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Effect of nitrogen levels and cuttings (main and ratoon) on golden rod (*Solidago canadensis* L.) during summer and rainy season planting

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ABSTRACT

An experiment was conducted in two seasons and two cuttings in each were taken (main and ratoon) with six nitrogen levels (0, 50, 100, 150, 200 and 250 kg N/ha). Nitrogen was applied once during main harvest. Main harvest had pronounced effect on vegetative parameters during summer and rainy plantings except number of suckers and fresh weight of plant, which was higher during both plantings. While earliest flowering (80.20 days) was observed in ratoon harvesting during summer planting. Nitrogen levels had increased all vegetative growth parameters. Earliest flowering was found at 200 kg N/ha (73.70 days) during summer and at 250 kg N/ha (98.10 days) during rainy planting.

Key words: Golden rod, nitrogen, stem cutting, planting time.

INTRODUCTION

Solidago canadensis L. commonly known as 'Golden rod' belongs to family Asteraceae. It is perennial flower crop cultivated for its flower stalks. Few species like *S. canadensis*, *S. virgourea*, and *S. memeoralis* grown in beds, borders or rock garden and some of which produced yellow flowers and panicles for several months of a year, which are very attractive as cut flowers and are used in bouquet and also for table decoration purpose. Though being a perennial herb the crop were response to nitrogenous fertilizer, and its growth is highly affected by seasonal variation, very little research work had been carried out on an application of chemical fertilizers as well as time of harvesting through cuttings on Golden rod in Gujarat. Hence, the trial was carried out to evaluate the nitrogen level and type of cuttings during two summer and rainy seasons on performance solidago.

MATERIALS AND METHODS

The present experiment was carried out at Horticulture Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during February 2004 to March 2005, in a factorial randomized block design with four replications. Two planting seasons (summer and rainy) and six nitrogen levels were applied with 12 combinations in which two cuttings (main harvest and ratoon crop) were taken. Half dose of nitrogen corresponding to treatment in form of ammonium sulphate and full dose of phosphorus (150 kg/ha) and potash (150 kg/ha) in form of single super phosphate and murate of potash, respectively, were applied as basal before transplanting and well mixed in the soil. The remaining half dose of nitrogen to each treatment was given 30 days after planting. After detaching the suckers from mother plant immediately they were planted in each plot at spacing of 30 cm x 30 cm on 2nd week of February for summer season. The second planting was done in *kharif* on 2nd week of June. The gap filling was carried out within 20 days in both the seasons.

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RESULTS AND DISCUSSION

The growth parameters showed an increasing trend with increase in levels of nitrogen. The highest level of nitrogen N_6 (250 kg/ha) recorded maximum plant height (24.48 cm), plant spread (293.76 cm^2), fresh weight of plant (240.40 g) and dry weight of plant (78.28 g) during summer planting, while during rainy planting, this hectare resulted in maximum plant height (31.05 cm), plant spread (265.28 cm^2), fresh weight of plant (252.98 g) and dry weight of plant (67.50 g). This might be due to effect of nitrogen on promoting growth, to enhanced synthesis and accumulation of proteins, amino acids and enzymes, which are responsible for cell division and cell elongation. The results are supported by (Sodha and Dhaduk, 7) in golden rod and (Yadav *et al.*, 12) in tuberose. Increased in plant spread under highest level of nitrogen (N_6) might be due to formation of new cells and increased in size (Verma, 11). Maximum fresh weight and dry weight of plant at highest level of nitrogen might be due to conservation of more dry matter at higher level of nitrogen, which helped to increase in weight of biomass. Numbers of days taken for flowering were reduced to 73.95 and 98.10 days during summer and rainy planting, respectively, under highest level of nitrogen (Table 3). These results are in close agreement with

(Sodha and Dhaduk, 7) in golden rod and (Kumar and Rana, 3) in carnation. Maximum panicle length (71.46 and 83.60 cm), number of inflorescence, branches per panicle (41.75 and 48.28), rachis length (42.78 and 46.36 cm), diameter of cut flower stalk (5.38 mm and 5.68 mm) were observed under the 250 kg N/ha during summer and rainy planting, respectively. These results are also in agreement with findings of (Tingare *et al*., 10).

The gradual increase in level of nitrogen also resulted in increased longevity of inflorescence *in situ*, (22.65 and 24.24 days for summer and rainy plantings, respectively). This might be due to high protoplasmic and moisture content of panicle with increased level of nitrogen. Similar findings have also been published by Banker and Mukhopadhyay (1) and Gowda *et al*. (2) in tuberose. Maximum fresh weight of panicle (102.70 and 122.38 g) was resulted with highest level of nitrogen (Table 6) during summer and rainy planting, respectively. The results are found in line with Singatkar *et al*. (6) in gaillardia. The maximum numbers of panicles (3.33 and 3.68) per plant (Table 6) and maximum numbers of panicles per hectare (3.69 lakhs and 4.08 lakhs) resulted from the highest nitrogen level (250 kg/ha) during summer and rainy planting, (Table 7). Yield of flower crop depends on the amount of vegetative growth (Singatkar *et al*., 6). Increase dose of nitrogen adversely affected on vase-life of panicle, thus, maximum vase-life (7.28 and 8.06 days) was recorded under control during summer and rainy planting, respectively (Table 7). This might be due to over feeding of nitrogen leads to succulence and softness in stem, leaves and petals.

The effect of different harvestings on growth parameters of golden rod, *viz*., plant height, plant spread, fresh weight of plant and dry weight of plant found to be significant during summer planting. Similarly, it was also to be significant for all above growth parameters, except plant height in rainy planting. Higher plant height noted was in main harvest (25.73 cm) during summer planting as compared to ratoon harvest (16.19 cm), whereas, significantly higher plant spread in main harvest (293.64 and 298.45 cm^2) was recorded as compared to ratoon harvest (158.04 and 139.76 cm^2) during summer planting and rainy planting, respectively (Table 1). Dry weight of plant was recorded maximum in main harvest (68.87 and 54.33 g) during summer and rainy planting, respectively (Table 2). There was significant increase in dry weight of plant in main crop during both summer and rainy planting as compared to ratoon harvest. Number of days taken for flowering was reduced in ratoon harvest (80.20 days) during summer planting (Table 3). It might be due to reason that ratoon crop did not required establishment period and hence required less days to flower (Page *et al*., 4).

Panicle length (66.53 and 71.90 cm), number of inflorescence branches (40.15 and 44.62), and rachis length (44.65 and 43.16 cm) were significantly higher in main harvest as compared to ratoon harvest during summer and rainy planting, respectively. Significant increase in diameter of cut flower stalk was noted in main harvest (5.97 and 6.55 mm) during both summer and rainy planting, respectively. Longevity of inflorescence *in situ* was recorded longer in main harvest (19.71 days) during rainy planting. It might be due to high water availability in flower during rainy planting. According to (Prasad and Singh, 5) low uptake of water and nutrients in ratoon harvest keep them low with food material, which results in shorter longevity of inflorescence *in situ*. Higher fresh weight of panicle (113.14 g) was obtained in ratoon harvest (Table 6). Fresh weight of panicle was increased during ratoon harvest in rainy planting might be due to low atmospheric temperature during ratoon harvest in winter months (Sundara, 9).

Significantly decrease in number of days taken for flowering (92.85 days) was at interaction S_1N_6 during rainy planting. There was significant increase in length of panicle (93.65 cm) in (Table 3), number of inflorescence branches (52.20) and length of rachis (51.55 cm) in (Table 4) due to interaction S_1N_6. Fresh weight of panicle (Table 6) was found higher due to interaction S_2N_6 (115.95 and 148.25 g) during both summer and rainy planting, respectively. Number of panicles per plant (4.25) and numbers of panicles per hectare (4.72 lakhs) were obtained highest at interactions S_2N_6 during summer planting. While during rainy planting maximum number of panicles per plant (5.00) and per hectare (5.56 lakhs) were resulted due to interaction S_1N_6. But vase-life of panicles (Table 7) was recorded highest at interaction S_2N_1 (8.66 days). The highest net return and CBR at highest level of nitrogen (250 kg N/ha) was obtained due to maximum yield at highest level of nitrogen (Table 8). Also higher net return and CBR was observed in rainy planting (3, 19,978 and 1:4.61) than summer planting (2,80,978 and 1:4.17) at highest level of nitrogen (250 kg N/ha) which was supported by (Subrahmanyam and Sudha, 8) in China aster.

It is concluded that nitrogen level at 250 kg/N/ha for maximum growth and production of golden rod flowers was found most desirable and from economic point of view, it is also observed that rainy planting was most profitable as it recorded higher net returns and CBR values in golden rod over summer planting.

Table 1. Plant height (cm) and plant spread in N-S and E-W direction (cm^2) at full bloom stage in *Solidago canadensis* **L.**

Nitrogen (kg/ha)	Plant height at full bloom stage (cm)						Plant spread in N-S and E-W direction (cm^2)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	21.92	11.15	16.54	19.38	18.29	18.83	235.47	105.70	170.59	234.25	95.45	164.85
N_2-50	24.18	13.20	18.69	21.43	21.63	21.53	254.44	115.25	184.85	265.20	119.80	192.50
N_3-100	25.61	15.35	20.48	22.60	22.22	22.41	282.91	130.90	206.90	297.65	129.90	213.78
N_4-150	26.62	17.15	21.89	23.78	23.30	23.54	297.56	189.50	243.53	322.20	145.35	233.78
N_5-200	28.05	19.30	23.68	27.10	29.17	28.14	321.24	185.98	253.61	329.35	159.55	244.45
N_6-250	27.99	20.98	24.48	31.55	30.55	31.05	366.62	220.90	293.76	342.05	188.50	265.28
Mean	25.73	16.19	—	24.31	24.19	—	293.64	158.04	—	298.45	139.76	—
Harvest (Main and ratoon)												
CD at 5%		1.33			NS			15.09			12.14	
Nitrogen												
CD at 5%		2.31			1.97			26.13			21.03	
Interaction (SxN)												
CD at 5%		NS			NS			NS			NS	
CV (%)		10.82			7.99			11.38			9.43	

Table 2. Fresh weight of plant (g) and dry weight of plant (g) in *Solidago canadensis* L.

Nitrogen (kg/ha)	Fresh weight of plant (g)						Dry weight of plant (g)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	100.40	83.65	92.02	111.70	142.40	127.05	39.95	28.30	34.13	32.70	28.25	30.48
N_2-50	109.30	134.70	122.00	164.50	178.80	171.65	53.70	36.10	44.90	39.10	35.60	37.35
N_3-100	157.95	150.75	154.35	184.05	206.20	195.13	63.85	43.95	53.90	45.70	42.35	44.02
N_4-150	181.55	201.60	191.58	224.15	234.25	229.20	72.30	47.95	60.13	60.00	48.40	54.20
N_5-200	192.80	246.55	219.68	243.80	250.35	247.08	86.30	54.46	70.35	66.75	50.00	58.38
N_6-250	218.00	262.80	240.40	248.25	257.70	252.98	97.10	59.45	78.28	81.70	53.40	67.50
Mean	160.00	180.00	—	196.08	211.62	—	68.87	45.02	—	54.33	43.00	—
Harvest (Main and ratoon)												
CD at 5%		12.32			5.20			4.34			3.50	
Nitrogen												
CD at 5%		21.33			9.01			7.51			6.06	
Interaction (SxN)												
CD at 5%		30.17			NS			10.62			8.57	
CV (%)		12.33			4.34			12.96			12.23	

Table 2. Fresh weight of plant (g) and dry weight of plant (g) in *Solidago canadensis* L.

Nitrogen (kg/ha)	Fresh weight of plant (g)						Dry weight of plant (g)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	100.40	83.65	92.02	111.70	142.40	127.05	39.95	28.30	34.13	32.70	28.25	30.48
N_2-50	109.30	134.70	122.00	164.50	178.80	171.65	53.70	36.10	44.90	39.10	35.60	37.35
N_3-100	157.95	150.75	154.35	184.05	206.20	195.13	63.85	43.95	53.90	45.70	42.35	44.02
N_4-150	181.55	201.60	191.58	224.15	234.25	229.20	72.30	47.95	60.13	60.00	48.40	54.20
N_5-200	192.80	246.55	219.68	243.80	250.35	247.08	86.30	54.46	70.35	66.75	50.00	58.38
N_6-250	218.00	262.80	240.40	248.25	257.70	252.98	97.10	59.45	78.28	81.70	53.40	67.50
Mean	160.00	180.00	-----	196.08	211.62	------	68.87	45.02	-----	54.33	43.00	------
Harvest (Main and ratoon)												
CD at 5%		12.32			5.20			4.34			3.50	
Nitrogen												
CD at 5%		21.33			9.01			7.51			6.06	
Interaction (SxN)												
CD at 5%		30.17			NS			10.62			8.57	
CV (%)		12.33			4.34			12.96			12.23	

Table 3. Number of days taken for flowering (days) and length of panicle after harvesting (cm) in *Solidago canadensis* L.

Nitrogen (kg/ha)	Number of days taken for flowering (days)						Length of panicle after harvesting (cm)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	112.60	98.95	105.78	119.90	124.60	122.25	52.51	48.90	50.71	51.50	53.80	52.65
N_2-50	105.80	86.45	96.13	113.30	112.40	112.85	65.43	54.33	59.88	60.85	61.95	61.40
N_3-100	97.20	80.70	88.95	110.15	106.60	108.38	67.74	58.60	63.17	65.35	66.52	65.94
N_4-150	78.20	75.35	76.78	108.65	105.65	107.15	69.80	63.13	66.46	70.00	68.70	69.35
N_5-200	77.90	69.50	73.70	100.25	103.95	102.10	70.17	66.56	68.66	90.05	71.60	80.83
N_6-250	77.65	70.25	73.95	92.85	103.35	98.10	72.93	69.99	71.46	93.65	73.55	83.60
Mean	91.56	80.20	-----	107.52	109.43	------	66.53	60.25	-----	71.90	66.02	------
Harvest (Main and ratoon)												
CD at 5%		3.32			NS			2.82			2.04	
Nitrogen												
CD at 5%		5.74			4.58			4.95			3.53	
Interaction (SxN)												
CD at 5%		NS			6.48			NS			4.99	
CV (%)		6.57			4.15			7.66			5.02	

Table 4. Number of inflorescence branches per panicle and length of rachis (cm) in *Solidago canadensis* L.

Nitrogen (kg/ha)	Number of inflorescence branches per panicle						Length of rachis (cm)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	32.90	22.75	27.83	32.80	31.75	32.28	38.24	25.80	32.02	33.85	33.20	33.53
N_2-50	34.95	23.65	29.30	38.80	33.40	36.10	42.05	27.75	34.90	38.10	34.90	36.50
N_3-100	38.05	24.70	31.38	43.85	34.00	38.93	44.49	29.65	37.07	42.75	36.08	39.41
N_4-150	42.00	29.00	35.50	48.55	38.35	43.45	45.01	31.20	38.11	46.00	37.45	41.73
N_5-200	45.40	31.50	38.45	51.50	41.45	46.48	47.05	32.60	39.82	46.70	38.70	42.70
N_6-250	47.60	35.90	41.75	52.20	44.35	48.28	51.06	34.50	42.78	51.55	41.18	46.36
Mean	40.15	27.92	-----	44.62	37.22	------	44.65	30.25	-----	43.16	36.92	------
Harvest (main and ratoon)												
Cd at 5%		2.80			1.80			1.29			0.99	
Nitrogen												
Cd at 5%		4.85			3.12			2.23			1.72	
Interaction (sxn)												
Cd at 5%		NS			4.41			NS			2.43	
Cv (%)		13.99			7.48			5.84			4.22	

Table 5. Diameter of cut flower stalk (mm) and longevity of inflorescence *in situ* (days) in *Solidago canadensis* L.

Nitrogen (kg/ha)	Diameter of cut flower stalk (mm)						Longevity of inflorescence *in situ* (days)					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	4.90	2.20	3.55	5.65	2.45	4.05	11.63	12.50	12.06	12.83	13.40	13.12
N_2-50	5.30	2.55	3.93	5.95	2.80	4.38	13.33	15.17	14.25	16.08	14.60	15.34
N_3-100	6.05	2.70	4.38	6.40	3.15	4.78	17.48	16.58	17.03	19.08	16.80	17.94
N_4-150	6.30	3.20	4.75	6.90	3.35	5.13	18.67	18.50	18.59	21.83	18.30	20.07
N_5-200	6.60	3.45	5.03	7.15	4.00	5.78	19.31	20.25	19.78	22.83	20.60	21.72
N_6-250	6.65	4.10	5.38	2.25	4.10	5.68	24.04	21.25	22.65	25.58	22.90	24.24
Mean	5.97	3.03	-----	6.55	3.30	------	17.41	17.38	-----	19.71	17.77	------
Harvest (Main and ratoon)												
CD at 5%		0.31			0.15			NS			0.99	
Nitrogen												
CD at 5%		0.54			0.27			1.76			1.72	
Interaction (SxN)												
CD at 5%		NS			NS			NS			NS	
CV (%)		11.82			5.33			9.96			9.00	

Table 6. Panicle weight (g) and number of panicles per plant in *Solidago canadensis* L.

Nitrogen (kg/ha)	Panicle weight (g)						No. of panicles per plant					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	57.05	35.25	46.15	38.55	70.95	54.75	1.25	1.35	1.30	1.85	1.20	1.53
N_2-50	69.15	52.00	60.58	51.95	92.80	72.38	1.45	1.70	1.58	2.30	1.40	1.85
N_3-100	73.55	68.30	70.93	64.35	106.85	85.60	1.65	2.40	2.03	3.20	1.60	2.40
N_4-150	76.05	83.65	79.85	79.80	124.70	102.25	2.20	3.10	2.65	4.05	1.75	2.90
N_5-200	81.15	99.25	90.20	90.10	135.30	112.70	2.20	3.65	2.93	4.75	2.15	3.45
N_6-250	89.45	115.95	102.70	96.50	148.25	122.38	2.40	4.25	3.33	5.00	2.35	3.68
Mean	74.40	75.73	-----	70.21	113.14	------	1.86	2.74	-----	3.53	1.74	------
CD at 5%		NS			2.36			0.11			0.34	
Nitrogen												
CD at 5%		9.26			4.08			0.19			0.59	
Interaction (SxN)												
CD at 5%		13.10			5.77			0.27			0.84	
CV (%)		12.12			4.37			8.29			22.16	

Table 7. Yield of panicles (No./ha) and vase-life (days) of panicles in *Solidago canadensis* L.

Nitrogen (kg/ha)	Yield of panicles (No. in lakh /hectare)						Vase-life (days) of panicles					
	Summer planting			Rainy planting			Summer planting			Rainy planting		
	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean	Main harvest (S_1)	Ratoon harvest (S_2)	Mean
N_1-00	1.39	1.50	1.44	2.06	1.33	1.69	6.86	7.87	7.28	7.46	8.66	8.06
N_2-50	1.61	1.89	1.75	2.56	1.56	2.06	6.48	7.24	6.83	6.86	7.95	7.40
N_3-100	1.83	2.67	2.25	3.56	1.78	2.67	6.12	6.71	6.42	5.88	6.60	6.24
N_4-150	2.44	3.44	2.94	4.50	1.94	3.22	5.38	6.14	5.76	6.08	6.45	6.26
N_5-200	2.44	4.06	3.25	5.28	2.39	3.83	4.52	5.57	5.04	5.07	5.79	5.43
N_6-250	2.67	4.72	3.69	5.56	2.61	4.08	3.58	5.24	4.46	4.54	4.19	4.36
Mean	2.06	3.05	-----	3.92	1.94	------	5.49	6.43	-----	5.98	6.61	------
CD at 5%		0.01			0.38			0.28			0.22	
Nitrogen												
CD at 5%		0.22			0.66			0.48			0.38	
Interaction (SxN)												
CD at 5%		0.31			0.93			NS			0.53	
CV (%)		8.29			22.16			7.96			5.89	

Table 8a. Economics and cost: benefit ratio of golden rod as influenced by nitrogen (Summer planting) in *Solidago canadensis* L.

Treatment (kg per ha^{-1})	Combined yield (main and ratoon) (lakh/ha)	Gross realization (Rs./ha)	Total cost of cultivation (Rs./ha)	Net return (Rs./ha)	Additional return over control (Rs./ha)	C:B ratio
N_1- 00	2.89	1,44,500	81,367	63,133	--------	1:1.77
N_2- 50	3.50	1,75,000	82,798	92,202	29,069	1:2.11
N_3- 100	4.50	2,25,000	84,229	1,40,771	77,638	1:2.67
N_4- 150	5.88	2,94,000	85,660	2,08,400	1,45,267	1:3.43
N_5- 200	6.44	3,22,000	87,091	2,34,909	1,71,776	1:3.69
N_6- 250	7.39	3,69,500	88,522	2,80,978	2,17,845	1:4.17

Table 8b. Economics and cost benefit ratio of golden rod as influenced by nitrogen (Rainy season planting) in *Solidago canadensis* L.

Treatment (kg per ha^{-1})	Combined yield (main and ratoon) (lakh/ha)	Gross realization (Rs./ha)	Total cost of cultivation (Rs./ha)	Net return (Rs./ha)	Additional return over control (Rs./ha)	C:B ratio
N_1- 00	3.43	1,71,500	81,367	90,133	--------	1:2.10
N_2- 50	4.12	2,06,000	82,798	1,23,202	33,069	1:2.48
N_3- 100	5.34	2,67,000	84,229	1,82,771	92,638	1:3.16
N_4- 150	6.44	3,22,000	85,660	2,36,340	1,46,207	1:3.75
N_5- 200	7.67	3,83,500	87,091	2,96,409	2,06,276	1:4.40
N_6- 250	8.17	4,08,500	88,522	3,19,978	2,29,845	1:4.61

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