



RESEARCH ARTICLE

Genetic variability studies in the underutilized vegetable *Momordica cymbalaria* Hook F.

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Abstract

The study aimed to examine the genetic variability and relatedness among 23 genotypes of athalakkai (*Momordica cymbalaria* Hook F.) evaluated at the college orchard, Department of Horticulture, Agricultural College and Research Institute, Madurai, Tamil Nadu. The study assessed yield-related traits such as days to sprouting, vine length, number of vines per plant, fruit stalk length, number of fruits per vine, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds and yield per plant. Results showed significant variations in the mean performance of 23 athalakkai genotypes for various traits, indicating substantial genetic diversity and high breeding potential within the germplasm. The study of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) in *M. cymbalaria* germplasms showed variability in traits such as fruits per vine, number of seeds, number of fruits per vine, number of vines per plant, vine length and yield per plant. High heritability estimates and genetic advance were observed, indicating that variation is due to a high degree of additive effect and can be improved through selection. Correlation and path analysis results showed that vine length, number of seeds, number of fruits per plant, number of fruits per vine, fruit weight and fruit stalk length had a significant positive direct effect on the number of fruits per plant, suggesting these traits could be considered for yield improvement programs in *M. cymbalaria*.

Keywords: correlation and path analysis; genetic variability; genotypes; *Momordica cymbalaria*

Introduction

Athalakkai (*Momordica cymbalaria* Hook F.) is a perennial herbaceous climber belonging to the family Cucurbitaceae. It resembles bitter melon in morphology. It is commonly known as karchikai (Kannada) or athalakkai (Tamil) or kasarakayee (Andhra Pradesh) and kakrol (Hindi). Athalakkai is classified as an underutilized vegetable and it is widely distributed in the tropical regions of Africa and India. It is distributed across several Indian states, including Tamil Nadu (Virudhunagar, Madurai, Theni, Dindigul, Tuticorin, Ramanathapuram), Andhra Pradesh, Maharashtra and Madhya Pradesh. These vegetables are available in the market during November and December and off-season fruits are available during June-July every year (1). The plant is commonly grown along bunds (boundary of fields), fences and field margins for its fruits (2). Tender fruits are consumed as vegetables and valued for their medicinal properties, especially as healthy food for diabetics. Propagation is through seeds and tubers. The plant has a tuberous root, which helps to maintain perennial habits, pubescent or subglabrous. The plants dry and disappear at the end of the season. The tubers remain in the soil and emerge in the next season. Athalakkai is found to be in cultivation from very early times in Tamil Nadu and it has been extensively used in Asian traditional medicines

over a long period of time. It is rich in tannins, alkaloids, aminoacids, macro and micro nutrients, phenolic acids, flavonoids, carotenoids, cucurbitane triterpenoids and phytosterol (3). It is also highly useful against rheumatism, ulcers, skin diseases and diarrhoea, besides being a good antioxidant. The tubers are used effectively against diabetes mellitus and act as an antioviulatory agent. Black cotton soils (vertisols) of Tamil Nadu are a source of livelihood for small farmers with cucumber and athalakkai (4).

Although consumed by rural communities in Southern Tamil Nadu, athalakkai remains less popular due to its bitter taste, limited awareness of its nutritional value and lack of standardized recipes (5). There is no named variety available in India and it has occurrence of wide variability is common. The magnitude of variability and its quantitative estimation for each character would indicate the potential of each tree and the scope for improving the desirable and economic characters through selection. Morphological characterization has been the major tool for classifying major vegetable crop genotypes into different genomic groups. With this background, the present investigation on genetic variability, correlation, path analysis and diversity studies of athalakkai was carried out at the Department of Horticulture, Agricultural College and Research Institute, Madurai, during the years from 2020 to 2022.

Materials and Methods

The study was conducted at the Department of Horticulture, Agricultural College and Research Institute, Madurai. In the present study, 23 athalakkai genotypes were collected from different parts of Tamil Nadu (Table 1) viz., Virudhunagar, Madurai, Theni and Dindigul districts and used for this study. The experiment was laid out in a randomized block design (RBD) with 23 treatments and 3 replications and followed the basic cultural practices (6). The genotypic and phenotypic coefficient of variation (GCV and PCV), heritability and genetic advance were estimated for various quantitative and qualitative traits. These included days to sprouting, days to first flowering, vine length, number of vines per plant, fruit stalk length, number of fruits per vine, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds, yield per plant, vitamin C content, crude fibre content and protein content, observed from 10 randomly selected representative plants.

Table 1. List of *M. cymbalaria* germplasm used in this study

Accessions	Germplasm	Source
MC01	Odaipatti, Kallikudi	Madurai
MC02	P.M.Pudupatti, Aruppukottai	Virudhunagar
MC03	Palayampatti, Aruppukottai	Virudhunagar
MC04	Kattankudi, Aruppukottai	Virudhunagar
MC05	Nalluthevanpatti, Kallikudi	Madurai
MC06	Athikaripatti, Peraiyur	Madurai
MC07	Vandari, Peraiyur	Madurai
MC08	Rengasamuthiram, Aundipatti	Theni
MC09	Karattupatti, Aundipatti	Theni
MC10	Sevaikaranpatti, T. Kallipatti	Virudhunagar
MC11	Karadikkal, Peraiyur	Madurai
MC12	Kovilankulam, Aruppukottai	Virudhunagar
MC13	Kilankulam, Peraiyur	Madurai
MC14	Chittur, Thirumangalam	Madurai
MC15	T. Paraikulam, T. Kallupatti	Madurai
MC16	Kallanai, Kallikudi	Madurai
MC17	Athipatti, Periyur	Madurai
MC18	Aruppukottai, Aruppukottai	Virudhunagar
MC19	Kathanur, Kallikudi	Virudhunagar
MC20	Gopalapuram, Aruppukottai	Virudhunagar
MC21	Ramanujapuram, Aruppukottai	Virudhunagar
MC22	Kariyapatti, Aruppukottai	Virudhunagar
MC23	Chathvapatti, T. Kallipatti	Madurai

Table 2. Mean performance of growth traits of 23 *M. cymbalaria* genotypes

Accessions	Days to sprouting (days)	Days to first flowering	Vine length (cm)	Number of vines per plant	Fruit stalk length (cm)
MC01	6.00	19.53	109.00	5.33	1.78
MC02	5.67	18.50	140.67	8.67	1.81
MC03	6.00	19.30	125.33	5.00	1.76
MC04	6.33	19.20	114.00	5.67	1.69
MC05	7.00	20.33	107.67	8.00	1.70
MC06	7.00	20.33	117.33	4.67	1.68
MC07	6.33	19.67	82.00	5.33	1.67
MC08	7.00	20.33	76.67	6.33	1.70
MC09	7.33	21.00	85.67	5.67	1.71
MC10	6.00	19.33	83.00	5.68	1.69
MC11	6.67	20.33	87.33	7.00	1.69
MC12	8.00	21.00	71.00	5.33	1.59
MC13	6.67	20.67	82.33	6.33	1.58
MC14	6.67	19.00	123.33	7.67	1.62
MC15	6.67	21.33	107.33	7.00	1.66
MC16	6.00	20.33	114.00	6.33	1.65
MC17	6.67	19.23	118.00	6.01	1.68
MC18	6.67	20.33	86.67	5.67	1.70
MC19	6.33	19.20	104.00	5.67	1.71
MC20	6.07	20.67	82.33	6.33	1.69
MC21	7.33	21.00	90.10	5.33	1.74
MC22	6.00	19.43	86.00	5.67	1.68
MC23	6.67	19.00	113.33	7.67	1.74
Mean	6.56	19.96	97.84	6.190	285.43
SEd	0.42	0.470	4.448	1.341	0.035
CD @ 5 %	0.85	0.95	8.964	2.703	0.072
CV (%)	4.10	1.66	21.13	17.25	2.90

Biometrical analyses were carried out to estimate genotypic and phenotypic coefficients of variation (7), broad sense heritability (8) and genetic advance as a percent of the mean (9). Correlation and path coefficient analyses were performed for the studied characters (10, 11).

Results and Discussion

Analysis of variance (ANOVA) showed highly significant differences among various growth and yield parameters studied. ANOVA for various characters of 23 athalakkai genotypes results revealed that the genotypes were highly significant for all the traits, thereby suggesting the existence of a great amount of variation among the genotypes. Thus, there is a scope for considerable selection of crop improvement through the characters such as vine length, days to first flowering, number of fruits per vine, average fruit weight, fruit length, fruit girth, number of seeds per fruit, yield per plant and fruit stalk length (1, 12–14).

The mean performance for 15 morphological, growth, yield and qualitative characters of 23 athalakkai genotypes is presented in Tables 2–4. Significant differences were observed among the various characters studied. GCV, PCV, heritability and genetic advance as percent mean of 15 traits of athalakkai genotypes were mentioned in Table 5. PCV exceeded GCV for all traits, reflecting environmental influence on phenotypic expression. Highest PCV was recorded for the number of seeds (38.63 %), followed by the number of fruits per vine (38.39 %), the number of vines per plant (30.41 %), vine length (27.08 %) and yield per plant (24.00 %). In contrast, the lowest PCV values were observed for crude fibre content (0.567 %), vitamin C (1.08 %), protein (1.353 %), days to first flowering (4.84 %), fruit stalk length (5.42 %) and fruit girth (8.82 %). These characters will be considered for the direct selection of a particular genotype (15, 16). GCV is a better tool to understand useful variability, as it is free from the environmental components and also helps in comparison and measurement of genetic variability among different characters. The highest GCV values were recorded for the traits such as number of fruits per vine (35.291 %), vine length (26.55 %), yield per plant

Table 3. Mean performance of yield traits of 23 *M. cymbalaria* genotypes

Accessions	Number of fruits per vine	Number of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of seeds per fruit	Yield per plant (g/ plant ⁻¹)
MC01	11.65	63.60	4.64	3.51	0.82	3.30	52.30
MC02	12.30	71.67	4.91	3.76	0.93	3.68	65.10
MC03	11.57	58.00	4.73	3.50	0.73	3.50	42.33
MC04	10.33	60.67	4.73	3.23	0.67	3.48	41.00
MC05	11.43	62.00	4.00	3.57	0.77	3.57	48.13
MC06	9.00	54.33	4.20	3.08	0.60	3.33	33.80
MC07	10.10	48.33	4.42	3.23	0.70	3.00	33.97
MC08	8.33	52.33	4.40	3.23	0.73	3.00	43.50
MC09	5.00	46.67	4.20	3.37	0.79	3.33	37.22
MC10	6.67	44.67	4.53	3.55	0.75	3.00	33.01
MC11	6.33	48.33	4.27	3.20	0.76	3.67	36.76
MC12	6.67	43.33	3.73	3.03	0.57	3.00	32.93
MC13	5.67	47.00	4.10	3.53	0.79	3.00	36.99
MC14	11.33	48.00	4.83	3.70	0.83	3.63	62.15
MC15	8.67	51.00	4.33	3.68	0.80	3.33	42.80
MC16	9.00	44.33	3.97	3.40	0.79	3.00	33.57
MC17	10.33	60.67	4.73	3.23	0.67	3.48	42.40
MC18	9.00	43.67	4.20	3.47	0.77	3.33	36.99
MC19	10.33	62.67	4.73	3.23	0.79	3.38	41.00
MC20	5.67	47.00	4.10	3.53	0.79	3.00	36.99
MC21	8.67	45.33	4.87	3.03	0.57	3.00	32.93
MC22	8.67	42.55	4.52	3.53	0.76	3.30	43.50
MC23	11.33	48.00	4.83	3.70	0.83	3.63	62.15
Mean	9.59	3.39	3.36	1.70	4.43	3.32	43.82
SEd	1.18	2.998	0.46	0.21	0.09	0.26	5.526
CD @ 5 %	2.39	6.042	0.94	0.43	0.19	0.52	11.13
CV (%)	15.83	19.88	7.40	2.05	1.84	6.18	12.61

Table 4. Mean performance quality traits of 23 *M. cymbalaria* genotypes

Accessions	Vit C (mg 100 g ⁻¹)	Crude fibre content (g)	Protein (mg 100 g ⁻¹)
MC01	287.00	6.38	2.14
MC02	289.00	6.40	2.15
MC03	285.65	6.37	2.13
MC04	284.54	6.34	2.11
MC05	288.12	6.33	2.12
MC06	284.75	6.34	2.13
MC07	285.00	6.36	2.12
MC08	286.95	6.35	2.12
MC09	286.00	6.36	2.11
MC10	286.14	6.33	2.13
MC11	286.45	6.34	2.11
MC12	284.12	6.30	2.10
MC13	286.20	6.32	2.11
MC14	288.50	6.31	2.09
MC15	285.57	6.33	2.12
MC16	284.69	6.34	2.12
MC17	287.47	6.34	2.11
MC18	281.47	6.36	2.13
MC19	282.54	6.35	2.13
MC20	284.12	6.34	2.11
MC21	284.68	6.31	2.12
MC22	281.24	6.32	2.10
MC23	284.69	6.34	2.13
Mean	0.750	52.70	43.82
SEd	0.252	0.028	0.025
CD @ 5 %	4.540	0.057	0.050
CV (%)	2.67	3.3	4.0

Table 5. GCV and PCV heritability and genetic advance as per cent mean of 15 traits of *M. cymbalaria* genotypes

S. No.	Variables	GCV	PCV	Heritability	GA as percent mean
1.	Days to sprouting	7.308	10.720	46.480	10.264
2.	Days to first flowering	3.899	4.844	64.780	6.465
3.	Vine length	26.555	27.086	96.120	53.632
4.	Number of vines per plant	15.996	30.411	27.670	17.333
5.	Number of fruits per vine	35.291	38.390	84.510	66.831
6.	Fruit length	7.022	14.563	23.250	6.976
7.	Fruit girth	4.148	8.826	22.090	4.017
8.	Fruit weight	7.202	17.230	17.470	6.201
9.	Number of fruits per plant	13.990	15.658	79.820	25.748
10.	Vitamin C	0.503	1.089	21.320	0.478
11.	Crude fibre	0.159	0.567	7.860	0.092
12.	Protein	0.461	1.353	11.630	0.324
13.	Fruit stalk length	4.800	5.429	78.160	8.741
14.	Yield per plant	17.310	24.003	52.010	25.715
15.	Number of seeds	7.654	12.314	38.630	9.799

(17.310 %), number of vines per plant (15.996 %), number of fruits per plant (13.99 %) whereas the lowest value was exhibited in vitamin C (0.503 %), crude fibre content (0.159 %), protein (0.461 %) and days to first flowering (3.899 %). The higher values of GCV indicate a greater range of variability within the spine gourd population, suggesting that these traits can be effectively improved through simple selection (17). Higher variability between PCV and GCV was recorded for days to sprouting, number of vines per plant, fruit length, fruit weight, yield per plant and number of seeds while the minimum variability between PCV and GCV was observed for the traits such as days to first flowering, number of fruits per plant, vitamin C, crude fibre content and fruit stalk length. Lower variation between PCV and GCV revealed greater stability of the character against environmental fluctuation (18).

In the present study, most of the characters exhibited high estimates of heritability for the traits such as vine length (96.12 %), number of fruits per vine (84.51 %), number of fruits per plant (79.820 %), fruit stalk length (78.16 %), days to first flowering (64.78 %) and yield per plant (52.010 %). It suggests that direct selection is most effective for these characters. The character that exhibited high heritability indicated the presence of additive gene action and such a character could be fixed by resorting to selection (19, 20). Moderate heritability was observed in days to sprouting (46.480 %), number of vines per plant (27.67 %), fruit length (23.25 %), fruit girth (22.09 %), whereas the lowest heritability was noticed for crude fibre content (7.86 %), protein (11.63 %) and fruit weight (17.47 %). High heritability coupled with high genetic advance indicates additive gene effects, making selection effective (9).

Genetic advance as percent over mean was the highest for number of fruits per vine (66.831 %), vine length (53.632 %), number of fruits per plant (25.748 %), yield per plant (25.715 %), days to sprouting (10.264 %) and number of seeds (9.799 %) where as the lowest for crude fibre content (0.092 %), protein (0.324 %), vitamin C (0.478 %) and fruit girth (4.017 %). Higher values of genetic advance as percentage over the mean indicate predominance of the additive gene component. High heritability, along with high genetic advance as percent over the mean, is an important factor for predicting the resultant effect for selecting the best individuals. High heritability values accompanied by low genetic advance for the rest of the characters were probably due to non-additive gene effects involving dominance deviation and epistatic influence (21).

Correlation studies were conducted to determine the suitability of various characters for indirect selection. It also provides information on the nature and extent of association between any 2 metric traits and it will be possible to bring about genetic upgradation in 1 trait by selection against the other (Table 6). Results of the correlation studies revealed that the yield per plant had significantly and positively correlated with days to sprouting (0.669), vine length (0.664), number of seeds per fruit (0.532), number of fruits per vine (0.594), number of fruits per plant (0.762), fruit weight (0.764) and fruit stalk length (0.784). Hence, it might be inferred that these traits could be considered as the most important yield contributing traits in athalakkai (14, 22–24). Fruit weight had a positive and significant association with the number of vines per plant, fruit girth, number of fruits per vine and fruit length (12, 16). The characters such as vine length, number of fruits per vine, number of fruits per plant and fruit weight showed significant correlation with yield as well as had significant correlation among them.

Path analysis was carried out to estimate the direct and indirect contributions of various component characters for recommending a reliable selection criterion (Table 7). Path coefficient analysis of yield characters revealed that the yield per plant is the most pronounced character contributing directly to the fruit weight (0.422), number of vines per plant (0.378) and number of fruits per plant (0.155). Therefore, direct selection of these traits could be useful in the athalakkai improvement program. Thus, traits with strong positive associations and direct effects on yield should be prioritized for selection (16, 17, 25).

Conclusion

Based on the results of the present investigation, it can be concluded that the high estimates of PCV for the number of fruits per vine (38.39 %) and number of seeds (38.63 %), along with moderate PCV and GCV observed for most of the traits, indicate the presence of adequate genetic variation among the genotypes. High heritability estimates coupled with high genetic advance for the traits such as number of fruits per vine, vine length, yield per plant and number of fruits per plant confirmed that these traits are under the control of additive gene action. Therefore, these characters should be prioritized for further selection and breeding programs.

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Authors' contributions

CR carried out the experiment, observed and drafted the manuscript. PA formulated the concept and correction of the manuscript. MG participated in the data analysis and performed the statistical analysis. CS conceived of the study and participated in its design and coordination. KSVS provided statistical tools for the analysis of the manuscript. AV participated in the data analysis and revised the manuscript. SSSSS participated in the overall correction of the manuscript. All authors reviewed the results and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process: During the preparation of this work, the author(s) used ChatGPT to elaborate on the study in a clearer and more accessible way. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

Table 6. Simple correlation coefficient analysis for various morphological traits of 23 *M. cymbalaria* genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.0	0.669	-0.152	-0.189	-0.294	-0.400	-0.337	0.077	-0.494	-0.311	0.114	-0.380	-0.402	-0.433	-0.535	-0.420
2		1.000	-0.266	-0.025	-0.485	-0.495	-0.011	-0.130	-0.159	-0.598	0.171	-0.452	-0.526	-0.575	-0.597	-0.415
3			1.000	0.471	0.664	-0.033	0.145	0.523	0.122	0.627	0.373	0.170	0.350	0.392	0.420	0.416
4				1.000	0.074	-0.111	0.293	-0.035	0.459	0.115	0.405	0.071	0.158	0.199	0.267	0.271
5					1.000	0.159	0.159	0.364	0.278	0.762	0.129	0.394	0.563	0.556	0.504	0.709
6						1.000	0.209	0.173	0.135	0.249	-0.318	0.157	0.012	0.305	0.187	0.415
7							1.000	0.210	0.764	-0.033	0.153	-0.247	-0.025	-0.015	-0.095	0.369
8								1.000	0.058	0.408	0.193	-0.014	-0.189	0.003	-0.038	0.227
9									1.000	0.234	0.167	0.075	0.233	0.288	0.219	0.634
10										1.000	0.069	0.315	0.467	0.594	0.571	0.717
11											1.000	0.011	0.176	0.159	0.031	0.139
12												1.000	0.645	0.773	0.767	0.415
13													1.000	0.785	0.683	0.494
14														1.000	0.784	0.702
15															1.000	0.598
16.																1.000

1- Days to sprouting; 2- Days to first flowering; 3- Vine length; 4- Number of vines per plant; 5- Number of fruits per vine; 6- Fruit length; 7- Fruit girth; 8- Number of seeds per fruit; 9- Fruit weight; 10- Number of fruits per plant; 11- Vitamin C; 12- Crude fibre; 13- Protein; 14- Fruit stalk length; 15- Leaf length and 16- Yield per plant.

Table 7. Path coefficient analysis of various morphological characters of 23 *M. cymbalaria* genotypes

Variables	Days to sprouting (Days)	Days to 1 st flowering	Vine length	No. of vines per plant	No. of fruits per vine	Fruit length	Fruit girth	No. of seeds	Fruit weight	No. of fruits per plant	Vit. C	Crude fibre	Protein	Fruit stalk length
Days to sprouting (days)	0.1257	0.4865	-0.0617	0.0763	0.1570	0.0603	-0.1528	-0.0024	-0.4275	-0.2467	-0.1208	-0.0733	-0.0898	-0.3502
Days to first flowering	0.1043	0.5864	-0.1048	0.0074	0.2084	0.0842	0.0039	-0.0409	-0.0910	-0.4082	-0.1718	-0.0771	-0.1206	-0.4637
Vine length	-0.0215	-0.1709	0.3596	-0.1858	-0.2687	0.0044	0.0508	0.1441	0.0897	0.3957	-0.3193	0.0287	0.0884	0.2830
No. of vines per plant	-0.0353	-0.0159	0.2457	-0.2720	-0.0254	0.0358	0.0801	-0.0173	0.3782	0.0747	-0.3512	0.0456	0.0177	0.1836
No. of fruits per vine	-0.0508	-0.3149	0.2491	-0.0178	-0.3880	-0.0279	0.0512	0.0936	0.1745	0.5036	-0.0960	0.0630	0.1783	0.4061
Fruit length	-0.0666	-0.4335	-0.0138	0.0954	-0.0952	-0.1140	0.1158	0.0656	0.0824	0.2428	0.3797	0.0770	0.0302	0.2775
Fruit girth	-0.0721	0.0086	0.0687	-0.0818	-0.0746	-0.0496	0.2663	0.0389	0.7624	-0.0573	-0.1173	-0.0420	-0.0417	-0.0686
No. of seeds	-0.0013	-0.1057	0.2285	0.0208	-0.1601	-0.0330	0.0457	0.2269	0.0092	0.2947	-0.2208	0.0208	-0.0673	-0.0042
Fruit weight	-0.1274	-0.1265	0.0765	-0.2438	-0.1604	-0.0222	0.4812	0.0049	0.4219	0.2235	-0.4210	0.0085	0.1157	0.3485
No. of fruits per plant	-0.0510	-0.3934	0.2338	-0.0333	-0.3211	-0.0455	-0.0251	0.1098	0.1550	0.6085	-0.0864	0.0487	0.1323	0.4358
Vitamin C	0.0273	0.1816	0.2070	-0.1722	-0.0671	0.0780	0.0563	0.0903	0.3202	0.0948	-0.5548	-0.0042	-0.0355	0.1983
Crude fibre	-0.1191	-0.5845	0.1334	-0.1606	-0.3161	-0.1134	-0.1447	0.0611	0.0464	0.3838	0.0301	0.0773	0.4343	1.2181
Protein	-0.0627	-0.3925	0.1765	-0.0267	-0.3839	-0.0191	-0.0616	-0.0847	0.2710	0.4467	0.1095	0.1864	-0.1802	0.9094
Fruit stalk length	-0.0640	-0.3957	0.1481	-0.0726	-0.2293	-0.0460	-0.0266	-0.0014	0.2140	0.3859	-0.1601	0.1371	0.2385	0.6872

Residual effect= 0.4373

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