The Ecological Variety Testing of Foreign Melon and Watermelon Hybrids in the Climatic Conditions of Southeastern Kazakhstan

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Abstract. The results of the ecological variety testing of melon and watermelon hybrids are presented in the paper. In the period from 2018 to 2020, 10 foreign varieties and hybrids of melon and watermelon were evaluated according to economic and valuable characteristics in the adaptation nursery in the climatic conditions of southeastern Kazakhstan. According to the set of qualities and indicators, 4 melon and watermelon varieties were distinguished and suggested for production.

1. Introduction
Melon cultivation is a highly profitable branch of agriculture in Kazakhstan. Melons (watermelon, melon) are cultivated in almost all regions, while the main areas are concentrated in the south and southeast of the country. The area under melons reached 105 thousand hectares, gross harvests exceeded 2.5 million tons, the average yield of fruits is about 24 tons / ha [1].

The consumption rate of melon products per 1 inhabitant of the republic is 26 kg per year. Taking this into account, the internal demand of Kazakhstan for melons is about 500 thousand tons, the security is 500%.

Watermelon and melon are of great value as sources of easily digestible sugars, vitamins, mineral salts, organic acids and other biologically valuable substances. In terms of the content of a number of vitamins, melons are not inferior, but are equated and even surpass many fruit and berry crops. Melon fruits are especially valuable, because they contain a rich set of vitamins: ascorbic acid, beta-carotene, tocopherol, nicotinic and pantothenic acid, riboflavin, pyridoxine, folacin and thiamine. Melon is better in terms of nutritional value than many types of fruits. The high taste qualities of the tender juicy pulp of the fruit are complemented by an extraordinary variety of aromas. Melon products are in great demand among the population of the country [2].

As can be seen from the statistics, there is an overproduction of watermelon and melon in our country. In this regard, there is an urgent need to search for foreign sales markets. Kazakhstan has traditionally exported melon products. Now, taking into account the significant increase in production volumes, new sales markets are required. It is important to ensure high quality indicators and transportability of watermelon and melon fruits. In this aspect, there is a need to select varieties (hybrids) of these crops, both with high yields, and with the best quality and ease of production.
The "State Register of Breeding Achievements Approved for Use in the Republic of Kazakhstan" includes 29 varieties of melon, of which 19 varieties (65.5%) are of Kazakh selection. The share of melon varieties (hybrids) from abroad is 13.8% (4 hybrids). As for the watermelon, 34 varieties and hybrids are zoned and cultivated in the regions of Kazakhstan, including 11 varieties of domestic selection (32.4%) [3].

Melon growers of Kazakhstan, along with domestic varieties, also use foreign varieties (hybrids). In this regard, varieties of watermelon and melon of foreign selection were studied to offer melon growers of the country the best samples in terms of yield and quality.

The importance of the quality of exported melon products is also increasing due to Kazakhstan's accession to the World Trade Organization. Organic production is developing in many countries of the world. Eco-friendly natural products are in great demand among the population and are widely used. The importance of the transition to the production of organic agricultural products has been noted by many scientists and specialists [4–8]. Kazakhstan in the world community of producers of products may well act as an exporter of organic and/or environmentally friendly melon products.

The above stated determines the relevance of the research.

2. Research methods
The soil of the experimental plantation of the "Kainar" Regional branch is dark chestnut, has a fully developed profile, the mechanical composition is medium loamy. The upper layer of the soil contains 2.9–3.0% of humus; 0.18–0.2% of total nitrogen; 0.19–0.2% of total phosphorus. The content of mobile phosphorus in the arable layer is 30–40 mg/kg of soil, exchangeable potassium is 350–390 mg/kg. The capacity of cation exchange is 20–21 mg·eq./100 g of soil. The reaction of the soil solution is slightly alkaline, close to neutral (pH 7.3–7.4). The volume mass of the soil is 1.1–1.2 kg/cm³, the lowest moisture capacity is 26.6%. The structure of the soil is loose, weakly expressed.

The climate of the foothill zone of the south-east of Kazakhstan is sharply continental. The average temperature in July is 22–24 °C above zero, in January – 6–10 °C below zero. A steady transition of air temperature through 0 °C in spring occurs at the end of the II-beginning of the III decade of March, in autumn – at the end of the I – beginning of the III decade of November. The sum of positive temperatures is 3450–37500 °C, and the sum of temperatures for the period above 100 °C is 3100–34000 °C. The duration of the frost-free period is 140–170 days. The average annual precipitation is 350–600 mm. In the years of research (2018–2020), meteorological conditions significantly differed from the average long-term data.

Within 3 years, 20 foreign samples of melon crops were studied according to economically valuable characteristics. The purpose of the research is to evaluate foreign varieties and hybrids of watermelon and melon to identify the productivity, taste, transportability of fruits and adaptation to the conditions of the south-east of Kazakhstan, to recommend the best of them for production.

In the studies on the ecological variety testing of melon crop samples, classical methods (techniques) such as: methods of state variety testing of agricultural crops (potatoes, vegetables and melons) [9]; methods of experimental work in vegetable growing and melon growing [10], methods of selection of watermelon and melon [11] were used.

3. Results
10 samples of melons of foreign selection (Turkey, Germany, France) were evaluated according to economically valuable characteristics at the selection plantation of the laboratory of vegetable and melon breeding of the "Kainar" Regional Branch of the Kazakh Scientific Research Institute of Fruit and Vegetable Growing LLP.

According to the total fruit yield in the early-ripening group, 3 melon varieties were distinguished, the excess of the Shugyld standard (13.8 t/ha) was 38.9% for the Sari Ball hybrid, 22.9% for Darwina F1, 19.4% for the DS 45-259 F1. In the mid-late group, not a single sample stood out in terms of yield, the samples of Giallo da Inverno and Pirona F1 showed a slightly lower yield (19.6 t/ha), against the background of the Muse standard (20.9 t/ha). All the selected varieties had a high (95.0-97.2%)
marketability, a high content (10.41-15.0%) of dry soluble substances and a high tasting score of 4.5-5.0 points. These varieties are suitable for cultivation in the conditions of the south-east of Kazakhstan.

According to productivity, 4 melon hybrids are recommended for cultivation in melon farms in the south-east of the country. They are: Sari Ball, Darwin F1, AH 6404 F1, Giallo da Inverno.

### Table 1. Yield and quality of the selected melon varieties and hybrids.

| Melon varieties | Total yield, t/ha | Including in 2 harvests | Averaging fruit weight, kg | Content of dry substances,% | Tasting rating, point | Exceeding standard,% |
|-----------------|-------------------|-------------------------|---------------------------|-----------------------------|---------------------|---------------------|
| Shugyla, Standard | 14.4 | 13.5 | 94.2 | 6.0 | 41.8 | 1.2 | 13.0 | 4.8 | - |
| Sari Ball | 20.0 | 13.9 | 96.8 | 6.2 | 31.1 | 2.7 | 13.5 | 5.0 | 38.9 |
| Lilian F1 | 15.1 | 14.2 | 94.5 | 6.2 | 41.0 | 1.6 | 12.5 | 4.5 | 4.8 |
| Darwin F1 | 17.7 | 17.0 | 96.0 | 7.1 | 40.1 | 1.5 | 11.0 | 5.0 | 22.9 |
| AX 6404 F1 | 15.2 | 14.4 | 95.0 | 5.5 | 36.2 | 1.5 | 13.5 | 5.0 | 5.5 |
| DC 45-259 F1 | 17.2 | 16.7 | 97.1 | 6.8 | 39.8 | 2.1 | 12.0 | 4.0 | 19.4 |
| DC 45-160 F1 | 14.6 | 13.8 | 94.7 | 6.1 | 41.3 | 2.5 | 13.0 | 4.5 | 1.4 |
| Muse, Standard | 20.9 | 20.0 | 95.6 | 4.2 | 20.3 | 2.1 | 12.0 | 4.8 | - |
| Giallo da Inverno | 19.6 | 18.7 | 95.7 | 3.6 | 18.7 | 2.8 | 13.0 | 4.8 | - 6.2 |
| Darimo F1 | 17.9 | 17.3 | 96.6 | 5.2 | 29.2 | 1.9 | 15.0 | 5.0 | - 14.3 |
| Ax70-158F1 | 15.1 | 14.5 | 96.0 | 3.7 | 24.4 | 1.8 | 11.0 | 4.0 | - 27.7 |
| Pirona F1 | 19.6 | 18.9 | 96.3 | 6.2 | 31.8 | 2.5 | 15.0 | 5.0 | - 6.2 |

Table 2 shows the biometric and morphological characteristics of samples (hybrids) of melon of foreign selection. As can be seen from the data, the fruits of different hybrids of the culture differ markedly in weight, size, shape, pattern, juiciness, taste and other indicators.

In the conditions of the south-east of Kazakhstan, the main harmful disease of melon is powdery mildew. This disease, regardless of the conditions of the year, appears at the end of the growing season of plants, and in some years even earlier, it quickly spreads and causes great damage to melon crops. Consequently, the yield, taste and commercial qualities of the fruits are significantly reduced.

The most common and harmful diseases of infectious origin in Kazakhstan, causing great damage to the crop and its quality, are: powdery mildew, anthracnose, bacteriosis and fusarium infection. Diseases such as bacteriosis, viral mosaic affect melon crops, including melon, in some years and, as a rule, do not cause much damage. Among non-infectious diseases, physiological wilting and root rot are widespread.

According to the results of the assessment, disease-resistant melon samples are: Darimo F1, Darwin F1, Ah70-158 F1, Pirona F1, DS 45-160 F1 (table 3).

It should be noted that the following melon hybrids (Darimo F1, Darwin F1, Ah70-158 F1, Pirona F1, DS 45-160 F1) were resistant to a complex of culture diseases – powdery mildew, perongosporosis and fusarium. This is very important, since the treatment of melon crops with fungicides is excluded or minimized. This is very profitable both economically, since there is no need to spend money on expensive pesticides (fungicides), and environmentally, which is expressed in the purity of products. Based on this, these melon hybrids can be recommended for production.
10 foreign samples were studied for watermelon in order to adapt and evaluate valuable traits. As a result of 3-year crop productivity accounting, all samples of different maturation periods significantly exceeded the standards.

| №  | Variety name                  | Weight, kg | Length, cm | Width, cm | Shape  | Backgrou nd | Pattern       | Rind thickness | Taste       | Juice content | Pulp consistency | Pulp colour     | Pulp thickness |
|----|-------------------------------|------------|------------|-----------|--------|-------------|---------------|----------------|-------------|--------------|----------------|----------------|---------------|
| 1  | Shugyla, Standard             | 1.2        | 20         | 16        | Circular | Yellow      | Net           | 0.9            | Sweet       | Juicy        | Melting         | White           | 4.8           |
| 2  | Sari Ball                     | 2.7        | 15         | 16        | Oval    | Yellow      | Wrinkled      | 0.9            | Very sweet  | Juicy        | Melting         | White and green | 6.2           |
| 3  | Giallo da Inverno             | 2.8        | 27         | 17        | Fusiform | Yellow      | Wrinkled      | 1.0            | Sweet       | Juicy        | Grainy          | White           | 5.5           |
| 4  | Lilian F1                     | 1.6        | 20         | 16        | Elongated oval | Yellow      | Net           | 0.9            | Not sweet   | Not very juicy | Melting         | Light orange    | 4.8           |
| 5  | Darwinia F1                   | 1.5        | 14         | 15        | Circular | Brown       | Net           | 1.0            | Very sweet  | Very juicy   | Melting         | Green           | 3.8           |
| 6  | Darimo F1                     | 1.9        | 15         | 14        | Oval    | Bright brown | Net           | 1.0            | Not very sweet | Extremely juicy | Melting         | White           | 5.0           |
| 7  | Ax70-158F1                    | 1.8        | 16         | 15        | Oval    | Brown       | Elongated stripe s | 1.0            | Pineapple   | Not juicy     | Crispy          | Orange          | 3.5           |
| 8  | AX 6404 F1                    | 1.52       | 15         | 16        | Circular | Brown       | Net           | 0.9            | Not very sweet | Juicy         | Melting         | White and orange | 6.2          |
| 9  | DC 45-259 F1                  | 2.1        | 13, 5      | 15        | Circular | Light yellow | Net           | 0.8            | Low sweet   | Not very juicy | Melting         | Light green     | 4.5           |
| 10 | DC 45-160 F1                  | 2.5        | 21         | 17        | Oval    | Bright yellow | Net           | 1.1            | Sweet       | Not very juicy | Grainy          | White           | 4.3           |
| 11 | Pirona F1                     | 2.5        | 21         | 15        | Oval    | Brown       | Net           | 0.9            | Not very sweet | Extremely juicy | Melting         | White           | 5.0           |
Table 3. The degree of susceptibility of foreign varieties and hybrids of melon to diseases.

| Melon varieties | Origin    | powdery mildew | peronosporosis | fusarium infection |
|-----------------|-----------|----------------|----------------|--------------------|
| Shugyla, stand. | Kazakhstan| Average perceptive | Low perceptive | Resistant          |
| Sari Ball       | Turkey    | Low perceptive | Average perceptive | Average perceptive |
| Giallda da      | France    | Low perceptive | Low perceptive | Low perceptive     |
| Inverno         |           |                |                |                    |
| Lilian F1       | Germany   | Average perceptive | Low perceptive | Resistant          |
| Darwina F1      | Germany   | Resistant       | Resistant      | Resistant          |
| Darimo F1       | Germany   | Resistant       | Resistant      | Resistant          |
| Ax70-158 F1     | Germany   | Resistant       | Resistant      | Resistant          |
| AX 6404 F1      | Germany   | Low perceptive | Low perceptive | Average perceptive |
| DC 45-259 F1    | Turkey    | Average perceptive | Average perceptive | Resistant          |
| DC 45-160 F1    | Turkey    | Resistant       | Resistant      | Resistant          |
| Pirona F1       | Germany   | Resistant       | Resistant      | Resistant          |

In the early-ripening group, AX-CR258 F1, AX-CR268 F1, AX-AL 368 F1, AX-AL 428 F1, AX-AL 438 F1 were distinguished, as they exceeded the standard variety of Mezhduurechensky by 21.2-31.7%. Bella F1, AX-AL 448 F1, AX-CR157F1 and DS 44-22 F1 distinguished themselves in the mid-season and mid-late group, exceeding the Melitopol 147 standard variety by 8.5-10.0%. The distinguished watermelon varieties had a high (94.0–98.0%) marketability, a high content (10.0–11.0%) of dry substances and a high tasting rating (table 4).

Table 4. Yield and quality of distinguished foreign varieties of watermelon.

| Watermelon varieties and hybrids | Total yield, t/ha | Marketability, quantity, t/ha | In 2 harvests, quantity, t/ha | Averag. fruit weight, kg | Refractometer indicator, % | Tasting rating, point | Exceeding standard, % |
|---------------------------------|-------------------|-------------------------------|-------------------------------|--------------------------|---------------------------|------------------------|------------------------|
| Mezhduurechensky, Standard      | 25.5              | 23.2                          | 92.                           | 9.1                      | 35.                       | 5.3                    | 9.0                    | 4.8                    | -                      |
| AX-CR268 F1                     | 31.1              | 30.0                          | 96.                           | 12.9                     | 41.                       | 5.7                    | 11.0                   | 5.0                    | 21.9                   |
| AX-AL 438 F1                    | 33.6              | 31.9                          | 95.                           | 15.1                     | 45.                       | 6.5                    | 10.0                   | 5.0                    | 31.7                   |
| AX-CR138F1                      | 28.9              | 27.8                          | 96.                           | 12.4                     | 42.                       | 7.5                    | 10.0                   | 4.9                    | 13.3                   |
| AX-AL 428 F1                    | 31.6              | 30.8                          | 97.                           | 14.9                     | 47.                       | 6.3                    | 10.0                   | 5.0                    | 23.9                   |
| AX-AL 368 F1                    | 31.0              | 28.9                          | 96.                           | 14.9                     | 46.                       | 7.3                    | 11.0                   | 5.0                    | 21.5                   |
| AX-CR258 F1                     | 31.4              | 30.2                          | 96.                           | 13.6                     | 43.                       | 4.6                    | 10.0                   | 5.0                    | 23.1                   |
| Melitopolsky 142, standard      | 25.9              | 24.1                          | 93.                           | 6.7                      | 25.                       | 5.0                    | 9.5                    | 4.6                    | -                      |
| Bella F1                        | 28.1              | 26.6                          | 94.                           | 4.7                      | 16.                       | 7.6                    | 11.0                   | 5.0                    | 8.5                    |
| AX-AL 448 F1                    | 28.1              | 26.6                          | 94.                           | 7.1                      | 25.                       | 6.0                    | 12.0                   | 5.0                    | 8.5                    |
| DS 44-22 F1                     | 30.9              | 29.9                          | 96.                           | 7.5                      | 23.                       | 6.9                    | 10.0                   | 4.6                    | 19.3                   |
| AX-CR157F1                      | 28.5              | 27.4                          | 96.                           | 9.1                      | 32.                       | 6.2                    | 10.0                   | 5.0                    | 10.0                   |
Table 5 shows the biometric and morphological characteristics of the studied varieties of watermelon of foreign selection. As can be seen from the data, the fruits of different hybrids of the culture differ markedly in weight, size, shape, pattern, juiciness, taste and other biometric indicators.

**Table 5. Biometric indicators and description of foreign watermelon varieties.**

| №  | Watermelon varieties and hybrids | Fruit weight, kg | Fruit length, cm | Fruit width, cm | Fruit shape | Fruit background | Fruit pattern | Pattern colour | Rind thickness | Pulp colour |
|----|---------------------------------|------------------|------------------|-----------------|------------|------------------|----------------|---------------|---------------|-------------|
| 1  | Mezhdurechensky, Standard       | 5.3              | 23.5             | 22.0            | Oval       | Green            | Narrow stripes | Dark green    | 1.5           | Red         |
| 2  | Bella F₁                       | 7.6              | 26.0             | 22.0            | Circular   | Light green      | Thorn stripes  | Dark green    | 1.1           | Red         |
| 3  | AX-AL 448 F₁                   | 6.0              | 24.0             | 22.5            | Cylindrical| Light green      | Thorn stripes  | Dark green    | 1.3           | Red         |
| 4  | DC 44-22 F₁                    | 6.9              | 24.0             | 23.0            | Cylindrical| Light green      | Wide stripes   | Dark green    | 1.2           | Dark red    |
| 5  | AX-CR268 F₁                    | 5.7              | 22.0             | 21.5            | Oval       | Light green      | Wide stripes   | Dark green    | 1.5           | Red         |
| 6  | AX-AL 438 F₁                   | 6.5              | 26.0             | 22.0            | Cylindrical| Light green      | Wide stripes   | Dark green    | 1.5           | Red         |
| 7  | AX-CR138F₁                     | 7.5              | 37.0             | 19.5            | Oval       | Light green      | Wide stripes   | Dark green    | 1.3           | Red         |
| 8  | AX-CR157F₁                     | 6.2              | 25.0             | 23.0            | Oval       | Light green      | Wide stripes   | Dark green    | 1.7           | Red         |
| 9  | AX-AL 428 F₁                   | 6.3              | 25.0             | 190             | Cylindrical| Light green      | Wide stripes   | Dark green    | 1.0           | Dark red    |
| 10 | AX-AL 368 F₁                   | 7.3              | 31.0             | 23.0            | Cylindrical| Light green      | Wide stripes   | Dark green    | 1.4           | Dark red    |
| 11 | AX-CR258F₁                     | 4.6              | 22.5             | 20.0            | Oval       | Light green      | Wide stripes   | Dark green    | 1.5           | Red         |

Table 6 shows the data of biochemical analyses of fruits of different watermelon varieties studied in the adaptation nursery.

**Table 6. Qualitative indicators of foreign watermelon varieties.**

| Watermelon varieties          | Origin     | Dry substance, % | Total sugar, % | Vitamin C, mg % | Nitrates, mg/kg |
|-------------------------------|------------|------------------|----------------|-----------------|-----------------|
| Mezhdurechensky, Standard     | KazRIPVG   | 10.1             | 8.2            | 5.3             | 55              |
| Bella F₁                     | Turkey     | 10.2             | 10.5           | 6.6             | 45              |
| AX-AL 448 F₁                 | Germany    | 11.0             | 11.0           | 7.6             | 63              |
| DS 44-22 F₁                  | Turkey     | 8.0              | 7.5            | 6.6             | 58              |
| AX-CR268 F₁                  | Germany    | 10.0             | 9.5            | 7.2             | 50              |
| AX-AL 438 F₁                 | Germany    | 10.0             | 11.0           | 8.8             | 60              |
| AX-CR138F₁                   | Germany    | 10.0             | 10.1           | 6.6             | 69              |
| AX-AL 428 F₁                 | Germany    | 11.0             | 10.0           | 7.2             | 45              |
| AX-CR157F₁                   | Germany    | 10.0             | 9.5            | 5.8             | 59              |
| AX-AL 368 F₁                 | Germany    | 10.0             | 10.5           | 5.0             | 55              |
| AX-CR258F₁                   | Germany    | 9.0              | 8.2            | 5.8             | 63              |

Foreign watermelon hybrids differed significantly in quality indicators. The content of dry substances in the fruits ranged from 8.0–11.0%, total sugar amounts to 8.2–11.0%. The level of nitrates in the products was below the maximum permissible concentration – 45–69 mg/kg. According to the content
of total sugar in fruits (11%), the AX-AL 428 F1, AX-AL 448 F1 varieties distinguished themselves in the conditions of the foothills of the south-east of Kazakhstan.

4. Conclusion
20 foreign samples were evaluated according to the complex of economically valuable characteristics, including 10 - watermelon varieties and 10 – melon varieties.

According to the results of the melon, 3 varieties were distinguished in the early-ripening group in terms of total yield, the excess of the Shugyl standard (13.8 t/ha) was 38.9% for Sari Ball, 22.9% for Darwin F1, and 19.4% for DS 45-259 F1. In the mid-late group, not a single sample stood out in terms of yield, Giallo da Inverno and Pirona F1 showed a slightly lower yield (19.6 t / ha), against the background of the Muse standard (18.2 t/ha). All the selected melon varieties had a high (95.0–97.2%) marketability, a high content (10.41–15.0%) of dry substances and a high tasting score of 4.5–5.0 points.

As for the watermelon, taking the yield into account, all samples of different ripening periods significantly exceeded the standards. In the early-ripening group, AX-CR258 F1, AX-CR268 F1, AX-AL 368 F1, AX-AL 428 F1, AX-AL 438 F1 were distinguished, exceeding the Mezhdurechensky standard by 21.2–31.7%. The Bella F1, AX-AL 448 F1, AX-CR157 F1 and DS 44-22 F1 varieties, exceeding the Melitopol 147 standard by 8.5–10.0%, distinguishing themselves in the middle-ripe and mid-late group. All the selected watermelon varieties had a very high marketability of fruits (94.0–98.0%), a high dry substance content (10.0–11.0%) and a high tasting rating.

According to the research results, 4 melon hybrids are recommended for cultivation in the conditions of the south-east of Kazakhstan. They are: Sari Ball, Darwin F1, AH 6404 F1, Giallo da Inverno. 5 watermelon hybrids are offered for production. They are: AX-CR268 F1, AX-AL 428 F1, AX-AL 368 F1 (early-ripening varieties), Bella F1, AX-CR157 F1 (late-ripening varieties).

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