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Boris Timofeevich Matienko and Early Research on Cucurbit Crops at the Moldavian Academy of Sciences

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Abstract. **Boris Timofeevich Matienko (1929–2004) was a respected plant anatomist and physiologist in Soviet Moldova. Matienko's research was primarily on the growth, development, and senescence of cucurbits, as well as apples, plums, and other vegetable crops. His studies provided a wealth of information to those interested in the anatomic structure of pumpkins, squash, gourds, watermelon, and minor Cucurbitaceae. Using insightful and detailed descriptions, he depicted cellular changes of the fruit during development, aging, and senescence. Practical experiments on storage corroborated his detailed microscope studies. Matienko worked during a time when the problems of the agriculture sector in Moldova were immense and varied, and he faced structural and societal challenges that underscore his scientific accomplishments. The quality of cucurbits grown in Moldova and the region improved as a result of this research. He was widely respected by colleagues and the scientific community, and his work continues to provide insight to researchers of these important crops.**

At the start of 1959, Boris T. Matienko was invited to head the department of plant physiology at the Moldavian branch of the Soviet Academy of Sciences. The diversity of fruit and vegetable crops grown in Moldova required a scientist for this role with broad interests and knowledge, who could conduct practical and fundamental research. Matienko arrived at the Academy from Tiraspol University, where he had demonstrated his abilities with research on plant anatomy and physiology of vegetable crops. At the Academy, Matienko would integrate his capabilities in plant research, breadth of knowledge, and prolific writing to become one of the great biologists of Moldova. In more than 40 years as a researcher, Matienko conducted comprehensive studies on cell structure, carpology, anatomy, development, and senescence of cucurbits and other specialty crops that are still appreciated to this day.

In the late 1940s and 1950s, agricultural science in the Moldavian Soviet Socialist Republic (SSR) was undergoing significant changes. The postwar period was characterized by shortages in supplies and other structural disruptions in the region (Borza 1963; Dinu and Rowntree 1994). This was a time ripe for research, but challenges and unrest persisted. Moldova was considered the fruit basket of the United Soviet Socialist Republic (USSR) (Sheffield 1996), and the region was extremely important for fruit, vegetable, and grape production. Biological institutes and agricultural research stations existed to serve Moldova's producers; however, research on vegetable crops was limited. Grains, potatoes, and other cash crops dominated in plant physiology, pathology, and breeding research within the USSR. In Moldova, the research focus was primarily on corn used for animal feed, tobacco, wheat, and other row crops (Lupashku 1979). Important foreign publications on agriculture in the Soviet republics made limited mention of vegetable production (Bennett 1949; Volin 1951). Even a delegation from the United States to the USSR in the late 1950s to understand horticulture production of the Union did not visit the Moldavian SSR and made no mention of their fruit and vegetable production (Rodenhiser 1959).

There were additional challenges to research in the biological fields in the USSR during this time. Funding came from a centralized location and was often limited (Ashby 1947). Planning for research topics had to be approved and could be politically motivated. Challenges to publishing freely, and the belief by some scientists in Lysenko's teachings were also present (Ashby 1947). Much has been written of the political influences of Lysenko and "Soviet pseudoscientists," which had negative effects on a generation of researchers (DeWitt 1961; Medvedev 1979). Although some fields of study were not in the spotlight, the prevalence of Lysenko's teachings had significant effects on research and scientific progress (Herr 1961). There were also structural problems in Moldova during the postwar period, including poor irrigation water quality, substandard storage facilities, and infrastructure disruptions, which made agricultural research at the start of Matienko's career more difficult. Despite these challenges, research on vegetable crops was necessary because of their importance to the region's health and economy.

Researchers in the Academy of Science department of plant physiology, including G.I. Rotaru, A.I. Ciubotaru, and B.T. Matienko, spent much time studying and developing a foundation of the specialty crops grown in Moldova. Matienko's focus was on cucurbits and they remained central to his research program. This was likely a result of their extensive use in Moldova, utility, and long history as a crop in the Soviet Union. Cucurbits are an extremely diverse group of crops that are widely cultivated for their nutritional and health qualities. There were research stations in Volgograd, Astrakhan, Rostov, Crimea, Tiraspol, and other regions of the Union devoted to the standalone branch of agronomy *bakhchevodstvo* (cucurbit growing)— the study of the production and cultivation practices of melon, watermelon, squash, and pumpkin. In the USSR, significant works from scientists such as K.I. Pangalo, A.I. Filov, N.I. Vavilov, N.E. Zhiteneva, and V.V. Arasimovic on cucurbit biochemistry, morphology, evolution, and diversity demonstrated the importance of these crops. A significant portion of this research came from Soviet Moldova, where many of these researchers worked during their careers. The semiarid continental climate, 40 to 50 cm of annual rain, and rich chernozem soils of Moldova are ideal for cucurbit production (Dinu and Rowntree 1994). Matienko was likely influenced by Pangalo, who was the head of the Moldova Institute of Irrigated Farming and Vegetable Production at Tiraspol during Matienko's tenure, and an expert in cucurbit systematics and breeding. Personal letters inviting Pangalo to seminars on microscopy of pumpkin and watermelon cell structure were warm and congenial (Dzenzelevskaja et al. 1988). The concentration of research from this period that addressed cucurbits highlights the interest and importance derived from this plant family.

Born into an educated family in Aug 1929 in Kushmirka, Moldova, Matienko attended primary school at the local gymnasium. During the war years, Matienko was enrolled at a school in Soroca and then attended university in Kishinev. He proceeded to study for his doctorate under V. Alexandrov, a respected plant scientist in St. Petersburg. Matienko developed his skills in microscopy and the study of plant development there and returned to Tiraspol University as a lecturer. He initiated the department of botanical studies at Tiraspol, and after becoming botany head in

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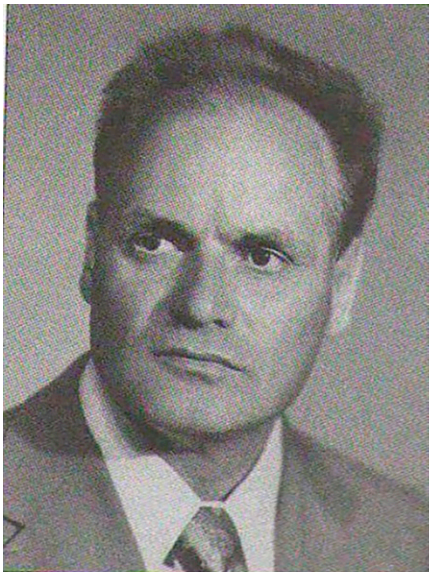

Fig. 1. Boris Timofeevich Matienko, early career. Photo reprinted with permission of Akademos, The Academy of Science of Moldova.

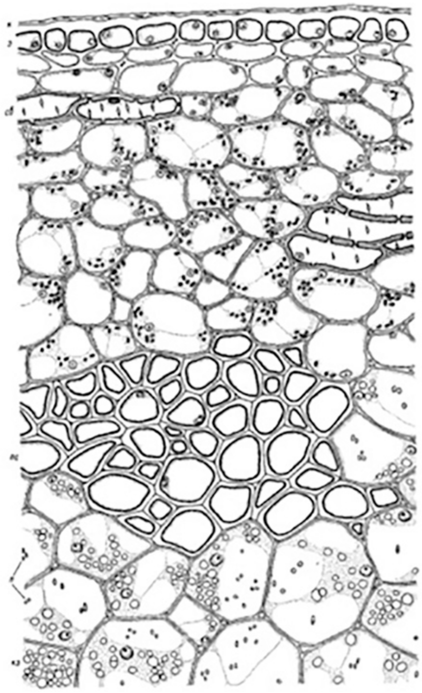

Fig. 2. Histological section showing pericarp layer of *Sechium edule*, including epidermal layer and sclerified cells. Figure courtesy of *Botanical Journal*, Russian Academy of Science. Reprinted with permission.

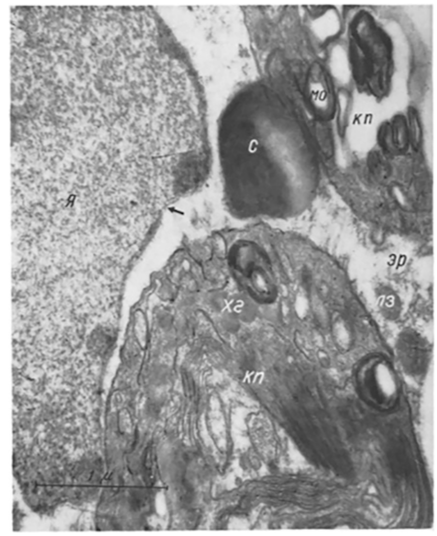

Fig. 3. Electron micrograph detailing *Cucurbita maxima* ‘Ispanskaya’ hypodermal cell after 6 months in storage. Arrow designates the membrane pore in the flattened nucleus. Я = nucleus; C = lipid globule; MO = myelin-like formation; Kп = carotene-plastid (chromoplast); XΓ = chromolipoid globule; ЭP = ergastoplasmic element; п3 = lysosome-like mitochondria. Bar = 1 μM. From the Botanical Garden of the Academy of Science of Moldova. Reprinted with permission.

1959, Matienko was invited to become a member at the Academy of Science in Kishinev (Fig. 1). He also would oversee the botanical gardens that were responsible for both research and pedagogy, similar at that time to a Western research institute.

Early works of Matienko at the Academy focused on the pericarp structure of cucurbits. With a steady hand using camera lucida, Matienko detailed carefully the histological layers of many of these crops, and sought to understand the developmental changes and differences among cultivars and species. Cucurbits offer fascinating material for study due to the multilayer pericarp and exocarp that develops adnate to the mesocarp, the many formed trichomes and stomata, lignin layers present at certain growth stages in some species and cultivar groups, and the vascular bundles that develop during fruit growth (Krasnow and Hausbeck 2016). Matienko's studies included not only the commonly cultivated pumpkin, squash, and watermelon, but also lesser known cucurbits such as *Luffa cylindrica*, *Sechium edule*, *Momordica charantia*, *Ecballium elaterium*, and *Benincasa Savi* (Fig. 2). These works were often published in the Soviet *Botanicheskii Zhurnal* (Botanical Journal). To study the cellular structure of cucurbit fruit carefully, Matienko had to fine-tune the fixatives and stains used during sample preparation. Cucurbit samples can be difficult to fix because of the formation of air bubbles and large vacuoles. Matienko tested numerous fixatives and found that 1.5% to 2% glutaraldehyde in phosphate or barbital buffer at a pH of 7 to 7.4 and a temperature of 4 °C was most effective for epidermal sections of *Cucurbita maxima* (Salinskii and Matienko 1965). He also improved the fixation of lignified cucurbit rinds by soaking them in hydrogen fluoride and ethanol solution, followed by methacrylate fixation (Matienko and Rotaru 1965). This allowed for the beautiful illustration of sections of lignified rinds of decorative cucurbit fruit.

To study cellular structure more completely, Matienko used the transmission electron microscope (TEM). Despite the challenges present in the early days of electron microscopy, especially with senescent and vacuolated plant tissues (Mohr and Cocking 1967), Matienko's works were very detailed. The clarity of his micrographs are remarkable, given that he was the pioneer in this field in the biological sciences in Moldova. The first Soviet-produced electron microscopes were not commercially available until 1945/1946 and had low resolution (Mashanskii 1967). There was no TEM in Moldova until 1958, and the original use was for the study of materials and medical images (Mashanskii 1967; Matienko 1990). The electron microscope used by Matienko and researchers of the Academy was a TESLA BS-50 or 513 A (75 kV) with 10-Å resolution, or a local model produced by Sumy Co. (Ukrainian SSR). Matienko kept a broad view of the cell, studying cellular and organelle structure, effects of processing, and developmental changes. Matienko published the first book in the USSR on plant ultrastructure, which included original research from Kishinev. Other studies observed microtubules and chromoplasts of senescing cucurbit fruit (Fig. 3). Matienko also examined the effects of fungal and viral diseases. Looking at the infection process of *Fusarium gibbosum* into watermelon fruit, hyphae were observed penetrating intracellularly (Artemova et al. 1988). After the initial flattening of host cell ribosomes, osmophilic bodies were observed forming along the tonoplast, with disruption of vacuoles before cell destruction and microconidia production.

Additional studies were both practical and innovative to aid plant breeders. Matienko cut thin slices of watermelon, and using glass plates and reflected light, improved viewing of specimens in the field, even with the assistance of stereomicroscopes (Matienko 1961). Samples of fruit tissue could be clarified further by inserting small sections into a syringe base and using manual pressure to infiltrate them gently with water. This method improved the visibility of watermelon pieces, which have large cells, intercellular spaces, and vacuoles. Cells could even be viewed whole if handled properly. The location of the carotenoid crystals that were localized around the nucleus or spread throughout the cell were detailed clearly using this technique (Fig. 4). The changes that occur in cucurbits after harvest were also of great importance to Matienko (Furdui 2009; Matienko and Kleiman 1979). Despite the infancy of postharvest research in Moldova, proper storage of these crops was significant for Moldovans midway through the century, because they were used for both animal feed and human consumption. The feed watermelons were high in pectin, bland, and could be stored for long periods. Maintaining fruit quality in storage until the new year and beyond had heightened significance for food security. The postharvest characteristics of produce were referred to with the general meaning of storability (*lëzhkost*), although this was not a set discipline. Improving postharvest quality of cucurbits with new varieties, transport containers, and methods of handling was the subject of significant research

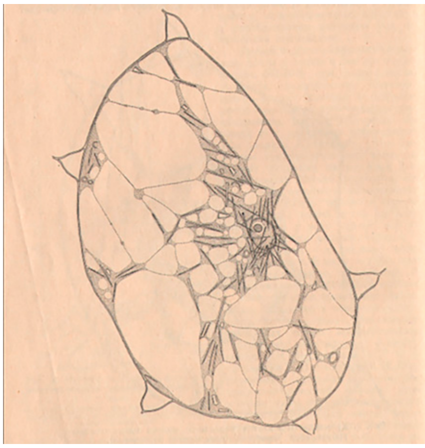

Fig. 4. Watermelon ‘Siguv’ parenchymal cell with carotenoid crystals surrounding the nucleus. Cells cleared and observed using the syringe infiltration technique. Figure courtesy of *Botanical Journal*, Russian Academy of Science. Reprinted with permission.

efforts at the Academy and in the USSR during the middle of the 20th century (Aliyev 1982; Ludilova 1962; Matienko and Kleiman 1979).

Practical production recommendations to aid growers with postharvest issues were important but not widely available in Moldova during the Soviet period. Field research was issued in the form of government-approved experiments. Extension recommendations from specialists of the Machine Tractor Stations or from within individual collective farms (*kolkhozy*) were standard during the Soviet era (Stuart 1972). From 1959 to 1969, the chairmen of *kolkhozy* in Moldova had the greatest percentage of specialized and secondary education in all of the USSR (Stuart 1972) and this encouraged Matienko to conduct relevant research. Working directly with *kolkhozy*, Matienko tested simple methods to improve watermelon storage that were both practical and economical. He showed that watermelon could be stored longer with the vine left attached to the fruit, and that optimal storage was achieved when the fruit were stored on grain (e.g., oat, pea, wheat), covered by a 3- to 4-cm layer of the grain (Matienko and Kleiman 1979). Many growers in Moldova did not have cold storage and had rudimentary storage facilities. The improvement in storage time for watermelons was corroborated with microscope studies showing that the intractable postharvest pathogen *Fusarium* could enter the fruit via the pedicel wound left after removing the vine. This work was of direct benefit to local growers working with limited access to modern crop protection products (Herr 1961; Matienko and Kleiman 1979).

During the 1960s, there was a major consolidation of farms in Moldova to improve specialization and reduce losses of specialty crops (Makeenko and Khalitov 1973). The focus in the region was on self-sufficiency. Major causes of food loss occurred during storage and transport, and were a concern at all levels, with up to 30% to 60% postharvest losses reported (Dinu and Rowntree 1994; Lupashku 1979). Many problems with diseases and pests could be more dramatic as a result of the increased quantities of produce grown (Lamont and Muravsky 1994). In addition, the transport system was still poor, and many regions of Soviet Moldova did not have adequate storage facilities. This was a concern for regional food security and the export market. Vegetable production continued to increase, with more than 1 million tons produced in the late 1970s (Filippov 1982). One goal of Matienko’s was to be able to determine the quality of produce in postharvest storage using microscopic markers, such as organelle stage of degradation. A sample could be taken and the exact stage of fruit senescence could be determined using microscopy and imputing information about the cell organelles into a computer program (Zagorneanu et al. 1993). This was a novel concept, especially as many traditional fruit quality indexes such as size, color, weight, and sugar content are still used to determine quality in storage and the appropriate harvest period.

The economic effectiveness of *kolkhozy* in the USSR was also a result in part of the processing of produce. Matienko looked at the effects of pectin, vacuole size, and cell organization on the flavor and texture of pumpkins and winter squash (*C. maxima*) in a detailed report (Matienko 1970). By understanding at the cellular level what gives the desirable pasty consistency to the cooked product, and by distinguishing the source of quality impairment such as watery or fibrous texture, research could be directed to specific horticultural aspects and improving postharvest fruit quality. In similar research, he described the microscopic structural changes of zucchini summer squash (*Cucurbita pepo*) fruit that were used as a frozen product (Matienko 1975). Comparing freezing temperatures (–20 and –60 °C), he described the mechanisms of cell damage and the starch grains breaking down and leaving vacuoles in their place. There was no damage to the cell walls, but membranes lost their original form. Cell organelles did not move significantly in the samples that froze more rapidly. Despite the differences observed, the higher temperature freeze preserved the cells sufficiently for processing purposes. Selecting varieties with smaller parenchymal cells was recommended to reduce changes in the thawed product.

Matienko was a strong administrator and led the successful implementation of the microscopy department at the Academy. He knew the importance of this tool and worked to ensure its success (Matienko 1990). Many students and researchers worked with the departmental microscopes under Matienko’s guidance (Brinzan A, personal communication). In addition to research, Matienko also taught and guided graduate students, with 17 graduated PhD students. Matienko could translate advanced topics into interesting lectures and seminars. As colleague Aleksei Spaskii (1979, p 92) noted, “[Matienko] was a popular speaker who delivered excellent lectures.” Toward the end of his career, Matienko’s publications on cucurbits decreased. He worked to design a postharvest wing at the Academy, the “Carpotron,” which was fully equipped to be able to handle all aspects of physiological and postharvest research on fruit and vegetables. This wing included controlled storage rooms, germplasm cabinets, incubators, pathology capabilities, sensory quality testing, and microscopy, all in one building. This was an integral part of research until the institute closed and relocated nearby (The Institute of Genetics, Physiology and Plant Protection, ca. 2005).

In 2004, Matienko died in Moldova. He was widely respected by his colleagues and students, especially in Moldova, Romania, and Ukraine. With more than 400 publications, Matienko’s research touched on many aspects of cucurbit growth, development, and senescence. Few researchers have published as widely on cucurbits. His reports, well written and accurate, afforded a wealth of information to those interested in postharvest physiology, development, and anatomy of these crops. In addition, he published on apples and other fruit and vegetables of significance to Moldova. The descriptions of cellular changes during development, aging, storage, and senescence are insightful and detailed.

Matienko worked during a time when the problems of plant physiology and postharvest management in Moldova were immense and varied. Vegetable growers suffered great losses as a result of pathogens, poor storage conditions, and structural challenges in society. He was fortunate, to have the backing of Soviet institutions that, despite political nuance, took research seriously and provided the necessary tools and funding when required. Matienko contributed to our understanding of numerous vegetable crops with his research, especially in fruit development, anatomic structure, and postharvest changes. His studies improved our understanding of cucurbits and other specialty crops, and led to improved quality of local varieties (Furdui 2009). The detail and insight of his works will continue to benefit researchers in Moldova and around the world.

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