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Efficacy of herbal extracts in alleviating corm dormancy in gladiolus (*Gladiolus grandiflorus* L.)

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Being one of the most sought-after crops as a cut flower for borders, decoration and display, gladiolus is in high demand among flower lovers. In order to boost planting of freshly harvested corms which is hindered by presence of dormancy, several herbal extracts have been investigated on different varieties of gladiolus along with the commercially used chemical GA_3. Among all the treatments, *Azadirachta indica* (Neem) extract at 2% came out as most effective treatment in improving corm sprouting parameters and was also found to be statistically at par with GA_3 at 100 ppm. Among varieties, V_2 (Morning Gold) was found to be most responsive variety under the effect of herbal extracts. Through this study it was indicated that natural plant products which are environmentally sound and safe to use can be used as alternatives to chemicals used in breaking the dormancy of gladiolus and expanding its limits of cultivation.

Keywords: Dormancy, Gladiolus, GA_3, Herbal extracts, Varieties

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Gladiolus (*Gladiolus grandiflorus* L.) is acclaimed as one of the prominent flowering bulbs grown in our country with production share of approximately 7% among the flower crops. It is a flower of glamour and perfection with attractive flower spikes where florets are arranged to showcase different forms, shapes, sizes and majestic colours. Gladiolus has excellent keeping quality in vases so it is widely used as a cut flower and in many flower arrangements. It is also ideal for gardens as well as for floral decoration. As a cut flower, it is widely cultivated throughout the country right from the hilly regions to the plains in order to meet the demand of spikes during special occasions. In the Indian continent, gladiolus is grown in different parts but its commercial cultivation is practiced in West Bengal, Uttar Pradesh, Uttarakhand, Punjab, Haryana, Sikkim, Karnataka, Gujarat, Maharashtra, Jammu and Kashmir, Himachal Pradesh, Tamil Nadu, Madhya Pradesh, Delhi and Rajasthan[1]. Commercial production of gladiolus spikes is extremely profitable, particularly around the metropolitan cities, as at every occasion gladiolus spikes are highly demanded. For this, the supply of gladiolus spikes must be continuous, that is, round the year. But the dormancy present in the corms and cormels of gladiolus presents the main hindrance in the commercial gladiolus cultivation due to which it can only be cultivated once in the year. Cold treatment of corms kept at 4-5^{o}C for duration of 3-4 months is a largely followed technique for countering the dormancy in gladiolus that restricts its cultivation only to one season[2]. This also causes the shortage of quality planting material for gladiolus cultivation due to which farmers are not taking up this venture on commercial scale. So, the researchers are focussing on other ways to combat the problem of dormancy and so many chemicals have been recommended for dormancy breaking and early corm sprouting. GA_3, ethaphon, salicylic acid and thiourea are the commonly used chemicals for breaking dormancy in gladiolus[2-4]. However, the chemical substances employed are not easily affordable by small scale growers, and for beginners in gladiolus cultivation, this cost is quite incurring. Again, they are not much safe for humans as well as for environment[5]. Therefore, the growers should be provided with the

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quick, easy, inexpensive and safe solutions to solve the problem of dormancy which is a major impediment in the year-round cultivation of gladiolus. Herbal extracts possess natural constituents that have stimulating functions when used on crop plants. Apart from being used as therapeutants traditionally, plant extracts have a long history of usage in crop production; neem (*Azadirachta indica*) is used traditionally as a fertilizer, a soil conditioner and a powerful insect repellent[6]. Also, antimicrobial properties of neem plant against menerous pathogens have been implicated in several studies[7]. Similarly turmeric (*Curcuma longa*) and tulsi (*Ocimum spp*.) is also used in pest management due to their pesticidal properties[8,9]. Also, to improve germination and sprouting in crop plants, several practices were in use by our ancestors which were mentioned in our ancient literatures, such as, smearing of seeds with ash of *Sesamum indicum* and *Solanum indicum*, smearing with oil of *Alangium salviifolium*, sprinkling with cow milk, smearing with cow dung and treatment with honey[10].

Although no findings have been reported regarding herbal extracts affecting the dormancy in gladiolus, studies in other crops have highlighted the potential role of plant extracts in improving germination, sprouting, rooting and other plant propagation parameters. In one study, treatment of lentil seeds with Neem extract at 50% resulted in 90.80% germination, which was highest among all other treatments[11]. On seed treatment with neem extract, more vigorous seedlings with better root growth, shoot growth and dry weight were achieved in comparison to untreated seeds in rice[12]. Improved seed germination along with beneficial effects on growth parameters have been achieved in *Vigna radiata* and *Cicer arietinum* when treated with aqueous extracts of *Ocimum sanctum* and *Ocimum basilicum*[13]. Antioxidant properties has been found in *Bacopa monnieri* extract which play a role in scavenging potentially harmful ROS and could be crucial for seed survival and sprouting[14]. Similarly, turmeric is a rich source of bioactive compounds and growth promoting effects of turmeric rhizome extract have also been seen in crop plants[15]. Plant extracts possess numerous compounds with a wide range of biological activities with potential medicinal, growth regulatory and antimicrobial effects[16], which can prove miraculous to alleviate the problem of corm dormancy in gladiolus.

Materials and Methods

The present experiment was planned and conducted at G. B. Pant University of Agriculture and Technology in the month of April consecutively for 2 years during (2014 and 2015) in order to investigate the effect of herbal extracts on corm sprouting as well as their comparison with commercially used GA_3 application.

Preparation of herbal extracts: For preparation of herbal extracts, fresh leaves of neem (*Azadirachta indica*) and Tulsi (*Ocimum sanctum*) were collected from Model Floriculture Centre, G. B. Pant university of Agriculture and Technology, Pantnagar and rhizomes of turmeric (*Curcuma longa*) were purchased from local market. Alcoholic extracts were prepared following the standard procedure. Due to the unavailability of raw material, brahmi (*Bacopa monnieri*) leaf extract was procured from Kuber Impex Limited, Indore (M.P.) as fresh alcoholic extracts of 100% strength. Fresh raw material of neem, tulsi and turmeric were washed three times with distilled water and then sanitized with sodium hypochlorite solution at 50 microgram/ml. Then material was shade dried, then powdered and kept in plastic bags in dry conditions till use. Then, alcoholic extracts were prepared from dried herbs by dissolving 10 g of dried powder in 100 mL of organic solvent (95% ethanol). Prepared solution was then kept in a rotary shaker for proper mixing later it was filtered and subsequently centrifuged at 5000 x g for 15 min. Supernatants were collected and used in the study as 100% extract. Further dilutions were done with distilled water to make desired concentration.

Corm treatment: Freshly harvested corms of gladiolus varieties; Nathan Red (V_1), Morning Gold (V_2), Black Star (V_3) and Peter Pears (V_4) were kept for treatment with the different herbal extracts; (*Azadirachta indica* (neem) extract at 2%, *Ocimum sanctum* extract (tulsi) at 2%, *Curcuma longa* (turmeric) at 2% and *Bacopa monnieri* extract (brahmi) at 2%) and GA_3 at 100 ppm as corm dip treatments for a duration of 12 h. Later corms were dried under shade for 12 h.

Conduct of experiment: Treated corms along with the control (no treatment) were planted as per treatment at a spacing of 20 x 30 cm in beds (1m x1m x 0.15m) at 5-6 cm depth which accommodates 15 corms per treatment. With six treatments and four varieties and total treatment combination of 24, the experiment was replicated thrice and planted in

randomized block design (factorial). Recommended cultural practices were followed during the experiment. Observations were recorded for all the corm dormancy parameters during both the years as per treatments and then subjected to analysis of variance using randomized block design year wise and pooled analysis for both the years using OP-STAT software at 5% significance level.

Results and Discussion

Analysis of variance revealed the expected potential of herbal extracts in combating the problem of corm dormancy in gladiolus as well as the differential response of varieties towards different herbal extracts through pooled results of both the years. Neem extract at 2% was found to be superior among all the treatments for all the corm sprouting parameters and was observed to be statistically at par with GA_3 at 100 ppm, commercially used treatment for breaking dormancy in gladiolus. Among varieties, V_2 (Morning Gold) was found to be most responsive variety under the effect of herbal extracts.

1. Days to corm sprouting (Table 1): Significant effect of corm dip treatments, varieties and their interaction was observed as per the pooled analysis. Among herbal extract, early corm sprouting (23.77 days) was observed in H_1 (neem extract at 2%) followed by H_5 (GA_3 at 100 ppm) where both treatments were found at par. Delayed corm sprouting (61.03 days) was found in H_6 (control). Among varieties, in V_2 (Morning Gold), sprouting of the corms was completed in 29.35 days which was earliest among all. After that, variety V_4 (Peter Pears) took 32.00 days, V_1 (Nathan Red) took 33.91 days and V_3 (Black star) took 35.69 days for corm sprouting. Among interactions of varieties and corm dip treatments, neem extract at 2% treated corms of Morning Gold variety (H_1V_2) completed corm sprouting in minimum time (20.58 days) and it was also found to be statistically at par with corm sprouting of GA_3 at 100 ppm treated corms of Morning Gold variety (H_5V_2) (21.54 days) and tulsi extract at 2% treated corms of Morning Gold variety (H_2V_2) (22.46 days), whereas, H_6V_3 (untreated corms of Black Star variety) took maximum days (64.61) for corm sprouting.

2. Sprouting percentage (Table 2): Among the different treatments, when neem extract at 2% (H_1) was used, sprouting recorded came out to be 98.33% which was reportedly maximum among all. Corms treated with GA_3 at 100 ppm (H_5) also registered 96.11% sprouting which was statistically same as H_1. Least sprouting (60.83%) was observed in untreated corms (H_6). Relating to the effect of varieties, V_2 (Morning Gold) resulted in maximum sprouting percentage (89.26%) followed by V_4 (Peter Pears) (87.41%), where both were at par with each other. V_3 (Black star) recorded minimum sprouting (76.66%). Interactions effect of varieties and treatments remained nonsignificant, however, H_1V_2 attained maximum corm sprouting (100%), whereas, H_6V_3 attained minimum corm sprouting (50.00%) among interactions.

3. Number of sprouts per corm*:* As presented from pooled analysis in Table 3, significant results were exhibited for number of sprouts per corm. Among the

Table 1 — Effect of herbal extracts, varieties and their interaction on corm sprouting of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Corm sprouting (days)														
	1st Year					2nd Year					Pooled				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	26.00	21.74	28.06	25.47	25.32	23.85	19.41	24.47	21.13	22.22	24.92	20.58	26.27	23.30	23.77
H_2	30.30	23.81	30.73	27.76	28.15	24.91	21.11	26.52	23.22	23.94	27.60	22.46	28.62	25.49	26.04
H_3	37.40	30.84	39.35	32.48	35.02	29.08	25.59	32.56	28.11	28.84	33.24	28.21	35.96	30.30	31.93
H_4	34.20	26.87	33.40	30.58	31.26	27.27	23.77	29.05	25.49	26.40	30.74	25.32	31.22	28.04	28.83
H_5	27.33	22.97	28.90	26.57	26.44	24.34	20.10	26.07	22.36	23.22	25.84	21.54	27.49	24.46	24.83
H_6	63.82	61.00	67.27	62.87	63.74	58.38	55.04	61.94	57.92	58.32	61.10	58.02	64.61	60.39	61.03
Mean	36.51	31.20	37.95	34.29		31.30	27.50	33.44	29.70		33.91	29.35	35.69	32.00	
			S. Em.±		CD (5%)		S. Em.±		CD (5%)			S. Em.±		CD (5%)	
Varieties			0.446		1.271		0.418		1.191			0.339		0.966	
Corm dip treatments			0.547		1.557		0.512		1.459			0.415		1.183	
Varieties × Treatments			1.094		3.115		1.025		2.919			0.831		2.367	

V-Varieties; V_1- Nathan Red, V_2- Morning Gold, V_3- Black Star, V_4- Peter Pears

H-Corm dip treatments; H_1- Neem (*Azadirachta indica*) leaf extract at 2%, H_2- Tulsi (*Ocimum sanctum*) leaf extract at 2%, H_3- Brahmi (*Bacopa monnieri*) leaf extract at 2%, H_4- Turmeric (*Curcuma longa*) rhizome extract at 2%, H_5- GA_3 at 100 ppm, H_6 – Control

Table 2 — Effect of herbal extracts, varieties and their interaction on sprouting percentage of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Sprouting percentage (%)														
	1st Year					2nd Year					Pooled				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	100.00	100.00	100.00	100.00	100.00	97.78	100.00	93.33	95.55	96.67	98.89	100.00	96.67	97.78	98.33
H_2	93.33	95.55	77.77	95.55	90.55	93.33	93.33	80.00	93.33	90.00	93.33	94.44	78.89	94.44	90.27
H_3	80.00	86.67	66.66	82.22	78.89	77.78	82.22	71.11	80.00	77.78	78.89	84.44	68.88	81.11	78.33
H_4	88.89	91.11	73.33	88.89	85.55	88.88	88.88	73.33	91.11	85.55	88.89	90.00	73.33	90.00	85.55
H_5	97.78	100.00	95.55	100.00	98.33	95.55	97.78	88.89	93.33	93.89	96.67	98.89	92.22	96.67	96.11
H_6	64.44	71.11	51.11	68.88	63.88	57.77	64.44	48.89	60.00	57.77	61.11	67.77	50.00	64.44	60.83
Mean	87.41	90.74	77.40	89.26		85.18	87.78	75.92	85.55		86.29	89.26	76.66	87.41	
			S. Em.±		CD (5%)			S. Em.±		CD (5%)			S. Em.±		CD (5%)
Varieties			1.56		4.46			1.37		3.90			0.91		2.59
Corm dip treatments			1.92		5.46			1.67		4.78			1.11		3.18
Varieties × Treatments			3.84		N.S.			3.35		N.S.			2.23		N.S.

V-Varieties; V_1- Nathan Red, V_2- Morning Gold, V_3- Black Star, V_4- Peter Pears

H-Corm dip treatments; H_1- Neem (*Azadirachta indica*) leaf extract at 2%, H_2- Tulsi (*Ocimum sanctum*) leaf extract at 2%, H_3- Brahmi (*Bacopa monnieri*) leaf extract at 2%, H_4- Turmeric (*Curcuma longa*) rhizome extract at 2%, H_5- GA_3 at 100 ppm, H_6 – Control.

Table 3 — Effect of herbal extracts, varieties and their interaction on number of sprouts per corm of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Number of sprouts per corm														
	1st Year					2nd Year					Pooled				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	1.82	2.02	1.72	1.86	1.86	2.00	2.45	1.88	2.20	2.13	1.91	2.24	1.80	2.03	1.99
H_2	1.68	1.78	1.47	1.70	1.66	1.81	2.23	1.62	1.90	1.89	1.75	2.01	1.55	1.80	1.78
H_3	1.28	1.42	1.22	1.33	1.31	1.63	1.97	1.39	1.67	1.66	1.46	1.70	1.30	1.50	1.49
H_4	1.50	1.66	1.34	1.53	1.51	1.71	2.05	1.51	1.83	1.77	1.61	1.86	1.43	1.68	1.64
H_5	1.77	1.94	1.60	1.79	1.78	1.88	2.31	1.74	2.03	1.99	1.82	2.12	1.67	1.91	1.88
H_6	1.13	1.17	1.07	1.10	1.12	1.33	1.40	1.27	1.37	1.34	1.23	1.29	1.17	1.23	1.23
Mean	1.53	1.67	1.40	1.55		1.73	2.07	1.57	1.83		1.63	1.87	1.49	1.69	
			S. Em.±		CD (5%)			S. Em.±		CD (5%)			S. Em.±		CD (5%)
Varieties			0.045		0.128			0.048		0.137			0.031		0.088
Corm dip treatments			0.055		0.157			0.059		0.168			0.038		0.108
Varieties × Treatments			0.110		N.S.			0.118		0.336			0.076		0.216

V-Varieties; V_1- Nathan Red, V_2- Morning Gold, V_3- Black Star, V_4- Peter Pears

H-Corm dip treatments; H_1- Neem (*Azadirachta indica*) leaf extract at 2%, H_2- Tulsi (*Ocimum sanctum*) leaf extract at 2%, H_3- Brahmi (*Bacopa monnieri*) leaf extract at 2%, H_4- Turmeric (*Curcuma longa*) rhizome extract at 2%, H_5- GA_3 at 100 ppm, H_6 - Control.

corm dip treatments, treatment, maximum sprouts per corm (1.99) was obtained in H_1 (neem extract at 2%) which comes to be statistically similar with H_5 (GA_3 at 100 ppm) (1.88) in its effect. H_6 (Control) yielded least sprouts per corm (1.23) among all. Under the varietal effect, highest and lowest sprouts per corm (1.87 and 1.49, respectively) were found in Morning Gold (V_2) and Black Star (V_3), respectively, that varied significantly. Among interactions effect, neem extract at 2% treated corms of Morning Gold variety (H_1V_2) recorded highest sprouts per corm (2.24) and was found to be at par with H_5V_2 (2.12) and H_1V_4 (2.03), whereas, Untreated corms of Black Star variety (H_6V_3) resulted in minimum sprouts per corm (1.17).

4. Days to first true leaf appearance (Table 4): Pooled analysis exhibited the significant results for this parameter as among the different treatments, First true leaf appeared earlier (28.38 days) in H_1 (neem) extract at 2%). Similarly in H_5 (GA_3 at 100 ppm) it appeared in 29.90 days and was found to be statistically at par with H_1. H_6 (control) took maximum time (64.94 days) for appearance of first true leaf. As for the effect of varieties, earliest first true leaf appearance (33.96 days) was observed in Morning Gold (V_2) followed by 37.00 days in Peter Pears (V_4), 38.00 days in Nathan Red (V_1) and 40.91 days in Black star (V_3) which varied statistically. Varietal and treatment interaction also yielded significant variations in appearance of first true leaf.

Table 4 — Effect of herbal extracts, varieties and their interaction on days to appearance of 1st true leaf of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Days to appearance of 1st true leaf														
	1st Year					2nd Year					Pooled				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	31.19	25.38	32.23	30.18	29.74	27.67	23.89	29.75	26.77	27.02	29.43	24.63	30.99	28.48	28.38
H_2	35.00	28.91	35.97	33.00	33.22	30.96	26.91	32.00	28.69	29.64	32.98	27.91	33.98	30.85	31.43
H_3	41.30	34.64	43.87	37.08	39.22	33.99	30.20	38.39	33.62	34.05	37.64	32.42	41.13	35.35	36.64
H_4	37.82	31.63	38.33	35.18	35.74	32.44	27.86	34.67	30.10	31.27	35.13	29.74	36.50	32.64	33.50
H_5	31.84	27.73	34.16	31.12	31.21	30.31	25.06	31.26	27.70	28.58	31.08	26.39	32.71	29.41	29.90
H_6	58.57	64.97	72.48	66.60	65.66	64.89	60.34	67.74	63.94	64.23	61.73	62.66	70.11	65.27	64.94
Mean	39.28	35.54	42.84	38.86		36.71	32.38	38.97	35.14		38.00	33.96	40.91	37.00	
			S. Em.±		CD (5%)		S. Em.±		CD (5%)			S. Em.±		CD (5%)	
Varieties			0.890		2.535		0.376		1.072			0.452		1.287	
Corm dip treatments			1.090		3.105		0.461		1.313			0.553		1.576	
Varieties × Treatments			2.181		N.S.		0.922		2.626			1.107		3.153	

V-Varieties; V_1- Nathan Red, V_2- Morning Gold, V_3- Black Star, V_4- Peter Pears

H-Corm dip treatments; H_1- Neem (*Azadirachta indica*) leaf extract at 2%, H_2- Tulsi (*Ocimum sanctum*) leaf extract at 2%, H_3- Brahmi (*Bacopa monnieri*) leaf extract at 2%, H_4- Turmeric (*Curcuma longa*) rhizome extract at 2%, H_5- GA_3 at 100 ppm, H_6 - Control

In H_1V_2 (Neem extract at 2% treatment in Morning Gold variety) first true leaf appearance commenced in 24.63 days which was earliest among all and also found to be statistically similar to H_5V_2 (26.39 days), whereas, H_6V_3 (untreated corms of variety Black Star) resulted in delayed appearance of first true leaf (70.11 days).

Herbal extracts act as biostimulants and enhance the crop performance. Several plant-based substances have been tested as growth regulators for different cereal crops, vegetable crops, cotton and many other crops[17,18] Increased corm sprouting attributes with *Azadirachta indica* (Neem) extract at 2% might be ascribed to the fact that neem acts as natural plant protectant and treatment of corms with neem leaf extract might have protected the corms from adverse conditions and led to better sprouting. Various bioactive compounds (ascorbic acid, amino acids, nimbolide, nimbin etc) and some polyphenolic compounds (ß-sitosterol and quercetin) contributes for antifungal and antibacterial properties of neem leaf extracts that played significant role in better sprouting with neem extract[19]. Another possible reason could be that the neem leaf extract might have acted as stimulant for sprouting of corm indirectly by decreasing the concentration of abscisic acid (ABA), linolinic acid and ferulic acid, which have been identified as main inhibitors in gladiolus corms[2]. However, the potential role of principal constituents of neem, viz; azadirachtin, in encouraging the germination or sprouting in different crops still needs to be investigated. Beneficial effects of plant extracts or herbal extracts have been demonstrated by many researchers which give support to the findings of this experiment. Most satisfactory results for enhancing germination percentage, vigour index, germination speed, root length, shoot length and moisture content were achieved in *Brassica nigra* seeds on pre sowing treatment of seeds with aqueous extracts of common wild plants *Cassia obtusifolia*, *Catharanthus roseus*, *Pongamia pinnata* and *Azadirachta indica* in comparison to control (no treatment)[20]. Rice seeds when primed with neem seed extracts enhanced seed germination traits in all the four varieties tested[21]. Similar results were also observed in African Yam bean with different plant extracts where neem extract gave maximum germination percentage and seedling growth as in present study[22].

Different varieties significantly affected corm dormancy and showed varied responses in attributes of corm sprouting with early corm sprouting, maximum sprouting percentage, maximum sprouts per corm, early first true leaf appearance in variety Morning Gold followed by variety Peter Pears, Nathan Red and Black star. Possible reason for better performance of V_2 (Morning Gold) relates to its better corm size with comparatively short dormancy period which boosted its earlier emergence in comparison to other varieties. Large sized corms also have more food reserves that help in emerging out maximum sprouts in minimum time with better growth potential[23]. Further, different varieties usually differ in their genetic constitution that brought difference in their growth potential[24]. Similar results have been

reported where differences in different gladiolus cultivars were observed for their sprouting percentage[25].

By findings it can be concluded that natural plants extracts as herbal formulations can be a suitable alternative to the costly and deleterious chemicals to break the corm dormancy and expanding the cultivation of gladiolus beyond limits. Varieties respond variably under the effect of herbal extracts and in order to standardize we need replicated trials. However based on the 2-year data of the present study, we can conclude that, among different treatments, *Azadirachta indica* (neem) extract at 2% is effective in improving corm sprouting parameters and among varieties and response of V_2 (Morning Gold) is superior over the other varieties. Thorough investigation is needed in the field of herbal extracts in order to validate the physiological and biochemical basis of their action in alleviating corm dormancy.

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Conflict of Interest

Authors declare no competing or conflict of interest.

Author's Contributions

SK planned and guided the research work. RS conducted the research work. RS and HS prepared the manuscript and tables. HS corrected the manuscript. Manuscript has been read and approved by all the authors.

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