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Effect of herbicides on weed control efficiency (%), yield attributes, yield and profitability of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment entitled "Evaluation of herbicide for control of complex weed flora in wheat (*Triticum aestivum* L.)" was conducted at Crop Research Station, Masodha (U.P.) during *Rabi* season of 2011-12 and 2012-13 with an objective to evaluate the herbicide against grassy and broad leaved weeds. To find out the effect of weed control on weeds, yield of wheat and to find out the economics of various treatment combinations. The soil of the experimental field was silt loam, having pH 7.6, organic carbon 0.42, available N, P and K 145, 17.5 and 224 kg ha⁻¹, respectively, Field trial was laid out in RBD with three replication, having fourteen treatments viz. Metribuzin 210 g ha⁻¹, Clodinafop 60 g ha⁻¹, Pinoxaden 40 g ha⁻¹, Sulfosulfuron 25 g ha⁻¹, Clodinafop + Metribuzin 60 + 210 g ha⁻¹, Pinoxaden + Metribuzin 40 + 210 g ha⁻¹, Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹, Accord Plus (Fenoxaprop+Metribuzin) (120+210 g ha⁻¹) 1500 ml ha⁻¹, Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹), 40 g ha⁻¹, Atlantis (Mesosulfuron + Iodosulfuron) (14.4 g ha⁻¹) 400 g ha⁻¹, Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ and Isoproturon + 2,4-D 1000+500 g ha⁻¹, weed free and weedy check. The herbicides treatment were executed at 35 DAS with the help of manually operated knapsack sprayer fitted with flat fan nozzle. The minimum weed dry weight and maximum WCE(88.76%) were recorded with Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ which was at par with Tota I(Sulfosulfuron + Metsulfuron) (32 g ha⁻¹), 40 g ha⁻¹, and significantly better for effective weed control as compared to rest of the herbicidal treatment. All the yield contributing characters viz., no. of spike m⁻², no. of grain spike⁻¹, 1000-grain weight as well as grain yields were significantly higher in weed free over rest of the treatments. Among herbicides maximum no. of spike m⁻² (437.85) no. of grain (40.12)spike⁻¹, 1000-grain weight (37.33g) as well as grain yields (52.81q/ha.) were recorded with Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ With respect to economics, Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ recorded maximum net return (Rs. 59895) and B-C ratio (Rs. 2.43).

Keywords: wheat, herbicides, weed dry weight, yield attributes, yield

Introduction

Wheat is an important prime cereal crop among the food-grain is grown in an area of 29.65 m ha in India, with the production 93.5 million tonnes and average productivity 31.53 q ha⁻¹ (FAO, 2013). There are a number of factors responsible for lower productivity of wheat crop as compared to certain developed countries. Biotic as well as the abiotic factors are also posing serious threats in realizing the full potential. Among the abiotic factors, the global warming consequently increase in the temperature at milking stage of the crop is the major threat affecting the productivity adversely. Wheat crop is infested with a number of weeds namely *Phalaris minor*, *Cyperus rotundus*, *Cynodon dactylon*, *Chenopodium album*, *Anagallis arvensis*, *Avena fatua*, *Convolvulus arvensis* etc which can cause upto 33% reduction in wheat yield. *Phalaris minor* is one of the very serious problems in wheat. Significant reduction in wheat yield due to severe infestation of weeds ranging from 18-73% has been reported by Pandey and Verma (2004) [8]. However, some broad leaf weeds are also causing a threat but their control is comparatively easier and effective as compared to that of *Phalaris minor*, really serious challenge. The wild oat reduce grain yield of winter wheat by 17-62% depending upon cultivars.

There are several options like manual weeding and herbicidal application, available for the efficient management of weeds applied before sowing and successive crop growth stages. 2, 4-D is a stage specific herbicide and even tolerant cereal crops are very sensitive to 2, 4-D when applied at germination and seedling stages resulting in malformation of the spikes (Gill & Walia, 1987). Wheat found most sensitive to 2, 4-D applied at the 3 leaf to early tillering stages and most tolerant at the 4th to 5th leaf stages (Voedovim *et al.*, 1975) [11].

In order to control isoproturon resistant *P. minor* and other weed flora of wheat, sulfosulfuron & fenoxaprop (100 g ha⁻¹) are recommended as post emergence (Walia & Singh, 2005) [12]. Other new molecules of herbicides viz, clodinafop (60-80 g ha⁻¹), metribuzin (75-210 g ha⁻¹) metsulfuron methyle (4 g ha⁻¹) have been introduced for effective control of weeds (Tiwari and Vaishya, 2004 and Balyan, 2001) [10,2]. Pinoxaden has been found very effective against grassy weed specially *Phalaris minor*. Effective control of both type of weeds can be achieved by applying pinoxaden and metribuzin in sequential manner.

Materials and Methods

A field experiment entitled "Evaluation of herbicide for control of complex weed flora in wheat (*Triticum aestivum* L.)" was conducted at Crop Research Station, Masodha (U.P.) during *Rabi* season of 2011-12 and 2012-13 with an objective to evaluate the herbicide against grassy and broad leaved weeds. To find out the effect of weed control on weeds, yield of wheat and to find out the economics of various treatment combinations. The soil of the experimental field was silt loam, having pH 7.6, organic carbon 0.42, available N, P and K 145, 17.5 and 224 kg ha⁻¹, respectively. The geographical position of this farm is 26° 43'N latitude, 82° 8' E longitude and an altitude of 113 meters above mean sea level. Field trial was laid out in RBD with three replication, having fourteen treatments viz. Metribuzin 210 g ha⁻¹, Clodinafop 60 g ha⁻¹, Pinoxaden 40 g ha⁻¹, Sulfosulfuron 25 g ha⁻¹, Clodinafop + Metribuzin 60 + 210 g ha⁻¹, Pinoxaden + Metribuzin 40 + 210 g ha⁻¹, Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹, Accord Plus (Fenoxaprop+Metribuzin) (120+210 gha⁻¹) 1500 ml ha⁻¹, Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹,) 40 g ha⁻¹, Atlantis (Mesosulfuron + Iodosulfuron) (14.4 g ha⁻¹) 400 g ha⁻¹, Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ and Isoproturon + 2,4-D 1000+500 g ha⁻¹, weed free and weedy check. The herbicides treatment were executed at 35 DAS with the help of manually operated knapsack sprayer fitted with flat fan nozzle. Wheat cultivar HD-2733 was grown in the experimental field. The variety matures in about 135 days. A uniform seed rate of 100 kg ha⁻¹ was used in all the treatments. Urea, single superphosphate and muriate of potash were used to supply 120 kg N, 60 kg P₂O₅ and 40 kg K₂O ha⁻¹, respectively. Half dose of nitrogen and full dose of phosphate and potassium were applied as basal dressing. Remaining half dose of nitrogen through urea was top dressed in two equal doses. Adequate soil moisture was maintained at all the stages of crop growth. Four irrigations were given at crown root initiation, later tillering, flowering and dough stages of crop.

Results and Discussion

Weed and dry matter

Weed dry matter accumulation reduced appreciably due to the different treatment as compared to weedy check at all the stages of crop growth, except at 30 days stage, It was because of the fact that all the treatments were executed at 35 DAS. Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ reduced the dry matter accumulation appreciably as compared to other weed control treatments. However, other treatments e.g., Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹, Accord Plus (Fenoxaprop+Metribuzin) (120+210 gha⁻¹) 1500 ml ha⁻¹, Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹, Atlantis (Mesosulfuron + Iodosulfuron) (14.4 g ha⁻¹) 400 g ha⁻¹ and Sulfosulfuron 25 g ha⁻¹ also reduced the weed density and was at par with Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹)

400 g ha⁻¹ during 2011-12 while during 2012-13 Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ at par with Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹. These results were also in conformity with the work of Islam *et al.*, 1889 [4]; Mishra, 2002 [6] and Pandey, 2002 [7]; Tarundeep *et al.*, 2007 [9]. Chhokar *et al.*, (2006) [3] and Malik *et al.*, (2012) [5]. This might be due to fact that Metribuzin control the broad and narrow leaved weeds and Clodinafop and Pinoxaden control the narrow leaved weeds only.

Weed control efficiency (W.C.E. %)

As for as the weed control efficiency (W.C.E.%) was concerned, it was also affected due to various weed control treatments. The highest W.C.E. was recorded with Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ (88.76%) fb, Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹ (87.35%), Atlantis (Mesosulfuron + Iodosulfuron) (14.4 g ha⁻¹) 400 g ha⁻¹ (83.87%), Accord Plus (Fenoxaprop+Metribuzin) (120+210 gha⁻¹) 1500 ml ha⁻¹ (82.09%) and Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹. (81.39), and Sulfosulfuron 25 g ha⁻¹ (78.4%), respectively. After all, the Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ was found much effective to control the both type of weeds and resulted to this gave higher value of W.C.E. (%). It is because of the fact that Clodinafop control the narrow leaved as well as the broad leaved weeds and when ready mixed with Metsulfuron which take care of narrow leaf weeds especially *P. minor* enhance the efficacy of this combination and ultimately the Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ treatment proved superior with respect to control the different weed flora and achieved highest value of W.C.E. (88.76%). All most same finding given by Chhokar *et al.*, (2006) [3] and Malik *et al.*, (2012) [5].

Number of spike m⁻², no. of grains spike⁻¹ and test weight (g)

Regarding the number of spike (m⁻²), the highest number of spike was recorded due to Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ (437.85) which was at par with Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹ (427.96) Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹ (415.88) and Sulfosulfuron 25 g ha⁻¹ (410.69), while significantly higher than rest of the treatments. Number of spike directly related with number of tillers, the treatments have more number of tillers ultimately showed the more number of spikes also. All most same finding given by Chhokar *et al.*, (2006) [3]. Malik *et al.*, (2012) [5].

The highest number of grains per spike was recorded due to Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ (40.12) which was at par with Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹ (39.39), Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹ (37.31) and Sulfosulfuron 25 g ha⁻¹ (38.97), while significantly higher than rest of the treatments.

As for as the 1000-grain weight or test weight was concerned, the maximum grain weight was found with Vesta (Clodinafop + Metsulfuron) (60+4 g ha⁻¹) 400 g ha⁻¹ (37.33g) which was at par with Total (Sulfosulfuron + Metsulfuron) (32 g ha⁻¹) 40 gha⁻¹ (37.12), Sulfosulfuron + Metribuzin 25 + 210 g ha⁻¹ (36.39) and Sulfosulfuron 25 g ha⁻¹ (36.33), and significantly superior over the other herbicide treatments.

Grain yield (q ha⁻¹)

The grain yield is the fraction of the total biomass (total dry

matter accumulation) that gets available in the form of economics yield (grain yield) which is the ultimately result of the bio-physiological processes. This is reflected by the source-sink relationship. The grain yield is contributed by the different yield attributes e.g. number of spikes m^{-2} , number of grains spike $^{-1}$ and 1000-grain weight. The treatments in which these attributes got higher value ultimately would give more yields of grains as well as straw. As the different weed control treatments significantly influenced the growth attributes and yield attributes which resulted to this grain as well as straw yields significantly. A combination of ready mix Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$ (52.81) being at par with Total (Sulfosulfuron + Metsulfuron) ($32 g ha^{-1}$) $40 g ha^{-1}$ (51.15), Sulfosulfuron + Metribuzin $25 + 210 g ha^{-1}$ (49.89) and Sulfosulfuron $25 g ha^{-1}$ (50.26) and Pinoxaden + Metribuzin $40 + 210 g ha^{-1}$ (49.76 $q ha^{-1}$), while significantly higher than rest of the treatments. It might be because of the fact that these both the herbicides have the potential to control both type of weeds. These result are also in conformity with Anonymous (2009) [1], Chhokar *et al.*, (2006) [3]. Malik *et al.*, (2012) [5].

Economics

It is one of the very important components of any research programme which indicates the profitability of a particular treatment. In this experiment, a common cost of cultivation of growing a wheat crop was calculated and its value came out to Rs. 23101 ha^{-1} . Then the cost incurred on the different treatment was also calculated and added to the common cost and finally calculate the total cost of cultivation. The gross income of the different weed control treatments was calculated by multiplying the market unit value (Rs. q^{-1}) with respective yield of grain and straw and summed up. Both the net profit and benefit-cost ratio were calculated accordingly.

Among the different treatments Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$ recorded highest value of net profit (Rs. 59895 ha^{-1}) and benefit cost ratio (Rs. 2.43/ rupee invested) followed by Total (Sulfosulfuron + Metsulfuron) ($32 g ha^{-1}$) $40 g ha^{-1}$ Rs.57364 and 2.34, respectively. Weed free treatment also found less remunerative over Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$.

Summary and Conclusion

the weed control efficiency (W.C.E.%), number of spike(m^{-2}), number of grains per spike, 1000-grain weight, grain yield, net profit (Rs. 59895 ha^{-1}) and benefit cost ratio (Rs. 2.43/ rupee invested) were recorded maximum with Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$ which was at par with Total (Sulfosulfuron + Metsulfuron) ($32 g ha^{-1}$) $40 g ha^{-1}$, Sulfosulfuron + Metribuzin $25 + 210 g ha^{-1}$ and Sulfosulfuron $25 g ha^{-1}$, while minimum dry weight of weeds recorded with Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$. On the basis of the result obtained from the experiment following conclusions may be drawn. Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$ was more effective in controlling both narrow and BLWs followed by Total (Sulfosulfuron + Metsulfuron) ($32 g ha^{-1}$) $40 g ha^{-1}$, Sulfosulfuron + Metribuzin $25 + 210 g ha^{-1}$ and Sulfosulfuron $25 g ha^{-1}$, Atlantis (Mesosulfuron + Iodosulfuron) ($14.4 g ha^{-1}$) $400 g ha^{-1}$ and Accord plus (Fenoxaprop + Metribuzin) ($120 + 210 g ha^{-1}$) $1500 ml ha^{-1}$, as these herbicidal treatment showed higher WEC. It is suggested that application of Vesta (Clodinafop + Metsulfuron) ($60+4 g ha^{-1}$) $400 g ha^{-1}$ or, Total (Sulfosulfuron + Metsulfuron) ($32 g ha^{-1}$) $40 g ha^{-1}$ should be done for most effective control of the weeds and achieving higher yield and profitability of wheat crop.

Table 1: Effect of various weed control treatments on yield attributes

Treatments	Number of spike per m^2			Number of grains per spike			1000 grain weight (g)		
	2011-12	2012-13	mean	2011-12	2012-13	mean	2011-12	2012-13	mean
T ₁ : Metribuzin @ 210 $g ha^{-1}$	385.99	411	398.50	43.37	32.44	37.90	34.11	35.80	34.95
T ₂ : Clodinafop @ 60 $g ha^{-1}$	320.64	420	370.32	42.88	31.44	37.16	33.33	35.46	34.40
T ₃ : Pinoxaden @ 40 $g ha^{-1}$	360.10	398	379.05	42.49	30.14	36.31	32.95	34.88	33.92
T ₄ : Sulfosulfuron @ 25 $g ha^{-1}$	390.38	431	410.69	44.83	33.11	38.97	34.50	38.16	36.33
T ₅ : Clodi + Metri @ 60 + 210 $g ha^{-1}$	372.84	390	381.42	41.42	33.11	37.26	32.95	36.98	34.97
T ₆ : Pinoxa + Metri @ 40 + 210 $g ha^{-1}$	355.29	396	375.65	43.86	31.02	37.44	34.88	36.04	35.46
T ₇ : Sulfo + Metri @ 25 + 210 $g ha^{-1}$	394.77	437	415.88	43.86	30.76	37.31	35.27	37.50	36.39
T ₈ : Accord plus [Fenoxa+Metri] @ 120+210 $g ha^{-1}$	289.50	388	338.75	40.93	33.02	36.97	27.91	34.06	30.99
T ₉ : Total [Sulfo + Metsul] @ 32 $g ha^{-1}$	407.93	448	427.96	45.32	33.46	39.39	36.05	38.19	37.12
T ₁₀ : Atlantis [Mesosul + Iodosul] @ 14.4 $g ha^{-1}$	359.68	400	379.84	42.40	33.07	37.73	33.72	35.03	34.38
T ₁₁ : Vesta [Clodi + Metsul] @ 60 + 4 $g ha^{-1}$	416.70	459	437.85	45.81	34.43	40.12	36.05	38.60	37.33
T ₁₂ : Isopro + 2,4-D @ 1000 + 500 $g ha^{-1}$	350.90	423	386.95	40.45	31.44	35.95	32.17	34.72	33.45
T ₁₃ : Weedy check	259.23	382	320.62	41.23	29.58	35.41	32.79	31.90	32.35
T ₁₄ : Weed free	434.24	465	449.62	48.24	34.52	41.38	38.37	39.35	38.86
CD at 5%	56.90	18.71	42.35	6.75	3.19	5.28	6.00	2.86	4.70

Table 2: Effect of various weed control treatments on weed dry weight, WCE (%) and yield of wheat

Treatments	Grain yield ($q ha^{-1}$)			Weed dry weight (g)			WCE (%)		
	2011-12	2012-13	mean	2011-12	2012-13	mean	2011-12	2012-13	Mean
T ₁ : Metribuzin @ 210 $g ha^{-1}$	45.41	47.11	46.26	3.60 (12.46)	2.81 (6.90)	9.68	67.97	84.11	76.04
T ₂ : Clodinafop @ 60 $g ha^{-1}$	42.57	50.08	46.33	4.45 (19.34)	2.66 (6.07)	12.71	50.29	86.02	68.15
T ₃ : Pinoxaden @ 40 $g ha^{-1}$	38.60	46.09	42.33	4.66 (21.22)	2.81 (6.90)	14.06	45.46	84.11	64.78
T ₄ : Sulfosulfuron @ 25 $g ha^{-1}$	50.52	50.00	50.26	3.60 (12.46)	2.46 (5.07)	8.76	67.97	88.83	78.40
T ₅ : Clodi + Metri @ 60 + 210 $g ha^{-1}$	47.68	49.23	48.45	3.44 (11.53)	2.61 (5.83)	8.68	70.83	86.57	78.70
T ₆ : Pinoxa + Metri @ 40 + 210 $g ha^{-1}$	48.25	51.28	49.76	3.43 (11.26)	2.52 (5.33)	8.30	71.06	87.72	79.39
T ₇ : Sulfo + Metri @ 25 + 210 $g ha^{-1}$	49.95	49.83	49.89	3.07 (8.95)	2.68 (6.17)	7.56	76.99	85.79	81.39
T ₈ : Accord plus [Fenox.+Metri] @ 120+210 $g ha^{-1}$	46.54	44.73	45.63	2.91 (7.99)	2.76 (6.63)	7.31	79.46	84.73	82.09
T ₉ : Total [Sulfo + Metsul] @ 32 $g ha^{-1}$	51.92	50.38	51.15	2.75 (7.09)	2.25 (4.07)	5.57	84.04	90.62	87.35

T ₁₀ : Atlantis [Mesosul + Iodosul]@ 14.4 g ha ⁻¹	46.03	46.77	46.40	2.93 (8.13)	2.42 (4.93)	6.53	79.10	88.65	83.87
T ₁₁ : Vesta [Clodi + Metsul]@ 60 + 4 g ha ⁻¹	53.08	52.55	52.81	2.59 (6.21)	2.21 (3.90)	5.06	86.50	91.02	88.76
T ₁₂ : Isopro + 2,4-D@ 1000 + 500 g ha ⁻¹	44.67	48.98	46.82	3.56 (12.19)	2.80 (6.83)	9.51	68.67	84.27	76.47
T ₁₃ : Weedy check	34.06	40.14	37.10	6.28 (38.91)	6.66 (43.43)	41.17	0.00	0.00	0.00
T ₁₄ : Weed free	56.19	54.76	55.47	0.71 (0.00)	1.0 (0.00)	0.00	100.00	100	100
CD at 5%	5.91	2.42	4.51	0.68	0.21		-	-	-

Table 3: Economics of different treatments

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B-C ratio (Rs.re ⁻¹ invested)
T ₁ : Metribuzin @210 g ha ⁻¹	23566	79824	56258	2.38
T ₂ : Clodinafop @ 60 g ha ⁻¹	24051	74128	50077	2.08
T ₃ : Pinoxaden @40 g ha ⁻¹	24076	67728	43652	1.81
T ₄ : Sulfosulfuron @ 25g ha ⁻¹	24076	80416	56340	2.34
T ₅ : Clodi + Metri@ 60 + 210 g ha ⁻¹	24516	77520	53004	2.16
T ₆ : Pinoxa + Metri@ 40 + 210 g ha ⁻¹	24541	79616	55075	2.24
T ₇ : Sulfo + Metri@ 25 + 210 g ha ⁻¹	24541	74016	49475	2.02
T ₈ : Accord plus[Feno+Metri]@120+ 210 gha ⁻¹	24361	73008	48647	1.99
T ₉ : Total [Sulfo + Metsul]@ 32 gha ⁻¹	24476	81840	57364	2.34
T ₁₀ : Atlantis [Meso+Iodo]@14.4 g ha ⁻¹	24001	74240	50239	2.09
T ₁₁ : Vesta [Clodi+Metsul]@ 60+4 gha ⁻¹	24601	84496	59895	2.43
T ₁₂ : Isopro + 2,4-D@ 1000 + 500 g ha ⁻¹	24109	74912	50803	2.10
T ₁₃ : Weedy check	23101	59360	36259	1.57
T ₁₄ : Weed free	29101	88752	59651	2.04

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