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POST-EMERGENCE WEED CONTROL OF STRIP-PLANTED WHEAT BY HERBICIDES

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Abstract

Transformation of a wheat field from conventionally heavy tillage to strip-planting is beneficial considering soil health improvement and savings in cultivation cost. Therefore, an experiment was conducted at the experimental field of On-Farm Research Division, Bangladesh Agricultural Research Institute, Gazipur during *Rabi* season of 2017-18 and 2018-19 to evaluate some available post-emergence herbicides for managing weeds in strip-planted wheat *var*. BARI Gom-30 and to find out the most effective post-emergence herbicide and its suitable rate for controlling weeds under strip tillage system. Three post-emergence herbicides (ethoxysulfuron, carfentrazone-ethyl plus isoproturon and carfentrazone-ethyl) were tested at their label rate and double of the label rate and their performance were compared with two times manual weeded control treatment. The study revealed that application of ethoxysulfuron at label rate and double of the label rate was effective for grass weed control, but not for broadleaf weeds. Application of carfentrazone-ethyl plus isoproturon both at label rate and double of the label rate was effective to control all types of weeds. Moreover, the highest grain and straw yields were recorded from label rate application of carfentrazone-ethyl plus isoproturon and its double rate application was also offered similar results in case of grain and straw yields. However; considering undetermined herbicide residual issue and having adverse effect on wheat leaves and finally on yield, the study discourages double of the label rate application of carfentrazone-ethyl plus isoproturon for managing weeds in wheat under strip tillage system.

Introduction

Intensive crop cultivation is seriously affecting health and quality of soil. Heavy tillage is considered as the major reason of soil erosion as well as soil quality depletion. Moreover, high cultivation cost is involved with heavy tillage because of using enough fuel and labour. On the other hand, strip tillage reduces cultivation cost as it requires less fuel, labour and saves time of cultivation (Hossain *et al.,* 2015). Additionally, strip tillage reduces the rate of soil erosion compare to the conventional tillage because of less disturbance of soil. This minimum tillage also helps to preserve moisture in soil and it keeps soil micro-environment cool by practicing for long period (Salahin *et al.*, 2017). Furthermore, wheat gives better yield and economic return under strip tillage than conventional system (Hossain *et al.*, 2014).

But weed is the major barrier to get targetable yield in the strip tillage system (Zahan *et al.*, 2016). Now-a-days, unavailability and high wage of labour are diverting farmers to choose herbicides for weed control rather than manual weeding. Broadleaf weed infestation in wheat not only reduces the yield drastically but it also deteriorates the grain quality (Zand *et al.*, 2007). To control broadleaf weeds, there are very few post-emergence herbicides are registered and available in the market of Bangladesh. Besides, the response of wheat varieties to different post-emergence herbicides might be different because of the genetic and physiological variability within the varieties (Punia *et al.*, 1996). Therefore, an experiment was designed to evaluate weed controlling efficiency of some available post-emergence herbicides at different application rates in strip-planted wheat *cv.* BARI Gom-30 and to identify most suitable and effective herbicide for this new promising wheat variety.

Materials and Methods

The experiment was conducted at on-station field of On-farm Research Division, Bangladesh Agricultural Research Institute (BARI), Gazipur (23 59′12.67567′′ N and 90 24′38.17521′′ E) during *Rabi* season of 2017-18 and 2018-19. The soil of the experimental land was sandy in texture having low organic matter (1.41%) and soil pH 5.02. During the study period prevailing monthly average of maximum and minimum temperature and monthly total rainfall of the experimental site has been presented in Fig 1. Three post-emergence herbicides named ethoxysulfuron (early post-emergence), carfentrazone-ethyl plus isoproturon (late post-emergence) and carfentrazone-ethyl (late post-emergence) were evaluated at their label rate and double of the label rate comparing with a control treatment (manually weeded for two times at 20 and 40 days after sowing). The trade names of the used products of ethoxysulfuron, carfentrazone-ethyl plus isoproturon and carfentrazone-ethyl for the experiment were Sunrise 150WP,Affinity 50.75WP and Hammer 24EC, respectively. The experiment was laid out in RCB design with three replications. The unit plot size was 5 m x 3 m.

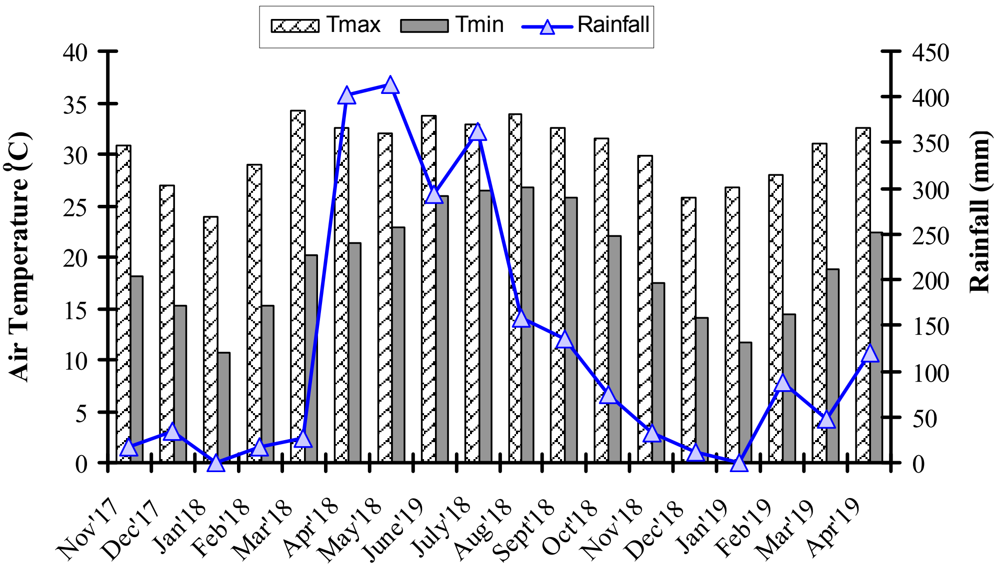

Fig 1. Prevailed monthly maximum and minimum averaged air temperature and monthly total rainfall at BARI, Gazipur during November 2018 to April 2019

Previous crop, T. *Aman* rice was harvested by retaining 20 cm residue in the field. The field was weed-free; therefore, no pre-planting herbicide was applied. Seeds of wheat var. BARI Gom-30 were sown at the rate of 150 kg ha^{-1} by a two-wheel tractor driven strip planter within the strips apart by 20 cm on 21 November 2017 and 17 November 2018. Before strip till, the land was fertilized with phosphorus, potassium and sulphur in the form of triple super phosphate (TSP), muriate of potash (MoP) and Gypsum @ 160, 50 and 110 kg ha^{-1}, respectively. All fertilizers were broadcasted in the field just before seeding wheat. Nitrogen fertilizer was applied in the form of Urea @ 200 kg ha^{-1} in two equal installments. First installment of urea was applied at 15 days after sowing (DAS) and the second one was at the spike initiation stage. Early post-emergence herbicide (ethoxysulfuron) was applied at 15 DAS and late post-emergence herbicides (carfentrazone-ethyl plusisoproturon and carfentrazone-ethyl) were applied at 25 DAS. Shallow irrigation was provided for four times to ensure proper germination and growth of wheat. Crop protection measures were also taken as and when necessary. Wheat was harvested on 19 March 2018 and 26 March 2019 at maturity. During 2019, crop required 11 days more to get maturity compared to the previous year because crop received heavy rainfall during February 2019 as well as March 2019 and the maturity period was delayed. Data on weed density and biomass were collected at 35 DAS from randomly selected two spots of 50cm×50cm sized quadrat. Weed species were also identified and weed population of each species was also counted. Data on yield contributing characters were recorded from randomly selected ten plants. Yield data were collected from the central 2m×3m area of each plot and converted in to t ha^{-1}. The collected data were analyzed by using a statistical package program 'R' (version 3.3.3).

Results and Discussion

Effect of herbicides on weeds

The wheat field was infested by seventeen (17) weed species during *rabi* season of 2017-18 among which four were grass weeds (*Cynodon dactylon*, *Digitaria sanguinalis*, *Echinochloa colona* and *Elusina indica*), one were sedges (*Cyperus rotundus*) and twelve broadleaf weeds (*Polygonum hydropiper*, *Chenopodium album*, *Vicia virsuta*, *Physalis heterophylla*, *Enhydra fluctuans*, *Gnaphalium affine*, *Nicotiana plumbaginifolia*, *Portulaca oleracea*, *Eclipta prostrate*, *Amaranthus viridis*, *Alternanthera sessilis* and *Brassica kaber*). During 2018-19, nine (09) weed species were identified among which five were grass weeds (*Cynodon dactylon*, *Digitaria sanguinalis*, *Echinochloa colona*, *Elusina indica* and *Oryza rufipogon*) and four (04) were broadleaf weeds (*Enhydra fluctuans*, *Blumea lacera*, *Brassica kaber*, *Marsilea quadrifolia* and *Amaranthus viridis*). The most infested weed species of strip planted wheat was *Echinochloa colona* during both years (Table 1). Grass weeds were dominant over other types of weeds (73% and 97% of the total infested weeds during 2017-18 and 2018-19, respectively).

The study revealed that herbicide treatments reduced densities of all weed species at 35 days after sowing (DAS) compared to the control. In case of grass weeds, application of ethoxysulfuron at double of the label rate offered the highest density reduction in 2017-18 whereas carfentrazone-ethyl plus isoproturon at double of the label rate gave the highest in 2018-19 (Table 2). In case of broadleaf weeds, carfentrazone-ethyl plus isoproturon at double of the label rate provided the highest reduction in densities during both years. During 2017-18, sedge weed were fully reduced by all herbicide treatments whereas this type of weed was absent in 2018-19.

Table 1. Infested weed species in controlled plots of wheat at 35 days after sowing under strip tillage system in Gazipur during *rabi* season of 2017-18 and 2018-19

Weed species	Local name	Family	Life cycle	% infestation	
				2017-18	2018-19
Grass					
Cynodon dactylon	Durba	Poaceae	Perennial	13.7	11.6
Digitaria sanguinalis	Angulighas	Poaceae	Annual	13.6	25.8
Echinochloa colona	Khudeshama	Poaceae	Annual	41.6	41.2
Elusina indica	Chapra	Poaceae	Perennial	4.1	12.5
Oryza rufipogon	Wild rice	Poaceae	Annual	-	5.4
Sedge					
Cyperus rotundus	Mutha	Cyperaceae	Perennial	2.1	-
Broadleaf					
Polygonum hydropiper	Biskatali	Polygonaceae	Perennial	4.3	-
Vicia sativa	Wild lentil/vetch	Fabaceae	Perennial	1.8	-
Physalis heterophylla	Foska begun	Solanaceae	Perennial	1.5	-
Portulaca oleracea	Nuneshak	Portulaceae	Perennial	2.5	-
Eclipta prostrata	Keshuti	Asteraceae	Perennial	1.8	-
Chenopodium album	Bathua	Chenopodiaceae	Perennial	3.2	-
Gnaphalium affine	Shetolomi/ Bon copi	Asteraceae	Perennial	3.2	-
Nicotiana plumbaginifolia	Bon tamak	Solanaceae	Perennial	1.2	-
Enhydra fluctuans	Helencha	Asteraceae	Perennial	2.1	1.6
Blumea lacera	Shialmutra	Asteraceae	Perennial	-	0.4
Amaranthus viridis	Shaknotey	Amaranthaceae	Perennial	2.1	-
Alternanthera sessilis	Chanchi	Amaranthaceae	Perennial	1.2	-
Marsilea quadrifolia	Shushnishak	Marsileaceae	Perennial	-	0.7
Brassica kaber	Bon sharisha	Brassicaceae	Perennial	-	0.8

Table 2. Effect of post-emergence herbicides on density reduction of weeds at 35 days after sowing of strip-planted wheat during *Rabi* season of 2017-18 and 2018-19 at on-station, OFRD, BARI, Gazipur

Treatments	% density reduction over control				
	Grass weeds		Sedge weed	Broadleaf weeds	
	2017-18	2018-19	2017-18	2017-18	2018-19
Control	-	-	-	-	-
Ethoxysulfuron@RD	71.1	61.3	100	90.5	77.8
Ethoxysulfuron@2RD	76.4	72.0	100	95.8	88.9
Carfentra+isop@RD	52.9	72.7	100	83.9	100.0
Carfentra+isop@2RD	54.9	73.7	100	94.0	100.0
Carfentra@RD	53.1	59.6	100	88.1	11.1
Carfentra@2RD	60.2	66.6	100	96.4	55.6

Here, carfentra+isop = carfentrazone-ethyl + isoproturon, carfentra = carfentrazone-ethyl, RD = label rate, 2RD = double of the label rate

The study demonstrated that herbicide treatments had significant effect on total weed density and biomass at 35 DAS (Fig. 1). The highest number of weeds as well as the highest weed biomass was recorded from control plots during both years. The lowest weed density was counted from ethoxysulfuron at double of label rate application during 2017-18 and from double of the label rate application of carfentrazone-ethyl plus isoproturon during 2018-19. In case of weed biomass, the lowest weight was obtained from double rate application of carfentrazone-ethyl plus isoproturon during both years because of giving effective control on broadleaf weeds.

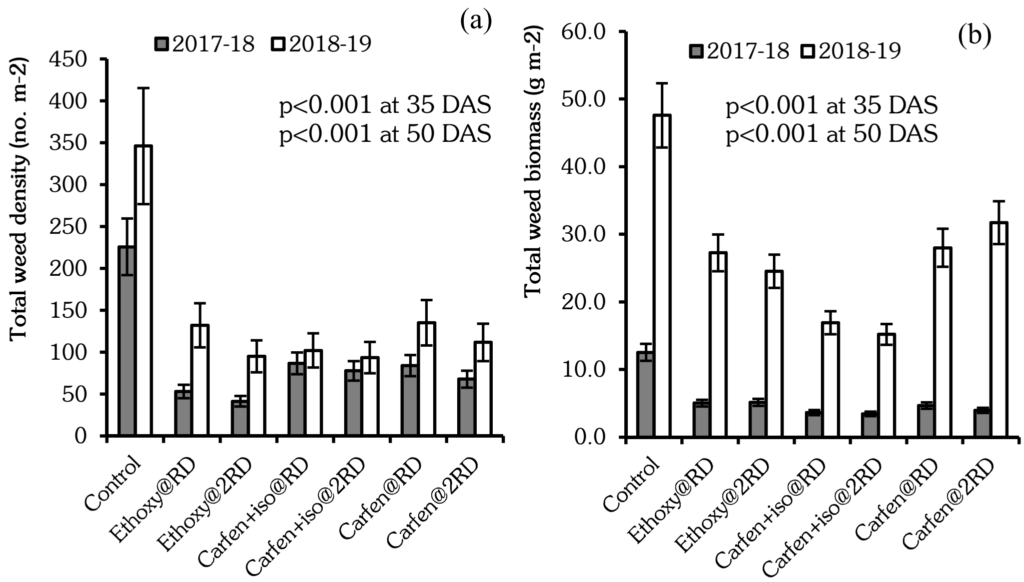

Fig. 1. Effect of herbicides on (a) total weed density and (b) total weed biomass at 35 days after sowing of wheat under strip tillage system during 2017-18 and 2018-19 at on-station, OFRD, BARI, Gazipur.

Effect of herbicides on wheat leaves

The effect of the tested post-emergence herbicides on wheat was visually assessed from the day of herbicide application up to harvest. No herbicide had any visual effect on wheat except carfentrazone-ethyl plus isoproturon. In case of carfentrazone-ethyl plus isoproturon, bleaching was observed on leaves of wheat from 3 days of application and later on bleaching turned into leaf yellowing and necrosis. The chemical family of this late post-emergence herbicide is triazolinone plus urea and because of being the family member of urea the site of action of carfentrazone-ethyl plus isoproturon is inhibition of photosynthesis at photosystem II. That's why; this herbicide had the bleaching effect on wheat leaves. But the fact is the length of the recovery period from adverse visual effect carfentrazone-ethyl plus isoproturon on wheat leaves. It was visually examined that wheat leaves recovered within 15 days after application (DAA) of carfentrazone-ethyl plus isoproturon at label rate; whereas those took 25-30 DAA to recovery at double of the label rate application (Fig. 2).

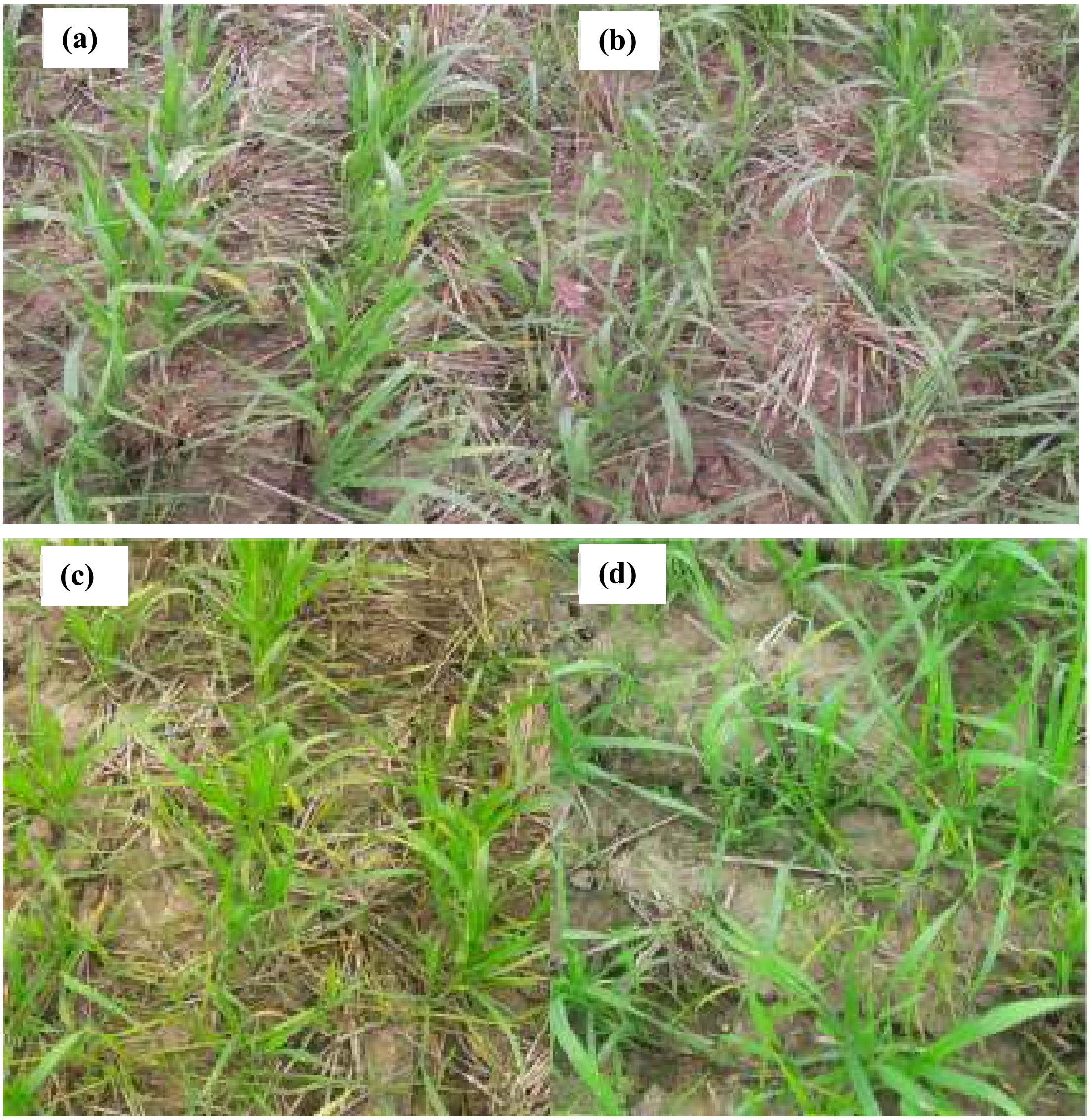

Fig. 2. Effect of carfentrazone-ethyl plus isoproturon at (a) label rate and (c) double of the label rate on wheat leaves at 5 days after application (DAA) and at 20 DAA for (b) label rate application and for (d) double of the label rate application.

Effect of herbicides on yield contributing characters and yield of wheat

Herbicide treatments had significant effect on yield contributing characters as well as yield of strip-planted wheat during both years except spike length and grains spike^{-1} (Table 3 and Table 4). During both years, the highest number of tillers and heads m^{-2}, grain yield and straw yield were obtained from carfentrazone-ethyl plus isoproturon at label rate of application and similar results except straw yield were also found from double rate application. The lowest numbers of tillers and heads m^{-2} and straw yield were recorded from control plots however the lowest grain yield was found from the double rate application of carfentrazone-ethyl.

Table 3. Effect of herbicides on yield and yield contributing characters of wheat under strip tillage system during 2017-18, Gazipur

Treatments	**Tillers m^{-2} (no.)**	**Spikes m^{-2} (no.)**	**Spike length (cm)**	**Grains $spike^{-1}$ (no.)**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**
Control	280 d	272 d	15.6	34	3.86 c	4.69 c
Ethoxysulfuron@RD	335 c	322 c	15.3	36	3.89 c	4.86 bc
Ethoxysulfuron@2RD	348bc	337 c	15.7	36	4.04 bc	5.01 bc
Carfentra+isop@RD	415 a	405 a	15.8	39	4.82 a	5.85 a
Carfentra+isop@2RD	390ab	377ab	15.3	34	4.56 ab	5.19 b
Carfentra@RD	360bc	347bc	15.6	37	4.22 bc	4.78 c
Carfentra@2RD	350bc	328 c	14.9	34	3.81 c	5.00 bc
Level of significance	***	***	ns	ns	*	***
CV (%)	6.97	6.60	5.14	9.34	8.08	3.93

In a column, means with similar letter(s) are statistically identical as per $LSD_{0.05}$
Here, carfentra+isop = carfentrazone-ethyl + isoproturon, carfentra = carfentrazone-ethyl, CV = co-efficient of variance,
*** = 0.1% level of significance, * = 5% level of significance, ns = non-significant

Table 4. Effect of herbicides on yield and yield contributing characters of wheat under strip tillage system during 2018-19, Gazipur

Treatments	**Tillers m^{-2} (no.)**	**Spikes m^{-2} (no.)**	**Spike length (cm)**	**Grains $spike^{-1}$ (no.)**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**
Control	239 d	236 e	17.5	45.3	2.63 e	3.83 d
Ethoxysulfuron@RD	253 c	249 de	17.8	47.1	3.10 de	4.73 bc
Ethoxysulfuron@2RD	255 c	255 cd	17.7	47.9	3.67 bc	4.90 b
Carfentra+isop@RD	281 a	281 a	18.1	49.1	4.37 a	5.63 a
Carfentra+isop@2RD	271 ab	271 ab	17.6	51.4	4.13 ab	5.10 b
Carfentra@RD	266 b	262 bcd	17.7	48.7	3.20 cd	4.43 c
Carfentra@2RD	271 ab	265 bc	17.9	49.4	3.13 cde	4.73 bc
Level of significance	***	***	ns	ns	***	***
CV (%)	2.42	2.92	2.60	5.84	8.79	5.22

In a column, means with similar letter(s) are statistically identical as per $LSD_{0.05}$
Here, carfentra+isop = carfentrazone-ethyl + isoproturon, carfentra = carfentrazone-ethyl, CV = co-efficient of variance,
*** = 0.1% level of significance, * = 5% level of significance, ns = non-significant

Economic Analysis

The results showed that plots with recommended dose of carfentrazone-ethyl plus isoproturon had the highest gross return as well as the highest gross margin (Table 5). The lowest gross return and gross margin were calculated from the control plots and the reason was related to the high cost involvement for manual weeding.

Table 5. Cost effectiveness of herbicides in strip-planted wheat during 2017-18 and 2018-19 at Gazipur

Treatments	2017-18			2018-19		
	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Control	56770	82833	26063	56070	82833	26763
Ethoxysulfuron@RD	43395	97733	54338	42695	97733	55038
Ethoxysulfuron@2RD	44295	114900	70605	43595	114900	71305
Carfentra+isop@RD	45390	136633	91243	44690	136633	91943
Carfentra+isop@2RD	48285	129100	80815	47585	129100	81515
Carfentra@RD	43211	100433.3	57222	42511	100433	57922
Carfentra@2RD	43926	98733.2	54807	43226	98733	55507

Market price (Tk. ha^{-1}) of commercial herbicides: pendimethalin = 2525, ethoxysulfuron @ RD = 900, ethoxysulfuron @ 2RD = 1800, carfentrazone-ethyl+isoproturon @ RD = 2895, carfentrazone-ethyl+isoproturon @ RD = 5790, carfentrazone-ethyl = 716, carfentrazone-ethyl = 1431

Manual weeding cost (Tk.): 50labours ha^{-1} for 2 times weeding (in weed-free check) @ 350 $labour^{-1}$ day^{-1}, Herbicide application cost (Tk.): 1labour ha^{-1} $round^{-1}$ @ 350 $labour^{-1}$ day^{-1}, Irrigation cost (Tk.): 6labours ha^{-1} for 3 times irrigation during 2017-18 and 4 labours ha^{-1} for 2 times during 2018-19 @ 350 $labour^{-1}$ day^{-1}, Harvest and post-harvest processing cost (Tk.): 45 labours ha^{-1} @ 350 $labour^{-1}day^{-1}$,

Market price of grain (Tk. Kg^{-1}): 30.00, and straw: 1.00.

Conclusion

Label rate application of carfentrazone-ethyl plus isoproturon provided the highest grain and straw yields as well as the highest economic return; however, double of the label rate application gave the most effective weed control. Therefore, the study suggested application carfentrazone-ethyl plus isoproturon at the label rate in strip-planted wheat *cv.* BARI Gom-30 as a profitable weed control practice.

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