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Morphometric and biochemical features of different *Bunias orientalis* L. genotypes in the M. M. Gryshko National Botanical Garden of the NAS of Ukraine

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Purpose. Determine a number of morphometric and biochemical parameters of various genotypes of *Bunias orientalis* L. in the M. M. Gryshko National Botanical Garden of the NAS of Ukraine (NBG). **Methods.** Plant samples of *B. orientalis* (6 genotypes created in the NBG) were examined during the flowering stage. Determination of dry matter, ash, calcium was carried out according to Hrytsaienko et al. (2003), phosphorus according to Pochinok (1976), sugars, ascorbic acid and lipids were determined according to Krishchenko (1983), β-carotene according to Pleshkov (1985). The energy value of plants was determined using an IKA C-200 calorimeter. The obtained results were analysed statistically. **Results.** The height of plants varied from 140.9 (Genotype 1) to 157.5 (Genotype 5) cm, stem diameter from 11.67 (Genotype 1) to 16.1 (Genotype 6) mm, the number of internodes from 18.7 (Genotype 1) to 25.7 (Genotype 6), the number of leaves on a stem from 14.11 (Genotype 1) to 21.8 (Genotype 5), leaf lamina length from 14.2 (Genotype 1) to 23.45 (Genotype 6) cm, leaf lamina width from 6.34 (Genotype 1) to 14.5 (Genotype 4) cm, inflorescence length from 27.4 (Genotype 1) to 45.4 (Genotype 3) cm, inflorescence width from 2.32 (Genotype 1) to 4.92 (Genotype 3) cm, and the number of stems from 2.55 (Genotype 2) to 5.33 (Genotype 1). The study of the content of structural and functional compounds and nutrients at the flowering stage showed that the dry matter content was in the range of 13.58–16.00%, sugars 5.07–8.86%, titratable acidity 3.28–4.25%, lipids 3.33–6.61%, ascorbic acid 382.83–693.82 mg%, β-carotene 0.94–3.48 mg%, ash 6.79–9.2%, calcium 1.00–2.44%, phosphorus 1.61–2.67% and energy value 3337.0–3498.0 cal/g. **Conclusions.** It was revealed that samples of various genotypes of *B. orientalis* are a valuable source of nutrients at the flowering stage. The biochemical composition of plants depended on the genotype and stage of growth. Results of the morphometric study showed variability of investigated parameters. The obtained data can be used to predict and evaluate the results of introduction and breeding studies with *B. orientalis* genotypes as promising crops in Ukraine.

Keywords: *Bunias orientalis; genotypes; morphometric parameters; nutrients.*

Introduction

The search and attraction of new, unconventional or forgotten plant species with useful properties continues to be a priority in modern biological and agricultural science. In this case, the introduction of plants is an important source of culture phytocenoses enrichment [1]. It should be noted that wild and non-traditional plants can be characterized by such useful properties as medicinal, food, fodder, energy, etc. [2, 3]. Among the wide variety of phytoresources, plants of the Brassicaceae family, containing antioxidants and anticancer components, deserve special attention for economic use [4]. Representatives of the Brassicaceae family are well known and widespread as food plants [5] and promising energy crops [6]. *Bunias orientalis* L. can be distinguished among this large group of plants with various uses [7]. This species originates from Eastern Europe and Central Asia and slowly spreads to other parts of Europe after its introduction into culture in the 18th century [8]. Species of the genus *Bunias* L. exhibited antioxidant, anticholinesterase, cytotoxic activities [9, 10]. Ethanol extracts from the aboveground phytomass of *B. orientalis* have high antioxidant, and from the root system – antimicrobial activity [11]. Studies of flavonols from the aerial part of *B. orientalis* showed increase of their concentration in flowers during the flowering stage in comparison with budding one [12]. Flavonoids are present in all tissues of *B. orientalis*; kaempferol, quercetin, and isorhamnetin are prevailing compounds [7].

At the M. M. Gryshko National Botanical Garden *B. orientalis* has been studied over the past decades as a fodder and energy plant [13, 14].

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This culture is characterized by a valuable biochemical composition, but the study of the characteristics of various genotypes is still a relevant direction for further breeding work [15]. This *study aims* to determine the biochemical composition of the aboveground organs of different *B. orientalis* genotypes in the conditions of the M. M. Gryshko National Botanical Garden of the NAS of Ukraine.

Material and methods

Plant material

The studies were carried out in the conditions of the M. M. Gryshko National Botanical Garden of the NAS of Ukraine (NBG) during 2017–2020. We used samples of plant organs of different *Bunias orientalis* L. genotypes (Genotype 1-Genotype 6), created at the NBG. The genotypes created by the method of multiple individual selection from different populations of plants introduced from the natural flora of Ukraine (except for one sample – Genotype 6, which was derived from a population imported from the Czech Republic) were investigated. The indicated genotypes are characterized by excellent biological, morphological, biochemical and productive characteristics. As perennial plants, the created genotypes of *B. orientalis* L. vegetate in one place from 4–5 to 10–12 years, depending on their characteristics. The generative period of development in all genotypes begins in the second year of vegetation.

Plant samples were selected and analyzed at the flowering stage, as the active phase of plant development, when they acquire the highest productivity. For analysis, 25 plants were selected from different parts of the plot. Biometric measurements were performed on 10 plants in four replicates.

Study of plant morphometric parameters

The following plant morphometric parameters were measured: plant height (cm), stem diameter (mm), number of internodes, number of leaves on the shoot, leaf lamina length (cm), leaf lamina width (cm), inflorescence length (cm), inflorescence width (cm), the number of stems (pcs.).

Biochemical analyses

Biochemical analyses of plants were carried out in the biochemical laboratory of the Department of Cultural Flora of the NBG. Dry matter was determined after drying plant samples at a temperature of 105 °C to constant weight. The ash content was investigated by burning samples in a muffle furnace (SNOL 7.2-1100, Termolab) at 200–500 °C [16]. After the combustion of the test sample, the ash was used to determine the content of calcium and phosphorus by titration methods. The ash was dissolved in hydrochloric acid solution to determine the total calcium content. After the usual procedure described in the method, the solution was titrated with Trilon-B with hydroxylamine and murexide [16].

The ash was dissolved in a nitric acid solution to determine the total phosphorus content. After adding molybdic acid ammonium, potassium oxalate solution, the whole mixture was titrated with sodium hydroxide with phenolphthalein [17].

The total sugar content was determined by Bertrand's Method using Fehling's solutions. The total content of ascorbic acid was determined by Tillmans' method [18]. The determination of β-carotene was carried out in extracts of gasoline Kalosh on a Unico UV 2800 spectrophotometer [19]. Lipid content was identified using the Soxhlet extractor in petroleum ether according to Krishchenko [18] with minor changes. Caloric content of raw materials was determined on an IKA C-200 calorimeter (benzoic acid as a standard).

Statistical analysis

The obtained data are analysed using Microsoft Excel software and presented as average values and standard deviation of the mean. Correlation analysis was carried out using Pearson's coefficient. The results are summarized in Tables 1, 2 and Figures 1–6.

Results and discussion

The morphometric parameters of the investigated *B. orientalis* genotypes were studied during the flowering stage (Table 1). These measurements were carried out for the first time.

It was revealed that the plant height varied from 140.9 to 157.5 cm, the stem diameter from 11.67 to 16.1 mm, the number of internodes from 18.7 to 25.7, the number of leaves on the stem from 14.11 to 21 8, leaf lamina length from 14.2 to 23.45 cm, leaf lamina width from 6.34 to 14.5 cm, inflorescence length from 27.4 to 45.4 cm, inflorescence width from 2.32 to 4.92 cm, the number of stems from 2.55 to 5.33, depending on the studied genotypes.

Analysis of morphometric parameters revealed a very strong positive correlation between the length and width of the inflorescence (r = 0.934), stem diameter and the number of leaves (r = 0.866), stem diameter and leaf lamina width (r = 0.852), the height of plants and the inflorescences width (r = 0.820) (Table 2).

Table 1

Morphometric parameters of different *Bunias orientalis* L. genotypes at the flowering stage

Plant parameters	Genotype 1*	Genotype 2*	Genotype 3*	Genotype 4*	Genotype 5*	Genotype 6*
Plant height, cm	144.67±11.32	152.44±13.70	157.52±8.49	140.90±13.30	154.31±13.11	141.20±13.31
Stem diameter, mm	11.67±0.96	12.11±0.96	13.53±0.64	15.50±0.57	15.81±0.73	16.10±1.18
Number of internodes, pcs.	17.56±1.03	23.22±0.95	18.70±0.95	18.81±0.53	23.71±0.20	25.70±0.77
Number of leaves on the shoot, pcs.	14.11±1.27	16.44±0.17	15.71±0.64	18.30±0.64	21.82±0.26	19.20±0.44
Leaf lamina length, cm	14.20±1.43	18.05±0.93	22.42±0.35	19.51±0.16	21.86±0.33	23.45±1.67
Leaf lamina width, cm	6.34±0.24	10.18±0.90	11.78±0.54	14.52±0.72	12.90±0.11	12.53±0.77
Inflorescence length, cm	27.42±1.91	38.98±2.94	45.42±2.46	33.41±0.24	35.60±0.35	36.85±0.97
Inflorescence width, cm	2.32±0.17	3.80±0.27	4.92±0.36	3.21±0.23	3.96±0.26	3.17±0.27
Number of stems	5.33±0.22	2.55±0.18	4.11±0.32	3.4±0.23	3.81±0.21	2.61±0.13

**Bunias orientalis* L. genotypes.

Table 2

Pearson's correlation coefficient between morphometric parameters of different *Bunias orientalis* L. genotypes at the flowering stage

Parameter	PH	SD	NI	NL	LL	LW	IL	IW	NS
SD	-0.275	1							
NI	0.212	0.478	1						
NL	-0.009	0.866	0.791	1					
LL	0.209	0.774	0.514	0.655	1				
LW	-0.050	0.852	0.361	0.732	0.775	1			
IL	0.657	0.115	0.203	0.079	0.686	0.422	1		
IW	0.820	0.130	0.223	0.187	0.633	0.442	0.934	1	
NS	0.101	-0.429	-0.621	-0.465	-0.546	0.590	-0.443	-0.256	1

Note. PH – plant height, SD – stem diameter, NI – number of internodes, NL – number of leaves, LL – leaf length, LW – leaf width, IL – inflorescence length, IW – inflorescence width, NS – number of stems.

The study of biochemical indicators of agricultural crops is a very important stage for a comprehensive assessment of plants, further research and selection of promising species, forms and varieties [15]. The study of *B. orientalis* samples showed that dry matter content in the aboveground phytomass ranged from 13.58 (Genotype 1) to 16.0 (Genotype 2)%, total sugar content from 5.07 (Genotype 2) to 8.86 (Genotype 1)%, lipids from 3.33 (Genotype 1) to 6.61 (Genotype 2)% depending on genotypic characteristics (Fig. 1). The acidity level ranged from 3.28 (Genotype 6) to 4.25 (Genotype 5)%. The lack of literature data on species of the genus *Bunias* complicates comparison. In this regard, we have compared the obtained results with the elaborated data of other representatives of Brassicaceae. The dry matter content in the samples of different *Camelina sativa* genotypes was 18.13–23.38%, ascorbic acid 207.23–410.23 mg/100 g, β-carotene 0.43–2.23 mg/100 g, ash 5.08–8.75%, calcium 1.008–2.633%, phosphorus 0.086–0.157%, sugars 4.76–8.12%. The energy value was 3925.71–4097.00 cal/g [20].

The study revealed that the content of ascorbic acid ranged from 382.83 (Genotype 1) to 693.82 (Genotype 3) mg/100 g and β-carotene from 0.94 (Genotype 2) to 3,48 (Genotype 6) mg/100 g (Fig. 2). In various food plants of the Brassicaceae family, the content of ascorbic acid was for *Brassica oleracea* var. *italica* – 93.2 mg/100 g in *B. rapa* var. *ruvo* 20.1; *B. oleracea* var. *gemmifera* – 90.3; *B. juncea* var. *juncea* 70.0; *B. rapa* var. *perviridis* 130.0 and *B. rapa* var. *rapa* – 60.0 mg/100 g [5].

The study of ash level and its components, as well as the determination of the caloric content of phyto-raw-materials, makes it possible to select promising energy genotypes. Thus, plants with a low ash level are the most valuable [21]. The energy value of the phytomass ranged from 3337 (Genotype 5) to 3498 (Genotype 2) cal/g (Fig. 3). At the same time, preliminary results of studies of other energy crops showed that the caloric content of *Miscanthus* spp. is 3811.87–4193.17 cal/g [22], *Panicum virgatum* – 3588.18–3719.22 [23], *sugar sorghum* – 2228.77–4075.62 cal/g [24]. The ash content in *B. orientalis* plants ranged from 6.79 (Genotype 5) to 9.2 (Genotype 4)%, calcium from 1.00 (Genotype 2) to 2.44 (Genotype 5)%, phosphorus from 1,61 (Genotype 4) to 2.67 (Genotype 3)%. According to Barbash et al. [25], the ash content in plants was 5.1%, cellulose 34.3%, lignin 22%.

As a result of studies on the accumulation of biochemical compounds in *B. orientalis* sam-

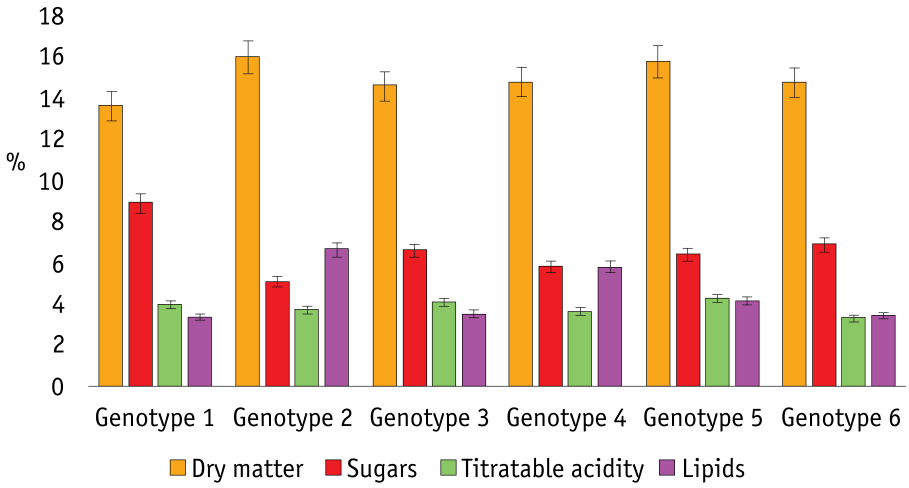

Fig. 1. The content of dry matter, lipids, sugars and the level of titratable acidity in the samples of different *Bunias orientalis* L. genotypes at the flowering stage

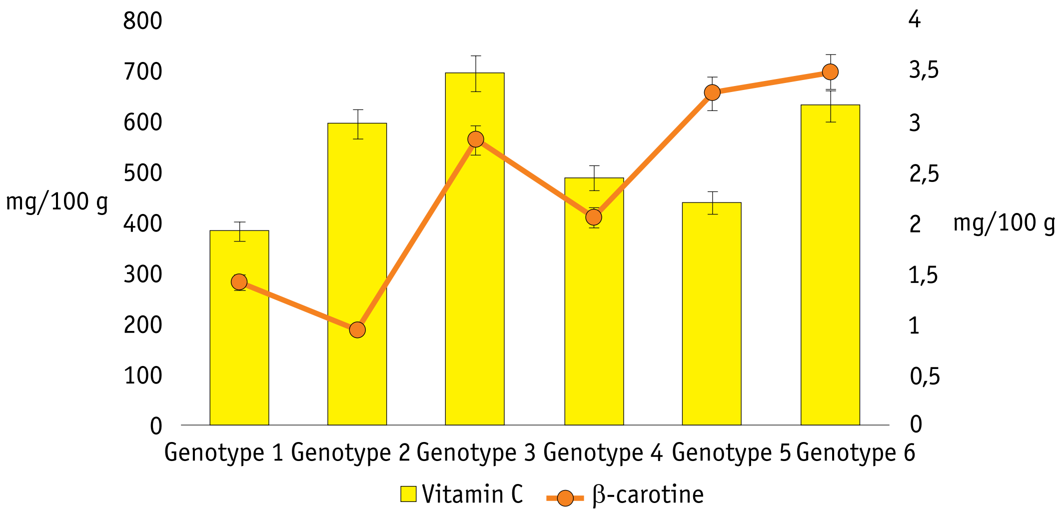

Fig. 2. Vitamin content in samples of different *Bunias orientalis* L. genotypes at the flowering stage

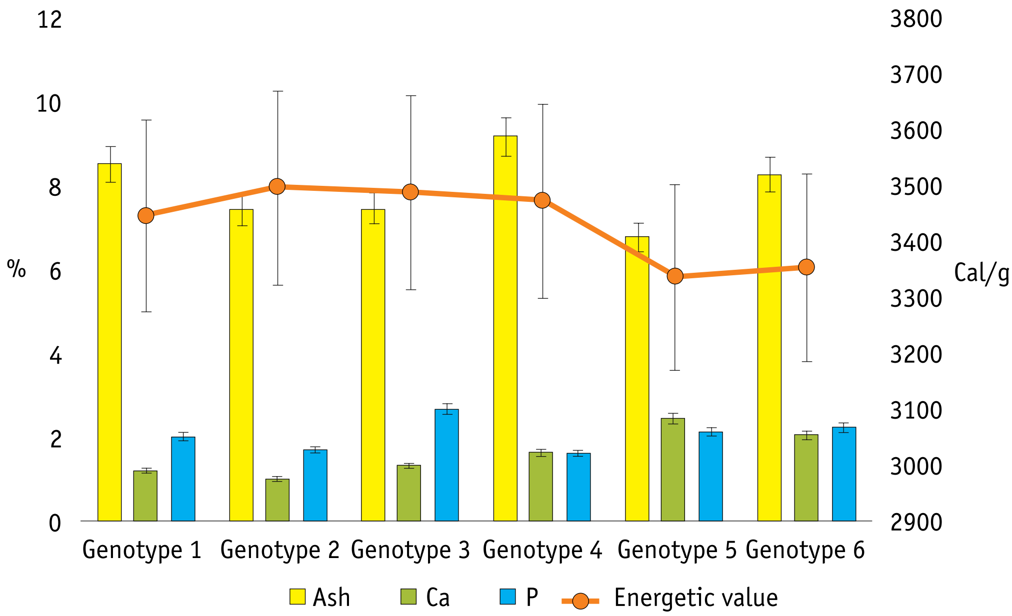

Fig. 3. Energy value and ash content in samples of different *Bunias orientalis* L. genotypes at the flowering stage

ples a very strong positive correlation was found between carotene and calcium levels (*r* = 0.834) (Table 3). A strong correlation was also found between the accumulation of ascorbic acid and tannins (*r* = 0.675), dry matter and lipids (*r* = 0.626), carotenes and phosphorus (*r* = 0.619). A moderate correlation is observed between the level of dry matter and tannins (*r* = 0.596), ascorbic acid and phosphorus (*r* = 0.492), lipids and calories (*r* = 0.489), tannins and carotene (*r* = 0.479), tannins and phosphorus (*r* = 0.442).

Table 3

Pearson's correlation coefficient between morphometric biochemical parameters of different *Bunias orientalis* L. genotypes at the flowering stage

Parameter	DM	TSC	AA	TC	TA	C	A	Ca	P	LC
TSC	-0.851	1								
AA	0.236	-0.459	1							
TC	0.596	-0.407	0.675	1						
TA	0.062	0.179	-0.372	-0.185	1					
C	0.047	0.052	0.268	0.479	0.377	1				
A	-0.627	0.263	-0.215	-0.676	-0.573	-0.247	1			
Ca	0.253	-0.019	-0.182	0.300	0.079	0.834	-0.234	1		
P	-0.250	0.328	0.492	0.442	0.293	0.619	-0.433	0.171	1	
LC	0.626	-0.787	0.018	-0.077	-0.188	-0.601	0.062	-0.335	-0.780	1
EV	-0.136	-0.221	0.239	-0.384	-0.003	-0.749	0.272	-0.911	-0.216	0.489

Note. DM – dry matter, TSC – total sugar content, AA – ascorbic acid, TC – tannin content, TA – titratable acidity, C – carotene, A – ash, Ca – calcium, P – phosphorus, LC – lipid content, EV – energy value.

Taking into account the preliminary results of the correlation analysis of various genotypes, the correlation coefficient depends on the species, form, varietal characteristics and phase of plant development [26, 27]. In addition, the correlation does not show a clear relationship between two parameters, but allows for a level of variability from one to the other.

Conclusions

Analysis of morphometric parameters revealed a strong positive correlation between the length and inflorescence width, stem diameter and the number of leaves, stem diameter and leaf lamina width, the height of plants and inflorescences width. It was determined that various *B. orientalis* genotypes are characterized by high nutrient content, in particular, ascorbic acid and β-carotene. The highest dry matter and lipid content was found in Genotype 2, sugar in Genotype 1, ascorbic acid and phosphorus in Genotype 3, β-carotene in Genotype 6, and ash in Genotype 4 and titratable acidity and calcium in Genotype 5.

Strong positive correlation between β-carotene and calcium, vitamin C and tannins, dry matter and lipids, β-carotene and phosphorus was defined. The obtained data can be used to predict and evaluate the results of introduction and breeding studies with *Bunias orientalis* genotypes as promising crops in Ukraine.

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Вергун О. М., Рахметов Д. Б.*, Шиманська О. В., Рахметова С. О., Бондарчук О. П., Фіщенко В. В. Морфометричні та біохімічні особливості різних генотипів рослин *Bunais orientalis* L. у Національному ботанічному саду імені М. М. Гришка НАН України. *Plant Varieties Studying and Protection*. 2021. Т. 17, № 1. С. 66–72. https://doi.org/10.21498/2518-1017.17.1.2021.228213

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Мета. Визначити деякі морфометричні та біохімічні параметри генотипів *Bunias orientalis* L. у Національному ботанічному саду імені М. М. Гришка НАН України (НБС). **Методи.** Рослинну сировину *B. orientalis* досліджували в період квітування (6 генотипів власної селекції НБС). Визначення сухої речовини, золи, кальцію проводили згідно з Грицаєнко та ін. (2003), фосфор – згідно з Починком (1976), цукри, аскорбінову кислоту та ліпіди – згідно з Крищенком (1983), β-каротин – згідно з Плєшковим (1985). Енергетична цінність визначалась на калориметрі IKA C-200. Дані проаналізовано статистично. **Результати.** Висота рослин становила від 140,9 (генотип 1) до 157,5 (генотип 5) см, діаметр стебла – від 11,67 (генотип 1) до 16,1 (генотип 6) мм, кількість міжвузлів – від 18,7 (генотип 1) до 25,7 (генотип 6) шт., кількість листків на стеблі – від 14,11 (генотип 1) до 21,8 (генотип 5) шт., довжина листкової пластинки – від 14,2 (генотип 1) до 23,45 (генотип 6) см, ширина листкової пластинки – від 6,34 (генотип 1) до 14,5 (генотип 4) см, довжина суцвіття – від 27,4 (генотип 1) до 45,4 (генотип 3) см, ширина суцвіття – від 2,32 (генотип 1) до 4,92 (генотип 3) см та кількість стебел – від 2,55 (генотип 2) до 5,33 (генотип 1) шт. Дослідження поживних речовин у період квітування показало, що вміст сухої речовини становив 13,58–16,00%, цукрів – 5,07–8,86%, титрована кислотність – 3,28–4,25%, ліпідів – 3,33–6,61%, аскорбінової кислоти – 382,83–693,82 мг%, β-каротину – 0,94–3,48 мг%, золи – 6,79–9,2%, кальцію – 1,00–2,44%, фосфору – 1,61–2,67%, енергетична цінність – 3337,0–3498,0 кал/г. **Висновки.** Рослинна сировина генотипів *B. orientalis* – цінне джерело поживних речовин у період квітування. Біохімічний склад рослин залежить від генотипу та фази розвитку. У результаті морфометричних вимірювань показано варіабельність досліджуваних параметрів. Отримані дані можуть бути використані для прогнозування та оцінювання результатів інтродукційної і селекційної роботи з генотипами *B. orientalis* як перспективних культур в Україні.

Ключові слова: *Bunias orientalis; генотипи; морфометричні параметри; поживні речовини.*

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