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Relative efficacy of in-organic salts as priming agent on germination, vigour, nitrate assimilation and yield in mungbean

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ABSTRACT A study was under taken for improving the germination, stand establishment, growth and yield of mungbean crop through the seed priming techniques. One year old seeds of three mungbean varieties (Samrat, Sulabh 2545 and SML 668) were taken and sand primed with the solutions of in-organic salts including $Mg(NO_3)_2$, $MgSO_4$ and KNO_3 in 30 mM concentration separately for twelve hours. A set of unprimed seeds were kept as control. Experiment was conducted in the cemented pots of 15 kg capacity during summer season in the year 2011-2012 at the research farm of Directorate of Seed Research (DSR) Mau. The results obtained revealed that priming of mungbean seeds with in-organic salts in 30 mM conc. significantly enhanced the seed germination, seedling growth, vigour, nitrate assimilatory enzymes activity, yield attributes and yield in all the varieties evaluated over unprimed control. Among the in-organic salts, the performance of $Mg(NO_3)_2$ was superior over others in respect of seed germination, seedling growth, vigour index 1&2 and attributes and yield whereas the activities of nitrate assimilatory enzymes *viz*: nitrate reductase and nitrite reductase were more influenced with KNO_3 as compared to $Mg(NO_3)_2$ and $MgSO_4$ salts.

Keywords: *Vigna radiata*, mungbean, seed priming, nitrate assimilatory enzyme, in-organic salts

Pulses constitute an integral part of agriculture because of their vital role in enhancing the human diet as well as soil fertility. Besides their higher nutritional value, pulses have a unique characteristic of maintaining and restoring soil fertility through biological nitrogen fixation and thus play a vital role in sustainable agriculture [1]. Generally, pulses are grown on marginal lands both as sole and intercrop during *kharif, rabi* and *summer* seasons. India is the largest producer and consumer of pulses in the world accounting for 33% of world's area and 22% of world's production of pulses. In India, mungbean grown mainly in the state of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Bihar, Port of Rajasthan, Himachal Pradesh and Jammu & Kashmir in an area of 3.44 million ha with production of 1.40 million ton with a productivity of 406 kg/ha [2]. Mungbean contributed 6.5% of total pulse production and it is an important protein rich pulses crop belong to the family *Fabaceae* having short growing period (55 to 60 days) and high nutritive values. Poor crop establishment is a major constraint for mungbean production [3-4] and high yields can be associated with early vigour [5]. Unfavorable environmental conditions are major cause of poor stand establishment and low crop yield. However rapid germination of seedlings could emerge and produce deep roots before the upper layers of the soil are dried and crusted, which may result better crop establishment and higher crop yield [6].

One way for achieving good crop stand under marginal lands is the use of seed enhancement techniques, particularly seed priming [7-8] that improves germination or seedling growth and enhances seed performance by rapid and uniform germination and vigorous seedlings in different crops [9-11]including mungbean and chickpea. With this background, the present

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experiment was laid to study the relative efficacy of different in-organic salts used as osmoticum for seed priming on germination, vigour, activities of nitrate assimilatory enzymes and yield of mungbean.

MATERIALS AND METHODS

The experiment was conducted during 2011-12 at the research farm of Directorate of seed research, Mau (U.P.). One year old farmer saved seeds of mungbean varieties Samrat, Sulabh- 2545 and SML 668 were collected from Mau district of U.P. The collected seeds were surface sterilized with 0.1% of $HgCl_2$ for five minutes.

Those seeds were thoroughly washed after surface sterilization and sand priming was performed as per treatments v/w in 30mM Mg $(NO_3)_2$ (T_1), 30mM $MgSO_4$ (T_2) and 30mM KNO_3 (T_3) separately in plastic container for the period of 12 hour. After priming treatment, the seeds allowed for shade drying. One set of unprimed control (T_0) was also maintained simultaneously. Primed and unprimed seeds of each variety were sown in pots and in germination paper by using between the paper methods with three replications.

Germination and root/shoot length were recorded after 7th days of germination count and the fresh seedlings were kept for drying in oven at 80°C for 24 hours. Dried samples were weighed with an electronic balance and the vigour index 1 & 2 was calculated as germination percent x seedling length and germination percent x seedling dry weight respectively.

The activity of nitrate assimilatory enzymes including nitrate reductase activity and nitrite reductase activity were assayed following the methods of [12] and [13]. At maturity, the yield attributes and yield were recorded and data was analyzed as per standard statistical procedure.

RESULTS AND DISCUSSION

The seeds primed with different in-organic salts *viz.*, Mg $(NO_3)_2$, $MgSO_4$ and KNO_3 showed significant improvement in seed germination, seedling length, seedling dry weight and vigour index I & II over unprimed control. Among the treatments, Mg $(NO_3)_2$enhanced the maximum seed germination (70.44% to 79.10%), followed by KNO_3 (70.44 to 76.66%). However, $MgSO_4$ did not influence the germination significantly (Table 1). The improvement in germination due to treatments through Mg $(NO_3)_2$ and KNO_3 were 12.29 & 8.83% respectively (Fig.1).

The variety Samrat showed maximum germination as well as degree of enhancement over rest of the varieties evaluated. Seedling length is the sum of shoot and root length and it was very much enhanced through seed priming with in-organic salts, the maximum enhancement was observed with Mg NO_3 (49.38%) followed by KNO_3 (17.68%) but the improvement with Mg SO_4 was not significant over control. Mungbean variety Sulabh 2545 showed maximum mean seedling length but the differences among the varieties were non-significant (Table 2 & Fig. 2).

Enhancement in seedling dry weight was also significantly with all the in-organic salts used for priming and maximum improvement (12.42%) was observed with $Mg(NO_3)_2$ followed by KNO_3 (11.84%) and $MgSO_4$ (8.06%) (Table 3 & Fig. 3). The variation was also observed among diffeerent varieties and maximum seedling dry weight was noted with Sulabh 2545 and lowest was recorded in Samrat.

Vigour index is the multiple product of germination X seedling length (Vigour index I) and germination X seedling dry weight (Vigour index II) and maximum values of both vigour index-I (Table 4 and 5)were also recorded with $Mg(NO_3)_2$ followed by KNO_3 and $MgSO_4$. Percent improvement over unprimed control was 67.04, 27.83 and 19.31

Table 1. Effect of different treatments on mean germination percent

Treatment	Germination percent			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	70.00	73.33	68.00	70.44
T_1	88.66	69.33	79.33	79.10
T_2	80.00	76.00	62.66	72.88
T_3	80.66	76.00	73.33	76.66
Mean	79.83	73.66		70.83
		SE(m)±	CD (p=0.01)	
Variety (V)		1.02	2.87**	
Treatment (T)		1.18	3.32**	
V× T		2.04	5.75**	

Table 2. Effect of different treatments on mean seedling length (cm)

Treatment	Seedling length (cm)			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	25.68	28.99	25.61	26.75
T_1	38.59	40.81	40.47	39.96
T_2	28.54	35.95	27.77	30.75
T_3	27.87	32.18	34.38	31.48
Mean	30.17	34.47	32.06	
		SE(m)±	CD (p=0.01)	
Variety (V)		1.60	NS	
Treatment (T)		1.84	5.20**	
V× T		3.20	NS	

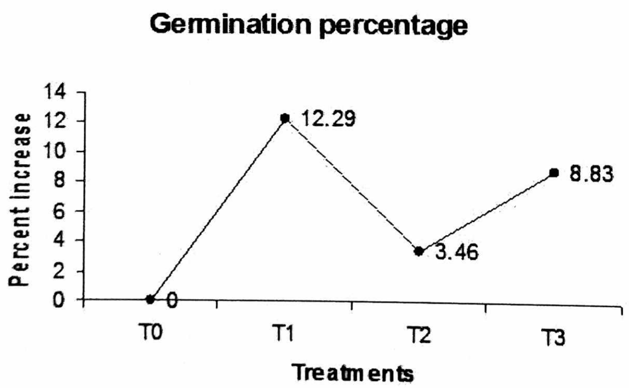

Fig. 1. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on germination of (*Vigna radiata* L.) seeds. T0=control, T1= MN, T2=MS, T3=PN.

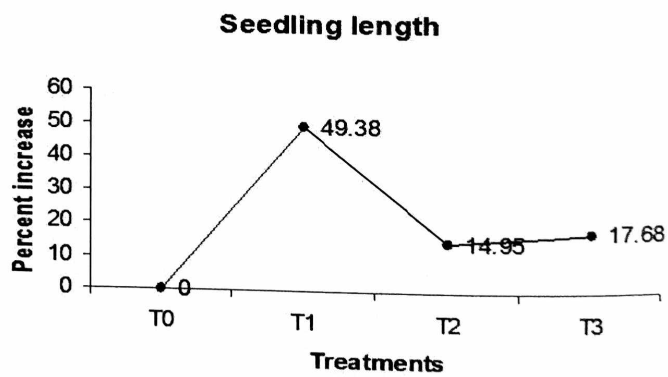

Fig. 2. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on seedling length of (*Vigna radiata* L.) seeds. T0=control, T1= MN, T2=MS, T3=PN.

in vigour index-I and 24.41, 21.14 and 10.65 in vigour index II (Fig. 4 & Fig. 5), respectively. Variety Samrat showed higher vigour index-I whereas vigour index II was recorded highest with Sulabh 2545. These results are very similar with the findings of [14] in tomato and cauliflower and [15] in maize.

Activities of nitrate assimilatory enzymes including nitrate reductase and nitrite reductase were also measured in young growing seedlings of mungbean and the results obtained clearly revealed that among the in-organic salts used, KNO_3 was found most effective followed by $Mg(NO_3)_2$ and $MgSO_4$ for enhancing the activities of enzymes and higher activities of these enzymes are supposed to accelerate the nitrate assimilation rate in the growing seedling which ultimately provided more nitrogen to the plant required for faster growth. Among the varieties SML 668 showed higher activities of nitrate reductase where as maximum nitrite reductase activity was noted with Samrat (Table 6 & 7).

Percent improvement in the activities of these enzyme as result of seed priming treatment indicates that $KNO_3$was the most potential salt and the same trend was also followed by another nitrate salt with magnesium $Mg(NO_3)_2$ but when the salt was $MgSO_4$ the response was relatively lower (Fig. 6 & 7). The findings are very similar with the findings of [16] in soybean, [17] in maize, [18] in sesame. Yield attributes including number of pods/plant, number of seeds/pod, test weight and grain yield/plant responded well towards seed priming treatments, the number of pods/plant were found significantly higher with all the in-organic salts used and they were statistically at par with each other over unprimed control. Interaction between varieties and treatments were significant and maximum pod (6.4) was recorded in variety Samrat with $MgSO_4$ (Table 8). Number of seeds per pod was not affected with these treatments and varieties did not vary among each other (Table 9).

The grain yield showed significant improvement due to these treatments over unprimed control. Maximum grain yield/plant was recorded with Mg $(NO_3)_2$ followed by KNO_3 and $MgSO_4$. Among the varieties, significantly higher grain yield was recorded in Sulabh 2545 over SML 668 and Samrat. Lowest values in this character were noted in Samrat (Table 10).

The improvement in yield due to treatments were 33.05, 13.55 and 18.64% with $Mg(NO_3)_2$, $MgSO_4$ and KNO_3 respectively over control. Osmo-priming with various in -organic salts to seeds eventually enhances the rate of germination and encourages fast emergence of seedling in field [19-20] and this might be lead in enhancement in subsequent stages of plant growth and finally to higher yield of a crop. Bose and Mishra [21-22] opinioned that during soaking of seeds in $Mg(NO_3)_2$or KNO_3solution the cations Mg++ or K+ and anions NO_3 in fluxed in the seeds and showed their carry over effects during vegetative growth period and consequently the yield was increased [23]. Bose and Pandey [24] opinioned that both nitrate and magnesium are not only the nutrients but also potential salts acting as signal for initiating various metabolic process and directly involved in synthesis part even while subjected as seed priming material.

The improvement in yield contributing characters and yield might be due to their effects on actively growing regions in such a way that they mobilized the nutrients absorbed elsewhere towards the shoot that led to more photosynthesis [25] and plant remained physiologically more active, source to sink relationship in plant parts and also build up sufficient food reserves for

Table 3. Effect of different treatments on mean seedling dry weight (mg)

Treatment	Seedling dry weight (mg)			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	154.33	219.00	200.66	191.33
T_1	173.33	237.66	234.33	215.11
T_2	166.33	228.00	226.00	206.77
T_3	179.66	251.66	210.66	214.00
Mean	168.41	234.08	217.91	
		SE(m)±	CD (p=0.01)	
Variety (V)		3.36	9.45**	
Treatment (T)		3.88	10.99**	
V×T		6.72	NS	

Table 4. Effect of different treatments on mean vigour index I

Treatment	Vigour Index I			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	1794.93	2120.65	1746.92	1887.38
T_1	3417.57	2826.60	3214.09	3152.75
T_2	2286.82	2732.80	1736.36	2251.99
T_3	2250.40	2453.96	2533.94	2412.76
Mean	2437.43	2233.50	2307.82	
		SE(m)±	CD (p=0.01)	
Variety (V)		20.62	307.8*	
Treatment (T)		30.27	523.7**	
V×T		52.24	575.6*	

Table 5. Effect of different treatments on mean vigour index II

Treatment	Vigour Index 2			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	10809.33	16045.66	13665.33	13506.77
T_1	15358.00	16473.33	18582.00	16804.44
T_2	13315.33	17331.66	14189.00	14945.33
T_3	14491.33	19125.66	15471.00	16362.66
Mean	13493.49	17244.07	15476.83	
		SE(m)±	CD (p=0.01)	
Variety (V)		192.2	1298.9**	
Treatment (T)		307.7	1553.6**	
V×T		582.8	1641.4**	

Table 6. Effect of different treatments on mean activity (n mole g^{-1} f.w.h^{-1}) of nitrate reductase

Treatment	Nitrate reductase activity			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	407.33	470.13	674.93	517.46
T_1	616.93	817.33	801.73	645.33
T_2	436.40	544.26	626.46	535.71
T_3	464.93	815.86	668.66	649.82
Mean	481.40	661.90	692.95	
			SE(m)±	CD (p=0.01)
Variety (V)			38.58	108.50**
Treatment (T)			44.54	125.29**
V×T			77.16	NS

Table 7. Effect of different treatments on mean activity (n mole g^{-1} f.w.h^{-1}) of nitrite reductase

Treatment	Nitrite reductase activity			Treatments
	Samrat	Sulabh 2545	SML 668	Mean
T_0	959.20	968.00	988.53	971.91
T_1	1487.20	1214.40	1229.00	1310.20
T_2	1434.40	1281.86	1129.33	1281.86
T_3	1947.33	1076.53	1358.13	1460.80
Mean	1457.13	1135.20	1176.25	
			SE(m)±	CD (p=0.01)
Variety (V)			30.40	85.50**
Treatment (T)			35.10	98.73**
V×T			60.80	171.01**

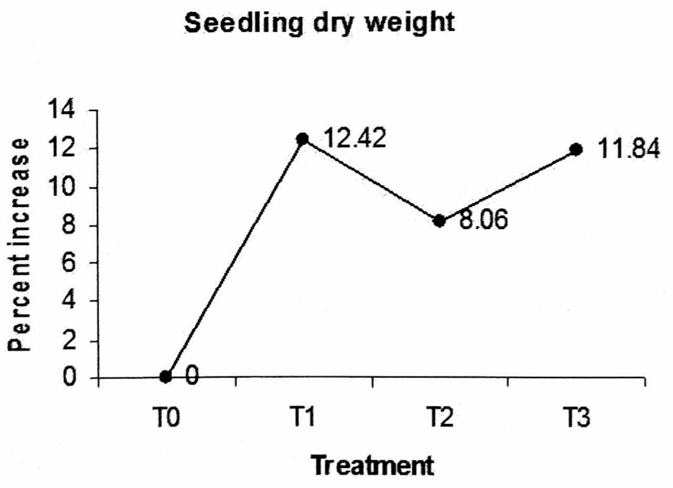

Fig. 3. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on seedling dry weight of (*Vignaradiata* L.) seeds. T0=control, T1=MN, T2=MS, T3=PN.

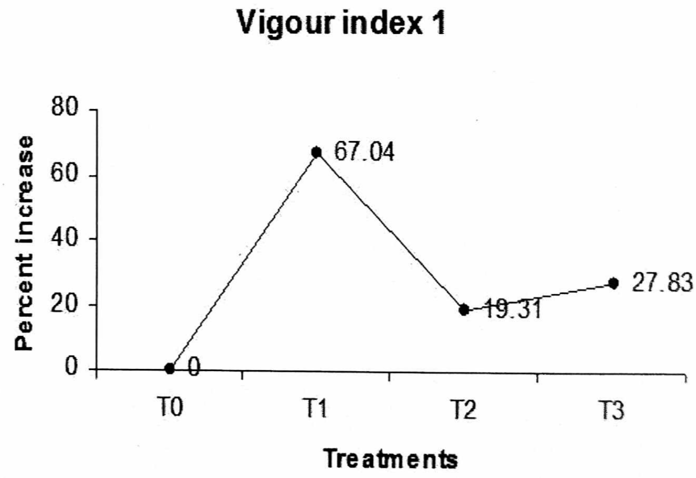

Fig. 4. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on vigour index 1 of (*Vigna radiata* L.) seeds. T0=control, T1= MN, T2=MS, T3=PN.

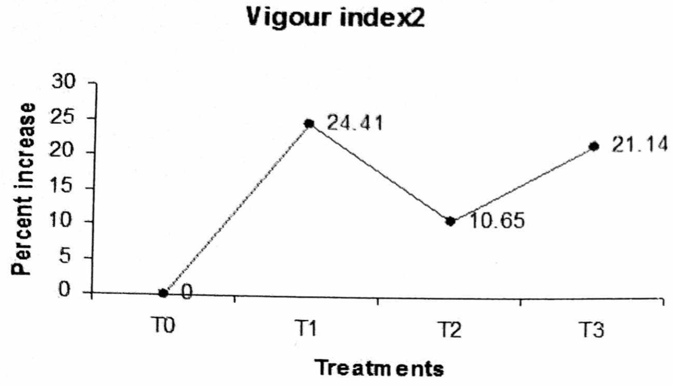

Fig. 5. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on vigour index 1 of (*Vigna radiata* L.) seeds. T0=control, T1= MN, T2=MS, T3=PN.

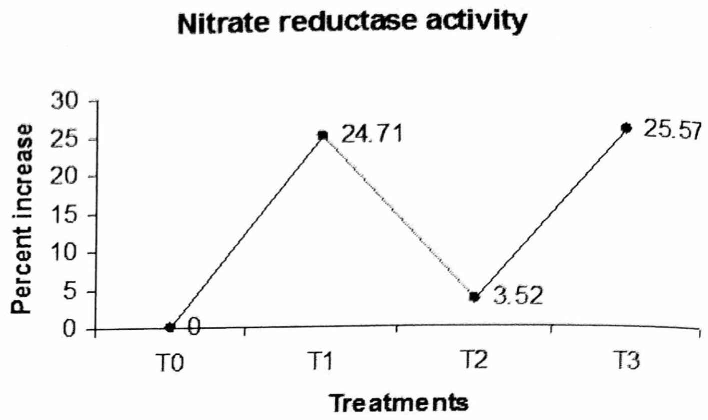

Fig. 6. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on Nitrate reductase activity of (*Vigna radiata* L.) seeds. T0=control, T1= MN, T2=MS, T3=PN.

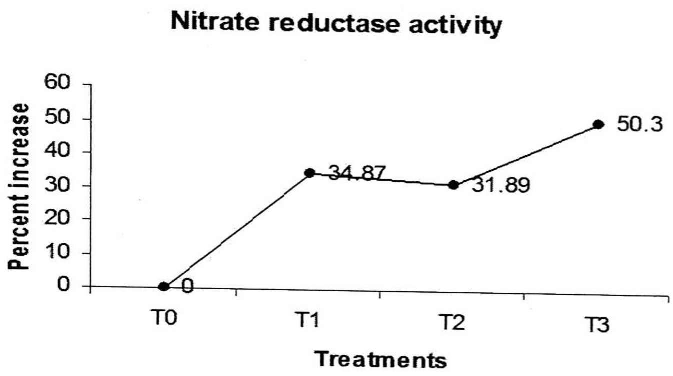

Fig. 7. Effect of various treatments [Magnesium nitrate (MN), Magnesium sulphate (MS) and potassium nitrate (PN)] on Nitrite reductaseactivity of (*Vigna radiate* L.) seeds. T0=control, T1=MN, T2=MS, T3=PN.

developing flowers and fruits as a result yield was increased.

The results are very similar with the findings of [26] in Sunflower, [14] in tomato and cauliflower, [27] in tomato, [28] in Canola, [29] in rice, [30] in mungbean, [31] in Okra, [32] in ground nut and [33] in Mustard. Conclusively, the productivity of mungbean *Vigna radiata* L. seeds was enhanced through priming with in-organic salts [$Mg(NO_3)_2$, $MgSO_4$ and KNO_3]. Among the inorganic salts, sand priming with $Mg(NO_3)_2$ for twelve hours in 30mM concentration gives the better germination, stand establishment and

Table 8. Effect of different treatments on mean number of pods/plant.

Treatment	Varieties			Mean
	Samrat	Sulabh 2545	SML 668	
Control(Unprimed)	4.4	4.7	5.2	4.8
Primed with $Mg(NO_3)_2$	6.2	5.0	5.6	5.6
Primed with$MgSO_4$	6.4	5.4	4.7	5.5
Primed with KNO_3	6.0	5.8	5.1	5.6
Mean	5.7	5.2	5.1	

		SE(m)±	CD (p=0.01)
Variety (V)		0.16	0.34*
Treatment (T)		0.19	0.54**
V×T		0.33	0.69*
CV	7.81%		

Table 9. Effect of different treatments on mean number of seeds/ pod

Treatment	Varieties			Mean
	Samrat	Sulabh 2545	SML 668	
Control(Unprimed)	8.1	8.2	6.4	7.5
Primed with $Mg(NO_3)_2$	8.5	8.4	8.5	8.4
Primed with $MgSO_4$	7.5	7.7	7.7	7.6
Primed with KNO_3	8.6	6.9	7.7	7.7
Mean	8.1	7.8	7.5	
			SE(m)±	CD (p=0.01)
Variety (V)			0.29	NS
Treatment (T)			0.34	NS
V×T			0.59	NS
CV	9.40%			

Table 10. Effect of different treatments on enhancement in mean yield/plant (gm)

Treatment	Varieties			Mean
	Samrat	Sulabh 2545	SML 668	
Control(Unprimed)	1.17	1.26	1.13	1.18
Primed with $Mg(NO_3)_2$	1.37	1.84	1.50	1.57
Primed with $MgSO_4$	1.34	1.29	1.40	1.34
Primed with KNO_3	1.27	1.50	1.45	1.40
Mean	1.29	1.47	1.36	
			SE(m)±	CD (p=0.01)
Variety (V)			0.03	0.08**
Treatment (T)			0.03	0.10**
V×T			0.06	0.17**
CV	5.43%			

enhanced productivity of crop, whereas in-organic salt KNO_3 enhanced the activity of Nitrate reductase and Nitrite reductase enzyme that will increase the activity of Nitrogen fixation in mungbean crops (*Vigna radiata* L.). It is an easy and cost effective technology for the resource poor farmers.

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