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Effect of weed management practices on growth and yield of Indian mustard

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Abstract
A field Experiment was conducted during rabi season in 2017-18 and 2018-19 to find out the weed control methods on growth and yield of mustard. The experiment was laid out in randomize block design with three replication. Fifteen weed control treatment was tested in the experiment. Application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (T_3) recorded significantly reduced density and dry weight of weed with WCE (98.46 and 99.02%), which was similar to T_5, T_9, T_{10}, T_{11}, and T_{12} treatments over other herbicide treatments. It resulted significantly increase growth parameters viz. Plant height, number of branch $plant^{-1}$, LAI, Dry matter accumulation and grain and straw yield of mustard crop.

Keywords: Grain yield, growth, herbicide, mustard and weed

Introduction
Mustard (*Brassica juncea* L.) is locally called *rai*, *raya*, *laha* and *raiya*, whereas, rapeseed is called sarson, toria and yellow toria. Its green tender plants are used for preparing vegetable commonly called as "Sarson Ka Saag". India is one of the important among the 3rd leading oilseed producing countries of the world after Canada and China. In world, during 2017-18 rapeseed-mustard occupied almost 36.68 million ha area with total production was 70.42 million tonnes and 1919 kg ha^{-1} productivity (DRMR, 2018) [1]. Mustard is the second most important edible oil seed crop after groundnut in India. In India, during 2017-18, the area of rapeseed-mustard was 6.07 mha with the production of 7.92 mt and productivity of 1304 kg ha^{-1} (DRMR, 2018) [1]. However, in Uttar Pradesh during the year 2017-18, the area of rapeseed-mustard was 0.90 mha with the production of 0.95 mt and productivity of 1055 kg ha^{-1} but the Rajasthan had the highest area (2.12 mha) and production (2.45 mt) with low productivity (1152 kg ha^{-1}) as compared to Gujarat productivity (1373 kg ha^{-1}). In U.P., productivity (1055 kg ha^{-1}) is quite low as compare to Gujarat (1373 kg ha^{-1}) and Rajasthan (1152 kg ha^{-1}). Productivity is low causes various factor viz. Moisture, nutrient, weeds. Weed is a major threat of the mustard crop, which competes at initial stage to crop for moisture, light, nutrient and space. It causes is loses of seed yield up to 35-60% or even more depending upon the weed density, type of weed flora and duration of infestations. By the use of new herbicides we can judge the best herbicide for particular crop. it controlis a preferred practice causes sparse and costly labour as well as lesser feasibility of mechanical or manual weeding. In order to optimize the weed control efficacy and minimize the application costs, use of pre-and post emergence herbicides, as well as herbicide mixtures, has become the alternative. This strategy also represents an important tool to avoid problems related to herbicide resistance. Considering above fact, the present experiment was planned to assess the relative bio-efficacy of pre and post emergence herbicide for broad spectrum weed control.

Material Methods
The present experiment was conducted during *rabi* season 2017-18 and 2018-19 at Agronomy Research Farm in Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya. The soil was silty loam in texture having low organic carbon 0.33 and 0.32% and available nitrogen (137.20 and 136.82 kg ha^{-1}) and medium in available phosphorus (15.2 and 14.5 kg ha^{-1}) and high in potassium (249.22 and 248.32 kg ha^{-1}). Fifteen weed management practices, *i.e.* T_1-Pendimethalin (PE) @ 1000 g ha^{-1}, T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS, T_3-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS,T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS, T_5-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_7-Metribuzin (PE) @ 175 g ha^{-1}, T_8-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at

20DAS, T_9-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS, T_{10}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS, T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{12}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS, T_{14}-Hand weeding at 20 and 40DAS and T_{15}-Weedy check were studied in randomized block design with three replications. The mustard variety cv. 'NDR-8501'was sown manually keeping the row distance of 45 cm and plant distance of 15 cm with the seed rate of 5 kg/ha for the period of2nd week of October during both the years of experiment. The recommended dose of fertilizer like Nitrogen (80 kg ha^{-1}), Phosphorus (40 kg ha^{-1}), Potash (20 kg ha^{-1}) and Sulphur (20 kg ha^{-1}) was applied under experimental field. However, half dose of nitrogen through Urea and full dose of Phosphorus by single super phosphate respectively were applied as basal. Remaining quantity of nitrogen was applied in two equal split. The herbicides were applied using knapsack sprayer fitted with flat fan nozzle with spray volume of 500 l/ha. The other package of practices was adopted to raise the crop as per the recommendations. After sowing, a light irrigation was given flowering and pod formation. The crop was harvested 23th March and 11th March during 2017-18 and 2018-19, respectively. The observations on number of weeds and dry matter of weeds were taken from randomly selected four spots by using 0.5 m^2 iron quadrate from net plot area. The weed data were subjected to square root transformation before analysis. Weed control efficiency was also calculated on the basis of dry matter production by weeds. Data on growth and yield were determined at harvest. The data were statistically analyzed by using statistical procedures and comparisons were made at 5% level of significance.

Result and Discussion

Effect of weed

Different weed management practices significantly reduced the weed density and dry weight of weed at maturity stage. However, besides Hand weeding at 20 and 40 DAS (T_{14}), the lowest density and dry weight was recorded with the application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (T_3), which was statistically at par with T_5 and T_9 as compare to remaining the weed management treatment during both the investigation years. Minimum density and dry weight of weed recorded under pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (T_3) was mainly due to chemical herbicide and manual weeding, Since the herbicides are plant killer, their use at appropriate dose and time make them selective to kill certain plant species leaving selected crop plants unaffected. Many weeds appear to be less sensitive to declining leaf water potential than those of the crop. For example, weeds with more extensive root system and better physical tolerance to drought can quickly exhaust the soil moisture and make crop to suffer greatly for want of soil water. Many researchers have reported lower weed population in mustard and similar crops with the use of herbicides like pendimethalin (Brar and Walia, 1995) [2], isoproturon (Yadav 2004) [3] and quizalofop-ethyl (Meena *et al*. 2011) [4].

The weed control efficiency (WCE %) at harvest was concerned, it was also affected due to various weed contol treatments (Table -1). Beside hand weeding at 20 and 40 DAS, the higher WCE was recorded in pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (98.46 and 99.02%), fb pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS (96.77 and 97.48%) and the lowest with weedy check (0.00 and 0.00) plots during both the years, respectively. Overall the herbicide treatments pendimethalin was found more effective to control the both types of weeds which resulted in higher WCE than other herbicide treatments. It was because of the effective control of broadleaved and grassy weeds due to pendimethalin during both the years. These findings are in close conformity with those reported by Patel *et al*. 2013. As it is well known fact that the weed index (WI %) is directly correlated with WCE, if a particular treatment showed the highest WCE means weeds have been controlled effectively. Thus, there was a inverse relationship between WCE and WI. Pendimethalin (PE) @ 1000 g ha^{-1} with hand weeding at 40 DAS recorded the lowest values of weed index (3.22 and 2.98) fb pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS (8.91 and 9.86) during both the years. It means minimum reduction in seed yield was recorded with T_3 fb T_5. However, the highest seed yield was recorded with hand weeding at 20 and 40 DAS and the lowest with weedy check, respectively

Effect on growth

Weed management practices was significantly affected on plant height, LAI, number of branch $plant^{-1}$, dry matter accumulation and days taken to flowering and maturity stages. However, tallest plant height was recorded with pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (T_3) which was statistically at par with T_5, T_9, T_{10}, T_{11}, and T_{12} treatments over other herbicide treatments. Higher plant height with T_3 was mainly owing to lower weed density during initial stage which was critical period of crop life cycle. Therefore, no more competition between crop and weed was observed for nutrients, moisture, space and light. This resulted in vigorous crop. Integrated weed management increased the uptake of nutrients by crop or weeds contributed to higher vegetative growth. On the other hand, reduction in uptake of nutrients by crop in weedy check and lower synthesis of growth regulators caused reduction in the vegetative growth of crop (Kumar *et al*. 2012 and Regar *et al*. 2007) [6, 7]. Similar trend was also found of LAI, dry matter accumulation, number of branch $plant^{-1}$ and days taken to flowering.

Effect on yield

Yield is the ultimate resultant of the bio-physiological process which coordinated interplay of growth characters and yield attributes. Seed and stover yields were influenced significantly by applying various weed management practices. Besides hand weeding at 20 and 40 DAS, application of herbicides had significant effect on seed and stover yield. The highest grain and stover yield of mustard was also recorded under pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (51.83 and 53.80 q ha^{-1}). It was found statistically at par with T_5, T_9 and T_{11}. Significantly lowest seed and stover yields were found under weedy check during both the years. Similar results were also reported by Yadav *et al*. (2013) [8]. The highest harvest index was also reported under pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS during both the years. The harvest index speaks the conversion efficiency of non-seed portion by turning up nutrient uptake as well as utilization.

Thus, it is concluded that the application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS was significantly reduced weed density and biomass which was highly effective on weed, and produced maximum grain and straw yield.

Table 1: Effect of different weed management practices on plant height, LAI, No of branch and dry matter accumulation of mustard crop.

Treatments	Plant height at harvest		LAI at 90 DAS		number of branches plant^{-1}at harvest		Dry matter accumulation at harvest	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1-Pendimethalin (PE) @ 1000 g ha^{-1}	141.50	143.40	3.38	3.50	17.10	17.85	33.75	34.95
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS	135.50	137.50	3.30	3.42	16.40	17.10	31.55	32.65
T_3-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	165.20	167.40	3.85	3.97	19.70	20.60	40.1	41.45
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	146.60	148.80	3.48	3.61	17.60	18.40	36.6	37.90
T_5-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	161.00	163.20	3.81	3.93	19.30	20.10	39.8	41.10
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	144.00	146.00	3.45	3.56	17.40	18.10	35.75	36.90
T_7-Metribuzin (PE) @ 175 g ha^{-1}	140.40	142.40	3.36	3.47	16.90	17.70	32.85	34.00
T_8-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20DAS	137.30	139.30	3.33	3.45	16.60	17.30	32.2	33.35
T_9-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS	158.10	160.00	3.76	3.87	18.90	19.70	39.3	40.50
T_{10}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS	152.90	155.10	3.62	3.75	18.30	19.20	37.95	39.20
T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	155.80	158.00	3.66	3.80	18.70	19.50	38.6	39.88
T_{12}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	150.00	152.10	3.53	3.65	18.00	18.80	37.5	38.70
T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS	142.60	144.70	3.42	3.54	17.20	18.00	34.85	36.00
T_{14}-Hand weeding at 20 and 40DAS	168.00	170.30	4.10	4.22	20.10	20.90	41.1	42.40
T_{15}-Weedy check	120.70	123.80	2.80	2.93	14.70	15.50	26.3	27.25
SEM±	5.74	5.56	0.13	0.17	0.78	0.78	1.42	1.52
CD (P=0.05)	16.62	16.11	0.36	0.48	2.27	2.25	4.11	4.40

Table 2: Effect of different weed management practices on days taken to maturity, grain yield, straw yield and harvest index of mustard crop.

Treatments	Days taken to maturity		Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest index (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1-Pendimethalin (PE) @ 1000 g ha^{-1}	115.5	116.40	16.10	17.25	44.24	45.59	26.68	27.45
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS	114.5	115.40	14.60	15.75	40.29	41.45	26.60	27.53
T_3-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	118.8	119.70	19.55	21.15	51.83	53.80	27.39	28.22
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	116.6	117.50	16.50	17.65	45.07	46.41	26.80	27.55
T_5-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	118.6	119.50	18.40	19.65	49.75	51.27	27.00	27.71
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	116.4	117.30	16.40	17.55	44.84	46.20	26.78	27.53
T_7-Metribuzin (PE) @ 175 g ha^{-1}	115.3	116.20	15.80	16.96	43.49	44.64	26.65	27.53
T_8-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20DAS	114.9	115.80	15.40	16.55	42.49	43.69	26.60	27.47
T_9-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS	118.2	119.10	18.00	19.25	48.79	50.34	26.95	27.66
T_{10}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS	117.6	118.50	17.20	18.42	46.79	48.34	26.88	27.59
T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	117.8	118.70	17.60	18.88	47.83	50.24	26.90	27.31
T_{12}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	117.2	118.10	16.80	18.00	45.79	47.27	26.84	27.58
T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS	116.0	116.80	16.20	17.32	44.47	45.71	26.70	27.48
T_{14}-Hand weeding at 20 and 40DAS	119.0	120.00	20.20	21.80	53.36	55.33	27.46	28.26
T_{15}-Weedy check	114.3	115.20	12.90	13.65	35.82	36.86	26.48	27.02
SEM±	5.45	4.51	0.72	0.70	1.76	1.67	-	-
CD (P=0.05)	NS	NS	2.09	2.03	5.09	4.84	-	-

Table 3: Effect of different weed management practices on day taken to maturity, grain yield, straw yield and harvest index of mustard crop.

Treatments	Days taken to maturity		Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest index (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1-Pendimethalin (PE) @ 1000 g ha^{-1}	115.5	116.40	16.10	17.25	44.24	45.59	26.68	27.45
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS	114.5	115.40	14.60	15.75	40.29	41.45	26.60	27.53
T_3-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	118.8	119.70	19.55	21.15	51.83	53.80	27.39	28.22
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	116.6	117.50	16.50	17.65	45.07	46.41	26.80	27.55
T_5-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	118.6	119.50	18.40	19.65	49.75	51.27	27.00	27.71
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	116.4	117.30	16.40	17.55	44.84	46.20	26.78	27.53
T_7-Metribuzin (PE) @ 175 g ha^{-1}	115.3	116.20	15.80	16.96	43.49	44.64	26.65	27.53
T_8-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20DAS	114.9	115.80	15.40	16.55	42.49	43.69	26.60	27.47
T_9-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS	118.2	119.10	18.00	19.25	48.79	50.34	26.95	27.66
T_{10}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS	117.6	118.50	17.20	18.42	46.79	48.34	26.88	27.59
T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	117.8	118.70	17.60	18.88	47.83	50.24	26.90	27.31
T_{12}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	117.2	118.10	16.80	18.00	45.79	47.27	26.84	27.58
T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS	116.0	116.80	16.20	17.32	44.47	45.71	26.70	27.48
T_{14}-Hand weeding at 20 and 40DAS	119.0	120.00	20.20	21.80	53.36	55.33	27.46	28.26
T_{15}-Weedy check	114.3	115.20	12.90	13.65	35.82	36.86	26.48	27.02
SEM±	5.45	4.51	0.72	0.70	1.76	1.67	-	-
CD (P=0.05)	NS	NS	2.09	2.03	5.09	4.84	-	-

Table 4: Effect of different weed management practices density and dry weight (g), WCE (%) and WI (%) of mustard crop

Treatments	Weed density at harvest		Weed dry matter at harvest		WCE %		WI %	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1-Pendimethalin (PE) @ 1000 g ha^{-1}	4.96 (24.20)	4.82 (22.80)	7.97 (63.25)	7.82 (60.80)	82.26	84.02	20.30	20.87
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS	5.83 (33.50)	5.68 (31.80)	8.90 (78.85)	8.73 (76.00)	75.44	77.72	27.72	27.75
T_3-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	1.61 (2.10)	1.38 (1.40)	5.15 (26.10)	5.04 (24.95)	98.46	99.02	3.22	2.98
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS	3.78 (13.80)	3.62 (12.60)	6.79 (45.80)	6.65 (43.75)	89.88	91.17	18.32	19.04
T_5-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	2.21 (4.40)	2.02 (3.60)	5.52 (30.00)	5.39 (28.65)	96.77	97.48	8.91	9.86
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	4.20 (17.20)	4.06 (16.00)	7.21 (51.50)	7.07 (49.50)	87.39	88.79	18.81	19.50
T_7-Metribuzin (PE) @ 175 g ha^{-1}	5.19 (26.50)	5.05 (25.10)	8.21 (67.10)	8.07 (64.70)	80.57	82.41	21.78	22.20
T_8-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20DAS	5.52 (30.00)	5.37 (28.40)	8.57 (73.00)	8.40 (70.30)	78.01	80.10	23.76	24.08
T_9-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS	2.47 (5.60)	2.30 (4.80)	5.70 (32.00)	5.57 (30.65)	95.89	96.64	10.89	11.70
T_{10}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS	3.28 (10.30)	3.13 (9.30)	6.35 (39.90)	6.21 (38.20)	92.45	93.48	14.85	15.50
T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	2.90 (7.90)	2.74 (7.00)	6.02 (35.80)	5.89 (34.30)	94.21	95.09	12.87	13.39
T_{12}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS	3.61 (12.60)	3.46 (11.50)	6.64 (43.75)	6.50 (41.90)	90.76	91.94	16.83	17.43
T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS	4.60 (20.70)	4.43 (19.20)	7.60 (57.35)	7.43 (54.80)	84.82	86.55	19.80	20.55
T_{14}-Hand weeding at 20 and 40DAS	1.30 (1.20)	1.14 (0.80)	3.31 (10.50)	3.20 (9.80)	99.12	99.44	0.00	0.00
T_{15}-Weedy check	11.68 (136.40)	11.95 (142.70)	14.43 (208.20)	14.52 (210.60)	0.00	0.00	36.14	37.39
SEM±	0.17	0.17	0.27	0.25	-	-	-	-
CD (P=0.05)	0.49	0.48	0.78	0.71	-	-	-	-

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