The Inter-varietal Specifics of Celery Seed Morphological Parameters

A F Bukharov¹, A F Razin¹, M I Ivanova¹* and O A Razin¹

¹ All-Russian Scientific Research Institute of Vegetable Growing – a branch of the Federal State Budgetary Scientific Institution “Federal Scientific Center of Vegetable Growing,” Moscow region, 14 Selektssionnaya str., VNISSOK Village 143080 Russia

E-mail: ivanova_170@mail.ru

Abstract. The authors studied 12 varieties of leaf, root, and petiole celery. The morphological parameters of seeds (such as their length, the lengths of the endosperm and the embryo) varied significantly. Samples of “K-635” and “Vanyusha” exceeded the average seed length at a p-value of 5%, and at 1% for the “Royal night” variety. The varieties “Royal night,” “Prague giant,” “Vanyusha,” and “K-635” had the above-average endosperm length. The varieties “Apple,” “K-635”, “Senezh”, and “Royal night” significantly exceeded the average embryo length. Different varieties displayed diverse coefficients of morphological parameter variation. They fluctuated between 12.0% and 17.8% for the embryo length, between 9.4% and 17.3% for the endosperm length, and between 9.4% and 17.9% for seed length. The authors established the $I_{emb/end}$ index, denoting the embryo to endosperm ratio. The sample maximums of this index (0.91) were observed in the “Malachite” and “Senezh” varieties. The authors analyzed statistical correlation for three parameter pairs and established the $R_{seed/end}$, $R_{seed/emb}$, and $R_{end/emb}$ indexes. The $R_{seed/end}$ index fluctuated from 0.774 in “Senezh” variety to 0.924 in “Malachite” variety. The other three indexes were relatively weak. $R_{end/emb}$ fluctuated between 0.192 and 0.318, and $R_{seed/emb}$ fluctuated between 0.157 and 0.254.

Keywords: Celery · Varieties · Seed production · Morphometric seed parameters

1. Introduction

Embryo underdevelopment is common in vegetable crops of Umbelliferae (Apiaceae) family [3, 8, 9, 10]. Their seed structure predetermines slow germination and frequent dormancy [1, 11].

The morphological parameters of seeds vary significantly under the influence of internal and external factors [14]. The morphological parameters of Umbelliferae seeds are affected by weather conditions, soils, the supply of mineral nutrition elements, and the quality and timing of agricultural operations [2, 7].

The plant architecture and the position of the reproductive organs affect the morphological parameters of Umbelliferae seeds [5, 12, 13]. The morphological parameters of the fruits of Umbelliferae vegetables depend on the ripeness at the time of harvest, physical and mechanical factors, after-ripening, drying, and seed sorting. These factors may cause late or uneven germination in Umbelliferae, especially if combined with bad weather conditions. Studies have shown that morphological parameters of dill fruits may vary significantly, depending on the variety [4]. Hereditary factors accounted for 48 – 91% of carrot seed variability, while environmental factors contributed less than 39% to the variability [6].
Therefore, this study aims to examine the morphological parameters of seeds of 12 leaf, root, and petiole celery varieties.

2. Materials and Methods

The authors studied the market samples of 12 leaf, root, and petiole celery varieties. The seed and the endosperm lengths were measured using vernier calipers (GOST 166–89). The authors measured the length of the embryo using a Levenhuk 670T microscope (Levenhuk, USA) and a DCM 300 MD digital microscope camera (Microscope Digital, China) at ×40 magnification, with the help of Scope Photo application (Image Software V. 3.1.386). The seeds were soaked in 14% aqueous solution of sodium hypochlorite for 1 hour. Then the seeds were washed under running water and placed on the filter paper soaked in distilled water. The authors then measured each seed’s length, separated the endosperm and the embryo by incisions, and measured their length. The experiment was replicated four times, with at least 20 seeds in each replication.

3. Results and Discussion

The authors studied 12 varieties of leaf, root, and petiole celery and found significant variations in the length of the seed, endosperm, and embryo (see table 1).

The morphological parameter variation coefficient (V) fluctuated significantly in different varieties. Maximum seed length variability was observed in the leaf varieties “Vanyusha” and “Senezh” (17.0–17.9%). The sample minimum was observed in the root variety “Yudinka” (9.4%). The sample maximum (17.3%) and the sample minimum (0.4%) of the endosperm variability were observed in the leaf varieties “Nemona” and “Zakhar,” respectively. The sample maximum and minimum of the embryo length variability were observed in petiole varieties.

Table 1. Inter-variety characteristics of the main linear parameters of seeds.

| Variety         | seed        |      | endosperm    |      | embryo     |      |
|-----------------|-------------|------|--------------|------|------------|------|
|                 | Length, mm  | V, % | Length, mm   | V, % | Length, mm | V, % |
| Leaf varieties  |             |      |              |      |            |      |
| Vanyusha        | 1.63±0.052* | 17.0 | 1.43±0.041*  | 15.7 | 0.41±0.011*| 14.6 |
| Senezh          | 1.50±0.049  | 17.9 | 1.27±0.034   | 14.6 | 0.53±0.015*| 15.2 |
| Zakhar          | 1.61±0.044* | 14.9 | 1.39±0.024   | 9.4  | 0.39±0.012**| 15.4 |
| Nemona          | 1.44±0.036  | 13.0 | 1.23±0.039*  | 17.3 | 0.40±0.011*| 15.1 |
| Petiole varieties |           |      |              |      |            |      |
| Atlant          | 1.47±0.035  | 13.1 | 1.25±0.027   | 11.8 | 0.43±0.012 | 13.6 |
| Malachite       | 1.41±0.029* | 11.0 | 1.28±0.041   | 15.0 | 0.41±0.010*| 12.0 |
| K-635 (Italy)   | 1.62±0.047* | 15.0 | 1.45±0.042*  | 15.8 | 0.54±0.017**| 17.2 |
| K-739 (Canada)  | 1.29±0.033**| 13.9 | 1.11±0.025** | 11.8 | 0.42±0.013 | 17.8 |
| Root varieties  |             |      |              |      |            |      |
| Apple           | 1.42±0.038  | 15.0 | 1.28±0.036   | 15.4 | 0.55±0.014**| 14.2 |
| Royal night     | 1.65±0.048**| 15.8 | 1.44±0.027*  | 10.2 | 0.53±0.014*| 14.4 |
| Prague giant    | 1.62±0.051  | 17.2 | 1.45±0.032*  | 11.0 | 0.47±0.012 | 12.1 |
| Yudinka         | 1.39±0.024* | 9.4  | 1.27±0.037   | 15.1 | 0.44±0.013 | 13.0 |
| Experiment average | 1.51±0.047 | 15.8 | 1.32±0.039   | 14.7 | 0.46±0.022 | 13.4 |

* differs from the average at a p-value of 5%  
** differs from the average at a p-value of 1%  
Source: Compiled by the authors.

The samples of “K-635” and “Vanyusha” exceeded the average seed length by 0.10–0.14 mm, at a p-value of 5%. The “Royal night” variety exceeded it at a p-value of 1%. Five varieties were average, and three varieties were well below average. The varieties “Royal night,” “Prague giant,” “Vanyusha,” and “K-635” exceeded the average endosperm length by 0.11–0.13 mm. The samples of “Nemona” and “K-739” were below average by 0.09 mm and 0.21 mm, respectively. Six varieties
were average. The varieties “Atlant,” “K-739”, “Yudinka,” and “Prague giant” were average by the embryo length (0.46 mm). The varieties “Apple,” “K-635”, “Senezh”, and “Royal night” exceeded the average considerably. The rest were well below average. The samples of “Royal night” and “K-635” outperformed in all three parameters.

The sample maximums of $I_{emb/end}$ index (the embryo to endosperm ratio) was observed in the “Apple” (0.43) and “Senezh” (0.42) varieties. The sample minimum, observed in the “Vanyusha” variety (0.28), was 1.5 times lower than the maximum (see table 2).

| Variety | Leaf varieties | Petiole varieties | Root varieties |
|---------|----------------|-------------------|---------------|
| Vanyusha | 0.28           |                   |               |
| Senezh  | 0.42           |                   |               |
| Zakhar  | 0.3            |                   |               |
| Nemona  | 0.33           |                   |               |
| Atlant  | 0.34           |                   |               |
| Malachite |               |                   |               |
| K-635 (Italy) | 0.37         |                   |               |
| K-739 (Canada) | 0.38       |                   |               |
| Apple   | 0.43           |                   |               |
| Royal night |               |                   |               |
| Prague giant |               |                   |               |
| Yudinka | 0.35           |                   |               |

Source: Compiled by the authors.

The authors studied the statistical correlation of three parameter pairs and established the $R_{seed/end}$, $R_{seed/emb}$, and $R_{end/emb}$ indexes (see table 3).

| Variety         | $R_{seed/end}$ | $R_{seed/emb}$ | $R_{end/emb}$ |
|-----------------|----------------|----------------|---------------|
| Leaf varieties  |                |                |               |
| Vanyusha        | 0.795          | 0.254          | 0.318         |
| Senezh          | 0.774          | 0.217          | 0.224         |
| Zakhar          | 0.904          | 0.196          | 0.238         |
| Nemona          | 0.881          | 0.165          | 0.264         |
| Petiole varieties|               |                |               |
| Atlant          | 0.896          | 0.224          | 0.286         |
| Malachite       | 0.924          | 0.192          | 0.291         |
| K-635 (Italy)   | 0.795          | 0.167          | 0.239         |
| K-739 (Canada)  | 0.869          | 0.185          | 0.220         |
| Root varieties  |                |                |               |
| Apple           | 0.791          | 0.157          | 0.342         |
| Royal night     | 0.834          | 0.224          | 0.217         |
| Prague giant    | 0.921          | 0.222          | 0.248         |
| Yudinka         | 0.889          | 0.169          | 0.192         |

Source: Compiled by the authors.

The $R_{seed/end}$ correlation coefficient varied from 0.774 in “Senezh” variety to 0.924 in “Malachite” variety. The $R_{end/emb}$ coefficient demonstrated a weak between the length of the embryo and endosperm (0.192 – 0.318). The correlation between the length of the embryo and the seed was also weak ($R_{seed/emb}$ varied in 0.157 – 0.254 range).

The $I_{emb/seed}$ index displays the same pattern. The sample maximum of the index (0.39) was observed in the “Apple” variety, the sample minimum (0.25) in the “Vanyusha” variety.
The variance of the I_{emb/seed} index was significantly lower (0.85–0.91). The sample maximum (0.91) was observed in “Malachite” and “Yudinka” varieties.

4. Conclusion
The celery varieties, studied in this experiment, displayed significant variance in the main morphological parameters, namely the length of the seed, the endosperm, and the embryo. The authors concluded that there is no significant correlation between length of the embryo and the lengths of seed and endosperm. These facts mean that the seed quality can be significantly improved by selective breeding. The samples of “Royal night” and “K-635” are the best potential candidates for selective breeding, as they outperformed in all three morphological parameters. The sample maximum of the I_{emb/seed} (embryo to endosperm ratio) was observed in the “Apple” (0.43) and “Senezh” (0.42) varieties.

References
[1] Baleev D N, and Bukharov A F 2012 Biology of development and seed germination of dill Russian Vegetables 1(14) pp 54-59
[2] Benech A R L, Fenner M, and Edwards P J 1991 Changes in germinability, ABA content and ABA embryonic sensitivity in developing seeds of Sorghum bicolor (L.) Moench. induced by water stress during grain filling New Phytologist 118(2) pp 339-347
[3] Bukharov A F, and Baleev D N 2012 The morphology of heterogeneity of seeds of vegetable Umbelliferae crops caused by place of development on the parental plant Russian Vegetables 2(15) pp 44-47
[4] Bukharov A F, Baleev D N, Ivanova M I, Bukharova A R, and Derevenskih O A 2019b Morphometric parameters of seeds of various dill varieties Bulletin of the Mari State University. Series: Agricultural Sciences. Economic Sciences 5(2) pp 145-149
[5] Bukharov A F, Baleev D N, Ivanova M I, Bukharova A R, and Razin O A 2018a Analysis of dill seed germination parameters characterizing their variability Bulletin of the Moscow State Regional University. Series: Natural Sciences 3 pp 125-137
[6] Bukharov A F, Baleev D N, Ivanova M I, Bukharova A R, and Razin O A 2018b Embryo morphometry as an element of dill seed quality testing system Proceedings of the Kuban State Agrarian University 72 pp 63-66
[7] Bukharov A F, Baleev D N, Kashnova E V, Kasaeva G V, Ivanova M I, and Razin O A 2019a Ecological and varietal variability of carrot seed morphometric parameters Potatoes and Vegetables 3 pp 37-40
[8] Eremenko L L 1975 Morphological features of vegetable plants in connection with seed productivity (Novosibirsk, USSR: Nauka)
[9] Grushvitsky I V, Agnaeva E Ya, and Kuzina E F 1963 On embryo variance in the mature carrot seeds Botanical journal Vol 48 No 10 pp 1484 – 1489.
[10] Grushvitsky I V 1961 Role of embryo underdevelopment in the evolution of flowering plants (Moscow; Leningrad, USSR: USSR Academy of Sciences)
[11] Harper J L 1977 Population biology of plants (London, UK: Academic Press)
[12] Ivanova M I, Karanova S L, and Ludilov V A 2011 Changes in morphological features of root celery in induced mutagenesis Agricultural Biology 46(5) pp 81-85
[13] Pereira R S, Nascimento W M, and Vieira J V 2008 Carrot seed germination and vigor in response to temperature and umbel orders Scientia Agricola 65(2) pp 145-150
[14] Strona I G 1966 General seed science of the field crops (Moscow, USSR: Kolos)