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BEHAVIOR OF NEW COWPEA LINES IN SANDY SOIL CONDITIONS IN SOUTHERN OLTENIA

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Abstract

*The research was carried out in the period 2024-2025 and aimed at the comparative competition culture behavior of seven new cowpea lines obtained at the Research and Development Station for Plant Culture on Dăbuleni Sands, in order to introduce the most valuable ones into culture. The results obtained showed that the vegetation period of the new cowpea lines lasted 69.5-82.5 days, by accumulating total thermal resources in the air of 1637.9-1970.7 0C, standing out by earliness of 12.5-15.5 days compared to the Doljana variety (control), the LD 5/2020 and LD 6/2020 lines. Compared to the control variety, the new cowpea lines recorded lower values of plant height and leaf index and better fruiting of the plant. The lines with the best production results (1718.51-2007.11 kg/ha) were highlighted: LD 3/2020, LD 5/2020 and LD 6/2020, which stood out significantly and distinctly significantly from the Doljana variety. The grain production obtained from the assortment of cowpea genotypes studied was distinctly significantly positively correlated with the number of pods/plant (r=0.838**) and significantly negatively correlated with the leaf area index (r= - 0.754*). From the point of view of production quality, the lines LD 1/2020, LD 3/2020, LD 5/2020 and LD 6/2020 stood out for their high crude protein content in the grain (26.19-26.72%), with differences of 1.59-2.2%, statistically assured compared to the control variety.*

Key words: drought; plant phenology; physiology; productivity, quality

INTRODUCTION

Originating in Central Africa, cowpea (*Vigna unguiculata L. Walpers*) is a legume with high drought tolerance and wide ecological plasticity, serving as the main grain legume for the African population (Emongor, 2007). Due to its deep root system, waxy leaf coating, and effective strategy to avoid foliar desiccation through stomatal closure, cowpea can efficiently exploit drought conditions (Olorunwa et al., 2021). Considered a key crop for achieving food security and an appropriate crop under future climate change scenarios, preserving cowpea's genetic biodiversity is essential in the current context, given the increasing global drought intensity and rising protein demand (Nunes et al., 2022; Choi et al., 2025).

International research has shown that the water content of sandy soils lies outside the optimal range characteristic for most plant species, representing a stress factor with significant implications for physiological processes in cultivated plants (Burzo, 2014; Ladányi, 2021; Manneh et al., 2024). Among leguminous crops, cowpea emerges as an alternative for drought conditions, with its resistance attributed to rapid branching, a waxy leaf layer, enhanced photosynthesis, and a well-developed root system (Adusei et al., 2022; Nunes et al., 2022). Furthermore, cowpea is a crop with low soil requirements and an essential source of protein for regions disadvantaged by climatic conditions (Matei et al., 2015; Drăghici et al., 2018, 2022), and it yields well on poor, sandy soils (Gerrano et al., 2015).

Owing to its ability to biologically fix atmospheric nitrogen through symbiotic bacteria of the genus *Rhizobium*, cowpea is successfully cultivated in crop rotations in areas with sandy soils (Oliveira et al., 2017). However, the efficiency of this symbiosis is influenced by environmental factors, including soil acidity, nutrient imbalance, and salinization caused by continuous cropping (Kebede, 2021; Zhu et al., 2025). Introducing legumes into crop rotations is a key measure for promoting sustainable agriculture, and cowpea is particularly recommended for drought-prone areas due to its tolerance to soil phosphorus and water deficiencies (Adusei et al., 2021). It also benefits subsequent crops by leaving nitrogen in the soil after the growing season (Sanchez-Navarro et al., 2021).

Given its high protein content in both the plant and the seeds, cowpea has multiple uses: in human nutrition as pods or grains; in soil fertility improvement through its cultivation in crop rotations on sandy soils or through incorporation as green manure (Zhiyuan et al., 2021; Drăghici et al., 2024); and in animal feeding, as part of dry or ensiled fodder mixtures along with sorghum or rye (Ciurerscu et al., 2020, 2022). Cowpea grains have nutritional components comparable to those of other legumes, with a low-fat content and a very high protein content. They contain 23–32% protein, 50–60% carbohydrates, and 1% fat (Kirse & Karklina, 2015; Abebe et al., 2022).

Developing new cowpea genotypes is essential, considering the implications of drought during the plant's reproductive stages, which have led to increased hundred-seed weight and seed protein levels, while starch content decreased, indicating a shift in resource allocation under stress (Chakravaram et al., 2025; Pudel et al., 2025). These findings suggest the need to improve a drought-resistant genotype through multi-stage selection to maintain yield under varying rainfall conditions

MATERIALS AND METHODS

The research was conducted during 2024–2025 to evaluate the performance of seven new cowpea lines (*Vigna unguiculata* L. Walpers) developed at Research Development Station for Plant Culture on Sands Dăbuleni under comparative competitive trials, relative to the cultivar *Doljana*. The biological material was obtained in 2020 through repeated individual selection within a naturally hybridized cowpea population. All stages of the breeding process were completed: selection field, control field, preliminary comparative trial, and competitive comparative trials.

The studies were conducted on a sandy soil characterized by low natural fertility, with poor supply of total nitrogen (0.025–0.03%) and exchangeable potassium (39.48–49.11 ppm), medium levels of organic carbon (0.67–0.69%), high extractable phosphorus content (92.16–105.5 ppm), and a slightly alkaline reaction (pH H_2O = 7.93–7.99). Sowing of cowpea was carried out when air temperature stabilized between 12–15°C, ensuring a sowing density of 20 viable seeds/m². The water requirements of cowpea during the vegetation period (May–August) were met by precipitation (137.7 mm) and 4–5 irrigations at an irrigation rate of 250 m³/ha.

Throughout the vegetation period of cowpea, observations and measurements were conducted regarding:

- the progression of phenological stages and daily climatic conditions for each cowpea genotype;
- during the flowering stage, plant height, leaf area index, stomatal conductance, and physiological processes related to photosynthesis and transpiration were determined;
- the leaf area index was calculated using the following methodology: number of leaves per plant × the area of a single leaf (measured in the laboratory with the AM 300 device) × 20 plants/m²;
- stomatal conductance and physiological processes were determined in the field using the LC Pro SD device;
- at maturity, the following traits were measured: number of pods per plant, number of seeds per pod, pod length, and the quantity and quality of yield (thousand-seed weight, hectoliter weight, and protein content). Protein content was determined using the spectrophotometric method with an NIR analyzer, INFRAMATIC model.

The experimental results were processed using analysis of variance (ANOVA) and appropriate mathematical functions.

RESULTS AND DISCUSSIONS

Evolution of Climatic Conditions

The climatic conditions recorded during the cowpea growing season highlighted an intensification of thermo-hydric stress compared with the multiannual average, with a surplus of 1.87°C in mean air temperature and a deficit of 84.9 mm in precipitation during May–August (Table 1). Climate evolution during the summer months (June–July), when most spring-sown crops develop both vegetative and reproductive structures, showed an exceedance of the multiannual mean temperature by 2.76–3.12°C and a precipitation deficit of 36.73–47.32 mm. Combined with very low relative air humidity, with minimum values of 13.81–14.08%, these conditions generated an arid microclimate in the sandy-soil region, significantly affecting the agricultural systems of drought-prone areas.

Table 1. Climatic conditions recorded during the growing season of cowpea crops

Climatic conditions		May	June	July	August	May-August
Air temperature 2024-2025 (°C)	average	16,39	24,71	26,13	24,93	23,04
	minimum	1,53	9,74	10,69	7,53	1,53
	maximum	29,87	40,51	41,21	40,95	41,21
Rainfall, 2024-2025 (mm)		84,7	22	17,1	13,9	137,7
Relative air humidity (%)	Average	71,75	61,08	56,1	53,82	60,69
	Minimum	22,18	14,08	13,81	13,07	13,07
	Maximum	100	100	100	100	100
Multiannual average temperature (1956-2024) (°C)		16,95	21,59	23,37	22,75	21,17
Rainfall multiannual average (1956-2024) (mm)		63,41	69,32	53,83	36,04	222,6
Deviation from multiannual temperature (°C)		-0,56	3,12	2,76	2,18	1,87
Deviation from multiannual rainfall (mm)		21,29	-47,32	-36,73	-22,14	-84,9

Under such conditions, cowpea represents a viable alternative to soybean and dry cowpea cultivation on sandy soils, due to its superior drought tolerance, which results from its strong root system with high absorption capacity, the waxy layer on the leaves, and the number of stomata per leaf, which ranges between 280–327 stomata/mm² on the upper surface (Zăvoi, 1967). Although cowpea is a drought-tolerant crop, its yield may still be affected when soil water stress occurs during the reproductive stage (Olorunwa et al., 2021; Tankari et al., 2021). To mitigate the adverse impacts of water stress, supplemental irrigation was required, consisting of 4–5 irrigations at an application rate of 250 m³/ha during flower-bud formation and pod development. ***Monitoring of Plant Phenology***

Under the climatic conditions during the study period, cowpea genotypes emerged within 9–11 days after sowing, when mean air temperatures ranged from 16.3 to 17.3°C (Figure 1).

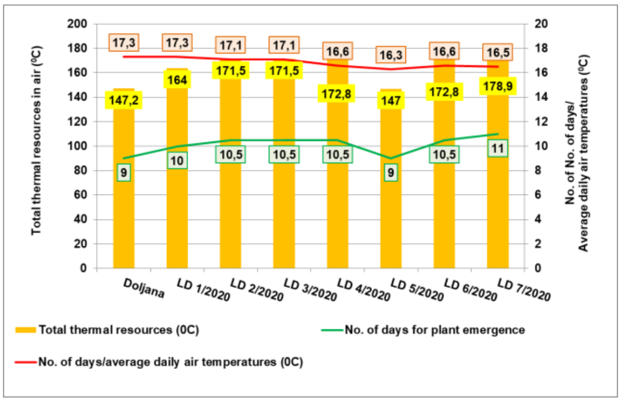

Figure 1. Thermal resources recorded during the sowing–emergence period of cowpea genotypes (2024–2025)

The total thermal resources required for emergence ranged from 147 to 178.9°C and varied depending on the germination capacity of the tested biological material. Under these conditions, all genotypes showed uniform emergence (Score 1).

The literature indicates that temperature is one of the climatic factors with the most significant influence on the germination process and early development of cowpea plants (Baros et al., 2020). The initial stage of plant growth is considered crucial, as successful establishment depends on the ability of seeds and seedlings to withstand adverse environmental conditions (de Andrade Melo Junior, 2018). For this reason, sowing should be carried out once temperatures become stable (above 12–15°C).

From Emergence to the End of the Vegetation Period

From emergence to the end of the vegetation period, all vital plant processes occurred under high-temperature conditions, ranging from 16.1 to 26.5°C, with a mean of 23.8°C for the entire growing season. In this microclimate, the vegetation period of the cowpea genotypes lasted 69.5–85 days, with total air thermal resources ranging from 1637.8 to 2040.1°C (Table 2). Compared with the control cultivar (*Doljana*), all selected lines exhibited earliness of 3–15.5 days, with lines *LD 5/2020* and *LD 6/2020* standing out, recording 12.5–15.5 days of earliness at technical pod maturity. Similar research conducted under the climatic conditions of Ahvaz, Iran, showed that from sowing to pod maturity, cowpea required 1150.5–1430.5°C, depending on the genotype (Khouzani, 2021).

Evaluation of Morphological and Productivity Traits

Cowpea growth and development differed by genotype (Table 3). The average plant height ranged from 34.9 to 68.2 cm, with the maximum recorded for the control cultivar *Doljana*. All newly developed lines had lower plant height than the control, and the differences were statistically significant or highly significant in the negative direction.

Similarly, leaf area index was lower in all new lines compared with the control cultivar, with statistically significant negative differences in lines *LD 3/2020* and *LD 5/2020.*

Table 2. Observations on the progression of vegetation phenophases in the assortment of cowpea genotypes

Cowpea genotype	Emergence-first true leaf		First leaf - 3 true leaves		3 true leaves - shoot formation		Shoot formation-flower stem formation		Flowering stems – flowering, pod formation		Pod formation – Maturity (>80%)		Vegetation period (emergence-maturity)	
	D	(∑ °C)	D	(∑ °C)	D	(∑ °C)	D	(∑ °C)	D	(∑ °C)	D	(∑ °C)	D	(∑ °C)
Doljana	10.5	167.1	11	243.2	8	190.1	19	483.3	14	370.6	22.5	585.8	85	2040.1
LD 1/2020	10	158.9	13	272.2	6.5	152.8	14.5	371.6	17.5	448.3	20.5	540.2	82	1944.0
LD 2/2020	9	140.7	14	293.4	7	165.9	14	361.8	12.5	337.8	25.5	659.0	82	1958.6
LD 3/2020	9	142.8	13.5	280.5	6	142.2	13	327.9	13.5	357.2	23.5	608.7	78.5	1859.3
LD 4/2020	9	148.3	12	273.6	7.5	152.9	15	377.6	14.5	395.0	24.5	623.3	82.5	1970.7
LD 5/2020	9.5	156.1	11.5	228.8	9	215.8	9	228.7	16	417.3	17.5	450.4	72.5	1697.1
LD 6/2020	9	148.3	10	198.9	10	240.7	10.5	268.4	13.5	350.1	16.5	431.4	69.5	1637.8
LD 7/2020	9.5	156.9	10.5	221.8	7	168.2	19	478.6	17.5	473.4	18	463.2	81.5	1962.1
Average daily air temperature (°C)		*16,1*		*21,1*		*23,4*		*25,4*		*26,5*		*25,9*		23,8

Table 3. Analysis of morphological and productivity characters in cowpea genotypes

Cowpea genotype	Plant height (cm)		Leaf Area Index (ISF)		Number of pods/plant		Number of beans in pods		Pod length (cm)	
	Value	Difference from the control	Value	Difference from the control	Value	Difference from the control	Value	Difference from the control	Value	Difference from the control
Doljana (Control)	68.2	Mt.	6.04	Mt	10.55	Mt	8.95	Mt.	11.39	Mt.
LD 1/2020	51.4	-16.0	5.89	-0.26	12.80	2.25	7.79	-1.17	11.24	-0.15
LD 2/2020	45.7	-22.0^{0}	5.75	-0.40	10.80	0.25	9.08	0.13	14.53	3.14*
LD 3/2020	40.4	-27.8^{0}	4.85	-1.31^{0}	14.45	3.90**	8.33	-0.63	13.52	2.13
LD 4/2020	49.2	-19.0	5.38	-0.78	10.55	0.00	6.98	-1.98	10.48	-0.91
LD 5/2020	39.6	-28.6^{0}	4.54	-1.62^{0}	13.25	2.70*	8.03	-0.92	11.73	0.33
LD 6/2020	34.9	-33.3^{00}	5.11	-1.05	14.05	3.50*	9.00	0.05	12.70	1.31
LD 7/2020	48.9	-19.30	5.26	-0.89	10.80	0.25	8.50	-0.45	12.94	1.55
LSD 5%		*21.55*		*1.31*		*2.47*		*2.28*		*2.91*
LSD 1%		*31.82*		*1.93*		*3.64*		*3.37*		*4.30*
LSD 0,1%		*49.19*		*2.98*		*5.63*		*5.20*		*6.65*

Plant productivity, expressed as the number of pods per plant, ranged between 10.55 and 14.45 pods/plant. Compared with the control cultivar, which produced 10.55 pods/plant, the cowpea lines *LD 3/2020, LD 5/2020*, and *LD 6/2020* showed higher pod numbers, with statistically significant or highly significant positive differences. The number of seeds per pod ranged from 6.98 to 9.08 seeds/pod, with differences falling within the experimental error. Pod length reached a maximum of 14.53 cm in line *LD 2/2020.* The leaf area index was significantly positively correlated with plant height and negatively correlated with the number of pods per plant (Figure 1).

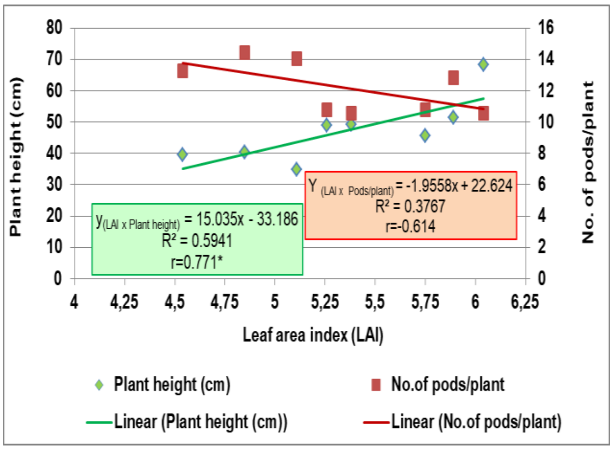

Figure 2. Correlations between the leaf area index recorded in the flowering phase of broad cowpeas with plant height and the number of pods per plant (n=8)

This confirms that an overly luxuriant leaf canopy can hinder sunlight penetration to the flower vexillum, a critical condition for pollen fertilization and, consequently, plant productivity. Studies conducted in China have shown that cowpea plant architecture and erect growth habit play a decisive role in cowpea yield (Gong et al., 2023).

Physiological Response of the Plant

The results on the physiological behavior of cowpea under stress conditions recorded during the flowering stage showed a diurnal pattern, with higher photosynthesis and transpiration values at 9:30 a.m., when the temperature inside the LC Pro SD measurement chamber ranged from 32.7 to 37.2°C (Figure 2). Increasing temperatures to 40–44.4°C caused stomatal closure and inhibited photosynthesis, resulting in very low CO_2 assimilation rates (0.93–10.35 µmol CO_2/m²/s), while transpiration decreased to 0.09–3.78 mmol H_2O/m²/s. Line *LD 3/2020* recorded the highest transpiration rate at 14:00, accompanied by a high photosynthetic rate, indicating that the transpiration was productive.

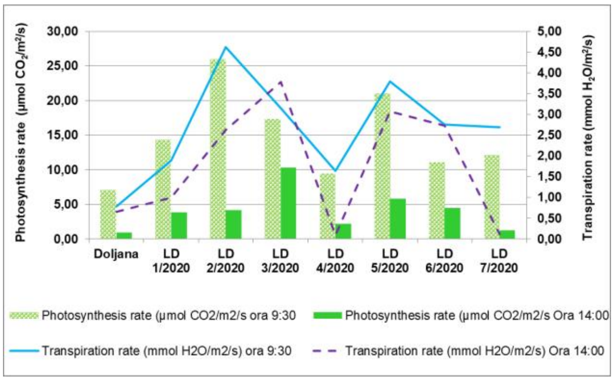

Figure 3. Diurnal variation of physiological processes in the studied cowpea genotypes

Degree of Stomatal Opening and Its Physiological Implications

The degree of stomatal opening is an essential indicator of plant response to thermo-hydric stress (Munjonji et al., 2018; Nunes et al., 2022). The diurnal results obtained for cowpea cultivated under sandy soil conditions in Romania showed that variations in stomatal conductance (0.02–0.16 mol H_2O/m²/s) directly influenced the rate of photosynthesis (4–15.83 µmol CO_2/m²/s) and leaf transpiration (0.72–3.47 mmol H_2O/m²/s). Statistical analysis of the results (Figure 4) indicated highly significant positive correlations between stomatal conductance and photosynthesis (r = 0.951**) and between stomatal conductance and leaf transpiration (r = 0.943**). Stomatal closure is a vital drought tolerance mechanism, and cowpea can be considered a conservative species—one that prioritizes water status preservation over photosynthetic rate (Oliveira et al., 2017).

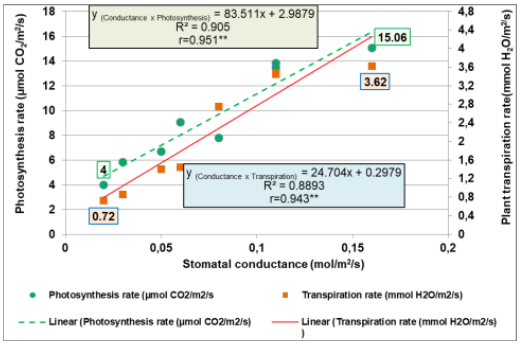

Figure 4. Correlations between stomatal conductance and photosynthesis and transpiration processes recorded in cowpea (n=8)

Statistical Analysis of Grain Yield

The grain yield results recorded at harvest varied between 1163.1 kg/ha in the cultivar Doljana and 2007.11 kg/ha in line *LD 6/2020* (Table 4). Compared with the control cultivar, yield differences of 555.41–844.01 kg/ha were observed, with differences statistically significant or highly significant in lines *LD 3/2020, LD 5/2020*, and *LD 6/2020*.

Table 4. Statistical analysis of the quantity and quality of bean production obtained in cowpea lines

Cowpea genotypes	Grain production (kg/ha)		Thousand-seed weight		hectoliter weight (kg/hl)		Crude proteine (%)	
	Value	Difference from the control	Value	Difference from the control	Value	Difference from the control	Value	Difference from the control
Doljana (Martor)	1163.10	Mt	104.5	Mt.	75.6	Mt	24.64	Mt
LD 1/2020	1182.55	19.45	164.0	59.5**	68.1	-7.6^{0}	26.19	1.59*
LD 2/2020	1460.35	297.25	141.0	36.5*	72.9	-2.7	24.50	-0.10
LD 3/2020	1937.98	774.88**	155.0	50.5**	72.0	-3.6	26.37	1.77*
LD 4/2020	1206.48	43.38	153.0	48.5**	68.3	-7.3^{0}	23.92	-0.69
LD 5/2020	1718.51	555.41*	144.0	39.5*	74.8	-0.8	26.72	2.12*
LD 6/2020	2007.11	844.01**	166.0	61.5**	68.5	-7.1^{0}	26.35	1.75*
LD 7/2020	1224.81	61.71	146.0	41.5*	71.9	-3.8	24.91	0.31
DL 5%		452.74		32.5		5.5		1.59
DL 1%		668.60		48.0		8.1		2.34
DL 0,1%		1033.47		74.1		12.5		3.62

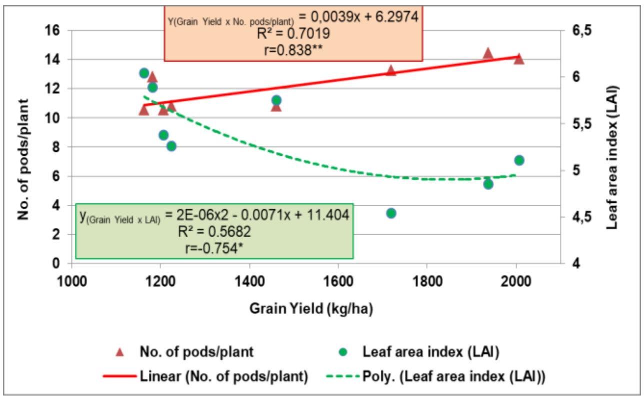

Figure 5. Correlations between cowpea grain production with the number of pods per plant and leaf area index n=8)

Regarding seed size, the new lines showed higher thousand-seed weight and lower hectoliter weight than the control, with statistically significant differences. From the perspective of chemical quality, the lines *LD 1/2020, LD 3/2020*, and *LD 6/2020* stood out by registering protein content of 26.19–26.72%, with differences of 1.59–2.12% compared with the control, which were statistically significant.

Functional correlations between grain yield, number of pods per plant, and leaf area index are presented in Figure 5. The calculated correlation coefficients indicate a highly significant linear increase in yield with increasing pod number per plant (r = 0.838**) and a significant decrease in yield with increasing leaf area index (r = 0.754*)

CONCLUSIONS.

The vegetative period of the new cowpea lines lasted 69.5–82.5 days, during which they accumulated total thermal resources of 1637.9–1970.7°C. *Lines LD 5/2020* and *LD 6/2020* stood out for their early maturity, maturing 12.5–15.5 days earlier than the cultivar *Doljana.*

Compared with the control cultivar, the new cowpea lines exhibited lower plant height and leaf area index, along with improved fruiting capacity.

The leaf area index recorded at flowering showed a positive correlation with plant height and a negative correlation with the number of pods per plant.

The intensity of photosynthesis and transpiration processes was positively correlated with stomatal conductance.

The highest yields (1718.51–2007.11 kg/ha) were recorded in lines *LD 3/2020, LD 5/2020*, and *LD 6/2020,* which differed significantly or highly significantly from the cultivar *Doljana.*

Grain yield was highly significantly and positively correlated with the number of pods per plant and significantly and negatively correlated with the leaf area index.

Lines *LD 1/2020, LD 3/2020, LD 5/2020*, and *LD 6/2020* showed the highest crude protein content (26.19–26.72%), with statistically ensured differences of 1.59–2.2% compared with *Doljana.*

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