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Effect of different doses and method of application of Metribuzin on wheat crop under rice residue cover situations

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Abstract

The escalating demands of a growing population necessitate not only the sustenance of wheat production but also its further augmentation through high-yielding approaches mainly effective weed management. Two field experiments to evaluate different doses and method of application of Metribuzin on growth and yield of wheat crop under zero and conventional tillage systems was conducted at Agronomy Research Farm of CCS Haryana Agricultural University, RRS, Kaul, during *rabi* season of 2021-22 and 2022-23. POE metribuzin 350 g ha^{-1} urea-mix broadcast at 35 DAS with PDN enhanced the growth and productivity of wheat and registered significantly taller height of plants, no. of tillers mrl^{-1} and grain yield (57.35 and 54.10 q ha^{-1} in zero tillage; 61.40 and 58.04 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively) and lowest grain yield was observed with pre-emergence application of Metribuzin at a dose of 210 g ha^{-1}. Additionally, the application of pinoxaden, a post-emergence herbicide, along with different metribuzin treatments led to an increase in wheat grain yield under both tillage systems (51.37 and 48.12 q ha^{-1} in zero tillage; 53.62 and 50.26 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively) as compared to no PDN (48.42 and 45.17 q ha^{-1} in zero tillage; 50.13 and 46.77 q ha^{-1} in conventional tillage during 2021-22 and 2022-23, respectively).

Keywords: Metribuzin, pinoxaden, productivity, tillage

Introduction

Wheat (*Triticum aestivum* L.), which serves as the primary staple food crop in North-Western India, frequently encounters weed infestation, posing a significant challenge to its cultivation. The escalating demands of a growing population necessitate not only the sustenance of wheat production but also its further augmentation through high-yielding approaches. To achieve this, it is imperative to mitigate agricultural losses while increasing overall production. Weeds, in particular, emerge as a major obstacle, inflicting the highest magnitude of damage among all pests. Weed competition constitutes a critical constraint in crop production, as these invasive plants vie with cultivated crops for essential resources such as moisture, nutrients, light, and space, thereby depriving the crops of crucial inputs. A comprehensive investigation by Chhokar *et al*. (2012) [2] emphasized the substantial impact of weeds on wheat cultivation, reporting a remarkable 51% reduction in grain yield observed in weedy check plots compared to treated plots (Singh *et al*., 2015) [12].

Phalaris minor (*P. minor*), a troublesome grass weed, has been found to cause significant reductions in crop yields on a large scale (Chhokar *et al*., 2012) [2]. Resistance in *Phalaris minor* against the herbicide isoproturon first emerged in 1992-93, likely due to its prolonged and continuous use for more than 10-15 years, coupled with the practice of monocropping rice-wheat rotations. This resistance led to complete crop failure or immature crop harvest for fodder (Malik and Singh, 1995) [7]. Consequently, isoproturon was replaced with alternative herbicides in 1997-98 and onwards. However, several of these alternate herbicides, including clodinafop-propargyl, fenoxaprop-ethyl, sulfosulfuron, and pinoxaden, which were recommended for controlling *Phalaris minor*, have also become ineffective due to the evolution of resistance (Brar *et al*., 2002; Dhawan *et al*., 2012; Kaur *et al*., 2016) [1,3,5]. Therefore, it is necessary to screen and evaluate new herbicides, either alone or in combination, as they remain crucial tools in managing resistant *Phalaris minor*. However, the availability of novel herbicides with different modes of action and comparable efficacy against *Phalaris minor* is currently limited. *Phalaris minor* emergence is influenced by factors such as wheat planting time, weather conditions, moisture availability, and field preparations.

Under zero tillage conditions, the initial emergence of P. minor is lower compared to conventional tillage methods for sowing wheat. In India, herbicides are typically applied once during the wheat crop season, making the timing of herbicide application crucial to minimize crop-weed competition and maximize the effectiveness of the herbicide.

Metribuzin, a herbicide that inhibits Photosystem II (PS II), has been proven effective in controlling *P. minor* as well as other grassy and broadleaf weeds (Malik *et al*., 2005; Punia *et al*., 2005) [8, 10]. Research has shown that compared to sulfosulfuron and tralkoxydim, metribuzin outperforms in suppressing weed growth and increasing wheat yield (Pandey and Verma, 2002) [9]. Metribuzin applied 40 DAS provided good control of P. minor resulting in similar yield to manual weeding. Other studies indicated that application of metribuzin at the 2-leaf stage of grass weeds was more effective. Fedoruk and Shirtliffe (2011) [4] found that metribuzin was more effective against weeds in lentil when applied early at four node stage to avoid crop injury. Similarly, its application at the 2-leaf stage of winter wheat and 4-tiller stage of spring wheat was found better for crop safety. Stage of weed at herbicide application is important for weed control efficiency as 2-leaf stage of *P. minor* and *A. ludoviciana* proved more appropriate to achieve better control with isoproturon compared to 6-leaf weed stage (Singh and Malik, 1993; Singh *et al*., 1999) [14, 16]. Similar results on stage of P. minor were observed for other graminicides (Singh *et al*., 2010) [15]. The current study aims to assess the efficacy of metribuzin in managing P. minor in wheat and its impact on wheat growth and productivity. This evaluation will involve testing different application timings, varying dosages, and different methods of application, both with and without the presence of rice crop residue.

Materials and methods

Studies to observe the growth and yield of wheat crop as affected by weed management practices under zero and conventional tillage system began in November 2022 and 2023 at Agronomy Research Farm of CCS Haryana Agricultural University, RRS, Kaul. Soil of experimental field was clay loam in texture, low in available N (106 kg ha^{-1}), medium in available P (21 kg ha^{-1}) and high in available K (360 kg ha^{-1}) with alkaline in reaction (pH 8.65). The size of each plot was 7.0 m × 2.2 m. The wheat variety used for sowing in the experiment was WH 1184 during 2021-22 and 2022-23. The seeding rate was 100 kg ha^{-1} and row spacing was 20 cm. Recommended dose of fertilizers (20 kg N and 40 kg P ha^{-1} through DAP) was applied as basal dose at sowing and need based irrigation was given to the crop through flooding. Pre-emergent herbicides were applied just after sowing in moist soil, early post-emergence (EPOE) herbicides and post-emergence (POE) herbicides were applied at 21 and 35 DAS with a knapsack sprayer fitted with a flat fan nozzle using a spray volume of 500 L ha^{-1} and broadcasting treatments with different media *viz.* sand and urea. The crop was managed according to the standard agronomic practices of the state university. The experiment was laid out in factorial randomised block design with three replications. The treatments consisted of total sixteen metribuzin (MTZ) treatments with and without pinoxaden (PDN) *viz.* PRE MTZ @ 210 and 350 g ha^{-1} spray; EPOE (21 DAS) MTZ @ 105 spray and MTZ @ 210, 280 and 350 g ha^{-1} sand and urea-mix broadcast; POE (35 DAS) MTZ @ 105 spray and MTZ @ 210, 280 and 350 g ha^{-1} sand and urea-mix broadcast. For recording the plant height, ten plants were selected randomly and height was measured from the ground level to the top of the plant. The number of tillers per meter row length (mrl^{-1}) was counted in each plot at 120 DAS, and the average value was calculated. After threshing, grain yields from each plot were weighed separately. The weight of the bundle was recorded before threshing, and the weight of the straw was measured and expressed in kg ha^{-1}.

Before statistical analysis, the data on density of weeds were subjected to square root to improve the homogeneity of the variance. All the data were subjected to the analysis of variance (ANOVA) separately for each year for better understanding of the results. The significant treatment effect was judged with the help of ‘F’ test at the 5% level of significance. The ‘OPSTAT’ software of CCS Haryana Agricultural University, Hisar was used for statistical analysis (Sheoran *et al*. 1998) [11].

Result and Discussion

The dominant weed species found in the experimental fields were primarily *Phalaris minor*, accompanied by other broad-leaf weeds such as *Melilotus indica, Rumex dentatus*, and *Medicago denticulata,* although their densities were relatively low. Plant height is a crucial parameter that signifies the growth and development of crops, reflecting their strength, vigour, and adaptability to the surrounding environmental conditions. At 120 days after sowing (DAS), the recorded plant heights are presented in Table 1. Significantly taller plants were observed when metribuzin at a rate of 350 g ha^{-1}, combined with a urea-mix broadcast application at 35 DAS, was used alongside post-emergence PDN (113.1 and 106.9 cm in zero tillage; 117.2 and 112.3 cm in conventional tillage system during the years 2021-22 and 2022-23, respectively). This result was statistically comparable to the use of POE metribuzin at rates of 210, 280, and 350 g ha$^{-1,}$ applied as sand and urea-mix broadcast at 35 DAS. The number of tillers per meter row length (mrl^{-1}) at 120 DAS is presented in Table 2. The data demonstrates that the highest number of tillers mrl^{-1} was achieved with the application of metribuzin at a rate of 350 g ha^{-1}, combined with a urea-mix broadcast and post-emergence PDN (131 and 124 in zero tillage; 134 and 130 in conventional tillage system recorded in the years 2021-22 and 2022-23, respectively). When PDN was applied post-emergence with metribuzin, an increase in the number of tillers mrl^{-1} was observed compared to treatments without PDN. Additionally, a greater number of tillers mrl^{-1} was obtained when metribuzin application was performed at 35 DAS compared to the same treatment applied at an earlier post-emergence stage (21 DAS). Better weed management resulted in to greater number of effective tillers and consequently higher yields. These results are in conformity with earlier findings (Singh *et al*. 2015, Kaur *et al*. 2017) [13,6]. The analysis of data presented in Table 3 indicated that the treatments had a significant effect. The grain yield of wheat showed a consistent increase with higher doses of metribuzin ranging from 210 to 350 g ha^{-1} in both years. The application of metribuzin as a post-emergence treatment at 35 days after sowing (DAS) resulted in higher grain yield compared to the same treatment applied at 21 DAS. The lowest grain yield was observed with pre-emergence application of metribuzin at a dose of 210 g ha^{-1} (42.09 and 38.84 q ha^{-1} in zero tillage; 43.60 and 40.24 q ha^{-1} in conventional tillage system during

2021-22 and 2022-23, respectively), but it increased as the dose was increased to 350 g ha^{-1}. When comparing the application of metribuzin as a urea-mix versus a sand-mix at both 21 and 35 DAS, the urea-mix resulted in higher grain yield. Additionally, the application of pinoxaden, a post-emergence herbicide, along with different metribuzin treatments led to an increase in wheat grain yield (51.37 and 48.12 q ha^{-1} in zero tillage; 53.62 and 50.26 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively) compared to when pinoxaden was not applied (48.42 and 45.17 q ha^{-1} in zero tillage; 50.13 and 46.77 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively). The average straw yield data recorded at harvest (Table 4) was significantly affected by the different treatments. Among the various treatments, the highest straw yield was obtained with metribuzin at a dose of 350 g ha^{-1} as a urea-mix broadcast at 35 DAS with the addition of PDN. This treatment resulted in significantly higher straw yield compared to the other treatments (78.54 and 76.08 q ha^{-1} in zero tillage; 82.09 and 79.56 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively). The application of PDN in combination with metribuzin significantly increased the straw yield in both years. The post-emergence application of metribuzin at 35 DAS with both urea and sand-mix broadcast showed better grain yield compared to the post-emergence application at 21 DAS. The pre-emergence application of metribuzin at a dose of 210 g ha^{-1} without PDN resulted in the lowest straw yield, *i.e.* 71.23 and 67.17 q ha^{-1} in zero tillage; 72.43 and 69.53 q ha^{-1} in conventional tillage system during 2021-22 and 2022-23, respectively. Significant effect of stage of weed on herbicide efficacy has been well documented for several herbicides (Singh *et al.*, 1999) [12]. Other studies indicated that application of metribuzin at the 2-leaf stage of grass weeds was more effective.

Table 1: Effect of metribuzin (MTZ) and pinoxaden (PDN) on plant height (cm) at 120 DAS of wheat in both zero and conventional tillage during 2021-22 and 2022-23.

Treatment	Time of application	Zero tillage						Conventional tillage					
		2021-22			2022-23			2021-22			2022-23		
		With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean
MTZ-210 spray	PRE	101.1	100.4	100.8	94.9	94.2	94.6	105.2	104.5	104.9	100.3	99.6	100.0
MTZ-350 spray		101.6	100.8	101.2	95.4	94.6	95.0	105.7	104.9	105.3	100.8	100.0	100.4
MTZ-105 spray	21 DAS	105	102	103.5	98.8	95.8	97.3	109.1	106.1	107.6	104.2	101.2	102.7
MTZ-210 sand-mix		105.4	102.5	104.0	99.2	96.3	97.8	109.5	106.6	108.1	104.6	101.7	103.2
MTZ-280 sand-mix		105.8	102.8	104.3	99.6	96.6	98.1	109.9	106.9	108.4	105.0	102.0	103.5
MTZ-350 sand-mix		106.2	103.2	104.7	100.0	97.0	98.5	110.3	107.3	108.8	105.4	102.4	103.9
MTZ-210 urea-mix		106.7	103.9	105.3	100.5	97.7	99.1	110.8	108	109.4	105.9	103.1	104.5
MTZ-280 urea-mix		107.1	104.4	105.8	100.9	98.2	99.6	111.2	108.5	109.9	106.3	103.6	105.0
MTZ-350 urea-mix		107.5	104.8	106.2	101.3	98.6	100.0	111.6	108.9	110.3	106.7	104.0	105.4
MTZ-105 spray	35 DAS	108.2	107.9	108.1	102.0	101.7	101.9	112.3	112	112.2	107.4	107.1	107.3
MTZ-210 sand-mix		111.1	108.6	109.9	104.9	102.4	103.7	115.2	112.7	114.0	110.3	107.8	109.1
MTZ-280 sand-mix		111.6	109.1	110.4	105.4	102.9	104.2	115.7	113.2	114.5	110.8	108.3	109.6
MTZ-350 sand-mix		112	109.5	110.8	105.8	103.3	104.6	116.1	113.6	114.9	111.2	108.7	110.0
MTZ-210 urea-mix		112.4	109.8	111.1	106.2	103.6	104.9	116.5	113.9	115.2	111.7	109.0	110.4
MTZ-280 urea-mix		112.7	110.2	111.5	106.5	104.0	105.3	116.8	114.3	115.6	111.9	109.4	110.7
MTZ-350 urea-mix		113.1	110.7	111.9	106.9	104.5	105.7	117.2	114.8	116.0	112.3	109.9	111.1
Mean		108.0	105.7		101.8	99.5		112.1	109.8		107.2	104.9	
CD (p=0.05)	PDN treatments = 0.7 MTZ treatments = 2.0 PDN × MTZ = NS				PDN treatments =0.6 MTZ treatments = 1.8 PDN × MTZ = NS			PDN treatments = 0.8 MTZ treatments = 2.2 PDN × MTZ = NS			PDN treatments = 0.7 MTZ treatments =2.1 PDN × MTZ = NS		

Table 2: Effect of metribuzin (MTZ) and pinoxaden (PDN) on no. of tillers mrl^{-1} of wheat at 120 DAS in zero and conventional tillage conditions

Treatment	Time of application	Zero tillage						Conventional tillage					
		2021-22			2022-23			2021-22			2022-23		
		With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean
MTZ-210 spray	PRE	87	84	86	80	77	79	90	87	89	87	84	86
MTZ-350 spray		87	86	87	83	81	82	90	89	90	89	86	88
MTZ-105 spray	21 DAS	98	89	94	91	82	86	101	92	97	98	89	94
MTZ-210 sand-mix		100	90	95	93	82	88	103	93	98	100	90	95
MTZ-280 sand-mix		102	91	97	95	84	90	105	94	100	102	91	97
MTZ-350 sand-mix		103	93	98	96	86	91	106	96	101	103	93	98
MTZ-210 urea-mix		105	95	100	98	88	93	108	98	103	105	94	100
MTZ-280 urea-mix		106	95	101	101	90	95	109	98	104	106	95	101
MTZ-350 urea-mix		108	97	103	101	90	96	111	100	106	108	97	103
MTZ-105 spray	35 DAS	111	109	110	104	102	103	114	112	113	111	109	110
MTZ-210 sand-mix		121	111	116	114	104	109	124	114	119	121	111	116
MTZ-280 sand-mix		122	113	118	115	105	110	125	116	121	122	113	118
MTZ-350 sand-mix		125	114	120	118	107	113	128	117	123	125	114	120

MTZ-210 urea-mix		127	117	122	120	110	115	130	120	125	127	117	122
MTZ-280 urea-mix		128	119	124	123	112	118	131	122	127	128	118	123
MTZ-350 urea-mix		131	120	126	124	113	119	134	123	129	130	120	125
Mean		110	101		104	95		113	104		110	101	
CD (p=0.05)	PDN treatments = 2 MTZ treatments = 5 PDN × MTZ = NS				PDN treatments = 2 MTZ treatments = 4 PDN × MTZ = NS			PDN treatments = 2 MTZ treatments = 5 PDN × MTZ = NS			PDN treatments = 1 MTZ treatments = 4 PDN × MTZ = NS		

Table 3: Effect of metribuzin (MTZ) and pinoxaden (PDN) on grain yield (q ha^{-1}) of wheat in zero and conventional tillage conditions

Treatment	Time of application	Zero tillage						Conventional tillage					
		2021-22			2022-23			2021-22			2022-23		
		With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean
MTZ-210 spray	PRE	42.78	42.09	42.44	39.53	38.84	39.19	43.96	43.60	43.78	40.60	40.24	40.42
MTZ-350 spray		43.10	42.67	42.89	39.85	39.42	39.64	44.21	43.88	44.05	40.85	40.52	40.69
MTZ-105 spray	21 DAS	47.72	43.78	45.75	44.47	40.50	42.49	49.45	44.64	47.05	46.09	41.28	43.69
MTZ-210 sand-mix		48.98	44.22	46.60	45.73	40.97	43.35	49.91	45.63	47.77	46.55	42.27	44.41
MTZ-280 sand-mix		49.09	44.95	47.02	45.84	41.70	43.77	50.73	45.96	48.35	47.37	42.60	44.99
MTZ-350 sand-mix		49.88	45.60	47.74	46.63	42.35	44.49	51.25	46.54	48.90	47.89	43.18	45.54
MTZ-210 urea-mix		50.27	45.74	48.01	47.02	42.49	44.76	51.72	47.06	49.39	48.36	43.70	46.03
MTZ-280 urea-mix		50.59	46.25	48.42	47.34	43.07	45.21	52.35	47.34	49.85	48.99	43.98	46.49
MTZ-350 urea-mix		51.00	47.12	49.06	47.75	43.87	45.81	52.83	48.75	50.79	49.47	45.39	47.43
MTZ-105 spray	35 DAS	52.01	51.74	51.88	48.76	48.49	48.63	54.04	53.59	53.82	50.68	50.23	50.46
MTZ-210 sand-mix		54.87	52.32	53.60	51.62	49.07	50.35	57.87	54.56	56.22	54.51	51.20	52.86
MTZ-280 sand-mix		55.09	53.01	54.05	51.84	49.76	50.80	58.36	54.95	56.66	55.00	51.59	53.30
MTZ-350 sand-mix		55.92	53.25	54.59	52.67	50.00	51.34	59.30	55.66	57.48	55.94	52.30	54.12
MTZ-210 urea-mix		56.36	53.72	55.04	53.11	50.47	51.79	59.90	56.12	58.01	56.54	52.76	54.65
MTZ-280 urea-mix		56.97	54.01	55.49	53.72	50.76	52.24	60.67	56.74	58.71	57.31	53.38	55.35
MTZ-350 urea-mix		57.35	54.25	55.80	54.10	51.00	52.55	61.40	57.12	59.26	58.04	53.76	55.90
Mean		51.37	48.42		48.12	45.17		53.62	50.13		50.26	46.77	
CD (p=0.05)		PDN treatments = 0.45 MTZ treatments = 1.27 PDN × MTZ = 1.79			PDN treatments = 0.49 MTZ treatments = 1.39 PDN × MTZ = 1.97			PDN treatments = 0.43 MTZ treatments = 1.21 PDN × MTZ = 1.71			PDN treatments = 0.49 MTZ treatments = 1.38 PDN × MTZ = 1.95		

Table 4: Effect of metribuzin (MTZ) and pinoxaden (PDN) on straw yield (q ha^{-1}) of wheat in zero and conventional tillage conditions

Treatment	Time of application	Zero tillage						Conventional tillage					
		2021-22			2022-23			2021-22			2022-23		
		With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean	With PDN	Without PDN	Mean
MTZ-210 spray	PRE	71.34	71.23	71.29	67.94	67.17	67.56	72.68	72.43	72.56	69.85	69.53	69.69
MTZ-350 spray		71.76	71.31	71.54	68.30	67.85	68.08	72.74	72.53	72.63	69.96	69.73	69.84
MTZ-105 spray	21 DAS	73.85	7184	72.85	71.39	69.38	70.39	76.40	73.01	74.71	73.87	70.48	72.18
MTZ-210 sand-mix		73.91	71.92	72.91	71.45	69.46	70.45	76.47	73.92	75.20	73.94	71.39	72.67
MTZ-280 sand-mix		73.94	72.04	72.99	71.48	69.58	70.53	77.18	74.05	75.62	74.65	71.52	73.09
MTZ-350 sand-mix		74.35	72.08	73.22	71.89	69.62	70.76	77.60	74.45	76.02	75.07	71.92	73.49
MTZ-210 urea-mix		74.80	72.27	73.54	72.34	69.81	71.08	77.87	74.69	76.28	75.34	72.16	73.75
MTZ-280 urea-mix		74.94	72.50	73.72	72.48	70.04	71.26	78.57	75.01	76.79	76.04	72.48	74.26
MTZ-350 urea-mix		74.98	72.76	73.87	72.52	70.30	71.41	79.03	76.21	77.62	76.50	73.68	75.09
MTZ-105 spray	35 DAS	76.24	76.21	76.23	73.78	73.75	73.77	79.93	79.36	79.64	77.40	76.83	77.11
MTZ-210 sand-mix		78.15	76.80	77.48	75.69	74.34	75.02	81.11	80.00	80.56	78.58	77.47	78.03
MTZ-280 sand-mix		78.43	77.00	77.72	75.97	74.54	75.26	81.16	80.07	80.62	78.63	77.54	78.09
MTZ-350 sand-mix		78.20	77.10	77.65	75.74	74.64	75.19	81.43	80.26	80.84	78.90	77.73	78.31
MTZ-210 urea-mix		78.48	77.26	77.87	76.02	74.80	75.41	81.55	80.67	81.11	79.02	78.14	78.58
MTZ-280 urea-mix		78.28	77.34	77.81	75.82	74.88	75.35	81.57	80.72	81.15	79.04	78.19	78.62
MTZ-350 urea-mix		78.54	77.72	78.13	76.08	75.26	75.67	82.09	80.89	81.49	79.56	78.36	78.96
Mean		75.64	74.21		73.06	71.59		78.59	76.77		76.02	74.20	
CD (p=0.05)		PDN treatments = NS MTZ treatments = 1.12 PDN × MTZ = NS			PDN treatments = NS MTZ treatments = 1.20 PDN × MTZ = NS			PDN treatments = NS MTZ treatments = 1.83 PDN × MTZ = NS			PDN treatments = NS MTZ treatments = 2.10 PDN × MTZ = NS		

Conclusion

Based on present investigation, it may be concluded that POE metribuzin 350 g ha^{-1} urea-mix broadcast at 35 DAS with PDN enhanced the growth and productivity of wheat. The grain yield of wheat showed a consistent increase with higher doses of metribuzin ranging from 210 to 350 g ha^{-1} during both years. Timely application, however, is crucial for the control of grassy and broadleaf weeds to realize full potential of herbicide and increased productivity at farmers' field.

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