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EFFECT OF SOIL, ENVIRONMENTAL CONDITIONS, AND AGROTECHNICAL PRACTICES ON THE YIELD AND QUALITY OF MELON (*CUCUMIS MELO* L.) IN SOUTHEAST KAZAKHSTAN

E. TAISHIBAYEVA[1*], J. MAMYRBEKOV[1], S. MAKHMADJANOV[2], A. NUSSUPOVA[1], E. NURBAYEVA[1], G. IBRAGIMOVA[1], U. MANABAYEVA[1], A. AITBAYEVA[1], A. JANTASSOVA[3], and B. ZORZHANOV[1]

[1]Kazakh Research Institute Fruit and Vegetable Growing, Almaty, Kazakhstan
[2]LLP - Agricultural Experimental Station of Melon and Cotton Growing, Atakent, Turkestan Region, Kazakhstan
[3]Kazakh National Agrarian Research University, Almaty, Kazakhstan
*Corresponding author's email: elvira701@mail.ru
Email addresses of co-authors: mamyrbekov70@mail.ru, max_s1969@mail.ru, aigul.nusupova.65@mail.ru, elmira-1401@mail.ru, gulnara.0868@mail.ru, manabaeva1971@mail.ru, aitbaeva_a_86@mail.ru, aigerim-jantasova@mail.ru, berik_zorzhanov@mail.ru

SUMMARY

The detection of the soil, environmental conditions, and agrotechnical practices' effects on the yield and quality of melon (*Cucumis melo* L.) in Southeast Kazakhstan was the chief focus of this research. The results recognized that sandy loam sierozem soils of the foothill-steppe zone of Southeastern Kazakhstan have proven to be the most favorable soil for better growth and development of melons. In the soils with heavy mechanical composition, the quantitative and qualitative indicators of Central Asian cultivars incurred sharp effects and declined compared with melon genotypes grown on soils with light mechanical composition. Melon cultivars of the European subspecies exhibited the highest plasticity in relation to soil and environmental conditions. During the first 10 and 20 days of May, it emerged as the most optimal sowing period. For early- and mid-season melon cultivars, the most optimal plant density was 10,200 plants/ha, while mid-late and late-ripening cultivars were the best, with a plant density of 8,100 plants/ha. For the early- and mid-season melon cultivars, the best sowing pattern was 280 cm × 70 cm × 70 cm, while the mid-late and late cultivars grew best with the pattern of 350 cm × 70 cm × 70 cm.

Keywords: Melon (*C. melo* L.), cultivars, soil and environmental conditions, agrotechniques, productivity, biochemical composition

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Key findings: Melon (*C. melo* L.) cultivars of the European subspecies exhibited the highest plasticity in relation to soil and environmental conditions. The first 10 and 20 days of May were notably the most optimal sowing periods for melon. Specific conclusions resulted about the influence of a particular ecological zone on the growth and development of melon.

INTRODUCTION

Melon (*Cucumis melo* L.) is a highly economical crop of the agriculture sector in Kazakhstan. Presently, the area under melon crops has reached 105,000 hectares (Aitbayev *et al*., 2021; Committee on Statistics, 2024). Watermelons and melons are highly essential sources of easily digestible sugars, vitamins, mineral salts, organic acids, and biologically valuable substances (Gutsalyuk and Aitbayev, 2012). The melon benefits are in the crucial substances required for better human health (Koleboshina *et al*., 2016, 2017, and 2019). The use of new agricultural technologies, regionalized and promising cultivars, and hybrids of watermelon and melon adapted to regional conditions develops feasible conditions for improving the quality and reducing product losses at minimal cost (Gutsalyuk, 1997).

Plant breeding, seed production, and agrotechnics have the critical task of developing new cultivars and hybrids with complex, economically valuable traits. In breeding for cultivar development, one of the parental genotypes must be a variety zoned in a given area and already adapted to these environmental conditions. The second parental genotype must have those valuable characteristics necessary for the future variety that have not appeared in the existing cultivar. These are some primary conditions that a breeder adheres to by developing new cultivars and hybrids in melons (Gutsalyuk and Aitbayev, 2012). Yield, early maturity, transportability, shelf life, palatability, taste qualities, and durable resistance to different diseases are the complex polygenic traits making up a complex of economically valuable qualities of a melon genotype (Mamyrbekov *et al*., 2016).

Central Asian melon cultivars are sexually andromonoecious, and the hermaphroditic flowers of these genotypes are quite capable of self-pollination. The Central Asian farming community has long noticed that some cultivars of melon do not split in the offspring, despite constant culture in a mixture with other cultivars. The melon cultivars with over-pollination under natural conditions considerably vary among the cultivars and individual plants within a variety (Gutsalyuk, 2006). For breeders, a vital task is to develop new, promising melon cultivars with resistance to temperature, water, and edaphic stresses, as well as various diseases (Suslova and Galichkina, 2022).

Raising melon production, in particular, is possible with the help of breeding and the development of qualitatively new and competitive cultivars and hybrids. In improving the efficiency of domestic melon and vegetable production, well-managed plant breeding strategies and seed production play a vital role in enhancing their production (Nemtinov *et al.,* 2015; Varivoda and Maslennikova, 2019; Varivoda *et al.,* 2019, 2020). The use of molecular markers is an accurate and efficient way of screening melon germplasm and needs a shorter time for early selection of desirable melon accessions with higher yield and accurate resistant genes (Ribaut and Ragot, 2007; Sousaraei *et al.,* 2018; Nyirahabimana and Solmaz*,* 2021).

Currently in melons, the most common method of grafting is the F1 hybrid, which provides healthy dominant genes in one genotype. The F1 hybrid cultivars are technically superior for their fruit yield, early maturity, quality, uniformity, growing season duration, disease and pest resistance, and shorter time to produce new cultivars with considerable genotypic adaptability (Munshi and Alvarez*,* 2004; Adıgüze *et al.,* 2023; Shoibekova *et al.,* 2023).

The yield and quality of melons sustain strong influences from important factors, such as soil and environmental conditions, applied agrotechnical methods, variety peculiarities, transportation, and storage. Among these factors, the crucial ones affecting the fruit yield and quality of the melon crop are the soil and its mechanical composition, the characteristics of a particular variety, sowing time, plant density, and product storability (Adıgüze *et al.,* 2023).

In Kazakhstan, several melon cultivars and hybrids, zoned and cultivated, have 15 out of 31 melon cultivars as domestic. The continuous research in the foothills of the southeastern zone of the Republic of Kazakhstan aims to manage the water erosion of soils, reduce doses of mineral fertilizers, and address the shortage of irrigation water and pesticides polluting the environment, which are extremely relevant. One of the solutions is developing highly productive and adaptive cultivars of melon and watermelon, relatively resistant to temperature fluctuations, high humidity, and other stress factors.

MATERIALS AND METHODS

The research material comprised five melon cultivars with different maturity periods and subspecies of the selection of KazRIFVG, i.e., ultra-early variety (Taisia), early-maturing (Altynochka), medium-maturing (Shugyla and Mayskaya), and medium-late (Muza). The presented research sought to study the influence of different soil types and mechanical composition on the melon fruit yield and quality. The study occurred during 2022–2024 at the ordinary sierozem with sandy loam mechanical composition in the Zhambyl District, Almaty Region, and on medium loamy chestnut soil of foothills in the conditions of Karasay District, Almaty Region, Kazakhstan.

The study also probed five melons of KazRIFVG selection to determine the peculiarities of vegetative and generative organs' growth and development of melon cultivars of different maturity. The research, as conducted in 2022–2024, consisted of two soil-environmental conditions, i.e., the pre-mountain-steppe zone of the Zhambyl District of Almaty Region and the pre-mountain zone of Karasay District, Almaty Region, Kazakhstan.

The soil cover of the foothill zone of Southeastern Kazakhstan (Almaty Region) has various types of soils with different mechanical compositions. In most parts, the soils of this region are fully sufficient with mobile forms of nutrients, in relatively good relief conditions, accessible to irrigation and mechanized processing, and favorable for the cultivation of vegetable crops and potatoes.

The soil in the experimental station of the Russian Federation TOO "KazNIIPO" "Kainar" is dark chestnut, medium loamy in mechanical composition, with a fully developed profile, clearly differentiated into genetic horizons. The arable soil layer contains 2.9%–3.0% humus, 0.18%–0.20% total nitrogen, and 0.19%–0.20% total phosphorus. The soil of the site has moderately available mobile forms of nutrients. The content of mobile phosphorus in the arable layer is 30–40 mg/kg of soil, and the exchangeable potassium is 350–390 mg/kg. The amount of absorbed bases (cation exchange capacity) is 20–21 mg-eq/100 g soil.

The climate of the foothill zone of the southeast of Kazakhstan is sharply continental. The average temperature in July is 22 °C–24 °C above zero; in January, it is –6 °C–10 °C below zero. The steady transition of air temperature through 0 °C in spring occurs from the end of the 20 days to the beginning of the 30 days of March, and in autumn, from the end of 10 days to the beginning of the 30 days of November. The sum of positive temperatures is 3,450 °C–3,750 °C, and the sum of temperatures for the period above 100 °C fluctuates within the range of 3,100 °C–3,400 °C. Spring frosts in the region cease in the last week of April, while autumn frosts resume in the last week of September or at the beginning of October. The duration of the frost-free period is 140–170 days. The annual amount of precipitation is 350–600 mm. Of these, 120 mm fall during the warm period of 300 mm. Stable snow cover forms in late November to early December and lasts 85–100 days. The snow depth reaches 20–35 cm.

The field experiments' layout and observations proceeded in accordance with the 'Methodology of the State Variety Testing of Agricultural Crops,' as well as 'Methodology of Field Experiments' and methodological guidelines for breeding melons. The study of foreign cultivars and hybrids of melon included a complex of biologically and economically valuable traits, such as maturity, yield, marketability of the crop, duration of the phases of plant development, resistance to diseases, taste, and morphological features. A detailed assessment relied on the morphological uniformity of progeny and quality of harvest (fruit size, color, netting, marketability, density of bark and pulp, and general appearance).

From the complex of economically valuable traits, the study considered the fruit taste of greatest value. The refractometer, used to measure the content of dry matter, indicated a close correlation with the sugar content in fruits. Tasting evaluation of the melon fruits in each genotype succeeded. Field experiments and laboratory studies continued based on the following generally accepted classical methods.

- Methodology of experimental work in vegetable and melon growing (Belik, 1992),
- Methodology of field experiments (Dospekhov, 1980),
- Methodology of watermelon and melon breeding (Gutsalyuk, 1998),
- Assessment for qualitative indicators of melon and analyzed products (fruits), and
- Dry matter measurement by the weight method (drying); total sugar by the Bertrand method; vitamin C and carotene contents by the Murri approach; and nitrates measured potentiometrically (with ion-selective electrodes).

RESULTS

The results established that soil with light mechanical composition proved most favorable for better crop growth and production in melons (Table 1). In the experiment, the variant with light mechanical composition appeared superior in all parameters versus the variant with heavy mechanical composition. However, the differences in the indicators based on the maturity duration and cultivar origin were different. For the ultra-early variety Taisia, the important parameters were considerably at par in both variants, i.e., fruit yield (17.9-18.4 t/ha), dry matter content (12.5-13.1% %), the sum of sugars (9.8-10.4 %), and tasting score (4.8 points).

For early-ripening and medium-ripening cultivars Altynochka and Shugyla in both variants, the differences in fruit yield were nonsignificant (23.3–21.5 t/ha and 25.0–24.4 t/ha, respectively). However, the differences for qualitative indicators were significant, i.e., dry matter (13.8%–12.0% and 14.0%–11.5%, respectively). These three melon cultivars were notable with round fruit shapes and belong to the European subspecies of melon.

Central Asian subspecies melon cultivars that are medium-ripening (Mayskaya) and medium-late (Muza with elongated fruit forms) responded sharply to the variations in soil conditions. On soils with heavy mechanical composition, the quantitative and qualitative indicators of these cultivars suddenly decrease compared with the said traits recorded in the melon cultivars on soils with light mechanical composition. For all considered parameters, these two cultivars emerged with lower values of 31%–45%.

Thus, the results authenticated the early-maturing cultivars Taisia and Altynochka and the medium-maturing cultivar Shugyla as belonging to European subspecies and can form a potential yield in the fertile soil. However, the qualitative parameters of their fruits displayed a significant decline on soils with heavy mechanical composition. Cultivars of Central Asian subspecies, medium-ripening Mayskaya and medium-late Muza, showed higher fruit yield with better quality indicators only on the soils (sandy/sandy loam) with light mechanical composition.

Studying the influence of sowing time on fruit yield and quality parameters of domestic melon cultivars in Southeast Kazakhstan continued with sowing the said cultivars on three different dates, i.e., May 5, May 15, and May 25. Based on the results, in Kazakhstan, cultivars with different maturity durations and high fruit yield with better quality indicators were evident in the first two variants (10 and 20 days of May) (Table 2). The variant with late sowing (30 days of May)

Table 1. Influence of soil mechanical composition on the yield and quality of melon fruits.

Soil type	Mechanical structure	Cultivars	Yield (t/ha)	Dry matter content (%)	Total sugars (%)	Tasting score (points)
Common serozem	Sandy loam	Taisia	18.4	13.1	10.4	4.8
		Altynochka	23.3	13.8	11.0	5.0
		Shugyla	25.0	14.0	11.5	5.0
		Mayskaya	29.6	14.4	11.0	4.9
		Muza	35.2	12.5	9.7	4.5
		LSD_{05} = 8.23, Sxcp = 2.73				
Chestnut	Medium loam	Taisia	17.9	12.5	9.8	4.8
		Altynochka	21.5	12.0	9.6	4.7
		Shugyla	24.4	11.5	8.7	4.0
		Mayskaya	20.0	9.4	7.0	3.7
		Muza	21.5	8.5	6.3	3.0
		LSD_{05} = 8.92, Sxcp = 2.96				

Table 2. Effect of sowing dates on the melon yield and fruit quality.

Sowing time	Cultivars	Yield (t/ha)	Dry matter content (%)	Total sugars (%)	Tasting score (points)
1st 10 days of May	Taisia	18.0	13.0	10.1	4.7
	Altynochka	22.7	12.2	9.5	4.2
	Shugyla	24.4	11.5	9.0	4.0
	Mayskaya	28.6	13.8	10.5	4.8
	Muza	33.3	12.5	9.7	4.3
	LSD_{05} = 10.21, Sxcp = 3.38				
20th of May	Taisia	18.4	13.1	10.4	4.8
	Altynochka	23.3	13.8	11.0	5.0
	Shugyla	25.0	14.0	11.5	5.0
	Mayskaya	29.6	14.4	11.0	4.9
	Muza	35.2	12.5	9.7	4.5
	LSD_{05} = 8.23, Sxcp = 2.73				
30th of May	Taisia	18.0	12.8	9.8	4.3
	Altynochka	18.5	11.0	8.7	4.0
	Shugyla	17.8	10.4	8.0	3.5
	Mayskaya	20.1	9.1	7.3	3.0
	Muza	19.6	8.5	6.0	2.5
	LSD_{05} = 9.49, Sxcp = 3.15				

showed the lowest values for all parameters in the studied melon cultivars, except the ultra-early cultivar Taisia. Especially low values were prominent for fruit yield and quality traits in Central Asian subspecies cultivars Muza and Mayskaya.

Such a negative impact of late sowing can be ascribable to the low humidity of the topsoil during the growing period. Given the delayed sowing, uneven sprouts were noticeable, which led to a low plant density per hectare. It is a fact that, based on morphological features of plants, soil fertility, and applied agrotechnical methods, different crops' cultivation used different plant densities with appropriate sowing schemes. Melon cultivars with different ripening durations can also succeed in cultivation with varied plant densities and planting schemes.

In determining the effect of plant density on fruit yield and quality parameters, the melon cultivars with different maturity durations underwent growing in the field experiment with three variants. These are a seeding scheme = 210 cm × 70 cm × 70 cm with a plant density of 13,600 plants/ha; 280

cm × 70 cm × 70 cm with a plant density of 10,200 plants/ha; and c - 350 cm × 70 cm × 70 cm with a plant density of 8,100 plants/ha. The sowing scheme was strip sowing, two rows, with 210, 280, and 350 cm distance between the rows, and the ribbon plants' arrangement was in two rows, with a distance of 70 cm. The distance between plants was also 70 cm.

In the studied melon cultivars, the highest quantitative and qualitative parameters occurred (Table 3) for the second variant (280 cm × 70 cm × 70 cm), i.e., fruit yield (18.5–36.2 t/ha), dry matter content (13.3%–14.5%), the sum of sugars (10.8%–12.7%), and the tasting score (4.4–5.0 points). The lowest values for the above traits resulted in the melon cultivars with the first variant (210 cm × 70 cm × 70 cm) viz., fruit yield (13.7–17.5 t/ha), dry matter content (9.0%–12.7%), the sum of sugars (6.6%–9.5%), and tasting score (3.0–4.2 points).

In the third variant (350 cm × 70 cm × 70 cm), the melon cultivars with early and medium maturity were inferior to the second variant for fruit yield (16.7–25.9 t/ha) and qualitative indicators, such as dry matter content (13.7%–14.9%), the sum of sugars (11.5%–12.6%), and tasting score (4.8–5.0 points). The cultivar with medium-late maturation (Muza) showed a fruit yield at the level of the second variant (36.0 t/ha) with high-quality indicators.

As per observations, the medium-late variety Muza, with a powerful plant and branched root system, responds positively to an increase in the area of plant nutrition. The early-ripening and medium-ripening maturation group cultivars, in the third variant, indicated direct relations to the low plant density per hectare. Thus, in Southeastern Kazakhstan, the optimal plant density of early-ripening and medium-ripening melon cultivars was 10,200 plants/ha. For medium-late and late-ripening melon cultivars, the most suitable plant density was 8,100 plants/ha. Exceeding the plant density of more than 12,000 plants/ha negatively affected the yield and quality traits of melon.

Table 3. Effect of plant density (sowing scheme) on the melon yield and quality of melon fruit yield.

Sowing scheme	Plant density (000/ha)	Cultivars	Yield (t/ha)	Dry matter content (%)	Total sugars (%)	Tasting score (points)
210 cm × 70 cm × 70 cm	13.6	Taisia	16.3	12.5	9.3	4.2
		Altynochka	16.7	12.7	9.5	4.2
		Shugyla	17.5	11.0	8.7	4.0
		Mayskaya	14.3	9.5	7.0	3.5
		Muza	13.7	9.0	6.6	3.0
		LSD_{05} = 5.65, Sxcp = 1.87				
280 cm × 70 cm × 70 cm	10.2	Taisia	18.5	13.5	11.6	4.8
		Altynochka	23.5	14.0	12.0	5.0
		Shugyla	25.3	14.5	12.4	5.0
		Mayskaya	30.0	14.4	12.0	5.0.
		Muza	36.2	13.3	10.8	4.4
		LSD_{05} = 10.38, Sxcp = 3.44				
350 cm × 70 cm × 70 cm	8.1	Taisia	16.7	13.8	11.9	5.0
		Altynochka	20.6	14.7	12.4	5.0
		Shugyla	20.5	14.7	12.4	5.0
		Mayskaya	25.9	14.9	12.6	5.0
		Muza	36.0	13.7	11.5	4.8
		LSD_{05} = 5.76, Sxcp = 1.91				

DISCUSSION

During 2017–2020, the Andijan branch of the Uzbek Research Institute of Vegetable and Melon Crops and Potato, Uzbekistan, developed the progressive technology of melon cultivation in gray soils of the Fergana Valley, Eastern Uzbekistan. The progressive technology included effective agrotechnics and methods of melon cultivation, which considerably contributed to the improvement of fruit yield and quality and showed a reduction in labor costs. This technology also includes an increased plant density (16,000 plants/ha) and applying mineral fertilizers (N30P60K60), with a reduced number of harvests to save the labor costs at harvesting (Mirahmedov and Kushakov, 2022).

In the promising research under the environment of Southeast Kazakhstan, the maximum plant density in melon plants comprised Central Asian subspecies cultivars (8,100 plants/ha) and European subspecies cultivars (10,200 plants/ha). Densification of melon plants with more than 12,000 plants/ha showed a negative impact on fruit yield and quality in melons. In the Bykovskaya Melon Breeding Experimental Station, the research work continued on the determination of optimal sowing dates of melons (watermelon, melon, and pumpkin). The experimental results have shown that both early- and late-sowing timings caused negative effects on the melon plants, and the fruit yield decreased from 9.8% to 75.4%. For melon sowing, the first 10 days of May appeared as the optimum date (Koleboshina *et al*., 2017).

In the presented experiment in melon cultivars, higher fruit yields with better quality indices were noteworthy in the first two variants—in the 10 and 20 days of May (22.7–33.3 and 23.3–35.5 t/ha, respectively). In late sowing (30 days of May), the melon cultivars showed the lowest values for fruit yield and quality traits. However, the ultra-early variety Taisia gave a stable fruit yield (18.0 t/ha) in all the variants.

In 2018–2020, the impact of the sowing scheme underwent evaluation at the experimental base of the Scientific Center for Vegetable and Technical Crops of the Ministry of Economy of the Republic of Armenia. The use of sowing schemes, 200+80/2×60, 200+80/2×80, and 200+80/2×100 cm, served for phenological and qualitative indicators, yield, average fruit weight, seed yield, and disease resistance. It was evident that with sparse plant growth (1.4 m^2), the weight of one fruit is the highest (4.0 kg), but yield declined by 11.6% compared with the control and by 19.3% in thickened crops. However, as the area of nutrition of one plant increases, the commercial yield also enhances naturally (92.3%, 94.1%, and 95.3%, respectively) in relation to the total yield (Paylevanyan *et al*., 2021).

The plant density was the most effective in this study's zone, as shown by the experimental scheme of sowing (280 cm × 70 cm × 70 cm). The yield indicators are 18.5–36.2 t/ha, the content of agricultural products is 13.3%–14.5%, the amount of sugars is 10.8%–12.7%, and the tasting score is 4.4–5.0 points. In the presented study, it was also reliably apparent that the gray soils with light mechanical composition in the pre-mountain-steppe zone of Southeast Kazakhstan proved the most suitable for melon cultivation. Based on the melon-ripening period, the fruit yield in the pre-mountain-steppe zone (sandy loam sierozem) was 18.4–35.2 t/ha against 17.9–20.0 t/ha on medium loamy chestnut soil.

Past studies under the conditions of the Astrakhan Region established that melon cultivation on alluvial-meadow, heavy loamy soils led to a usual nitrate nitrogen content in fruits exceeding maximum permissible concentrations (1.8 to 4.3 times). In melon fruits from desert-steppe, light loamy soils, nitrates were within norms. The melon grown in different agroecological conditions, with substantiated terms and sowing schemes, will provide an increase of resource-saving effect to the obtained fruit yield. Profitability at application of optimum terms and sowing schemes makes 23.0% to 25.2% on light loamy soils and 60.8%–61.0% on medium loamy soils (Sannikova, 2009).

CONCLUSIONS

Early- and mid-season melon cultivars of the European subspecies Taisia, Altynochka, and Shugyla can produce higher fruit yields on different types of soil, but the fruit quality parameters deteriorate on soils with heavy mechanical composition. Cultivars of the Central Asian subspecies mid-season melon cultivar Mayskaya and mid-late cultivar Muza can also form higher fruit yields with better quality only on soils with a light mechanical composition. The first 10 and 20 days of May emerged as the optimal sowing dates for melons. For early- and mid-season melon cultivars, the best sowing pattern was 280 cm × 70 cm × 70 cm, with a plant density of 10,200 plants/ha, while the mid-late and late-ripening cultivars showed better performance with the sowing pattern 350 cm × 70 cm × 70 cm and a plant density of 8,100 plants/ha.

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