



Research Article



Morphometric parameters of plants of *Crambe* spp. during vegetation

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Plants of *Crambe* spp. belong to Brassicaceae Burnett family and some of them are known as economically important species. Extracts of *Crambe* spp. exhibited numerous biological activities such as antioxidant, antimicrobial, antiproliferative, cytotoxic, etc. This study was aimed to research morphometric parameters of plants of five species of *Crambe* L. during vegetation season (from the start of vegetation, budding stage, flowering stage, and to fruitage): *C. cordifolia* Steven, *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) Prina, *C. koktebelica* (Junge) N. Busch, *C. maritima* L., *C. steveniana* Rupr. The plant height, leaf length, leaf width, petiole length, length of panicle measured in cm, flower length, flower width, corolla length, petal length, petal width, fruit length, and fruit diameter measured in mm. The increment of investigated plants at the period of vegetation start-budding was 47.7–128.9 cm and plant height increased 2.67 (*C. maritima*) – 5.57 (*C. koktebelica*) times, at the budding-flowering period 9.7–94.4 cm and plant height increased 1.08 (*C. cordifolia*) – 1.85 (*C. steveniana*) times, at the period flowering-fruiting 8.20–26.0 cm and plant height increased 1.06 (*C. cordifolia*) – 1.10 (*C. maritima*) times. The variability of morphometric features during vegetation was following: height of plant from 0.57 to 13.98 %, length of leaf from 1.25 to 13.65 %, width of leaf from 2.17 to 48.10 %, length of petiole from 3.34 to 18.01 %, length of panicle from 1.41 to 13.09 %, width of panicle from 1.62 to 17.37 %, and stem diameter from 2.89 to 23.47 %. The study of morphometric parameters of flowers showed that the length of flower was 5.03–16.46 mm, width of flower 2.01–5.54 mm, corolla length 2.94–10.58 mm, petal length 3.63–7.11 mm, and petal width 3.64–5.51 mm depending on species. The morphometric parameters of fruits were the following: fruit length 3.02–10.10 mm and fruit diameter 4.08–8.78 mm depending on species. The thousand-fruit weight was 7.30–12.50 g. Selected morphometric parameters showed Pearson's coefficients with high values ($r = 0.843\text{--}0.994$) during vegetation. A comparative study of the morphometric parameters of investigated species of *Crambe* in M.M. Gryshko National Botanical Garden had a variability of morphometric parameters depending on species, period of growth, and organ of a plant. These results can be useful for selective work and detecting the diagnostic signs.

Keywords: *Crambe*, morphometric parameters, correlation

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Introduction

Plants of the *Crambe* L. genus belong to Brassicaceae Burnett family and contain around 40 species (Francisco-Ortega et al., 2002; Prina, 2021). Some species from this genus are promising fodder, food, decorative and medicinal plants (Kalista, 2017). Plant raw is a rich source of nutrients (Vergun et al., 2018), especially ascorbic acid (Vergun et al., 2019). HPLC analysis of amino acid composition detected that *Crambe cordifolia* Steven and *C. koktebelica* (Junge) N.Busch contain the L-glutamic acid, glycine, L-arginine, L-leucine, which were predominant for both species (Slobodianiuk et al., 2021). Plant extracts of *Crambe* spp. exhibited cytotoxic, antiproliferative, allelopathic (Razavi and Nejad-Ebrahimi, 2009), antioxidant, and antimicrobial activities (Vergun et al., 2021). The essential oil of the leaves and flowering tops of *C. orientalis* includes nitriles, isothiocyanates, esters, fatty acids, alkanes, ketones, aldehydes, terpenes. The major components in the flowering top oil were 2-methyl-5-hexenenitrile and 3-butenyl isothiocyanate, in leaves octyl-acetate (Razavi and Nejad-Ebrahimi, 2009). The most well-known and economically important species among others is *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) that produces valuable vegetable oil with an erucic acid content of up to 50 % (Queiroz et al., 2019; Samarappuli et al., 2020). Through genetic engineering and cross, breeding was obtained transgenic crambe lines producing wax esters that are important industrial feedstock (Li et al., 2019). This species is used as an alternative renewable energy source for biodiesel production (Kurt et al., 2018).

The study of shoot's system of different species showed that these plants are chamaephytes (Sanyal and Decocq, 2015) or hemicryptophytes (Scherbakova and Kalistaya, 2013; Sanyal and Decocq, 2015). *C. abyssinica* and *C. maritima* can grow on saline soils and be tolerant to salty water irrigation (Vos et al., 2010; Qi et al., 2017).

Considering the important value of these plants and the lack of information this work was aimed to study some morphometric peculiarities of five *Crambe* species growing in the Forest-Steppe of Ukraine. The study of morphometric parameters of plants is a very important aspect due to origin, condition of growth, especially concerning introduction in a new area, peculiarities of vegetative reproduction (Buckley et al., 1997; Brindza et al., 2019). The research of morphometric parameters is also valuable for the ecological estimation of plants (Meng et al., 2009).

Material and methodology

Biological material

In this study investigated species from *Crambe* L.: *C. cordifolia* Steven, *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) Prina, *C. koktebelica* (Junge) N. Busch, *C. maritima* L., *C. steveniana* Rupr. The plants were studied in 2018–2019 at the experimental fields of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine in the Kyiv city (50° 24' 55" N, 30° 33' 45" E) during vegetation season. Photos of flowers taken with digital USB microscope Sigeta Expert.

Morphometric characteristics

Morphometric parameters fixed at the start of vegetation, budding, flowering, and fruitage. The measuring of plant height, length, and width of leaves, length of petioles, length of panicles were used. The length and width of flower, corolla length, length, and width of petal were used as morphometric parameters of flowers. The fruit length and diameter of fruits were used to measure the fruits. Thousand-fruit mass weighed on analytical scales Kern ACJ.

Statistical analysis

Data were analysed with the ANOVA test and differences between means compared through the Tukey-Kramer test ($p < 0.05$). The variability of all these parameters was evaluated using descriptive statistics.

Results and discussion

The study of morphological, morphometric, physiological, etc., characteristics of plants due to climate change is becoming a global last time. The temperature fluctuations influence duration of the vegetation period and biomorphological peculiarities of plants (Aslam et al., 2021). The leaf is one of the most significant features for the identification of concrete species in plant morphology among other plant organs. Wherein have used different classifications of leaf features (Kumar et al., 2019). The morphometric parameters of leaves can be useful in ecophysiological study to estimate the tolerance of a plant to the environment, for example, in the case of *C. maritima* as a salt-tolerant crop (Vos et al., 2010).

Investigated plants of *Crambe* belong to the perennial (*C. cordifolia*, *C. koktebelica*, *C. maritima*, *C. steveniana*) and annual (*C. hispanica* subsp. *abyssinica*) plants. They originate from the Mediterranean and East African regions, species distributed from Macronesian archipelagoes to the West of China and from the



Figure 1 Plants of *Grambe* L. genus at the start of vegetation
 1 – *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) Prina; 2 – *C. cordifolia* Steven; 3 – *C. koktebelica* (Junge) N. Busch;
 4 – *C. maritima* L.; 5 – *C. steveniana* Rupr.

Arctic Polar Circle to the Scandinavian Peninsula, etc. (Prina, 2009). In conditions of the Ukrainian Forest-Steppe, these plants pass a full cycle of growth and development. The duration of vegetation period for *C. cordifolia*, *C. koktebelica*, *C. maritima*, *C. steveniana* was 122, 121, 98, and 124 days, respectively. We observed that the average start of vegetation for all perennial plants was on 13th March–2nd April, budding started on 27th April–14th May, flowering started on 10th May–7th June, and fruiting on 3rd June–12th July. The start of growth at the beginning of vegetation depending on climate conditions of years that was also noticed in the study Fontana et al. (1998).

At the start of vegetation (spring growing), beginning from the second year, plants formed the rosette of leaves (Figure 1) after that formed following vegetative-generative plant shoots. This period continues to average 44–62 days.

We measured morphometric parameters during vegetation period, and plant height at the start of vegetation was from 15.00 to 28.40 cm (Table 1).

Leaf length and width in this period were 9.00–20.20 cm and 5.03–15.36 cm, respectively. The length of petioles was from 2.96 to 16.37 cm. The variability of morphometric parameters (V %) at the period of start vegetation was following: plant height 2.71–13.98 %, leaf length 3.71–13.65 %, leaf width 2.55–11.44 %, length of petiole 4.88–11.94 %. The level of variability of plant morphometric parameters is often studied in the context of weather conditions such as a sum of effective temperatures, precipitations (Mikolaychuk, 2007), and changing of growth conditions (Gorlacheva and Kustova, 2013). The study of selected morphobiometric parameters of plants is important to research differences between genotypes (Bella et al., 2020).

At the budding stage height of plants was from 63.80 to 157.10 cm, leaf length from 18.13 to 64.60 cm, leaf width from 7.13 to 39.00 cm, length of petiole from 8.31 to 30.10 cm, and length of panicles from 18.00 to 147.80 cm depending on species (Table 2). The increment of investigated plants was 47.7–128.9 cm and plant height increased 2.67 (*C. maritima*)–5.57

Table 1 Morphometric parameters of plants of *Crambe* spp. at the start of vegetation

| Species | Height of plant (cm) | Leaf length (cm) | Leaf width (cm) | Length of petiole (cm) |
|--|---------------------------|---------------------------|---------------------------|---------------------------|
| <i>C. cordifolia</i> | 27.80 ± 0.24 ^a | 17.62 ± 0.21 ^a | 15.36 ± 0.13 ^a | 16.37 ± 0.28 ^a |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 15.00 ± 0.67 ^c | 11.29 ± 0.49 ^c | 5.03 ± 0.18 ^c | 2.96 ± 0.08 ^d |
| <i>C. koktebelica</i> | 28.20 ± 0.65 ^a | 13.25 ± 0.20 ^b | 9.17 ± 0.08 ^b | 6.35 ± 0.10 ^b |
| <i>C. maritima</i> | 28.40 ± 1.11 ^a | 9.00 ± 0.30 ^d | 6.80 ± 0.20 ^c | 4.54 ± 0.17 ^c |
| <i>C. steveniana</i> | 25.00 ± 0.30 ^b | 20.20 ± 0.25 ^a | 12.35 ± 0.15 ^a | 8.88 ± 0.16 ^b |

Notes: different superscripts in each column indicate the significant differences in the mean at $p < 0.05$

Table 2 Morphometric parameters of plants of *Crambe* spp. at the budding stage

| Species | Height of plant (cm) | Leaf length (cm) | Leaf width (cm) | Length of petiole (cm) | Length of panicle (cm) |
|--|----------------------------|---------------------------|---------------------------|---------------------------|----------------------------|
| <i>C. cordifolia</i> | 116.00 ± 1.01 ^b | 37.80 ± 0.64 ^b | 39.00 ± 0.78 ^a | 29.90 ± 0.82 ^a | 75.60 ± 0.74 ^b |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 63.80 ± 1.72 ^c | 18.13 ± 0.29 ^c | 7.13 ± 0.13 ^c | 8.31 ± 0.20 ^c | 18.00 ± 0.75 |
| <i>C. koktebelica</i> | 157.10 ± 1.24 ^a | 64.60 ± 1.18 ^a | 26.60 ± 0.74 ^b | 13.80 ± 0.36 ^b | 147.80 ± 2.00 ^a |
| <i>C. maritima</i> | 76.10 ± 1.22 ^c | 29.50 ± 0.76 ^b | 25.60 ± 1.53 ^b | 16.60 ± 0.95 ^b | 66.10 ± 0.70 ^b |
| <i>C. steveniana</i> | 80.60 ± 2.56 ^c | 35.00 ± 0.80 ^b | 27.00 ± 0.78 ^b | 30.10 ± 1.43 ^a | 79.70 ± 0.58 ^b |

Notes: different superscripts in each column indicate the significant differences in the mean at $p < 0.05$

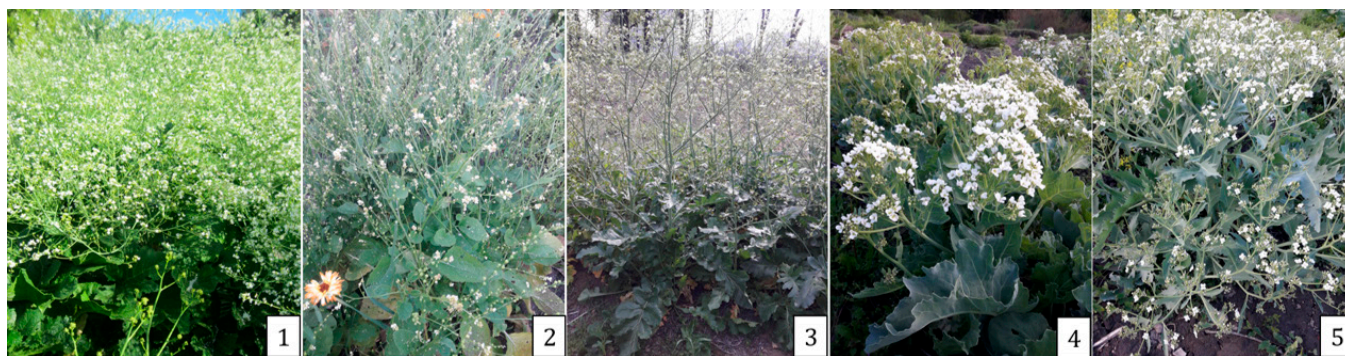


Figure 2 Plants of *Grambe* L. at the flowering stage
 1 – *C. cordifolia* Steven; 2 – *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) Prina; 3 – *C. koktebelica* (Junge) N. Busch;
 4 – *C. maritima* L.; 5 – *C. steveniana* Rupr.



Figure 3 Flowers of plants of *Grambe* L.
 1 – *C. cordifolia* Steven; 2 – *C. hispanica* subsp. *abyssinica* (Hochst. et R.E.Fr.) Prina; 3 – *C. koktebelica* (Junge) N. Busch;
 4 – *C. maritima* L.; 5 – *C. steveniana* Rupr.

(*C. koktebelica*) times. At the budding stage, the variability of morphometric parameters was 2.46–9.95 % for plant height, 5.04–8.03 % for leaf length, 5.53–18.71 % for leaf width, 7.70–18.01 % for length of petiole, 2.29–13.09 % for panicle length, 3.25–17.37 % for panicle width, and 6.02–23.47 % for stem diameter.

At the flowering stage (Figure 2) length of plants was from 73.50 to 251.50 cm, leaf length from 21.60 to 86.90cm, leaf width from 8.22 to 68.10 cm, length of petioles from 10.55 to 42.70 cm, and length of panicles from 25.60 to 160.90 cm depending on species (Table 3).

The height of plants of *C. hispanica* subsp. *abyssinica* was 51.9–90.7 cm, according to Kurt et al. (2018). The increment of studied plants at the budding-flowering

period was 9.7–94.4 cm and plant height increased 1.08 (*C. cordifolia*)–1.85 (*C. steveniana*) times. The variability of morphometric parameters at the period of flowering was following: plant height 1.90–3.64 %, leaf length 2.81–10.28 %, leaf width 2.28–48.10 %, length of petiole 5.91–9.89 %, length of panicles 2.77–9.24 %, width of panicle 2.46–6.78 %, and 6.21–9.90 %.

Flowers of *Crambe* spp. are typical for Brassicaceae and consist of 4 petals, 6 stamens (Figure 3) and collected in the panicles.

Flower elements had the following values depending on species: flower length was 5.03–16.46 mm, flower width was 0.23–0.55 mm, corolla length was 2.94–7.14 mm, petal length 3.63–6.56 mm, petal width 3.64–5.51 mm (Table 4).

Table 3 Morphometric parameters of plants of *Crambe* spp. at the flowering

| Species | Height of plant (cm) | Leaf length (cm) | Leaf width (cm) | Length of petiole (cm) | Length of panicle (cm) |
|--|----------------------|------------------|-----------------|------------------------|------------------------|
| <i>C. cordifolia</i> | 126.30 ±0.77b | 43.80 ±0.84b | 42.30 ±0.60b | 38.30 ±0.72a | 84.80 ±0.75b |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 73.50 ±0.86c | 21.60 ±0.71c | 8.22 ±0.06c | 10.55 ±0.20c | 25.60 ±0.76c |
| <i>C. koktebelica</i> | 251.50 ±2.84a | 67.60 ±0.61a | 29.80 ±0.36b | 21.20 ±0.67b | 160.90 ±1.97a |
| <i>C. maritima</i> | 95.10 ±0.83c | 48.00 ±0.90b | 35.70 ±1.20b | 28.80 ±0.62b | 79.90 ±1.16b |
| <i>C. steveniana</i> | 149.60 ±1.78b | 86.90 ±0.99a | 68.10 ±1.20a | 42.70 ±0.84a | 92.20 ±0.85b |

Notes: different superscripts in each column indicate the significant differences in the mean at p <0.05

At the fruiting stage length of plants was from 78.50 to 277.90 cm, leaf length from 25.60 to 96.10 cm, leaf width from 10.50 to 77.80 cm, length of petioles from 12.50 to 53.20 cm, and length of panicles from 33.80 to 186.50 cm (Table 5). At the period flowering-fruiting increment of investigated plants was 8.20–26.0 cm. According to Rakhmetov and Rakhmetova (2015), the increment of different genotypes of *Brassica rapa* L. × *B. campestris* f. *biennis* DC. at the period of flowering-ripening was in the range 10.1–20.6 cm. The variability of investigated parameters was 0.57–4.04 % for plant height, 1.25–6.39 % for leaf length, 2.17–6.73 % for leaf width, 3.34–6.37 % for length of petiole, 1.41–6.80 % for length of flowering, 1.62–4.93 % for the width of panicle, 2.89–8.00 % for stem diameter.

According to faceted classification, developed by Iljinska (2013), fruits of the *Crambe* genus are related to choriarticulate-pseudoseptate dimericarps. *Crambe* fruits consist of two segments, where the only top seed-containing segment is fully developed (Kalista et al., 2014).

Fruit length in our study was 3.02–10.10 mm, diameter 3.41–8.78 mm (Table 6). One of the most important characteristics of fruits and seeds is the thousand-fruit weight. That is a significant parameter, among others, of seed and oil yield (Kwiatkowski et al., 2020). Thousand-fruit weight in our study was 7.30–12.50 g. Kwiatkowski et al. (2020) determined this parameter for *C. abyssinica* as 7 g on average that was 1.5 g less than in our study.

The study of correlations between morphometric parameters is widely used in botanical science for different plant parts such as fruits (Ivanišová et al., 2017; Grygorieva et al., 2018a; Mangino et al., 2021), leaves (Chitwood and Otoni, 2017; Grygorieva et al., 2018b), etc. Between studied morphometric parameters, we found a correlation with different levels. A very strong correlation was found between leaf width and petiole length ($r = 0.959$), leaf length and width ($r = 0.844$), a strong correlation was between leaf length and length of petiole ($r = 0.708$) at the start of vegetation period (Table 7).

Table 4 Morphometric parameters of *Crambe* spp. flowers

| Species | Flower length (mm) | Flower width (mm) | Corolla length (mm) | Petal length (mm) | Petal width (mm) |
|--|---------------------------|--------------------------|---------------------------|--------------------------|--------------------------|
| <i>C. cordifolia</i> | 14.91 ± 0.21 ^b | 4.52 ± 0.01 ^a | 6.35 ± 0.05 ^b | 5.61 ± 0.08 ^a | 4.54 ± 0.08 ^a |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 12.04 ± 0.18 ^b | 2.01 ± 0.06 ^b | 10.58 ± 0.07 ^a | 7.11 ± 0.26 ^a | 4.22 ± 0.14 ^a |
| <i>C. koktebelica</i> | 5.03 ± 0.09 ^c | 2.32 ± 0.01 ^b | 2.94 ± 0.07 ^c | 3.63 ± 0.04 ^b | 3.64 ± 0.07 ^b |
| <i>C. maritima</i> | 16.14 ± 0.72 ^a | 4.27 ± 0.04 ^a | 6.23 ± 0.21 ^b | 5.49 ± 0.24 ^a | 4.71 ± 0.10 ^a |
| <i>C. steveniana</i> | 16.46 ± 0.10 ^a | 5.54 ± 0.01 ^a | 7.14 ± 0.28 ^b | 6.56 ± 0.09 ^a | 5.51 ± 0.07 ^a |

Notes: different superscripts in each column indicate the significant differences in the mean at $p < 0.05$

Table 5 Morphometric parameters of plants of *Crambe* spp. at the fruiting

| Species | Height of plant (cm) | Leaf length (cm) | Leaf width (cm) | Length of petiole (cm) | Length of panicle (cm) |
|--|----------------------------|---------------------------|---------------------------|---------------------------|----------------------------|
| <i>C. cordifolia</i> | 134.70 ± 0.48 ^a | 53.70 ± 1.10 ^b | 47.20 ± 0.42 ^b | 44.70 ± 0.48 ^a | 94.70 ± 0.71 ^b |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 78.50 ± 1.01 ^b | 25.60 ± 0.50 ^c | 10.50 ± 0.23 ^c | 12.50 ± 0.23 ^c | 33.80 ± 0.73 ^c |
| <i>C. koktebelica</i> | 277.90 ± 0.51 ^a | 76.70 ± 0.71 ^a | 37.30 ± 0.48 ^b | 25.00 ± 0.40 ^b | 186.50 ± 0.84 ^a |
| <i>C. maritima</i> | 104.40 ± 0.80 ^b | 53.70 ± 0.58 ^b | 43.80 ± 0.47 ^b | 36.30 ± 0.74 ^b | 87.80 ± 0.56 ^b |
| <i>C. steveniana</i> | 162.70 ± 0.67 ^a | 96.10 ± 0.38 ^a | 77.80 ± 0.54 ^a | 53.20 ± 0.62 ^a | 103.10 ± 0.53 ^b |

Notes: different superscripts in each column indicate the significant differences in the mean at $p < 0.05$

Table 6 Morphometric parameters and mass of fruits of *Crambe* spp.

| Species | Fruit length (mm) | Fruit diameter (mm) | Thousand-fruit weight (g) |
|--|---------------------------|--------------------------|---------------------------|
| <i>C. cordifolia</i> | 3.20 ± 0.13 ^b | 4.08 ± 0.06 ^b | 7.30 ± 0.15 ^b |
| <i>C. hispanica</i> subsp. <i>abyssinica</i> | 3.02 ± 0.12 ^b | 3.41 ± 0.09 ^c | 8.50 ± 0.17 ^b |
| <i>C. koktebelica</i> | 4.10 ± 0.10 ^b | 4.30 ± 0.10 ^b | 8.70 ± 0.15 ^b |
| <i>C. maritima</i> | 10.10 ± 0.35 ^a | 8.78 ± 0.15 ^a | 12.50 ± 0.23 ^a |
| <i>C. steveniana</i> | 5.30 ± 0.22 ^b | 5.58 ± 0.16 ^b | 11.10 ± 0.18 ^a |

Notes: different superscripts in each column indicate the significant differences in the mean at $p < 0.05$

Table 7 Pearson's coefficients between morphometric parameters of *Crambe* spp. at the start of vegetation

| Parameter | Height of plant | Length of leaf | Width of leaf | Length of petiole |
|-------------------|-----------------|----------------|---------------|-------------------|
| Length of leaf | 0.173 | 1 | | |
| Width of leaf | 0.537* | 0.843** | 1 | |
| Length of petiole | 0.473 | 0.708* | 0.959** | 1 |

Notes: ** – correlation is significant at the level of 0.01; * – correlation is significant at the level of 0.05

Table 8 Pearson's coefficients between morphometric parameters of *Crambe* spp. at the budding stage

| Parameter | Height of plant | Length of leaf | Width of leaf | Length of petiole | Length of panicle |
|-------------------|-----------------|----------------|---------------|-------------------|-------------------|
| Length of leaf | 0.955** | 1 | | | |
| Width of leaf | 0.524* | 0.489 | 1 | | |
| Length of petiole | 0.074 | 0.093 | 0.792* | 1 | |
| Length of panicle | 0.904** | 0.986** | 0.539* | 0.162 | 1 |

Notes: ** – correlation is significant at the level of 0.01; * – correlation is significant at the level of 0.05

Table 9 Pearson's coefficients between morphometric parameters of *Crambe* spp. at the flowering stage

| Parameter | HP | LL | WL | LP | LPN | LF | WF | LC | LPT | WP |
|-----------|----------|---------|---------|---------|----------|---------|---------|---------|--------|----|
| LL | 0.641* | 1 | | | | | | | | |
| WL | 0.232 | 0.843** | 1 | | | | | | | |
| LP | 0.103 | 0.659* | 0.945** | 1 | | | | | | |
| LPN | 0.953** | 0.676* | 0.334 | 0.246 | 1 | | | | | |
| LF | -0.731* | -0.004 | 0.483 | 0.585 | -0.588 | 1 | | | | |
| WF | -0.144 | 0.566* | 0.911** | 0.953** | 0.017 | 0.780* | 1 | | | |
| LC | -0.858** | -0.577 | -0.305 | -0.280 | -0.968** | 0.495 | -0.067 | 1 | | |
| LPT | -0.831** | -0.329 | 0.007 | 0.014 | -0.910** | 0.685* | 0.232 | 0.949** | 1 | |
| WP | -0.408 | 0.426 | 0.767* | 0.733* | -0.324 | 0.873** | 0.884** | 0.332 | 0.605* | 1 |

Notes: HP – height of plants; LL – length of leaf; WL – width of leaf; LP – length of petiole; LPN – length of panicles; LF – length of flower; WF – width of flower; LC – length of corolla; LPT – length of petal; WP – width of petal; ** – correlation is significant at the level of 0.01; * – correlation is significant at the level of 0.05

Table 10 Pearson's coefficients between morphometric parameters of *Crambe* spp. at the fruiting

| Parameter | HP | LL | WL | LP | LPN | FL | FD | TFW |
|-----------|---------|---------|---------|-------|--------|---------|---------|-----|
| LL | 0.659* | 1 | | | | | | |
| WL | 0.260 | 0.876** | 1 | | | | | |
| LP | 0.072 | 0.701* | 0.947** | 1 | | | | |
| LPN | 0.970** | 0.673* | 0.328 | 0.175 | 1 | | | |
| FL | -0.195 | 0.136 | 0.272 | 0.260 | 0.001 | 1 | | |
| FD | -0.195 | 0.196 | 0.363 | 0.365 | 0.008 | 0.994** | 1 | |
| TFW | -0.175 | 0.324 | 0.420 | 0.313 | -0.051 | 0.905** | 0.901** | 1 |

Notes: HP – height of plants; LL – length of leaf; WL – width of leaf; LP – length of petiole; LPN – length of panicles; FL – length of fruit; FD – fruit diameter; TFW – thousand-fruit weight; ** – correlation is significant at the level of 0.01; * – correlation is significant at the level of 0.05

A very strong correlation was determined between leaf length and petiole length ($r = 0.986$), plant height and leaf length ($r = 0.955$), the height of plant and panicle length ($r = 0.905$), and strong relation found between leaf width and petiole length ($r = 0.792$) at the budding period (Table 8).

At the flowering stage, a very strong correlation was detected between petiole length and plant height ($r = 0.954$), length of petiole and width of flower ($r = 0.953$), length of corolla and length of petal ($r = 0.949$), petiole length and leaf width ($r = 0.945$), width of flower and width of petal ($r = 0.884$), and between width and length of the leaf ($r = 0.843$) (Table 9).

At the fruiting period length of fruit strongly correlated with fruit diameter ($r = 0.994$), plant height and length of panicle ($r = 0.970$), plant height and petiole length ($r = 0.969$), leaf width and petiole length ($r = 0.947$), flower length and thousand-fruit weight ($r = 0.905$), length and width of leaf ($r = 0.877$), length of leaf and length of petiole ($r = 0.701$) (Table 10).

Conclusion

Thus, a study of the morphometric parameters of investigated species of *Crambe* genus in M.M. Gryshko National Botanical Garden can be useful for further biological investigations of these plants due to the previous partial lack of data. We found that the width of leaf for *C. steveniana* at the flowering was the most variable parameter and the plant height for *C. koktebelica* at the fruiting was the least variable one. Also, considering obtained data, the results can be used for selective work with plants of *Crambe* spp. In addition, assume that some results of our study may use for the determination of diagnostic signs.

Conflicts of interest

The authors declare no conflict of interest.

Ethical Statement

This article does not contain any studies that would require an ethical statement.

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