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WEED PERSISTENCE, CROP RESISTANCE AND PHYTOTONIC EFFECTS OF NEW MOLECULE HERBICIDES IN TRANSPLANTED RICE

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ABSTRACT

Weeds reduce rice yield as well as impair grain quality. To address the problem, a field experiment was conducted at the Bangladesh Rice Research Institute, Bangladesh during dry season of 2018, with the aim to identify the phytotonic effect of herbicides on weed and rice growth for sustained production in transplanted rice. The weed management treatments were the combination of pre and post emergence herbicide viz., mefeneset + bensulfuron methyl fb cyhalofopbutyl, mefeneset + bensulfuron methyl fb bispyribac sodium, Bensulfuron methyl + acetachlor fb Ethoxysulfuron, Pretilachlor + trisulfuron 2% + Penoxlum, weedy check (Unweeded) weed free by 3 HW. Results showed that the herbicide mefeneset + bensulfuron methyl + bispyribac sodium produced the lowest weed number and biomass of which weed control efficiency showed 93%. The treatment having mefeneset + bensulfuron methyl + bispyribac sodium had higher value of HEI (Herbicide efficiency index), CRI (Crop resistance index) and lower value of WPI (Weed persistence index) and WMI (Weed management index) than other weed management treatments. Yield and yield attributing parameters, and weed dynamics were significantly affected and the trend of higher production was influenced by the weed management practices. Among the weed management practices, Mefeneset + bensulfuron methyl + bispyribac produced the highest grain yield.

Keywords: Weed management, herbicide, weed indices

INTRODUCTION

Rice *(Oryza sativa* L.) is considered as the most important staple food in the world since it supplies the major food requirement for more than one half of the world's population. The yield gap of rice production is 0.83 t ha^{-1} (20.7%) between actual farm yield and potential farm yield in Bangladesh (Kabir *et al.,* 2015). If this yield gap could be reduced @ 1.135% $year^{-1}$, 4.8 MT rice surplus can be achieved in 2050 (Bhuiyan *et al*., 2021). Reducing the yield gap of 10-15 kg $year^{-1}$ ha^{-1} would provide a surplus of 3.07 MT in the year 2041 (Kabir *et al*., 2015). Improper weeding is one of the major caused to reduce yield in the farmers' field. To reduce yield gap proper weed management should be practiced which is safe for the crop and environment.

Yield loss due to improper weeding at farmer's field ranged from 4 to 22% depending on different rice ecosystem in Bangladesh (Bhuiyan *et al*., 2020). This average yield is almost less than 50% of the world average rice grain yield. Weed infestation and interference is a serious problem in rice fields that significantly decreases yield. With the introduction of short statured high yielding rice varieties with electrophilic leaves, the weed menace is becoming more acute (Mishra *et al.,* 2004). The weed flora under transplanted condition is very much diverse and consists of grasses, sedges and broad-leaf weeds causing yield reduction of rice crop up to 76% (Singh *et al.,* 2004). Hence, proper weed management practices are essential to obtain better yields in transplanted rice. Adoption of timely and effectively appropriate weed management techniques can reduce a significant amount of yield loss and about 0.43 million ton (MT) additional rice production is possible by 2030 (Bhuiyan *et al*., 2020). 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. However,

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herbicide should be applied at proper time and dose which can reduce about 61% weeding cost (Bhuiyan *et al*., 2020).

Herbicides are used to control weeds in crop as pre or post emergence application which reduces the population of weeds significantly resulting in higher yield and profit. Sometimes, herbicide apart from harming target species also affect the non-target living being which may sometimes augment yield (Phytotonic effect) or sometimes produce detrimental effect (phytotoxic) on plant. Information related to such action of herbicides is insufficient, as according to Mishra (2016) several cumbersome studies are required for the purpose. So, the present investigation was undertaken to identify the phytotonic effect of herbicides on crop growth for sustained production of transplanted rice.

MATERIALS AND METHODS

The experiment was 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 dry season 2018. The experiment was carried out with six treatments viz., T_1= Mefeneset + bensulfuron methyl (Pre emergence) fb cyhalofopbutyl (post emergence), T_2= Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence), T_3= Bensulfuron methyl + acetachlor (Pre emergence) fb Ethoxysulfuron (post emergence), T_4= Pretilachlor + trisulfuron 2% (Pre emergence) fb Penoxlum (post emergence), T_5= Weedy check (Unweeded) and T_6= Weed free by 3 HW.

All the treatments were laid out in a randomized complete block design with three replications. Thirty-five days old seedlings of BRRI dhan58 was transplanted on 16 January 2018 maintaining 20cm × 20 cm spacing. Fertilizer was applied following BRRI recommended dose for dry season; N:P:K:S= 120:19:60:24 kg ha^{-1} (BRRI, 2013). Herbicides were sprayed 3-7 days after transplanting (DAT) as pre emergence and 20-25 DAT as post emergence application with the help of a knapsack sprayer. In weed free treatment, the plots were kept weed free up to 50 DAT by three hand weeding. Different agronomic and weed management indices were calculated to observe the efficiency of herbicide and weed vegetation analysis.

Agronomic efficiency indices

Weed control efficiency (WCE%), and Weed Index (WI) was calculated using subsequent formula according to Rao (1985).

$$\textbf{Weed control Efficiency (WCE)} = \frac{\text{WC} - \text{Wt}}{\text{WC}} \times 100$$

WC= Average weed weight per unit area in weedy check
Wt= Average weed count or dry weed weight per unit area in treated plot

Higher values of WCE indicate greater effectiveness of the herbicide

$$\textbf{Weed Index (WI)} = \frac{\text{YHW} - \text{Yt}}{\text{YHW}} \times 100$$

where, YHW= Average yield of the crop in hand weeded, weed free plot or minimum weed competition plot
Yt= Average yield of the crop in plot under other weed control treatments.
Higher value of weed index indicates lower the yield and lower value of weed index indicate higher the yield.

Weed persistence index (WPI)

It is used to indicate the resistance of weeds against various tested treatments and to confirm the effectiveness of the herbicide efficiency of the selected treatments to kill the weeds.

$$\mathbf{WPI} = \frac{\text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times \frac{\text{weed density in control plot}}{\text{Weed density in treated plot}}$$

Crop resistance index (CRI)

It is the relationship between proportionate increase in crop dry weight in treated plot and the proportionate reduction in weed dry weight in treated plot.

$$\text{CRI} = \frac{\text{Dry matter production (DMP) by crop in the treated plot}}{\text{DMP by crop in the control plot}} \times \frac{\text{DMP of weeds in control plot}}{\text{DMP of weeds in treated plot}}$$

Weed Management Index (WMI)

It is the ratio between yield increase due to weed management and the proportionate control of weeds by the respective treatments.

$$\mathbf{WMI} = \frac{\%\ \text{yield over control}}{\%\ \text{control of weeds}}$$

Herbicide Efficiency Index (HEI)

Its indicates the weed killing potential of different herbicide treatments and their phytotoxicity on the crop (Walia, 2003) and can be calculated

$$HEI = \frac{(Yt - Yc)/Yc \times 100}{DMT/DMC \times 100}$$

where: Yt = Yield from treatment plot; Yc = Yield from control plot; DMT = Dry matter of weeds in treatment
DMC = Dry matter of weeds in control

Statistical analysis

Data were analyzed statistically by statistical software Crop stat 7.2 using analysis of variance, and treatments were compared with least significant difference (LSD) at the P=0.05 level of significance. Correlation and regression were done by Microsoft Excel program.

RESULTS AND DISCUSSION

Weed density, biomass, WCE% (Weed control efficiency) and weed vegetation analysis

Weed number per m^{-2} was the highest in un- weeded check plot (Table 1). As a result, weed dry weight also high at un-weeded check treatment. On the other hand, the lowest weed number and dry weight was showed by T_2 treatment. Table 1 shows all herbicide treatments reduced total weed density and biomass compared with non-treated check. All the combinations having pre-emergence herbicide fb and post emergence herbicide reduced total weed density and biomass compared with unweeded condition. Among the herbicide Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence) produced the lowest weed number and biomass which weed control efficiency was also high (93%). Bhuiyan and Gazi (2010) reported that mefenacet + bensulfuron methyl 53%WP @ 594 g ai ha^{-1} lead to higher WCE (> 80%) and lowest number and dry weight of weeds which ultimately resulted in higher yield attributes and grain yield of rice.

The treatment having Mefeneset + bensulfuron methyl (Pre emergence) and bispyribac sodium (post emergence) had higher value of HEI, CRI and lower value of WPI and WMI than other weed management treatments. Higher weed index was observed in unweeded plots. Generally, weed index was lower in herbicide treated treatments as observed by Mishra *et al*. (2016) in their study that weed persistence index

was the maximum in hand weeding treatment followed by cyhalofopbutyl and pyrazosulfuron. Hand weeding treatment has maximum phytotonic effect followed by fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl + (chlorimuron + metsulfuron). Fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl + (chlorimuron + metsulfuron) have recorded lower persistence of escaped weeds indicating broad spectrum effect in controlling the weeds. Khaliq *et al*. (2011) observed penoxsulam and bispyribac sodium showed about 40% and 60% HEI when compared with other non-chemical weed management treatment.

Table 1. Effect of weed management treatments on various agronomic indices at 50 DAT in BRRI dhan58 during Boro, 2018

Treatment	Weed no. (m^2)	Weed weight (g m^{-2})	WCE (%)	HEI	WPI	CRI	WMI	WI
T_1	20	9.303	88	0.26	1.68	14.28	0.85	4
T_2	14	6.257	93	0.41	1.52	21.95	0.82	2
T_3	16	7.700	92	0.32	1.58	18.16	0.82	3
T_4	21	10.563	88	0.23	1.56	11.48	0.85	5
T_5	247	79.933	-	-	-	-	-	76
T6	15	8.380	89	-	1.79	17.04	0.85	-
$LSD_{(.05)}$	38.59	9.86	ns	-		6.1	ns	-
CV(%)	38.2	26.6	2.2	-	24.5	19.8	3.3	-

T1= Mefeneset+ bensulfuron methyl (Pre emergence) fb cyhalofopbutyl (post emergence),
T2=Mefeneset+ bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence)
T3= Bensulfuron methyl+ acetachlor (Pre emergence) fb ethoxysulfuron (post emergence)
T4=Pretilachlor+ trisulfuron2% (Pre emergence) fb penoxlum (post emergence)
T5= Weedy check (Unweeded) and T6= Weed free by 3 HW

Grain yield, yield contributing characters and economices

All the herbicide treated plots had higher panicle numbers, grains per panicle and higher thousand grain weight than unweeded plot (Table 2). Among the treatments Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence) produced the highest panicle numbers, grains per panicle and higher 1000-grain weight. The highest grain yield was achieved in the treatment Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence) which is followed by Bensulfuron methyl + acetachlor (Pre emergence) fb ethoxysulfuron (post emergence) treatment. Weed management treatment strongly influenced grain yield as they produced almost double yield than in the season unweeded check. Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence) treatment had the maximum yield and higher B:C ratio, though in hand weed plot and other herbicidal plots showed higher B:C ratio than the unweeded control. Chauhan *et al.* (2013) reported that different herbicides have similar weed control effect and can be rotated in cropping system.

Table 2. Effect of weed control methods on yield and yield contributing characters

Treatment	Panicle m^{-2}	Grains $panicle^{-1}$	1000GW	Grain yield (t ha^{-1})	Benefit cost ratio (B:C)
T_1	269	127	23.47	7.30	2.23
T_2	315	150	23.86	7.63	2.44
T_3	299	141	23.68	7.45	2.25
T_4	267	122	23.11	7.22	2.2
T_5	198	90	22.27	3.62	0.89
T6	289	136	23.60	7.40	2.38
$LSD_{(.05)}$	64.30	21.81	0.85	1.23	
CV(%)	13.5	9.4	2.0	10.5	

Treatment details are same as Table 1

Correlation and regression of rice biomass, weed biomass and grain yield

The aboveground biomass of rice (DMP) and crop resistance index was closely related to each other. Higher the biomass, higher the crop resistance index, while lower the biomass of rice had lower crop resistance index. With increase in rice biomass corresponding crop resistance index increased (Fig 1.a). A positive linear correlation was observed in crop resistance index and dry matter production of rice (rice biomass). The relationship of grain yield with weed biomass and weed index indicating significant negative correlation with grain yield (Fig.1 b,c). The results of our regression analysis revealed that every 1 kg increase in weed biomass at 50 DAT resulted in decrease 7.8 kg of grain yield. Bhuiyan (2016) indicated that weed index showed the variation of grain yield is 100% due to different weed management treatments.

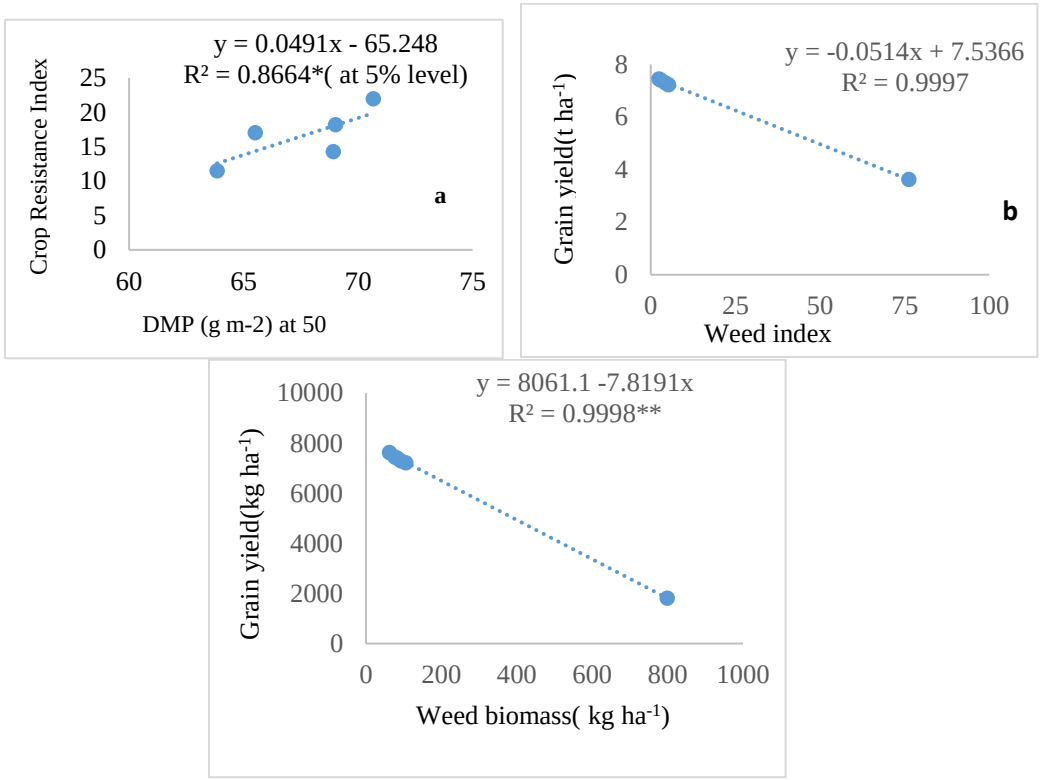


Fig.1 a. Relationship of crop resistance index and dry matter production at 50 DAT b. Dependence of grain yield on weed index c. Dependence of grain yield on weed biomass

CONCLUSION

The area under herbicide treated rice systems is expected to increase in the future because of labor and water shortages. Mefeneset + bensulfuron methyl (Pre emergence) fb bispyribac sodium (post emergence) could be the best broad-spectrum herbicide and more economic when applied as pre and post emergence application. Application of three hand weeding did not compete with herbicide treated plots in terms of grain yield

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