belonged to the families of Poaceae, Cyperaceae, Pontederiaceae, Marsileaceae, Sphenocleaceae and Asteraceae. The broadleaf weeds 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%). However, highest relative weed biomass (RWB) was observed for *Echinochloa*

Table 3. Rating of herbicide toxicity on rice plant under different treatments.

Treatment	Rating		Symptom
	Boro 2014-15	T. Aman 2015	
Authority 48 SC @ 150 ml ha^{-1} (72 ml a.i. ha^{-1})	1.10	1.10	No toxicity
Authority 48 SC @ 200 ml ha^{-1} (96 ml a.i. ha^{-1})	1.20	1.17	Sometimes slight yellowing of leaves
Authority 48 SC @ 250 ml ha^{-1} (120 ml a.i. ha^{-1})	2.10	2.10	Slight yellowing of leaves which required 5-7 days to recover
Rifit 500 EC @ 1000 ml ha^{-1} (500 ml a.i. ha^{-1})	1.10	1.15	No toxicity

Table 4. Weed composition, relative weed density (RWD) and relative weed biomass (RWB) in the untreated control plots in Aman 2014 at BRRI, Gazipur.

Weed species	Family	Class	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

crus-galli (32.75%) followed by *Cyperus difformis* (32.45%). Among the weeds, *Eclipta alba* was minor weed with 2.84% RWD and 3.45% RWB. It was observed that broadleaf weeds were less dominating species. Bhuiyan (2016) explained that efficacy and weed infestation of rice plant depends on different types of herbicides used.

Weed infestation during Boro season 2014-15

The number of infesting weed species was slightly different in Boro season than in T. Aman season. These weed flora were ecologically categorized into two broadleaves, two sedges and two grasses (Table 5). The major weed was *Cyperus difformis* of which relative weed density (RWD) and relative weed biomass (RWB) was 32.50% and 34.07%, respectively. The second dominant weed was *Echinochloa crus-galli* of which RWD was 31.48% and relative weed biomass (RWB) was 33.76%. In Boro season broadleaf weeds created less dominance than in T. Aman season. Authority 48 SC effectively control *Echinochola* and *Cyperus* sp. which was similar to the findings of Puniya *et al.*, 2007.

Weed ranking

The summed dominance ratio (SDR) is an important indicatorto showthe ranking of weeds in a community. The most dominant weeds in T. Aman 2014 were *Cyperus difformis, Echinochloa crus-galli, Scirpus maritimus* and *Monochoria vaginalis* (Fig. 1). *Cyperus difformis, Echinochloa crus-galli, Scirpus maritimus* and *Monochoria vaginalis* were also the most dominant weeds in Boro 2014-15. Mamun *et al.*, 2011 showed that SDR of a weed against same herbicide was almost similar in different seasons.

Table 5. Weed composition, relative weed density (RWD) and relative weed biomass (RWB) in the untreated control plots in Boro 2014-15 at BRRI, Gazipur.

Weed species	Family	Class	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

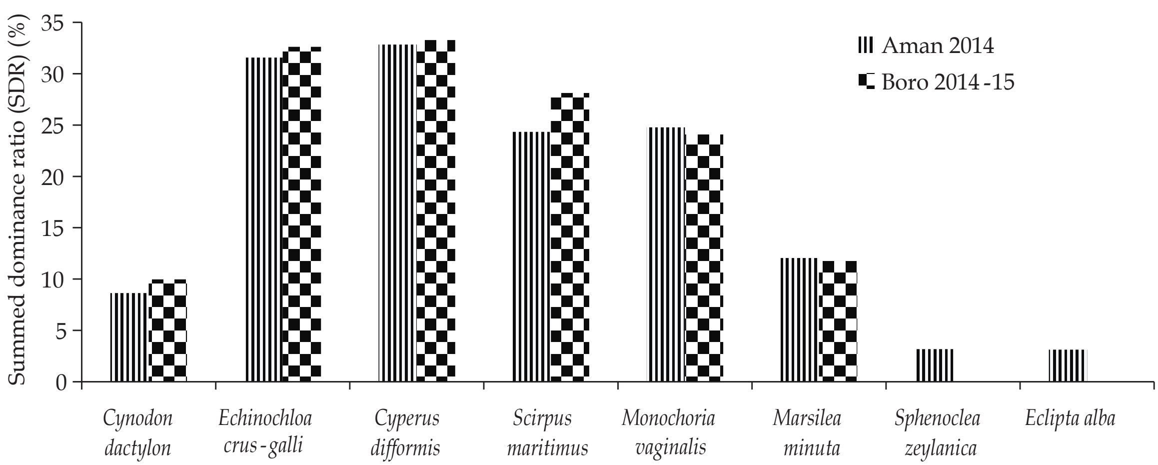


Fig. 1. Summed dominance ratio (SDR) of infesting weeds in transplanted rice.

Weed control efficiency (WCE)

Lower weed biomass as well as higher weed control efficiency was observed in all the growing seasons through Authority 48 SC. Weed control efficiency improved with the increases of herbicide dose irrespective of weed species. Treatment T_1 did not control all the weeds effectively (<80%) due to lower dose of application, whereas T_2, T_3 and T_4 control *Echinochloa crus-galli, Cyperus difformis, Scripus maritimus* and *Marsilea minuta* more than 80% in T. Aman season (Table 6). The trend of weed control efficiency in Boro 2014-15 was almost similar to T. Aman 2014 season. All the treatments controlled most of the weeds more than 80% except T_1. Treatments T_2, T_3 and T_4 controlled *Echinochloa crus-galli, Cyperus difformis, Scripus maritimus* and *Marsilea minuta* more than 80% (Table 7). It was evident from the study that pre planting herbicide Authority 48 SC @ 200 ml ha^{-1} and 250 ml ha^{-1} found effective for controlling weeds than other doses of that herbicide. Bhuiyan *et al*., 2017 reported that different groups of herbicides controlled more than 80% of weeds in different nitrogen management practices in hybrid rice.

Yield and yield attributes

Grain yield is the function of an interaction among various yield components, which were affected differentially by the growing conditions and crop management practices. All the treatments significantly increased rice grain yield over unweeded (control) plot (Table 8). In T. Aman 2014, the highest grain yield (5.22 t ha^{-1}) was recorded in T_2 treatment which was statistically similar to the treatments of T_4 and T_5 that produced 4.98 and 5.18 T ha^{-1} grain yield respectively. Minimum grain yield

Table 6. Effect of Authority 48 SC on weed control efficiency in transplanted rice in Aman 2014 at BRRI, Gazipur.

Weed	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodon dactylon	36.75	49.50	53.20	45.80
Echinochloa crus-galli	63.45	80.95	84.50	84.61
Cyperus difformis	70.25	82.60	83.65	81.54
Scripus maritimus	71.90	84.30	87.20	83.72
Monochoria vaginalis	65.45	74.65	78.70	80.59
Marsilea minuta	56.00	80.75	82.45	82.26
Sphenoclea zeylanica	52.40	73.55	78.90	72.65
Eclipta alba	54.20	63.50	66.90	62.75

T_1= Authority 48 SC @ 150 ml ha^{-1}, T_2= Authority 48 SC @ 200 ml ha^{-1}, T_3= Authority 48 SC @ 250 ml ha^{-1} and T_4= Pretilachlor @ 1000 ml ha^{-1}.

Table 7. Effect of Authority 48 SC on weed control efficiency in transplanted rice in Boro, 2014-15 at BRRI, Gazipur.

Weed	Weed control efficiency (%)			
	T_1	T_2	T_3	T_4
Cynodon dactylon	38.40	49.90	50.36	52.45
Echinochloa crus-galli	61.35	82.60	86.90	83.35
Cyperus difformis	72.40	82.15	85.60	85.60
Scripus maritimus	66.50	81.30	85.35	83.68
Monochoria vaginalis	60.05	75.80	78.20	83.40
Marsilea minuta	55.60	80.45	84.10	83.50

Table 8. Effect of Authority 48 SC on yield attributes of transplanted rice at BRRI, Gazipur.

Treatment	Panicle m^{-2}		Grain $panicle^{-1}$		Sterility (%)		TGW (g)		Grain yield (t ha^{-1})	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
T_1	226	261	17.70	16.87	105	112	21.86	25.41	4.87	5.34
T_2	235	286	16.13	14.63	107	116	21.87	25.44	5.22	5.67
T_3	214	255	18.10	17.67	96	104	21.75	25.42	4.69	4.97
T_4	237	283	17.27	15.27	103	114	21.76	25.53	4.98	5.69
T_5	236	287	16.23	14.60	107	117	21.93	25.27	5.18	5.75
T_6	186	214	19.77	19.07	78	93	20.84	24.92	3.21	3.37
CV (%)	4.56	4.03	4.05	9.06	3.47	5.14	2.2	1.1	3.48	3.51
LSD	18.48	19.35	1.29	2.69	6.28	10.26	ns	ns	0.29	0.32

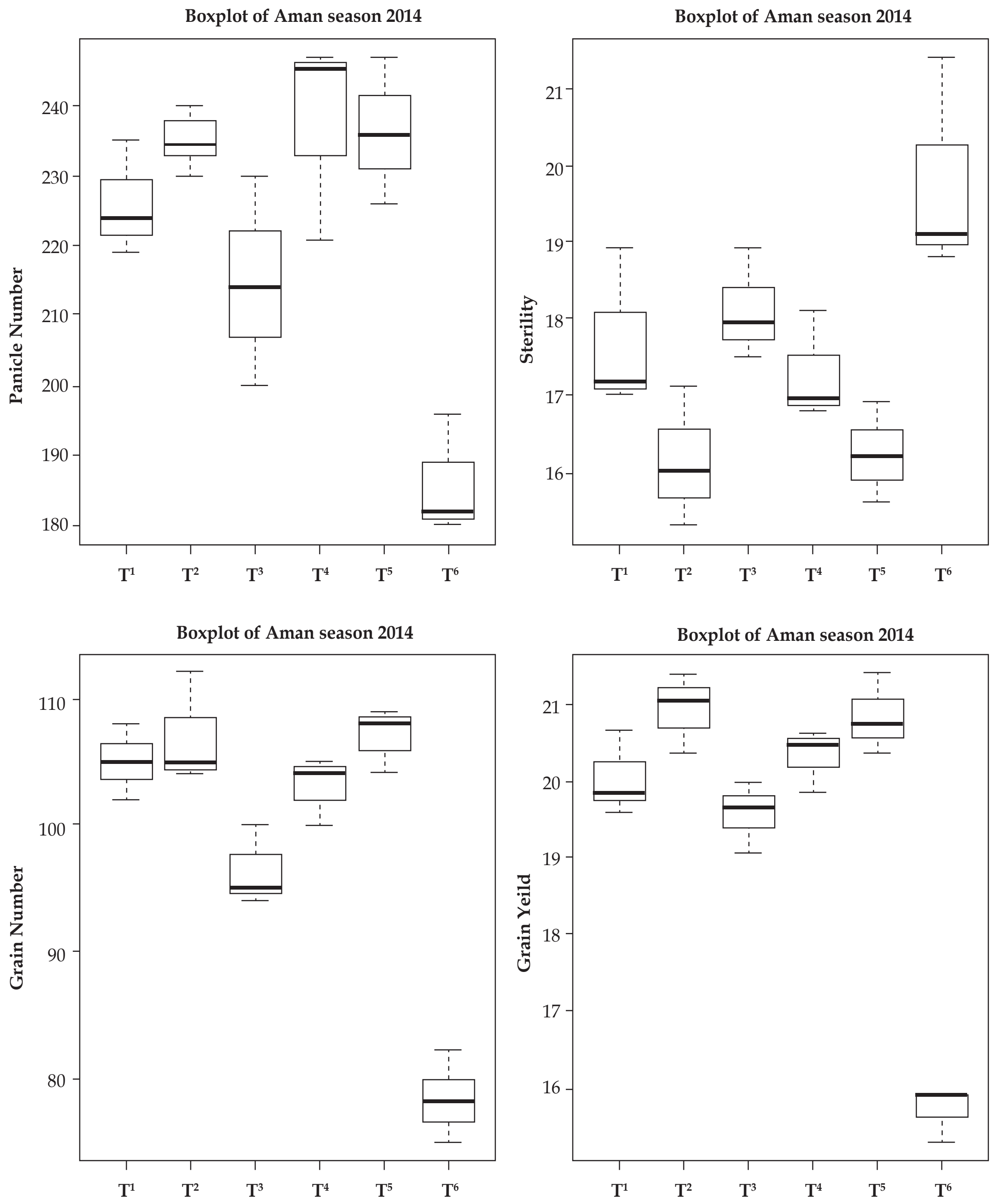
S_1= Aman 2014, S_2= Boro 2014-15. T_1= Authority 48 SC @ 150 ml ha^{-1}, T_2= Authority 48 SC @ 200 ml ha^{-1}, T_3= Authority 48 SC @ 250 ml ha^{-1} and T_4= Rifit 500 EC @ 1000 ml ha^{-1}, T_5= Weed free and T_6= control (unweeded).

(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. Thousand grain weight (TGW) did not differ significantly among the treatments although unweeded plots produced lower TGW in both the years. Treatment wise boxplot of yield attributes in T. Aman 2014 confirmed that most of the yield contributing characters were similar to T_2, T_4 and T_5 (weed free) treatments; whereas T_6 was outsider of the normal range and its data was also in disperse condition than the other treatments due to severe weed infestation (Fig. 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 resulted lowest grain yield (3.37 t ha^{-1}). The minimum number of panicles m^{-2} in the control plot was probably due to the higher competition for nutrient, air space, light and water between crop plants and weeds which confirm the results of Hasanuzzaman *et al.*, 2009. Maximum grain yield of 5.75 t ha^{-1} was recorded with T_5 treatment due to lower weed-crop competition. In Boro 2014-15; T_2, T_4 and T_5 (weed free) treatments are in similar range in boxplot of yield attributes (Fig. 3). Authority 48 SC @ 150, 200, 250 ml ha^{-1} gave effective control of grass, sedge and broadleaf weeds lead to increased grain yield. Herbicide treatments contributed to higher yield performance compared to control in all the growing seasons (Bari, 2010).

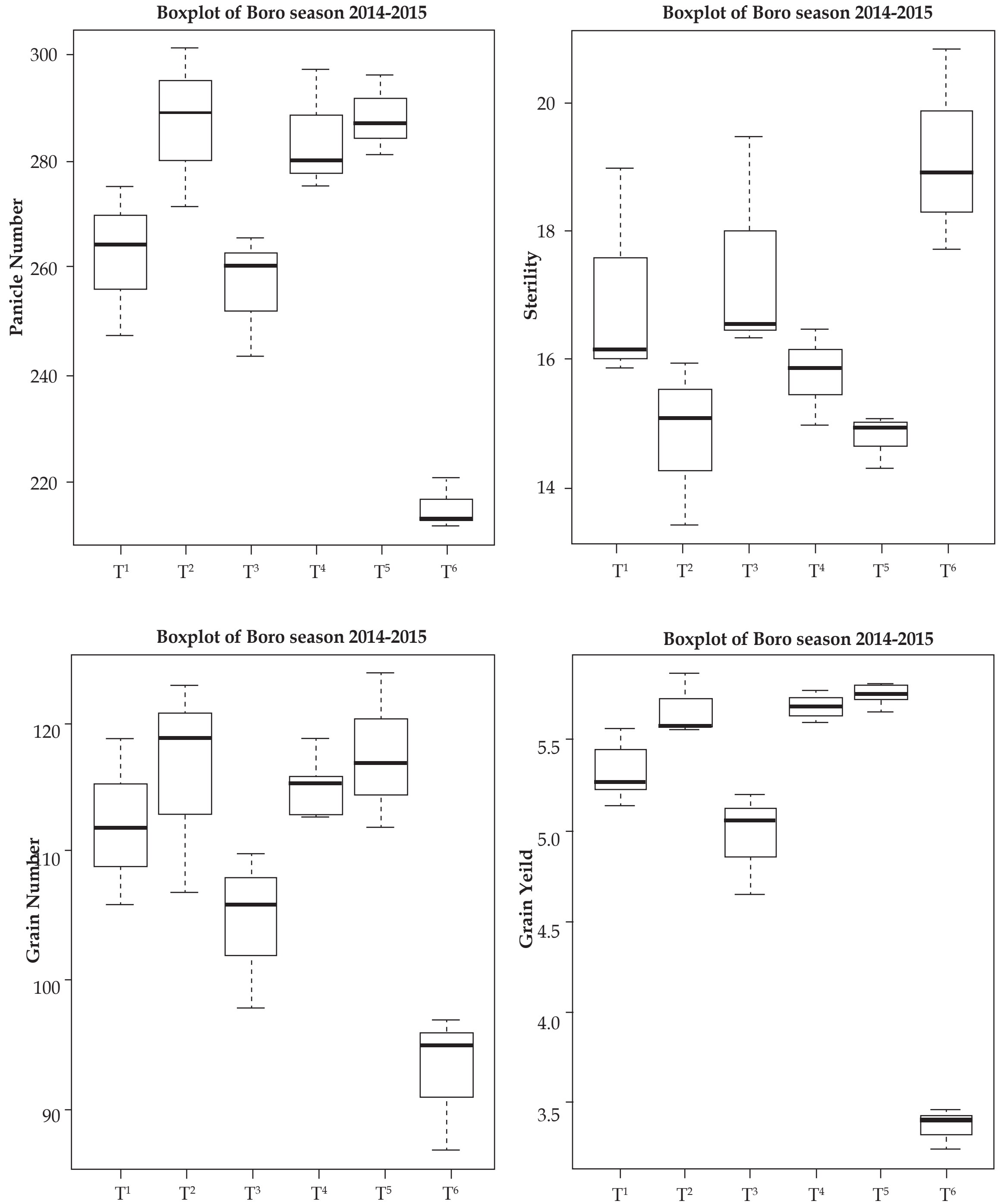
CONCLUSION

Grain yield and yield attributing parameters and weed dynamics were greatly influenced by different weed management practices. Authority 48 SC @ 250 ml ha^{-1} performed better weed control efficiency with slightly phytotoxity. Depending on the weeding efficacy, Authority 48 SC @ 200 ml ha^{-1} applied at three days before transplanting is effective for annual weed control option instead of hand weeding at peak period of labour crisis which can reduce the production cost.



T_1= Authority 48 SC @ 150 ml ha^{-1}, T_2= Authority 48 SC @ 200 ml ha^{-1}, T_3= Authority 48 SC @ 250 ml ha^{-1} and T_4= Rifit 500 EC@ 1000 ml ha^{-1}, T_5= Weed free and T_6= control (unweeded).

Fig. 2. Boxplot of yield attributes in Aman, 2014 at BRRI, Gazipur.



T_1= Authority 48 SC @150 ml ha^{-1}, T_2= Authority 48 SC @200 ml ha^{-1}, T_3= Authority 48 SC @250 ml ha^{-1} and T_4= Rifit 500EC @1000 ml ha^{-1}, T_5= Weed free and T_6= control (unweeded).

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

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