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GENETIC DIVERSITY AND ASSOCIATION ANALYSIS FOR YIELD TRAITS CHICKPEA (*CICER ARIETINUM* L.) UNDER RICE BASED CROPPING SYSTEM

P. L. JOHNSON*, R. N. SHARMA AND H. C. NANDA
Department of Genetics and Plant Breeding,
Indira Gandhi Krishi Vishwavidyalaya, Raipur - 492 012, Chhattisgarh, INDIA
e-mail: pyare_johnson@yahoo.co.in

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***Corresponding author**

ABSTRACT

The experimental material comprised of 112 genotypes (85 Germpasm accession, 12 improved varieties and 15 advance breeding lines) of chickpea carried out to study the nature and magnitude of genetic divergence using Mahalanobis's D^2 statistics, correlation using Miller and path analysis by Dewey and Lu. 112 genotypes of chickpea were grouped in eight cluster. The highest inter cluster distance was observed clusters IV and VII (6.296) followed by I and VII (5.867), IV and V (5.681), I and IV (5.658). The highest intra-cluster distance was observed for cluster V (2.328). Hence, genotypes belonging to this cluster viz. ICC 251834, ICC 275466, ICC 269530, Indira Chana-1, ICC 269563, RG 2011-01, RG 2011-03, JG 11 can be utilized as parents in future chickpea improvement programmes. Correlation coefficient analysis revealed that biological yield and harvest index exhibited the positive correlation with seed yield per plant. path coefficients for seed yield per plant recorded the highest positive direct effect contributing to seed yield plant^{-1} is harvest index, biological yield and pods plant^{-1}.

INTRODUCTION

Chickpea (Cicer arietinum L.) is an integral part of an Indian agriculture since time immemorial, because of its intrinsic value in terms of higher protein content, carbohydrates, minerals, nitrogen fixing ability and indispensability as alternative crop for crop diversification. On the basis of cultivated area, chickpea ranks 19th among the crops, and is grown in 34 countries of the world. Area under pulses in India, Pakistan, Nepal, and Bangladesh covers about 90% of the world acreage. It is an important pulse crop of India, grown in an area of 9.51 million hectares with the annual production of 8.83 million tonnes and with productivity of 929 kg/ ha. In Chhattisgarh, it is cultivated in around 0.267 million hectare, with an average productivity of 1069 kg/ ha, bigger than the national average cultivated under rainfed ecosystem and particularly in rice & soybean fallows (Anonymous, 2014).Limited or lack of genetic variability is important factor for the limited progress achieved in increasing the productivity of grain legumes including chickpea (Ramanujam, 1975). When the parents utilized in across are genetically similar, it is quite likely that the different lines derived reveals low diversity. On the contrary, when diverse parents are used in obtaining a segregating population, the derived lines reveal greater diversity despite sharing a common percentage. Yield components are the primary objectives under study for crop improvement as because Grafius (1978) suggested that there may not be genes for yield per se but rather for the various components, the multiplicative interactions of which result in the artifact of yield. In any program aimed at genetic amelioration of yield, genetic diversity is the basic requirement. Effective hybridization program between genetically diverse parents will lead to considerable amount of heterotic response in F_1 hybrids and broad spectrum of variability in segregating generations. Mahalanobis's D2 statistics is a powerful tool in quantifying the degree of variability at the genotype level. Several workers studied the genetic diversity, clustering pattern, relative contribution of different characters toward divergence and effectiveness of selection (Patil et al., 2003; Bisht et al., 2005). So, the present experiment was formulated to study the genetic divergence and clustering pattern of the chickpea genotypes for selection of suitable parents for utilizing in hybridization programme and to study the genetic parameters attributing to yield. For realizing genetic diversity among the parents with their direct and indirect effects of different traits on seed yield and selection of best diverse parents for Chickpea breeding programme at IGKV, Raipur present investigation was undertaken.Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. The path analysis helps in partitioning the correlation coefficient of yield components with seed yield into its direct and indirect effects to ensure the actual contribution of an attribute as well as its influence through other traits

MATERIALS AND METHODS

The experimental material comprised of 112 genotypes (85 Germplasm accession, 12 improved varieties and 15 advance breeding lines) of chickpea grown under rice based cropping system was grown during *Rabi* - 2013 at Research cum Instructional farm, Department of Plant Breeding and Genetics, Indira Gandhi Agricultural University, Raipur Chhattisgarh (Table 1). A augmented design was used to conduct the experiment. Each genotype was sown in two row of 3 m length. Genotypes were sown in six blocks each block 20 genotypes, with row-to-row spacing of 30 cm and plat to plant 10 cm. N, P and K were applied in the ratio of 20: 40: 20 kg ha^{-1} as basal, in the furrows. Normal sown conditions were applied. The

Table 1: Source of materials

S.N.	Accession No.	Source	S.N.	Accession No.	Source
1	ICC 6124	NBPGR, New Delhi	37	ICC 269787	NBPGR, New Delhi
2	ICC 12365	NBPGR, New Delhi	38	ICC 5810	NBPGR, New Delhi
3	ICC 11153	NBPGR, New Delhi	39	ICC 257635	NBPGR, New Delhi
4	ICC 1053	NBPGR, New Delhi	40	ICC 424383	NBPGR, New Delhi
5	JG 130	JNKVV, Jabalpur	41	ICC 5679	NBPGR, New Delhi
6	ICC 548066	NBPGR, New Delhi	42	ICC 411750	NBPGR, New Delhi
7	ICC 327395	NBPGR, New Delhi	43	ICC 5803	NBPGR, New Delhi
8	RG 2006-3	IGKV, Raipur	44	ICC 7497	NBPGR, New Delhi
9	RG 2006-7	IGKV, Raipur	45	ICC 5683	NBPGR, New Delhi
10	RG 2006-12	IGKV, Raipur	46	ICC 12539	NBPGR, New Delhi
11	RG 2006-4	IGKV, Raipur	47	ICC 5773	NBPGR, New Delhi
12	ICC 251762	NBPGR, New Delhi	48	ICC 5160	NBPGR, New Delhi
13	Akoli Chana	PKV, Akola	49	ICC 5713	NBPGR, New Delhi
14	ICC 251811	NBPGR, New Delhi	50	ICC 5766	NBPGR, New Delhi
15	ICC 251834	NBPGR, New Delhi	51	ICC 6038	NBPGR, New Delhi
16	ICC 275612	NBPGR, New Delhi	52	ICCV 13104	NBPGR, New Delhi
17	JGK 1	JNKVV, Jabalpur	53	ICC 5640	NBPGR, New Delhi
18	ICC 269725	NBPGR, New Delhi	54	ICC 5699	NBPGR, New Delhi
19	ICC 275627	NBPGR, New Delhi	55	ICC 5766	NBPGR, New Delhi
20	ICC 424295	NBPGR, New Delhi	56	ICC 9499	NBPGR, New Delhi
21	ICC 322782	NBPGR, New Delhi	57	ICC 269446	NBPGR, New Delhi
22	ICC 269712	NBPGR, New Delhi	58	ICC 269449	NBPGR, New Delhi
23	GNG 463	ARS Sriganganagar	59	ICC 269495	NBPGR, New Delhi
24	ICC 275466	NBPGR, New Delhi	60	ICC 269530	NBPGR, New Delhi
25	ICC 251820	NBPGR, New Delhi	61	Indira Chana-1	IGKV, Raipur
26	ICC 251890	NBPGR, New Delhi	62	Vaibhav	IGKV, Raipur
27	ICC 327512	NBPGR, New Delhi	63	ICC 269558	NBPGR, New Delhi
28	ICC 275517	NBPGR, New Delhi	64	ICC 269560	NBPGR, New Delhi
29	ICC 251819	NBPGR, New Delhi	65	ICC 269562	NBPGR, New Delhi
30	ICC 424304	NBPGR, New Delhi	66	ICC 269563	NBPGR, New Delhi
31	ICC 6022	NBPGR, New Delhi	67	ICC 269583	NBPGR, New Delhi
32	BGD 72	IARI, New Delhi	68	ICC 269584	NBPGR, New Delhi
33	ICC 9499	NBPGR, New Delhi	69	ICC 269587	NBPGR, New Delhi
34	ICC 5666	NBPGR, New Delhi	70	ICC 269604	NBPGR, New Delhi
35	ICC 5770	NBPGR, New Delhi	71	RG 2011-01	IGKV, Raipur
36	ICC 12440	NBPGR, New Delhi	72	ICC 269625	NBPGR, New Delhi
73	ICC 269634	NBPGR, New Delhi	93	JG 315	JNKVV, Jabalpur
74	ICC 269696	NBPGR, New Delhi	94	ICC 8319	NBPGR, New Delhi
75	ICC 269697	NBPGR, New Delhi	95	ICC 269720	NBPGR, New Delhi
76	ICC 269703	NBPGR, New Delhi	96	RG 2009-01	NBPGR, New Delhi
77	ICC 269706	NBPGR, New Delhi	97	RG 2003-28	IGKV, Raipur
78	ICC 269713	NBPGR, New Delhi	98	RG 2011-03	IGKV, Raipur
79	ICC 269716	NBPGR, New Delhi	99	IPC 94-94	IIPR, Kanpur
80	ICC 269721	NBPGR, New Delhi	100	IPC 98-12	IIPR, Kanpur
81	ICC 269733	NBPGR, New Delhi	101	ICCV 96029	NBPGR, New Delhi
82	RG 2011-06	IGKV, Raipur	102	ICCV 96030	NBPGR, New Delhi
83	ICC 269825	NBPGR, New Delhi	103	RG 2009-02	IGKV, Raipur
84	ICC 269856	NBPGR, New Delhi	104	RG 2009-04	IGKV, Raipur
85	ICC 269861	NBPGR, New Delhi	105	JG 97	JNKVV, Jabalpur
86	ICC 269862	NBPGR, New Delhi	106	JAKI 9218	JNKVV, Jabalpur
87	ICC 269865	NBPGR, New Delhi	107	JG 14	JNKVV, Jabalpur
88	ICC 269890	NBPGR, New Delhi	108	BG 372	IARI, New Delhi
89	RG 2003-15	IGKV, Raipur	109	DCP 92-3	IARI, New Delhi
90	RG 2003-20	IGKV, Raipur	110	Pant G 186	GBPUAT, Pantnagar
91	JG 16	JNKVV, Jabalpur	111	GCP 105	JAU, Junagadh
92	ICC 9698	NBPGR, New Delhi	112	JG 11	JNKVV, Jabalpur

soil type of experiment field was clay loam and recommended package of practices were adopted to raise the crop.Data were recorded on five randomly tagged plants for viz., days for 50 % flowering, days to maturity, plant height, 100 seed weight, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, protein content and seed yield plant^{-1}. Wilks (1932) criteria were used to test the significance differences in mean values of all the eight characters. Statistical analysis: Mahalanobis (1936) defined the distance between two populations as D2, which was obtained by Tochers method, described by Rao (1952). Contribution of individual characters towards divergence was estimated according to the method described by Singh and Choudhary (1985). Grouping of variety into various clusters was done and average intra and inter cluster distance were estimated. The experimental data was analyzed statistically by the method of analysis of variance for single factor (Gomez and Gomez, 1984) and lastly to find out the significance mean difference between varieties different genetic parameters were estimated.The correlation coefficient analysis was done by the formula proposed by Miller *et al*. (1958). The path analysis helps in partitioning the correlation coefficient of yield components with seed yield into its direct and indirect effects to ensure the actual contribution of an attribute as well as its influence through other traits. Path coefficient analysis suggested by Dewey and Lu (1959) proves helpful, in partitioning the correlation coefficient into measures of direct and indirect effects of a set of independent variables on the dependent variable.

RESULTS AND DISCUSSION

The one hundred tweleve (112) genotypes studied were grouped into eight clusters (Table 2) by using Tocher's methods described by Rao (1952). Clusters showing significant variability for selecting the genotypes for future breeding programmes. Clusters VI, II and III were the biggest clusters with 28, 21 and 18 genotypes respectively. Whereas, clusters VIII, I, V, VII and IV comprised of 16, 9, 8, 7 and 5 genotypes respectively. The intra- and inter cluster distances were computed for all the traits and are presented in the Table 3. Results of cluster analysis revealed that the highest intra- cluster distance was observed for cluster V (2.328) followed by cluster IV (2.211), VIII (2.161), II (2.139), III (2.124), VI (2.083), VII (2.063) and cluster I (1.728). The highest inter cluster distance was measured between the clusters IV and VII (6.296) followed by I and VII (5.867), IV and V (5.681), I and IV (5.658). Minimum inter cluster distance was observed between VI and VIII (2.134).

Mean performance of individual clusters for different characters in Table 4. The maximum number of pods plant^{-1} was exhibited by cluster VIII (45.25), followed by cluster VI (42.39), cluster IV (39.8), cluster V (36.0), I (30.67), II (30.14) and VII (29.14). Whereas, the lowest number of pods per plant was observed for cluster III (29.11). For 100 seed weight, cluster IV exhibited the highest 100 seed weight of 33.52 g flowed by III (20.25), VII (19.18) and V (18.99) all other clusters. The minimum 100 seed weight was observed for cluster I (14.96 g). The maximum biological yield was observed for cluster IV (17.40), followed by cluster VII (17.19 g), IV (17.06 g), cluster VI (16.96 g),

Table 2: distribution of 112 genotypes of chickpea in different clusters

Clusters No.	Total No. of Genotypes	Genotypes
I	9	ICC 1053, ICC 275627, ICC 5770, ICC 424383, ICC 5766, ICC 269625, ICC 269733, ICC 9698, ICC 8319.
II	21	RG 2006-03, RG 2006-07, ICC 275517, ICC 251819, ICC 6022, ICC 5666, ICC 257635, ICC 7497, ICC 5160, ICC 5713, ICC 269495, ICC 269562, ICC 269604, ICC 269634, ICC 269706, RG 2011-06, ICC 269825, ICC 269856, ICC 269890, JG 16, JG 315.
III	18	ICC 5083, ICC 5773, ICC 5699, ICC 269560, ICC 269587, ICC 269696, ICC 269697, ICC 269703, ICC 269713, ICC 269716, ICC 269721, ICC 269862, RG 2003-20, RG 2009-01, RG 2003-28, JAKI 9218, JG 14, Pant G 186.
IV	5	ICC 12365, ICC 11153, ICC 327395, BGD 72, ICC 9499
V	8	ICC 251834, ICC 275466, ICC 269530, Indira Chana-1, ICC 269563, RG 2011-01, RG 2011-03, JG 11.
VI	28	ICC 6124, JG 130, ICC 548066, RG 2006-04, ICC 251762, ICC 251811, ICC 275612, ICC 424295, ICC 269712, GNG 463, ICC 251820, ICC 327512, ICC 424304, ICC 12440, ICC 5810, ICC 5679, ICC 411750, ICC 5683, ICC 12539, ICC 6038, ICCV 13104, ICC 5640, ICC 269446, Vaibhav, ICC 269583, ICC 269861, BG 372, DCP 92-3.
VII	7	IPC 94-94, IPC 98-12, ICCV 96029, ICCV 96030, RG 2009-02, RG 2009-04, JG 97.
VIII	16	RG 2006-12, Akoli Chana, JGK-1, ICC 269725, ICC 322782, ICC 251890, ICC 9499, ICC 269787, ICC 5766, ICC 269449, ICC 269558, ICC269584, ICC 269865, RG 2003-15, ICC 269720, GCP 105.

Table 3: Estimated average intra and inter cluster distance for eight cluster in different genotypes

Clusters	I	II	III	IV	V	VI	VII	VIII
I	1.728							
II	2.684	2.139						
III	5.521	2.423	2.124					
IV	5.658	4.019	3.824	2.211				
V	2.399	3.282	3.437	5.681	2.328			
VI	2.904	2.820	2.421	4.124	3.364	2.083		
VII	5.867	5.264	4.596	6.296	5.145	5.756	2.063	
VIII	3.968	2.640	2.855	3.653	4.636	2.134	5.604	2.161

Table 4: Cluster mean for yield and its attributing characters

Characters	I	II	III	IV	V	VI	VII	VIII
Days to 50 % flowering	61.00	61.86	60.00	60.60	57.25	61.75	48.71	62.25
Days to maturity	104.22	104.19	104.11	104.40	103.38	104.61	93.71	104.00
Plant height (cm)	54.52	50.97	45.55	53.60	45.11	51.31	43.79	52.88
Primary branches plant^{-1}	02.67	3.24	2.61	3.40	2.75	3.36	2.14	3.31
Secondary branches plant^{-1}	07.22	8.48	8.11	8.20	7.25	7.43	7.43	7.94
Pods plant^{-1}	30.67	30.14	29.11	39.8	36.00	42.39	29.14	45.25
Biological yield (g.)	13.00	13.52	17.06	17.40	12.38	16.96	15.57	17.19
Harvest index (%)	69.00	54.00	49.00	42.00	73.00	55.00	48.00	43.00
100-seed weight (g.)	14.96	18.47	20.25	33.52	18.99	18.00	19.18	16.67
Seed yields plant^{-1} (g.)	8.89	7.33	8.39	7.22	9.0	9.18	7.43	7.44

Table 5: Correlation coefficients for seed yield and its components in chickpea under rice based cropping system

Characters	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Biological yield (g)	Harvest index (%)	100-seed weight (g)	Seed yield plant^{-1}(g)
Days to 50 % flowering	0.6189**	0.2912**	0.2018*	0.0768	0.1988*	0.0879	-0.0495	-0.1912*	0.0382
Days to maturity		0.3578**	0.2613**	0.0473	0.1935*	0.057	0.0791	-0.0011	0.1694
Plant height (cm)			0.2377**	-0.011	0.2664**	-0.0205	-0.0202	0.0132	-0.0456
Primary branches plant^{-1}				-0.0025	0.3337**	0.042	-0.0887	0.0299	-0.0429
Secondary branches plant^{-1}					0.0319	0.0223	-0.1134	0.1992*	-0.127
Pods plant^{-1}						0.2304*	-0.1507	-0.0539	0.0291
Biological yield (g)							-0.7105**	0.0941	0.2011*
Harvest index (%)								-0.2072	0.5309**
100-seed weight (g)									-0.1827*

cluster VII (15.57 g) and cluster II (13.52 g). The maximum biological yield was observed in IV (17.40) followed by VIII (17.19), III (17.06) and minimum V (12.38). Similarly in harvest index maximum harvest index was recorded by V 73.0 %) followed by I (69.00 %) and lowest was IV (42.00 %). Cluster VI was found to be the best with respect to seed yield per plant as it possessed the highest seed yield plant^{-1} (9.18 g), followed by cluster V (9.0 g), cluster I (8.89 g), cluster III (8.39 g) and cluster VIII (7.44 g). Whereas, the lowest seed yield per plant was noted for cluster IV (7.22 g). Similar resut were reported by Garje *et al.* (2013), Meshram *et al.* (2013), Nagy *et al.* (2013) and Sachil *et al.* (2014).

The pattern of distribution of 112 genotypes in various clusters revealed existence of considerable genetic diversity in the material. The genotypes were grouped into 8 clusters. The highest intra-cluster distance was observed for cluster V (2.328). Hence, genotypes belonging to this cluster *viz.* ICC 251834, ICC 275466, ICC 269530, Indira Chana-1, ICC 269563, RG 2011-01, RG 2011-03, JG 11 can be utilized as parents in future breeding programmes with the desirable genotypes belonging to clusters VII. These results are in general agreement with the findings of Sikarwar (2004).Raman and Singh (1987) suggested that genotypes belonging to clusters separated by high genetic distance maybe used in hybridization program to obtain a wide spectrum of variation among the segregates and in the present study similar suggestion had been made. Arunachalam and Bandopadhyay (1984) reported that crosses between divergent classes DC2 and DC3 will be more heterotic and promising than other combination of crosses. On the basis of divergence classes the potential parent's viz. ICC 251762, ICC 327512, ICC 12440, ICC 12539, ICC 5640, ICC 269583, Indira Chana-1, Vaibhav, BG 372, JG 14, JG 130, DCP 92-3, JG-11 and JG-315 can be used in the hybridization programme for chickpea improvement to obtain better transgressive segregants. This finding are in accordance with that of Dwevedi and Lal (2009), Wadikar *et al.* (2010), Akthar *et al.* (2011), Parameshwarappa *et al.* (2011), Jayalakshmi *et al.* (2012), Singh *et al.* (2012), Jain *et al.* (2013), Pandey *et al.* (2013), Puri *et al.* (2013), Gaikwad *et al.* (2014).

The analysis of correlation coefficients of various yield attributing characters (Table 5). The highest positive correlation of seed yield per plant was observed with harvest index, followed by biological yield and days to maturity. Whereas, negative correlation of seed yield per plant was observed with 100-seed weight and secondary branches plant^{-1}. The highest positive correlation of days to 50% flowering was observed with days to maturity followed by plant height, primary branches plant^{-1} and pods plant^{-1}. Days to maturity showed positive correlation with plant height, primary branches plant^{-1} and pods plant^{-1}. Plant height observed positive correlation with primary branches plant^{-1} and pods plant^{-1}. Primary branches plant^{-1} observed positive correlation with pods plant^{-1}. Secondary branches plant^{-1} showed positive correlation with 100 seed weight and Pods plant^{-1} with biological yield. Biological yield observed negative correlation with harvest index. Overall observation of correlation coefficient analysis revealed that biological yield and harvest index exhibited the positive correlation with seed yield per plant. Hence, direct selection for these traits can lead to the development of high yielding chickpea genotypes. Similarly, selection for early flowering may be advantageous for developing chickpea varieties with medium to bold seed size. The experimental findings of correlation coefficient analysis are in general agreement with the results reported earlier by Jeena and Arora

Table 6: Path coefficients of various characters for seed yield plant^{-1} in chickpea under rice based cropping system

Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Biological yield (g)	Harvest index (%)	100-seed weight (g)	Seed yield plant^{-1}(g)
Days to 50 % flowering	0.0069	-0.0111	0.0043	0.0096	0.0003	0.0112	0.1043	-0.0677	0.0028	0.0382
Days to maturity	0.0043	-0.0179	0.0053	0.0125	0.0002	0.0109	0.0677	0.1083	0.0000	0.1694
Plant height (cm)	0.0020	-0.0064	0.0147	0.0113	0.0000	0.0150	-0.0244	-0.0277	-0.0002	-0.0456
Primary branches plant^{-1}	0.0014	-0.0047	0.0035	0.0477	0.0000	0.0188	0.0499	-0.1215	-0.0004	-0.0429
Secondary branches plant^{-1}	0.0005	-0.0008	-0.0002	-0.0001	0.0036	0.0018	0.0265	-0.1553	0.0030	-0.1270
Pods plant^{-1}	0.0014	-0.0053	0.0039	0.0159	-0.0001	0.0564	0.2735	-0.2064	0.0008	0.0291
Biological yield (g)	0.0006	-0.0010	-0.0003	0.0020	0.0001	0.0130	1.1870	-0.9729	-0.0014	0.2011*
Harvest index (%)	-0.0003	-0.0014	-0.0003	-0.0042	-0.0004	0.0085	-0.8433	1.3693	0.0031	0.5309**
100-seed weight (g)	-0.0013	0.0000	0.0002	0.0014	0.0007	0.0030	0.1117	-0.2837	-0.0148	-0.1827*

(2005) and Gour *et al.*, (2014). Similar relation was also reported by Singh *et al.* (2007), Malik *et al.* (2009), Johnson *et al.* (2010), and Pandey *et al.* (2013). Sharma and Saini (2010), for biological yield. Thakur and Sirohi (2009), Meena *et al.* (2010) for harvest index. Path coefficient analysis was carried out by taking seed yield per plant as dependent variables and rest of the quantitative traits as independent variables (Table 6). path coefficients for seed yield per plant recorded the highest positive direct effect contributing to seed yield plant^{-1} is, harvest index followed by biological yield, pods plant^{-1}, primary branches plant^{-1} plant height, days to 50 % flowering. Whereas, negative direct effects on seed yield per plant were observed due to days to maturity and 100 seed weight. Similar results were reported by Farshadfar and Farshadfar (2008), Vaghela *et al.* (2009), Borate and Dalvi (2010) and Pandey *et al.* (2013)

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