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Perspective

Melothria scabra [Naudin] Provides New Opportunities for Agronomic Research

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A B S T R A C T

This manuscript attempts to bring *Melothria scabra* [Naudin] to the attention of agronomic researchers as an increasingly popular and economically important crop and to identify gaps in research that should be investigated with future studies. All relevant peer reviewed publications were examined in this study, with 79% of the studies published since 2000 c.e., while the remainder of the studies provide historical context. Major gaps in the research involving *M. scabra* offers a new frontier in agronomic studies, and will increase agronomist's knowledge of this uniquely meso-American crop species. In conclusion, *M. scabra* is an understudied crop with world-wide cultivation, and offers many opportunities for agronomists to research the genetics, physiology, and morphology of this small melon.

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INTRODUCTION

Melothria scabra [Naudin] belongs to the genus *Melothria*, which are known to be perennial creeping herbaceous plants, that have small yellow or white flowers, and membranous entire/lobed leaves (Devi & Naidu 1984). The male flowers of *Melothria* are generally in racemes, while the female flowers are either solitary or in umbels (Devi & Naidu 1984). The genus *Melothria* is often characterized by floral morphology, where male flowers that have two stamens which are 2-thecous, and one stamen that is 1-thecous (Simmons & Wilde 2000).

M. scabra is commonly known as the Chebbr, Cucamelon, Mexican Mini Watermelon, Mexican Sour Cucumber, Mini Cucumber, Mouse Melon, Pepquinos, or Sour Gherkin, and is part of a diverse family of *Cucurbitaceae* (Chomicki et al., 2020, Ittah & Kwon-Ndung 2019, Schaefer & Renner 2011). *M. scabra* is listed as a minor crop species by Chomicki et al., but has gained popularity among agriculturalists for its unique appearance and flavor (Chomicki et al., 2020). While *M. scabra* is native to meso-America, it is cultivated in Africa, Asia, Europe, and North America (Ahmed et al., 2019, Chomicki et al., 2020, Devi & Naidu 1984, Hoza 2013, Ittah & Kwon-Ndung 2019, Poot et al., 2008, Roberts et al., 2018).

Very little is known about *M. scabra* and the depth of information in scientific literature is limited. The purpose of this manuscript to review all known published manuscripts on this unique melon, and to identify gaps in the literature so that researchers can contribute to a greater understanding of this economically important food crop.

METHODS

Literature Review

Briefly, Google Scholar©, Research Gate©, and all of the North Carolina Community College System databases was searched using the key words '*Melothria'* as well as '*Melothria scabra'*. Searches were made from January – February 2022. Every manuscript mentioning *M. scabra* was considered for this study, even if they were historical in context.

Every manuscript was downloaded and analyzed for information pertaining to topics of interest, including:

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propagation, morphology, medical uses, phytopathology, genetics, and microbiology. The only manuscript that was not obtainable in its entirety was Dzevaltovsky & Zhalalov (1976), where only the abstract was available for review. All relevant manuscripts pertaining to *M. scabra* are provided in the 'Reference' section of this manuscript.

RESULTS

Propagation

Traditionally, seeds of *M. scabra* are saved from generation to generation, and hand sown in soil, but they have been shown to be propagated through hydroculture with a rooting success rate of 100% (Fira et al., 2012). After shoot cuttings were placed into hydroculture apparatuses, the roots emerged through the basal node of the shoot cutting (Fira et al., 2012). Images of the hydroculture apparatus and propagated plants are provided by the following study (Fira et al., 2012). Horticultural practices have not been reported for *M. scabra* and optimization of field or greenhouse propagation techniques has not been reported for *M. scabra.*

Morphological Studies

Historically, *M. scabra* has been used for various morphological studies. This includes comparisons of seed coat cell between members of the *Cucurbitaceae*, as well as for embryonic development, and phytolith studies (Barber 1909, Dzevaltovsky & Zhalalov 1976, Piperno et al., 2000). Dzevaltovsky & Zhalalov reported developmental characters of *M. scabra* that include: *M. scabra* has two cells within the developed pollen granule and has a dichotyledonous type anther cell wall (Devi & Naidu 1984, Dzevaltovsky & Zhalalov 1976). Phytolith morphology and descriptions of *M. scabra* was provided by Piperno et al., during their survey of neotropical cucurbits (Piperno et al., 2000). Piperno's research group described *M. scabra*'s phytoliths to be of 'Cucurbitaceae B type', which are between 26 μm and 55μm in length, and have decorated surfaces (Piperno et al., 2000). No current studies have provided a comprehensive vegetative morphological investigation of *M. scabra's* flowers, roots, shoots, or other parts. No current studies have shown different phenotypic or horticultural varieties of *M. scabra.*

Medical & Pharmacological Use

Botanicals are often investigated for their medicinal as well as pharmacological properties, and recent research into *M. scabra* shows promising therapeutic uses for this small melon. Historical studies by Fowden have shown biochemical composition within *M. scabra*, which could be useful for other comparisons in the future (Fowden 1965). Current research by Kamaruddin et al. shows the anti-oxidant activity of *M. scabra*, as well as the chemical composition of extracts from this plant (Kamaruddin et al., 2021). Preliminary research conducted by Govindula et al. suggests anti-diabetic and hypoglycemic properties of *M. scabra* (Govindula et al., 2019). Roberts at al. showed high concentrations of Arginine and Citrulline in *M. scabra*, which have been shown to have anti-cancer properties (Roberts at al., 2019). Citrulline is a non-proteinaceous amino acid that is a precursor to the amino acid Arginine, has been shown to have a high nitrogen to carbon ratio, and is often taken to improve muscle performance and recovery (Roberts et al., 2019). Other pharmacological uses of *M. scabra* include biopesticide effects against mosquitos, which are known to transmit diseases such as Dengue, Filariasis, Malaria, West Nile virus, and Zika virus (Ahmed et al., 2019). Recent research by Dinan et al. searched for phytoecdysteroids in a diverse group of plants (Dinan et al., 2019). Phytoecdysteroids are ecdysteroid mimics that are found in many invertebrate species. It is believed that plants contain phytoectysteroids to prevent predation, and might be a possible use as bioinsecticides (Dinan et al., 2019). After analysis, no detectable levels of phytoectysteroids were detected in *M. scabra* or in other members of the *Cucurbitaceae* family (Dinan et al., 2019).

Phytopathology

Just like any other plant, *M. scabra* is susceptible to a variety of diseases including: *Podosphaera xanthii* [(Schltdl.) U. Braun & S. Takam.], *Pseudoperonospora cubensis* [(Berk. & M.A. Curtis) Rostovzev], *Puccinia* spp [Pers.], *Stagonosporopsis citrulli* [M.T] (Berndt 2007, Poot et al., 2008, Rennberger et al., 2018, Rennberger et al., 2019). *M. scabra* has also been shown to be susceptible to a variety of plant viruses, including: Cucumber Green Mottle Mosaic Virus (CGMMV), Tobacco Ringspot Virus, Tobacco Rattle Virus, Tomato Ringspot Virus, Turnup Mosaic Virus (TuMV), and Watermelon Mosaic Virus (WMV) (Horvath 1985). No other diseases have been associated with *M. scabra*, and the phytopathology of *M. scabra* is generally under studied. No invertebrate associations have been reported to date, such as insects, nematodes, as well as any other members of this classification. No vertebrate associations have been reported with *M. scabra*, which leaves a large gap in the present research. Abiotic stresses as well as nutrient deficiencies have not been reported for *M. scabra*.

Genetic Information

To date, the genome of *M. scabra* has not been sequenced in its entirety, which is probably due to it being a lesser-known cucurbit. The Internal Transcribed Spacer (ITS) region of the nuclear Ribosomal DNA was sequenced by Hidayat and colleagues, and the accession number was provided from this study (Hidayat et al., 2021). While *M.*

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scabra was not the model organism for their particular study, they used *M. scabra*'s ITS region for a phylogenetic comparison. Studies by Schaefer & Renner investigated 14 different genomic regions of *Melothria capestris* [Naudin] and *Melothria sphaerocarpa* [Naudin], but did not include *M. scabra* (Schaefer & Renner 2011). Genetic regions from Schaefer & Renner's study could be used for further phylogenetic studies including comparisons with *M. scabra* (Schaefer & Renner 2011). The genetic regions studied by Schaefer & Renner include: Nuclear (*18S, ITS, 28S*), Plastid (*rbcl, matk, atpB, ndhf, trnl, trnl-trnf, rpl20-rps12, trns-trng, trnh- psba*), and Mitochondrial (*Matr, nad1*) (Schaefer & Renner 2011).

Microbiology

Except for a limited report of pathogens as mentioned above, no manuscripts have presented information about microorganisms associated with *M. scabra,* the surrounding rhizosphere, or any other association with *M. scabra*. To date, nobody has shown any mycorrhizal associations with *M. scabra*, including Arbuscular Mycorrhizal Fungi (AMF), ectomycorrhizal fungi, or endophytes. Studies presented by Ravi & Muthukumar showed that *M. scabra* grafted onto rootstock of *Cucurbita moschata x Cucurbita maxima* that was inoculated with AMF showed increased vigor, production, and quality of fruit (Ravi & Muthukumar 2019). Ravi & Muthukumar did not provide any insight into the mycorrhizal associations with *M. scabra.* This provides many opportunities for future studies into the agricultural ecology of *M. scabra*. No studies have attempted to study the bacteria, phytoplasms, slime molds, or other types of microorganisms that are often associated with plants.

DISCUSSION

M. scabra is a lesser studied cucurbit, although it is grown worldwide for food consumption, and is gaining popularity among a new generation of agronomists (Chomicki et al., 2020). There are major gaps in the research concerning *M. scabra*, even though this fruit appears in markets throughout every inhabited continent on Earth. Little is known about the genetics of *M. scabra*, the nutritional content of its fruits, as well as the microorganisms, both beneficial and pathogenic, that interact with this food crop. Future studies will be beneficial to professional agronomists, as well as to hobbyists that grow *M. scabra* on a small scale, because basic aspects of this species have yet to be elucidated.

One of the main reasons why *M. scabra* is increasingly encountered is because agronomists are looking for alternative crops to the traditional species grown for food consumption in order to increase biological diversity and support a healthy agricultural ecosystem (Chappell & LaValle 2011). While the cultivation of economically important cucurbits is well known in the United States, increasing biological diversity within agricultural ecosystems has not been a major area of focus within these conventional cropping systems. Adding *M. scabra* to traditional cropping systems can increase biological diversity in more ways than one. It can increase the diversity of crops produced within agricultural plots, but also provide habitat for beneficial insects, microorganisms, and vertebrates.

People are becoming more adventurous with their culinary preferences due to greater exposure of world cultures and an ever-increasing global marketplace (Latimer et al. 2015). As globalization continues, what was once a local economy is now a world economy. As humans migrate from country to country, and continent to continent, they want to either experience new cultures, or bring with them mementos of their own culture.

Another reason why *M. scabra* is growing in popularity is because the threat of climate change is making it more difficult to grow traditional crops in traditional ways (Schmidhuber & Tubiello 2007, Wheeler & Braun 2013). The more the climate fails to be consistent, the more agronomists will have to investigate alternative crops that might be more suited to the changing environment. The next century will be a challenging time for humans on Earth if we continue on our current agricultural trajectory. By introducing *M. scabra* to interested consumers, the market opens for farmers and allows for diversity within agronomic fields. If one crop fails to produce in a given season, the more farmers and consumers will appreciate diversity in selection at the marketplace.

The best horticultural practices have not been established, and factors that influence yield, as well as marketability, have not been investigated. There is an unlimited amount of research that can be conducted to determine what cultivation techniques are superior to other techniques (Diacono et al. 2020, Koukounaras 2020). At minimum, it would be beneficial to understand the field and greenhouse conditions that support the growth of *M. scabra*. Future studies with *M. scabra* should hone in on moisture, nutrient, and temperature minimums as well as maximums, to prepare for a changing climate. Other studies could be to select for genotypic and phenotypic traits to create new horticultural varieties.

Desperate attention needs to be paid to the microbial associations with *M. scabra*. Only a handful of fungal diseases have been associated with *M. scabra,* and it could be imagined that upwards of dozens, if not hundreds of fungi are associated with this economically important species (Berndt, 2007, Poot et al., 2008, Rennberger et al., 2018, Rennberger et al., 2019). To date, no bacterial associations with *M. scabra* of the surrounding rhizosphere has been elucidated, and this leaves ample room for future

research opportunities. Beneficial microbes as well as pathogenic organisms, should be researched in greater detail because those organisms are the most economically important aspects of cultivation of this crop species.

Bioprospecting for medicinal plants has become a trend in modern research (Coulibaly et al., 2014, Shrisha et al., 2011). While *M. scabra* hasn't gotten the attention of its larger cousins, there holds great promise for future investigation into the medicinal and pharmacological properties of these understudied plants. While limited research has shown promise in the fields of cancer, diabetes, and insecticidal research, there is much to be learned about *M. scabra.* Future studies could conduct extractions and trials involving these extractions to determine the active chemicals present in *M. scabra*. There are limitless possibilities to research the medicinal and pharmacological attributes of this tiny melon.

Only one gene of the potential tens of thousands of genes has been investigated in *M. scabra* (Hidayat et al., 2021). The genetics, proteomics, and metabolomics of this small, but flavorful fruit have yet to be investigated. This leaves major openings in the literature associated with *M. scabra*, and allows for an incredible number of studies to be completed to fill in these gaps. As the popularity of *M. scabra* increases, the need for complete genomic sequences will also increase. There will ample opportunities to make comparisons between the genome of *M. scabra* and other economically important members of this family.

All the prospects for the research mentioned above will provide researchers with unique opportunities to publish manuscripts and expand the agronomic knowledge of this miniscule melon.

CONCLUSION

M. scabra is an economically important crop species that is grown on every continent except Antarctica. It has untapped potential for medicines and pharmaceutical therapeutics, while at the same time, provides diversity to the agricultural cropping systems. Although *M. Scabra* hasn't been studied in as much detail as other cucurbits, this petite melon holds great potential for further agronomic research. Amit a fluctuating climate and variable economic markets, this unexpecting fruit could hold prospects that will enrich the lives of future generations to come.

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