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INDUCED GENETIC VARIABILITY FOR QUANTITATIVE TRAITS BY GAMMA RAYS IN SOYBEAN JS335

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ABSTRACT

JS335 variety of Indian soybean (*Glycine max* (L.) Merrill) was treated with 200, 250 and 300 Gy doses of gamma rays with the objective to study the variability in M_2 for the qualitative and quantitative characters. The experiment was conducted in the experimental farm of Samarth Agriculture College Deulgaon Raja, Buldana during kharif and Rabi 2016. The treated material along with untreated control planted in M_1 generation and individual plants were harvested separately. Harvested seeds of individual plants from M_1 generation were planted in non replicated field trial to raise M_2 generation. Observations were recorded on different yield attributing characters like days to flowering, days to maturity, plant height, number of branches plant^{-1}, length of primary root, number of pods plant^{-1}, 100 seed weight and grain yield plant^{-1}. In M_2 generation days to flowering and days to maturity increased significantly in all the treatments. Plant height, number of branches plant and length of primary root reduced significantly in all the treatments. Number of pods plant^{-1} and grain yield plant significantly increased in all the treatments and 100 seed weight significantly decreased in all the treatments as compared to control. Visible macromutants like chlorophyll mutants, early flowering, late flowering, early maturing, late maturing, dwarf, tall, increased root length, increased 100 seed weight, small leaf, wrinkled leaf, viney type mutants, sterile, high yielding, more pods, more branched mutants were identified and isolated in M_2 generation. The economical and morphological mutants were isolated from the variety of JS-335. High yielding mutant with 14 to 19 g yield as against 5.39 g in control were identified from this variety. Early maturing mutant matured 13.4 to 22.5 days earlier than control were isolated from this variety. These mutants need to be evaluated for their breeding behavior in further generation and their utilization in improvement of soybean.

Keywords: Soybean JS 335, gamma rays, mutation, quantitative traits

Introduction

Soybean (*Glycine max* (L.) Merrill) is referred as "Golden bean" and "Miracle crop" of 21st century. It is one of the important oilseed as well as legume crop. It contributes more than 50% to the global production of edible oil. Soybean contains 20% oil and 40% protein. Soybean protein is rich in all essential amino acids, vitamin A, B and D; health promoting phytochemicals like isoflavones, hence, soybean referred as "Wonder crop" or "Golden bean". Soybean oil is used as edible oil in Indian diet. It contains low level of saturated fatty acids. Therefore, soybean oil is better for human health. Soybean is highly self pollinated crop. Taxonomically soybean belongs to the order Fabales and family "Leguminoseae" and subfamily "Papilionidae" and the genus Glycine. Global output of soybean was reported as 155.1 million metric tonnes, and the main producers were the United States, Brazil, Argentina, China, and India (Anonymous, 2000).

Soybean originated in North Eastern China. It entered in India during 6 century AD. USA, Brazil, China, Argentina and India are the major soybean producing countries in the world. These countries accounts for 90% of the world production. India ranked 5" position in respect to area and production. The largest soybean producing states in India are Madhya Pradesh, Maharashtra and Rajasthan. In India, Maharashtra ranks second in area and production (Anonymous, 2016).

The concept of inducing mutation and utilizing them in plant breeding was first given by *Hugo de vries* (1903) for generating variability and achieving the goal of generating of new strains of cultivated crop plants. Among the various kinds of irradiation used for producing variation in crop plant, X-ray and gamma rays produce gene mutation more efficiently. Both these are ionising radiations and have many identical properties, but differing in the form of origin.Gamma rays an ionizing physical mutagen capable of inducing mutation in plants. Gamma rays are electromagnetic radiations similar to X-rays in their physical characteristics and action on the organism they are therefore, natural X-rays but of very short wavelength by virtue of which they are more penetrating. Most of the gamma rays wavelengths are of less than 0.01 A° as compared to 0.5A°of X-rays.Kharkwal and Shu (2009) Gamma rays are known to be an affordable and powerful type of ionising radiation because of their ease of access and their ability to infiltrate tissues. A variety of chemical and physical mutagens are commonly utilised to cause genetic diversity in plants.

Keeping in view the above aspects, the present study was undertaken to create variable population and select morphologically distinct mutants from the population.

Materials and Methods

Dry healthy and genetically pure seeds of soybean cultivar JS-335 were used in this investigation. The seeds of JS-335 were irradiated by gamma rays at Bhabha Atomic Research Centre, Trombay, and Mumbai. Equal quantity of seeds (i.e. 500 g of each lot) were irradiated by different dosages of gamma beams treatment. These seed were treatmented by three diverse dosages of gamma beams i.e. 200 Gy, 250 Gy and 300 Gy (Co^{60}at BARC, Trombay, Mumbai).

M_1 generation was raised in kharif 2017. The treated seeds along with the control were sown immediately after treatment to raise the M_1 generation at Samarth Agriculture College Deulgaon Raja Dist. Buldana. All the recommended cultural practices and management were given to raise a good crop and maximum multiplication of seed. The M_1 population was studied by recording observations at different growth stages. M_1 generation was screened for different morphological mutants. Seeds from each M_1 generation yielded independently and labelled with plant amount, doses and ancillary characters and stored to elevate to M_2 generation.

M_2 generation was elevated within Rabi 2017. By sowing seeds of each M_1 plants separately all the harvested seeds from each treatment were sown to raise M_2 population. The sowing was undertaken on the fertile and well levelled piece of land at Samarth Agriculture College Deulgaon Raja Dist. Buldana. The statistical analysis was done for Mean, Standard deviation (S.D.) and Coefficient of Variation (C.V.) by following standard formulas suggested by Singh and Choudhary (1985).

Results and Discussion

Data regarding the effect of gamma rays on different quantitative traits of soybean are presented in Table 1. Maximum mean value for days to flowering was observed in 300 Gy treatments (71.24 days) and was statistically significant, while the minimum days to flowering was recorded in 200 Gy treatments (66.94 days) as compared to their respective controls (66.95 days). The coefficient of variation increased in all the treatments for days to flowering as compared to control. The maximum coefficient of variation was observed in 250 Gy treatment (7.99%) while the minimum in 200 Gy treatment (5.75%). The range of variation in treated population was 5.75% to 7.99%. It is observed in these study that increase in days to flowering resulted from gamma rays treatment as compared to control. Dhole (1999) also noticed that the flowering delayed significantly in gamma rays treated soybean as compared to control.

Mean value for days to maturity was observed to increase in all the treatments as compared to control. The maximum mean value was observed in 250 Gy treatment (118.30 days) and minimum in 300 Gy treatment (116.24 days). The days to maturity in control was (116.10 days). The coefficient of variation increased in all the treatments as compared to control. The maximum variation was found to be in 250 Gy treatment (5.60%) while the minimum in 200 Gy treatment (4.60%). The range of coefficient of variation was 4.60 % to 5.60 %. Gopinath and Pavadai (2015) also observed that in M_1 and M_3 generations mean for days to maturity increased at mutagenic treatment than control in soybean.

Plant height (cm) reduced significantly in all the treatment as compared to control. Maximum plant height was observed in 250 Gy treatments (46.09 cm) while the minimum was in 200 Gy treatment (41.62 cm) as compared to control treatment (55.90 cm). The coefficient of variation for the plant height increased in all the treatments as compared to the control. The maximum variation was noticed in 200 Gy treatment (31.52 %) and 300 Gy treatment (30.20 %) and minimum in 250 Gy treatment (25.56 %) as compared to control treatment (14.22 %) respectively. The range for the coefficient of variation was 25.56 % to 31.52 %. El-Demerdash (2007) studied the effect of gamma irradiation doses of 100, 150 and 200 Gy on soybean plants and found that plant height deceased by gamma irradiation. Ellyfa *et al*. (2007) also observed that the lowest doses of irradiation (300 Gy) reduced the plant growth characters compared to the control in snapbean.

Data regarding number of branches plant^{-1} revealed that the highest mean value for the character was recorded in 250 Gy treatment (4.95) and the lowest in 200 Gy treatment (4.19). In general the number of branches decreased in all the treatments as compared to their control treatment (5.97). The variability studies showed that the coefficient of variation increased against their control in all the treatments. The variation for the character ranged from 34.55 % to 46.06 % as compared to control treatment(27.64%). The highest variation was recorded in 200 Gy treatment (46.06%) and 300 Gy treatment (38.19%) and the lowest in 250 Gy treatment (34.55 %).It is revealed that gamma rays treatment resulted in decrease in number of branches plant' as compared to control. El-Demerdash (2007) studied the effect of gamma irradiation doses of 100, 150 and 200 Gy on soybean plants and observed that number of branches plant^{-1} were deceased by gamma irradiation.

The mean value for length of primary root (cm) decreased in all the treatments of gamma rays as compared to control. The maximum mean value for the characters was observed in 300 Gy treatment (15.12 cm) and minimum in 250 Gytreatment (14.73 cm). The coefficient of variation increased in all the treatments for length of primary root as compared to control. The maximum coefficient of variation was observed in 250 Gy treatment (22.00%) while the minimum in 300 Gy treatment (14.62%). The range of coefficient of variation in treated population was 14.62% to 22.00%. It is revealed from this observation that the mean length of primary root decreased in gamma rays treatment as compared to control.

Nandanwar *et al*. (1995) reported reduction in root and shoot length as the doses of gamma rays increased in mungbean. Ellyfa *et al*. (2007) also observed that increase in dosage of gamma irradiation was accompanied with decrease in height, root length, oven-dry weight of shoot and survival of snap bean.

Table 1 : Effect of gamma rays on different quantitative traits of soybean

Characters	Parameters	Irradiation dose (Gray)			
		200 Gy	250Gy	300Gy	Control
Days to flowering	*Mean*	*66.94*	*68.20*	71.24	66.95
	SD	3.85	5.45	5.35	7.99
	CV %	5.75	7.99	7.51	5.60
Days to maturity	Mean	117.85	118.30	116.24	116.10
	SD	5.42	6.63	5.71	4.65
	CV %	4.60	5.60	4.91	4.01
Plant height (cm)	Mean	41.62	46.09	44.21	55.90
	SD	13.12	11.78	13.35	7.95
	CV %	31.52	25.56	30.20	14.22
No. of branches plant^{-1}	Mean	4.19	4.95	4.53	5.97
	SD	1.93	1.71	1.73	1.65
	CV %	46.06	34.55	38.19	27.64
Length of primary root (cm)	Mean	14.97	14.73	15.12	15.50
	SD	2.47	3.24	2.21	2.08
	CV %	16.50	22.00	14.62	13.42
No. of pod plant^{-1}	Mean	25.62	35.78	29.65	22.00
	SD	15.85	15.99	17.55	8.50
	CV %	61.87	44.69	59.19	38.63
100 seed weight (g)	Mean	12.12	11.77	10.94	12.98
	SD	1.07	1.71	1.84	0.67
	CV %	8.83	14.53	16.82	5.16
Grain yield plant^{-1}	Mean	5.97	6.97	6.24	5.39
	SD	2.62	2.60	2.52	1.26
	CV%	43.89	37.30	40.38	23.19

Table 2 : Effect of different treatments of gamma rays on different characters of macromutants in M_2 generation.

Treatment	Plant no	Characters	Days to flowering	Days to maturity	Plant height (cm)	No of branches plant^{-1}	Length of primary root (cm)	No. of pods plant^{-1}	100 seed weight (g)	Grain yield plant^{-1} (g)
T1 (200 Gy)	1	High yield, More pods	69	120	34	4	13	86	13	7
	2	More pods, High yield	66	109	57	6	15	35	12	9
	3	More branched, More pods,100 SW, HY	67	119	59	10	17	20	15	8
	4	Tall, Small leaf	65	123	63	4	17	36	11	9
	5	More branched	65	112	51	2	16	34	11	9
	6	Tall, More pods	72	121	69	6	17	20	12	7
	7	Dwarf, 100 SW, HY	64	114	23	4	13	36	15	6
	8	Tall, HY	65	116	63	7	16	22	13	19
	9	Early flowered, EM, Tall	59	105	61	6	14	20	15	7
	10	Tall, 100 SW	66	119	68	6	19	40	12	5
	11	Early flowered, More branched	61	116	37	4	12	35	11	8
	12	Early matured, Small leaf	68	106	30	4	16	30	12	5
	13	Early flowered	61	108	43	6	14	30	9	7
	14	Wrinkled leaf	70	125	47	5	14	32	10	6
	15	Small leaf	69	121	50	4	15	30	12	4
	16	Dwarf	66	117	22	4	15	20	10	5
	17	More branched	63	119	60	5	14	28	13	6
	18	Early flowered, Dwarf	62	114	26	6	12	24	12	4
	19	More branched	64	125	43	6	14	28	12	7
	20	Late flowering, LM	78	127	44	4	16	31	13	5
	21	Small leaves	66	119	37	4	15	24	11	4
	22	More branched, 100 SW	67	110	42	3	15	30	14	3
	23	Dwarf	62	113	20	4	10	12	12	4
	24	Dwarf	66	114	16	1	11	13	13	4
	25	Small leaf	66	119	37	3	13	26	12	3

	26	Wrinkled leaf	63	118	49	4	15	30	11	7
	27	Viney type, Wrinkled leaf,	69	121	32	0	14	8	11	4
	28	Late flowered LM	78	129	30	4	15	14	13	5
	29	Late maturity	75	128	47	3	14	18	10	4
	30	Tall, Root length above 20 cm	76	124	62	5	19	21	13	7
	47	Dwarf	70	123	23	1	23	2	11	4
	54	Root length above 20 cm	64	109	59	3	18	11	12	3
	76	Root length above 20 cm	65	126	34	6	18	12	13	4
	78	Sterile	-	-	49	4	14	-	-	-
	80	Sterile	-	-	56	3	14	-	-	-
	83	Viney type	69	118	42	0	12	13	13	4
	85	Chlorophyll deficient	-	-	13	-	-	-	-	-
	87	Chlorophyll deficient	-	-	12	-	-	-	-	-
	88	Chlorophyll deficient	-	-	13	-	-	-	-	-
T_2 (250 Gy)	1	High yield, More pods, More branched, EF, EM	61	97	44	7	16	99	10	16
	2	More branched More pods,100 SW	66	109	53	9	17	76	15	8
	3	More pods,100 SW, HY	69	111	52	7	13	61	12	11
	4	Early flowered, EM,	62	107	60	6	16	47	10	4
	5	Tall	63	113	64	7	16	16	12	3
	6	Tall, Small leaf	61	109	62	4	11	24	13	5
	7	More pods, EM	64	108	50	5	12	62	12	9
	8	Wrinkled leaf	63	120	58	6	12	43	11	8
	9	Dwarf , EF, EM	59	101	42	4	11	19	13	5
	10	High yield, 100 SW, small leaf	65	120	41	5	16	38	12	12
	11	High yield, 100 SW, Root length above 20 cm	70	125	52	3	19	47	14	12
	12	High yield, 100 SW	69	129	66	4	10	19	15	11
	13	More branched	65	112	46	8	16	33	13	5
	14	Tall, 100 SW	71	124	64	4	17	11	12	7
	15	Tall, Wrinkled leaf	68	119	66	6	18	24	13	8
	16	More branched	65	117	33	8	15	14	12	3
	17	Viney type	66	120	59	0	14	11	-	-
	18	Late matured	69	133	49	4	15	39	11	8
	19	Root length above 20 cm,	70	119	58	5	21	27	12	6
	20	More branched,	64	130	60	8	14	20	12	5
	21	Early flowered, More branched	63	110	49	9	14	41	11	6
	22	Late flowering, LM	93	129	46	3	10	20	11	4
	23	Small leaf	71	121	55	0	13	33	13	5
	24	Late flowering, LM	90	129	50	4	15	18	10	4
	25	Early flowering	58	115	52	3	14	49	13	4
	26	Late flowering	79	123	50	4	12	40	13	9
	27	Dwarf	70	118	20	5	13	38	12	5
	28	Tall	69	121	70	4	13	27	12	3
	40	Tall, Root length above 20 cm	66	115	60	6	20	44	11	4
	46	Dwarf, small leaf	64	115	23	3	14	19	12	4
	49	100 seed weight	71	125	51	5	15	11	14	6
	50	Late maturity,100 SW	77	126	50	4	14	17	13	8
	61	High yielding	64	119	44	5	13	41	11	10
	65	Tall, Root length above 20 cm	64	109	44	7	28	46	9	5
	70	Root length above 20 cm	67	120	42	4	18	28	8	7
	71	More pods, HY	72	125	55	5	14	55	12	13
	72	More pods	70	123	41	4	13	50	11	9
	75	More pods	67	118	25	7	14	73	9	10
	78	Dwarf	71	125	55	4	12	35	11	6
	85	Dwarf	72	123	13	2	11	16	9	4
	86	Chlorophyll deficient	-	-	10	-	-	-	-	-
	87	Chlorophyll deficient	-	-	12	-	-	-	-	-
	88	Chlorophyll deficient	-	-	20	-	-	-	-	-

	89	Chlorophyll deficient	-	-	12					
T_3 (300 Gy)	1	High Yield	64	117	60	5	15	50	13	11
	2	More branched, More pods, 100 SW, HY	70	120	52	8	16	78	15	13
	3	Tall, Wrinkled leaf	72	129	54	8	13	43	11	7
	4	Early flowered, EM, HY	58	101	41	6	15	42	11	12
	5	Root length above 20 cm, EM	69	103	51	4	21	30	12	5
	6	Dwarf	75	118	24	3	10	18	9	6
	7	Small leaves	79	122	39	4	12	32	10	4
	8	Late flowering, LM	83	109	47	3	21	33	12	5
	9	Early flowering, EM, Root length above 20 cm	55	103	47	4	22	17	12	4
	10	Tall	70	112	71	3	14	24	10	3
	11	Dwarf	73	120	23	1	18	9	11	4
	12	Tall	79	123	88	7	12	20	9	3
	13	High yielding	81	122	34	3	14	12	11	4
	14	Dwarf	64	111	50	2	13	10	12	5
	15	Late flowering, LM	86	129	50	3	13	8	9	3
	38	More branched, HY	66	115	58	8	17	58	10	13
	44	Dwarf	67	122	26	5	11	20	9	4
	52	Chlorophyll deficient	-	-	14	-	-	-	-	-
	53	Chlorophyll deficient	-	-	11	-	-	-	-	-

Data on number of pods plant^{-1} revealed that the mean value ranged from 200 Gytreatment (25.62) to 250 Gytreutment (35.78). The coefficient of variation for the characters augmented in all the treatments as evaluated to the control, the highest coefficient of variation was noticed in 200 Gytreatments (61.87%) and the lowest in 250 G3y treatments (44.69%). The variation for the character ranged from 44.69% to 61.87%. It is revealed that the mean number of pods plant^{-1} increased in gammarays treatment as compared to control. Waghmare and Mehra (2000) observed that the mean number of pods plant' were considerably reduced in higher doses than lower doses of gamma rays in grass pea. Soliman and Hamid (2003) also reported that the number of pods plant^{-1} was significantly increased by 147.3% and 133.6% over the corresponding control by irradiation with 2.5 and 5.0 k rad respectively.

Data regarding 100 seed weight revealed that the 100 seed weight decreased in all treatments as compared to control. The highest mean value for the character was in 200 Gytreatment (12.12 g) and lowest in 300 Gy treatments (10.94 g) as compared to their control treatment (12.98 g). The variations for the character were found to be increased in all the treatments, Maximum variation was observed in 300 Gy treatment (16.82%) followed by 250 Gy treatment (14.53%) and the minimum variation in 200Gy treatment (8.83%) as compared to controls treatment (5.16). It was found in this study that mean of 100 seed weight in general, reduced in gamma rays treatment. Waghmare and Mchara (2000) also observed the significant reduction of 100 grain weight in grass pea irradiated with gamma rays,

Data regarding grain yield plant^{-1}revealed that the maximum grain yield plant^{-1} was observed in 250 Gy treatment (6.97 g) and minimum in 200 Gytreatments (5.97 g). The variability studies showed that coefficient of variation increased in all the treatments. The maximum coefficient of variation was noticed in 200 Gytreatments (43.89%) followed by 300 Gytreatments (40.38%) and the minimum were in 250 Gytreatments (37.30%). The variation for this parameter ranged between 37.30% to 43.89%. It is revealed that mean value of grain yield plant^{-1} in general, increased in gamma rays treatment as compared to control. Khan *et al.* (2005) also observed similar result and reported that the gamma rays irradiation increased the grain yield significantly as compared to control. Mudibu et al, (2012) studied the effects of 0.2 kGy and 0.4 kGy irradiation in M_2generation and observed significant increase of grain yield and yield components in all the three soybean varieties cvs. Kitoko, Vuangi and TGX814-49D.Gopinath and Pavadai (2015) also reported that the yield parameters like number of seeds plant^{-1}, grain yicld plant^{-1}, recorded the moderate and high mean value of 0.5% of the EMS and 0.4% of the DES treated population in the 50 kR of gamma rays are relative to controlling plants in soybean.

From different treatments of gamma rays on soybean the economical and morphological mutants were isolated from the variety of JS-335 (Table 2). Visible macromutants like chlorophyll mutants, early flowering, late flowering, earlymaturing. late maturing. dwarf, tall, increased root length, increased 100 seed weight, small leaf,, wrinkled leaf, viney type mutants, sterile, high yielding, more pods, more branched mutants were identified and isolated in M_2 generation. Maximum number 82 mutants were identified in 200 Gytreatments out of which only 27 were economical mutants. It was followed by 250 Gytreatment in which 92 numbers of mutants were observed of which 24 were economical. High yielding mutants yielded 14 to 19 g as against 5.39 g in control. Khan *et al.* (2005) reported high yielding mutants in (*Cicer arietinum*) when treated with gamma radiation and similarly, Mudibu *et al.* (2012) reported substantial improvements in grain yields and yielding components in all three soybean varieties in the M_2 generation mutants. Similarly early maturing mutant matured in 13.4 to 22.5 days earlier than control. Landge *et al.* (2009) analyzed the 11 early maturing mutants were observed and the maturity ranged from 90-105 days for these mutants, compared to 169 days for the Westar cultivar in Central India. Khan and Goyal (2009) isolated two mungbean varieties after seed treatment with ethyl methane sulphonate (EMS), sodium azide (SA) and gamma rays in six lines of early maturing mutants in the M2 generation.

It is inferred from the study that the gamma rays had the potential to induce variability in yield contributing characters of soybean. It was observed that gamma rays had significant effect on days to flowering, days to maturity. Plant height, number of branches plant^{-1}, length of primary root, number of pods plant^{-1}, 100 seed weight and grain yield plant^{-1}. The economical mutants identified needs to be observed for their breeding behaviour in further generations and their utilization in improvement of soybean.

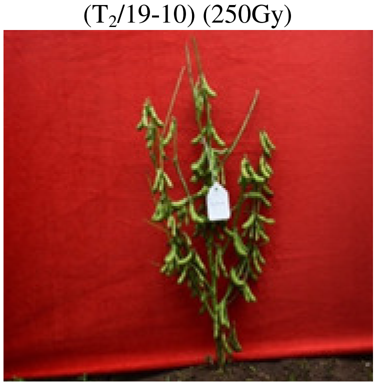
Tall (T_1/3-1) (200Gy)

Dwarf (T_2/24-12) (250Gy)

(T_2/19-10) (250Gy)

(T_1/14-14) (200Gy)

Early (T_2/21-10) (250Gy)

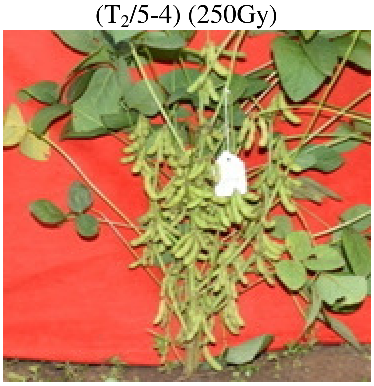


(T_1/14-7) (200Gy)

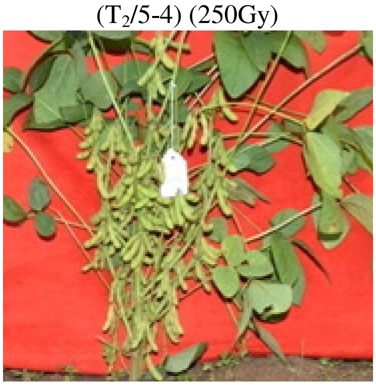
(T_2/5-4) (250Gy)

(T_2/5-4) (250Gy)

(T_1/5-2) (200Gy)



(T_2/5-5) (250Gy)



(T_2/19-2) (250Gy)

(T_2/19-4) (250Gy)

Plate 1 : Different types of mutant observed in M_2 generation

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