EFFECT OF NEWLY DEVELOPED HERBICIDES ON THE GROWTH AND YIELD OF WHEAT UNDER STRIP TILLAGE SYSTEM IN BANGLADESH

I. Hossain[1]*, G. Faruq[1], M. H. Ali[2] and S. M. Masum[3]

ABSTRACT

A field study was conducted at the Regional Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI), Rajshahi in 2017-18 and 2018-19 to compare the effects of different pre- and post-emergence herbicides on wheat (*Triticum aestivum* L.). Pre-emergence herbicides were Pendimethyline and Atrazine with post-emergence herbicides were Atrazine, Tembotrione (Laudis), Halosulfuron methyl (Sempra), Tembotrione (Laudis) + Atrazine and Halosulfuron methyl (Sempra) + Atrazine in Randomized Complete Block design. The population and dry weight of weeds were less when applied Atrazine as a pre-emergence herbicide and Atrazine + Laudis as a post-emergence herbicide over no pre and post emergence herbicide. Atrazine @ 500 g ha^{-1} + Laudis @ 120 g ha^{-1} in water at 15 and 30 days after seeding (DAS) was most effective in arresting weed growth as compared to other treatments and was at par with Sempra @ 90 g ha^{-1} + Atrazine @ 500 g ha^{-1}. Net profit was also the highest in Atrazine @ 500g ha^{-1} + Laudis @ 120 g ha^{-1} water treated plots and the lowest in the control plot. Overall performance of the experiment revealed that Atrazine @ 500 g ha^{-1} + Laudis @ 120 g ha^{-1} water at 15 and 30 DAS showed better performance both on weeds control as well as higher grain yield at par Sempra @ 90 g ha^{-1} +Atrazine @ 500 g ha^{-1}. On the other hand, Atrazine @ 500 g ha^{-1} + Laudis @ 120 g ha^{-1} water herbicides were economically suitable for the control of weeds comparatively with less cost. So, Atrazine @ 500 g ha^{-1} + Laudis @ 120 g ha^{-1} water at 15 & 30 DAS was recommended on weeds control in the wheat field under strip tillage system.

Keywords: Weed, Growth, Yield and Yield Components, Wheat, Weed control efficiency

INTRODUCTION

Modern agriculture encourages non-inversion, plough less tillage systems, and simplified plant cultivation methods. Ecologically friendly plant production technologies must nevertheless promise high yields of good quality (Jaskulska and Jaskulski, 2021). As part of the professed "green revolution", the evolution and use of herbicides facilitated laythe substance for falling yield losses and improving yield solidity in worldwide agronomy. Wheat (*Triticum aestivum* L.) is the second cereal crop in Bangladesh. The average yield of wheat (3.64 t ha^{-1}, BBS, 2021) in the country is comparatively low compared to other wheat-producing countries of the world. The low yield of wheat in Bangladesh is largely due to poor management practices, like weeding, imbalance fertilization, irrigation, etc. In order to increase wheat yields it is important to manageweeds, which resulted higher yield in wheat crop (Khan *et al*., 2003). Our farmers are usually reluctant to control weeds in the wheat field. However, sometimes they weeded by hand, which proves uneconomical due to be increasing labor wages. The hand labor-based weeding in many developing countries consumes up to half of the total labor demand. The mechanical methods of weed control would remain for the most widely used means of weed control for the years to come and is more likely to be sustainable than chemical weeding because of fewer financial, health, and environmental risks and easier to maintain with existing skills and facilities.

Moreover, high cultivation cost is involved with heavy tillage because of using enough fuel and labor. On the other hand, strip tillage as means ploughing where seeds were sown other portion remained unplough with reduces cultivation cost, and reduces the rate of soil erosion compare to the conventional tillage, and

[1] Bangladesh Wheat and Maize Research Institute, Rajshahi
[2] Fast Capital University of Bangladesh, Chuadanga-7200, Bangladesh
[3] Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
*Corresponding Author, Email: iliasrwrc@gmail.com

wheat gives better performance under strip tillage than conventional system (Hossain *et al*., 2014). However, weed is the major obstacle to get maximum yield in the strip tillage (Zahan *et al*., 2016). Therefore, the present research was undertaken to find out the most effective weedicides to control weed under strip till method in wheat.

MATERIALS AND METHODS

The investigation was carried out at Regional Wheat Research Center, BARI, Shyampur, Rajshahi, during the winter season of average two years 2017-18 to 2018-19 using wheat variety BARI Gom33. There were eighteen treatment combinations with doses and application timing given below:

Treatment options for strip-till winter wheat

Treatments	Herbicide	Dose (g a.i. ha^{-1})	Application time
Main plot: Pre-emergence herbicides			
PH_1	No pre-emergence	-	
PH_2	Pendimethalin	1000	Applied within two days after seeding at optimum moisture
PH_3	Atrazine	1000	Applied within two days after seeding at optimum moisture
Sub-plot: Post-emergence			
PO_1	No post-emergence		
PO_2	Atrazine	500	Applied at 15 & 30 DAS
PO_3	Tembotrione (Laudis)	120	Applied at 15 & 30 DAS
PO_4	Halosulfuron methyl (Sempra)	90	Applied at 15 & 30 DAS
PO_5	Tembotrione (Laudis) + Atrazine	120 + 500	Applied at 15 & 30 DAS
PO_6	Halosulfuronmethyl (Sempra) + Atrazine	90 + 500	Applied at 15 & 30 DAS

Before seed sowing applied glyphosate (1000 g a.i. ha^{-1}) as a blanket in all treatments to kill existing all types of weeds. A recommended dose of N (100 kg ha^{-1}) from urea, P (60 kg ha^{-1}) from triple superphosphate, K (40 kg ha^{-1}) from muriate of potash, and S (20 kg ha^{-1}) from gypsum was used. The entire amount of P, K, S, and 2/3rd of N was applied at the time of final land preparation. The remaining nitrogen was applied at the CRI stage after 1st irrigation as a top dress. Hand weeding was done after 1st irrigation. The experiment was laid out in a split plot design with three replications. The unit plot size was 5 m × 4 m. Seeds were sown on 26 November, 2017. Three irrigations were applied at CRI, maximum tillering and grain filling stage. The various species of weed were counted in a 1 m^2 demarcation place at 15 and 30 DAS of wheat with pre- and post- emergence weedicide application. In the same area total numbers of various weeds were collected after 45 DAS and at harvest of seeding and oven dry weight of weeds were recorded.

Data on yield and yield contributing characters were collected from randomly selected 1 m^2 demarcation places and statistically analysis. Weed control efficiency (WCE) was calculated as:

$$\text{WCE (\%)} = \frac{A - B}{A} \times 100$$

Where, A and B are the dry matter weight (g m^{-2}) of weeds of control and treatments, respectively.

Method of dry matter determination

The number of weeds per m^2 was calculated from 3 samples of same plot. The weed species were separated on three categories and packed and labeled separately. Then put the samples in oven for 24 hours at 105 ^{0}C temperature. Dry weight of weed species was measured by electric balance at normal room temperature. Grain yield was recorded from five representative sample of 1 m^2 area per plot. Yield component data were recorded from 10 plants plot^{-1}. All the data were analyzed by Crop Stat Model using LSD with Standard Error.

RESULTS AND DISCUSSION

Effect on weeds of different treatments

From the Table 1, it was observed that grasses were found dominant in all the treatments where sedges were the lowest. Atrazine treatment effectively reduced weed population resulting lower dry matter production (66.4 g) as compared to the control treatment (No pre-emergence, 108.2 g) in all weed species. It was also observed that Atrazine can significantly control sedge and broadleaf weed species rather than grasses. Similar results also reported by Moinuddin *et al*. (2018).

Table 1. Category-wise weed population (no. m^{-2}) and total dry weight (g) under pre-emergence herbicides application at 15 DAS in strip till wheat field

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No pre-emergence	58.4	9.2	12.7	108.2
Pendimethalin	50.7	8.9	12.7	97.3
Atrazine	41.4	3.6	3.1	66.4
LSD (0.05)	3.617	1.036	4.267	7.872
CV (%)	9.17	10.26	10.02	9.87

In case of post emergence herbicides, Table 2, we found that combined application of Tembotrione @ 120 g ha^{-1} +Atrazine @ 500 g ha^{-1} reduced the population of grasses and broadleaf resulting the lowest dry matter production (67.5 g) whereas Halosulfuran @ 90 g ha^{-1} + Atrazine @ 500 g ha^{-1} can effectively control all the weed species including sedges compared to control treatment (99.8 g). All the herbicides were found fairly effective for the broadleaf weeds. Similar results were also observed by Verma and Srivastava (1998).

Table 2. Category-wise weed population (no. m^{-2}) and total dry weight (g) under post- emergence herbicides application at 15 DAS in strip till wheat field

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No post-emergence	50.7	6.9	16.1	99.8
Atrazine	53.3	7.6	5.8	89.2
Tembotrione	54.6	7.8	6.7	93.3
Halosulfuran	56.7	7.6	4.4	91.8
Tembotrione + Atrazine	39.1	7.6	3.7	67.5
Halosulfuran + Atrazine	48.3	5.7	3.8	76.9
LSD (0.05)	3.172	0.587	1.207	4.342
CV(%)	9.87	7.78	10.25	9.77

In a column, means followed by common letters do not differ significantly at 1% level of DMRT

Table 3 showed that Atrazine significantly controlled all the weed species and produced the lowest dry matter (70.4 g) followed by Pendimethalin. Atrazine also showed fair effectiveness against broadleaf followed by grasses compared to control treatment. Tembotione + Atrazine produced the lowest dry matter (69.9 g) and significantly reduced grasses and broadleaf. None of the weedicides were found effective for sedges control at 30 DAS. Only Atrazine application was found highly effective for broadleaf weeds control. Similar results were also observed by Verma and Srivastava (1998).

Table 3. Category-wise weed population (no. m^{-2}) and total dry weight (g m^{-2}) under (a) pre-emergence and (b) post-emergence herbicides application at 30 DAS in strip till wheat field

a)

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No pre-emergence	79.1	14.5	12.7	143.8
Pendimethalin	63.9	15.7	5.4	102.5
Atrazine	53.7	11.6	2.1	70.4
LSD (0.05)	9.88	3.242	3.382	11.284
CV (%)	10.22	10.87	11.28	10.75

b)

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No post-emergence	69.1	10.8	19.1	122.7
Atrazine	64.0	14.2	0.43	117.5
Tembotrione	72.4	11.1	4.87	114.9
Halosulfuran	74.6	17.4	13.2	111.2
Tembotrione+ Atrazine	53.3	16.6	0.7	69.9
Halosulfuran+ Atrazine	60.0	18.5	2.21	96.9
LSD (0.05)	6.162	1.281	0.487	9.677
CV (%)	11.55	10.65	9.87	10.25

The reaction of all the weedicides treatments against all the weed species were found similar both at 30 DAS and 60 DAS compared to control treatment (Table 4a). Terbotrione + Atrazine significantly reduced broadleaf weeds and produced the lowest dry matter (88.1 g). All the weedicide treatments seem to be effective for broadleaf control at 60 DAS whereas only Atrazine was found highly effective in weed control (233.5 g).

Table 4. Category-wise weed population (no. m^{-2}) and total dry weight (g m^{-2}) under (a) pre-emergence and (b) post-emergence herbicides application at 60 DAS in strip till wheat field

a)

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No pre-emergence	81.7	16.4	19.6	233.5
Pendimethalin	75.2	13.8	6.1	175.8
Atrazine	46.2	8.7	2.0	126.6
LSD (0.05)	12.214	5.562	3.335	15.828
CV (%)	11.65	12.27	11.61	10.87

b)

Treatments	Weed Population (no. m^{-2})			Total dry weight (g)
	Grass	Sedge	Broadleaf	
No post-emergence	59.3	13.5	25.2	184.9
Atrazine	65.0	11.5	0.6	174.2
Tembotrione	67.2	22.1	5.9	184.3
Halosulfuran	92.9	5.4	20.6	204.7
Tembotrione+ Atrazine	89.8	23.2	0.8	88.1
Halosulfuran+ Atrazine	81.8	2.2	2.5	189.5
LSD (0.05)	3.882	3.117	0.343	7.242
CV(%)	7.87	11.25	10.54	10.25

Combine effect of pre and post-emergence herbicides on control of weeds in strip-till wheat

Combine effect of pre and post-emergence herbicides had significantly impact on weed population and weed dry weight at 15 DAS on grasses, sedges and broadleaf (Table 5). Maximum grass weed (72.7), (87.2) and (113.6) were found from no pre- emergence with anypost emergence treatments at 15, 30 and 60 DAS, respectively. It was at par with no pre-emergence with post emergence Halosulfuran treatments from same days after sowing. On the other hand, pre-emergence herbicide Atrazine with post emergence Tembotrione + Atrazine herbicide recorded least number of grass weed (21.7), (32.2) and (32.8) at 15, 30 and 60 DAS and it was also at par with pre-emergence Atrazine with post emergence Halosulfuran+Atrazine treatments at same days after sowing. Maximum sedge weed (13.3), (27.7) and (20.0) were found from no pre- emergence herbicide with any post emergence treatments at 15, 30 and 60 DAS. It was at par with no pre-emergence with post emergence Tembotrione treatments from same days after sowing. Minimum sedge weed (5.2), (15.4) and (31.1) were found from pre-emergence Atrazine with post emergence Tembotrione + Atrazine treatments at 15, 30 and 60 DAS and it was also at par with pre-emergence Atrazine with post emergence Halosulfuran + Atrazine treatments at same days after sowing (Table 5). Maximum broadleaf weed (36.1), (42.1) and (58.7) were found from no pre- emergence herbicide with any post emergence treatments at 15, 30 and 60 DAS. It was at par with no pre-emergence with post emergence Halosulfuran treatments from same days after sowing. On the other hand, pre-emergence herbicide Atrazine with post emergence Tembotrione + Atrazine recorded least number of broadleaf weed (1.9), (0.0) and (0.0) at 15, 30 and 60 DAS and it was also at par with pre-emergence Atrazine with post emergence Halosulfuran + Atrazine treatments at same days after sowing. The treatments combination pre-emergence herbicide Atrazine with post emergence Tembotrione + Atrazine showed statistically similar performance as compare with pre-emergence herbicide Atrazine with post emergence Halosulfuran + Atrazine in the wheat field.

Effect of number of weed species and total dry weight of weed at 15, 30 and 60 DAS in wheat field

Pre- and post-emergence treatments had significant impact on total dry weight of weed biomass in wheat field at 15, 30 and 60 DAS (Table 5). The treatment no pre-emergence herbicide with no post emergence herbicide which indicates no weed control showed the highest number of weed dry biomass (165.9 g m^{-2}), (312.2 g m^{-2}) and (264.7 g m^{-2}). The treatment combination as pre-emergence Atrazine with post emergence Tembotrione + Atrazine showed the least total dry biomass (27.6 g m^{-2}), (44.0 g m^{-2}) and (101.0 g m^{-2}) at 15, 30, and 60 DAS. The pre- emergence Atrazine with post emergence Tembotrione + Atrazine was applied till 15 and 30 DAS that controlled weed successfully at later stage. However, the treatment pre-emergence Atrazine with post emergence Halosufuran + Atrazine showed similar performance of weed suppression as of pre-emergence Atrazine with post emergence Tembotrione + Atrazine. These results are in line with those of Balyan (1999) who concluded that herbicides significantly affected the weed population per unit area.

Table 5. Combine effect of pre and post-emergence herbicides on control of weeds in strip-till wheat recorded at 15, 30 and 60 DAS

Treatments		Grass(no. m^{-2})			Sedge (no. m^{-2})			Broadleaf (no. m^{-2})			Total dry weight (g m^{-2})		
		15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
PH_1= No pre-eme.	PO_1	72.7	87.2	113.6	13.3	27.7	20.0	36.1	42.1	58.7	164.9	312.2	264.7
	PO_2	65.8	78.9	78.9	13.1	20.8	21.6	10.8	1.3	1.5	152.1	202.8	169.8
	PO_3	57.7	73.9	68.3	10.0	14.0	27.2	13.1	9.5	11.4	132.2	198.9	197.0
	PO_4	58.6	82.2	112.8	5.6	11.6	7.2	6.7	18.3	40.5	134.5	295.7	182.5
	PO_5	60.0	82.2	45.6	6.7	13.8	21.1	5.8	0.9	1.3	115.6	145.2	245.9
	PO_6	61.4	80.0	113.9	6.4	9.0	1.1	3.6	4.2	4.4	163.3	246.2	208.5
PH_2=Pendimethalin	PO_1	56.7	76.1	61.7	4.7	21.1	16.6	9.7	13.0	13.9	139.0	214.5	181.9
	PO_2	47.5	60.0	60.0	7.5	15.1	7.7	3.6	0.01	0.0	100.4	165.3	152.6
	PO_3	48.1	66.1	81.1	10.3	15.0	30.0	4.4	2.7	3.5	118.8	215.4	135.7
	PO_4	62.5	78.3	103.3	12.8	19.9	8.3	2.5	13.1	15.0	118.8	207.9	135.4
	PO_5	35.6	45.6	41.1	10.8	18.5	17.2	3.3	1.1	1.1	46.5	74.9	157.6
	PO_6	53.6	57.8	103.9	6.9	15.0	2.7	3.3	2.2	2.7	91.1	176.7	177.4
PH_3=At.	PO_1	42.8	53.9	45.6	2.8	23.7	3.8	2.5	2.2	2.8	64.1	128.2	134.9
	PO_2	46.7	53.3	56.1	2.2	6.6	5.0	3.1	0.01	0.0	100.0	154.5	112.9
	PO_3	58.1	77.2	52.2	3.1	4.2	8.8	2.5	2.3	2.8	93.6	138.4	166.4
	PO_4	49.2	63.3	62.8	4.5	20.6	0.5	3.8	7.9	6.2	80.2	149.1	192.5
	PO_5	21.7	32.2	32.8	5.2	15.4	31.1	1.9	0.0	0.0	27.6	44.0	101.0
	PO_6	30.0	42.2	37.8	7.6	16.7	42.7	4.4	0.3	0.4	36.4	145.6	118.9
LSD(0.05)		3.522	4.645	3.755	2.225	4.356	1.354	2.535	4.352	1.125	3.215	5.753	4.875
% CV		11.25	10.80	9.85	10.55	11.45	12.35	8.75	10.65	11.25	9.78	10.78	8.85

PO_1= No post emergence; PO_2= Atrazine (At.); PO_3= Tembotrione; PO_4= Halosulfuron; PO_5=Tembotrione+Atrazine; PO_6= Halosulfuron+Atrazine

Effect of treatments on dry matter and weed control efficiency

The cumulative effect of pre and post emergence herbicides had significant on grain and straw yield with weed control efficiency data were shown in Table 6. Shifting from pre emergence to post emergence herbicide resulted in significant yield increase of wheat, which attributed from higher straw yield and weed control efficiency. Maximum grain (5.32 t ha^{-1}) and straw yield (6.25 t ha^{-1}) was found when both pre and post emergence herbicide like Atrazine@ 500 g ha^{-1}+ Tembotrione (Laudis) @ 120g ha^{-1} water post emergence herbicide and it was at par with grain yield (5.08 t ha^{-1}) from Halosulfuron (Sempra) @ 90 g ha-$^{-1}$+Atrazine @ 500g ha^{-1}post emergence herbicide over only pre and post emergence herbicide. Grain yield was higher due to control of more weed species when applied of both pre and post emergence herbicide like Atrazine@ 500g ha^{-1}+ Tembotrione (Laudis) @ 120g ha^{-1}. Minimum grain yield (3.75 t ha^{-1}) was also found from only preemergence herbicide like Glyphosate was applied. The weed control efficiency of Tembotrione+ Atrazine were very high i.e. 80.5% and 86.7% at 15 and 30 DAS which at par with Halosulfuran+Atrazine i.e. 78.0% and 84.0% as compared to control i.e 37.8% and 38.9% at 15 and 30 DAS and other herbicides. So, Tembotrione+ Atrazine at 15 and 30 DAS of two leave stage were found better

from all other pre and post emergence herbicides (Table 6). The similar results also reported by Sharma *et al.* (1999).

Table 6. Combine effect of pre- and post-emergence herbicides on grain and stoveryieldwith weed control efficiency in wheat under strip-till method

Treatments combination		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	% Weed control efficiency (DAS)		
				15	30	60
No pre-emergence	No post-emergence	3.75	3.55	-	-	-
	Atrazine	4.22	5.75	42.0	54.0	50.7
	Tembotrione	4.05	5.18	37.8	38.9	35.8
	Halosulfuran	4.13	5.15	28.7	35.1	37.0
	Tembotrione+ Atrazine	4.45	5.52	44.6	56.3	36.1
	Halosulfuran+ Atrazine	4.63	5.74	41.5	25.9	43.2
Pendimethalin	No post-emergence	3.98	4.65	43.2	44.5	42.3
	Atrazine	4.55	5.25	59.0	50.2	60.3
	Tembotrione	4.47	5.38	51.5	65.3	64.7
	Halosulfuran	4.58	5.35	51.5	37.4	64.8
	Tembotrione+ Atrazine	4.95	5.64	81.0	77.4	59.0
	Halosulfuran+ Atrazine	4.72	5.32	79.8	76.8	53.9
Atrazine	No post-emergence	4.23	4.92	65.6	61.4	62.3
	Atrazine	4.97	5.38	59.2	53.5	70.6
	Tembotrione	4.78	5.42	61.8	58.3	56.7
	Halosulfuran	4.84	5.53	67.2	55.1	55.2
	Tembotrione+ Atrazine	5.32	6.25	80.5	86.7	73.7
	Halosulfuran+ Atrazine	5.08	5.74	78.0	84.0	72.7

Table 7: Cost related to herbicide in the different treatment combination

Treatments combination		Dose (g a.i. ha^{-1})	Weedicide cost	Grain price	Return (deducting weeding cost (Tk)
No pre-emergence	No post-emergence	-	0	135200	135200
	Atrazine	500	3900	181120	177220
	Tembotrione	120	3200	176800	173600
	Halosulfuran	90	2980	169920	166940
	Tembotrione+ Atrazine	120 + 500	7100	184800	177700
	Halosulfuran+ Atrazine	90 + 500	6880	180000	173120
Pendimethalin 1000 g	No post-emergence	-	2000	174720	172720
	Atrazine	500	1900	188000	184100
	Tembotrione	120	3200	189440	186240
	Halosulfuran	90	2980	183680	180700
	Tembotrione+ Atrazine	120 + 500	7100	192800	185700
	Halosulfuran+ Atrazine	90 + 500	6809	185920	179040
Atrazine 1000 g	No post-emergence	-	7800	177280	169480
	Atrazine	500	3400	190720	186820
	Tembotrione	120	3200	189640	186440
	Halosulfuran	90	2480	184640	181660
	Tembotrione+ Atrazine	120 + 500	7100	194880	187780
	Halosulfuran+ Atrazine	90 + 500	6880	192720	186840

Economic benefits

We made a calculation of return by reducing weeding cost, keeping all other input costs constant. Data from Table 7 reveals that the use of Tembotrione @ 120 g ha^{-1} + Atrazine 500 g ha^{-1} water sprayed at 15 and 30 DAS have given highest benefit Taka 187780 followed by Halosulfuran @ 90 g ha^{-1} + Atrazine 500 g ha^{-1} Taka 186840 and lowest return 135200 taka from no-pre-emergence and post emergence or control plot.

CONCLUSION

Overall performance of the experiment we observed that Tembotraine @ 120 g ha^{-1} + Atrazine 500 g ha^{-1} water at 15 and 30 DAS resulted with better performance both weeds control as well as higher grain yield at par with Halosulfuran @ 90 g ha^{-1} + Atrazine 500 g ha^{-1}. On the other hand, Tembotraine @ 120 g ha^{-1} + Atrazine 500 g ha^{-1} water at 15 and 30 DAS herbicide was economically suitable for the control of wheat weeds comparably with less cost. Though no-pre and post emergence herbicide was good but it was it was also applied by Glyphosate. So, Tembotraine @ 120 g ha^{-1} + Atrazine @ 500 g ha^{-1} water at 15 and 30 DAS were recommended in weeds control successfully in the wheat field under strip tillage method.

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