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Mohammed El Faïz

During recent years my own research on the medieval Islamic economy uncovered evidence—behind the massive transformation of agricultural activities—for a true "agricultural revolution."[1] Even though this revolution was initiated in the Muslim Middle East between the eighth and tenth centuries, it only came to fruition in Andalusia during the eleventh and twelfth centuries. These two centuries constitute the "Andalusian period" within the general progress of Arabic horticulture. Sevilla, after Cordoba and Toledo became an agricultural capital and the Mekka of agronomers.

How do horticultural changes in the wake of the "agricultural revolution" relate to political and social upheavals? We have selected the historic and geographic frame of Muslim Andalusia (eighth to fifteenth centuries) to study these relationships and to unravel their interactions with science and technology.

However, the analysis of the complex phenomenon of Arabic medieval horticulture demands preliminary attention to religious, political, social, and cultural influences. As we know, such factors, in the past as in the present, are tantamount to the success or failure of agricultural innovations. Islam, Arabic language, state policy, and political decentralization constitute some of the issues that will be shown to be conducive to horticultural changes.

Once this frame has been introduced, we will turn to the scientific and technical evolution of horticulture. Botany, agronomy, and hydraulics will be shown to be emerging sciences that lay at the basis of garden art and of the new horticulture. We shall pay special attention to the first "tropicalization" of the Mediterranean Andalusia, before the discovery of America favored a second larger "tropicalization" beginning in the sixteenth century.

The Role of Agronomy: The Texts and Terminology of the Agronomists

If the number of agronomic publications contributes to agricultural expansion, the rural history of Moslem Spain from the ninth to the fourteenth centuries appears especially fecund. Indeed, during this period, six agronomic treatises were published, giving rise to an agronomic movement that extended to several cities (Toledo, Sevilla, Granada, and Almeria). Let us concentrate on the most interesting titles: *The convincing book about agronomy*, by Ahmed Ibn Hajjâj in Sevilla in 1074; *The Book*

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of the Goal and Proof, by Mohammed Ibn Bassâl (1074-1085?); *The book of Agriculture*, by Abu L-Khayr in Sevilla (eleventh century?); *The Book of the Garden Flowers and of Spiritual Walk*, in Granada by Mohammed Al-Tighnari (1107-1110?); *The Book of Agriculture in Sevilla* by Yahya Ibn Al- 'Awwam (end of the twelfth century); *The book of the Parade of Beauty and Achievements of Fruitfulness*, about the foundation of the art of agronomy, by Sa'd Ibn Luyûn (1282-1349) in Almeria in the fourteenth century. The examination of the probable dates of these agronomic publications reveals outstanding moments during a long period of continuous scientific creativity. Indeed, in a relatively short period of time (from 1074-1110), Hispano-Arabic agronomy reached its apex. In less than a half-century, four agricultural treatises came to light (Ibn Bassâl, Ibn Hajjâj, Abû L-Khayr, Al-Tighnarî). Nearly one century elapsed before Ibn Al-'Awwâm wrote his encyclopedia of rural economy. Even a longer time went by before Ibn Luyûn brought to conclusion the publication of his agricultural poem, the glittering array of Andalusian agronomists. This goes a long way to show how the ebb and tide of agronomic reflection was bound to change with the economic situation. The agronomic writers under study comprised a community adhering to the same scientific paradigm that earned its name of "Agronomic School," by which it is generally known. However, the term Andalusian agronomists, which I use here for brevity, calls for some clarification. Indeed, they are agronomists in the restricted sense of specialists in technical aspects of husbandry. However important the technical contents of their publications, it was not the sole aspect of importance. They also took into account legal and economic issues, mingling sometimes the magico-astrological tips with considerations of a botanical pharmacological or medicinal nature.[2]

The word "agronomy" comes from two Greek roots meaning "field" and "law." It indicates in its current acceptation a part or totality of the sciences applied to agriculture. The Greeks also used the word *Geoponica* to indicate all that related to land tillage. As for the Romans, they chose the narrower terms of *re rustica* and *de agricultura* in order to indicate the vast field of rural economy.[3]

One can distinguish among the Arab agronomy treatises either a narrow or a broader understanding of agriculture. The first group restricts itself to the technical activities of agriculture, thus indulging in studies of the agricultural factors of production (water, ground, manure), the description of food, aromatic plants and tree cultivation. Only on the rare occasion can we find a digression relating to the ecosystem or to legal matters. On the contrary, other works supply information about poultry, apiculture and cattle. For instance, Ibn Al-'Awwam, in the twelfth century, subscribes to this broad understanding of rural activity. The Al-Andalus world owes to this writer its first large "Maison Rustique" or the country farm. This monumental work addresses agriculture and such related activities as breeding, veterinary medicine, poultry breeding, and bee-keeping.[4] Beyond the quest for a definition of agriculture, Arab agronomists debated whether agronomy was an art (*fann*) or a science (*'ilm*). However, Ibn Bassal did not wonder whether agriculture could be based on scientific research as he adopted a normative perspective. We are especially indebted to Ibn Hajjâj for considering agricultural activity both as a trade and a science focused on the analysis of cultivated lands.

Abû L-Khayr requires that the farmer be intelligent, sharp-witted, capable of availing himself of basic knowledge relative to agriculture and determining the causes and intricacies of this activity. Ibn Luyûn adds that agricultural trade demands careful study of its four basic factors, namely: grounds, water, manures and tillage. Following along the same vocabulary, Ibn Al-'Awwâm introduced the word "art" to designate agricultural trade. The Arab agronomists were practically unanimous in seeing agriculture as a professional practice resting upon the accumulation of a specialized knowledge. Yet only Al-Tighnarî demonstrated, more so than the previous agronomists, keen attention to definitions and agrarian vernacular. With him,

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agronomy reaches scientific accuracy and encompasses all of the rules and laws that apply to the improvement of any agricultural land. He doesn't forget, however, to mention how pleasurable for the eyes it should also be. Thus, when discussing agriculture, Hispano-Arabic agronomists defined and specified the contents of a comprehensive agriculture, integrating various aspects of rural economy. Such discussions do not reach for pure speculation, but rather seek to locate clearly agriculture among human activities. Following in the agronomists' footsteps, Ibn Khaldûn defines agricultural science as a branch of physics concerned with the production of food and grain. Abû L-Khayr Tashkoprozada (d. 1554), a turkish scientist, chooses the same classification, but gives agronomy a definition and a specific responsibility: it must not only ensure the growth of cereals, fruit trees, or other plants, but also must constitute a vital contribution to human life. It explains why its name *Al-filaha* derives from the root of the word *falah*, meaning perenniality. It also comprises, concludes this author, curious activities like the production of out-of-season fruits and of new varieties resulting from grafting.[5]

This conclusion provides the link to horticulture, an important topic in the teaching of Arab agronomists. Ibn Al-'Awwâm devotes a large part of its treatise of agriculture to garden art, fruit trees, cultivation, herb and kitchen gardens, aromatic and sweet-smelling plants, naturalizing and grafting. However, we have to wait until the publication in 1943 of the dictionary of agricultural terms by Moustapha Chehabi to find a scientific definition of horticulture considered as *bastana*, or garden culture, with all its developments (floriculture, kitchen gardening, fruit-growing, arboricultural, and ornamental trees).[6]

Social and Cultural Sources of Expansion Within the Arab World

Let us first review briefly some development factors that apply to the whole of the Arab world: first, the role of Islam that made a single religion and literary and scientific language into a source of unity for huge countries until then either insulated or fractured by internal war; second, the role of Arabic language spoken by all people from Baghdad to Cordoba that allowed the circulation of knowledge; third, the role of the Islamic State in disseminating the use of Arabic, translating important texts into Arabic, financing of academies, research teams and libraries, and supporting efforts at economic development.[7] In this context of cultural opening and voluntarist intervention, agriculture engaged in changes characterized by the improvement of farming methods and the development of horticulture. The latter appears more and more dependent on urban growth and demand issuing from cities that became, in the Middle Ages, windows for commerce and opulence. On top of these common development factors, the Al-Andalus region went through a rather original political situation, marked by a succession of centralization and decentralization of power. Although it is still difficult to determine the exact role of these political changes, the period of domination of the Tayfa kingdoms succeeded, it seems, in promoting competition between the larger Andalusian cities and stimulating horticultural progress in their garden-suburbs. Al-Andalus thinkers also singled themselves out, providing an interpretation of Islam favorable to agricultural and horticultural development. Agronomists, living in a context of economic growth, had no difficulty extracting from the corpus of Muslim legislation the recommendations necessary to the development for agricultural productive forces. In an effort to establish an ethnic construction conducive to the progress of rural economy, they called as well on tradition coming from the Prophet as Arabic pieces of advice and proverbs. The whole work offers a methodical presentation of recommendations and advice concerning various aspects of agricultural progress. In this study, we will only point to pieces of advice geared to encouraging tilling or to ensuring better farm-management. Al-Tighnarî and Ibn Al-'Awwâm gather a number of hadiths (sayings attributed to the Prophet) that set agricultural activities in a favorable light,

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signs pointing to the constitution of a well-structured hydraulic administration accumulate. Starting in the late eleventh century, one can even speak of the formation of an Andalusian school of hydraulics, not only able to continue the development of the hydraulic infrastructure built during the former centuries, but also to send experts to other areas of the empire. There is at present a large number of studies devoted to hydraulics in Moslem Spain demonstrating both surface and underground water control. Arabs, as soon as they settled in the Iberian peninsula, succeeded in marshaling out river waters for the benefit of irrigation mills and drinking water for the new cities. Dams became, in this context, a major regional development. After the study by Norman Smith, the contribution of the Moslem world and Al-Andalus to the history of dams became relatively well known.[12] In this domain, Moslem engineers could easily tap into the knowledge accumulated in the regions at the heart of innovation and hydraulic engineering since high antiquity, thanks to the vehicular role of the Arab language. The ideas eked out on the Tiger and Euphrates banks could thus quickly reach the most western part of the Moslem world (Sicily, North Africa, Andalusia).

The oldest dams are found on the Guadalquivir River. Arab engineers developed both the technique of the derivation dams and that of weirs (gravity dams). Smith quotes the multiple functions of the Cordoba dams setting mills into motion, protecting the city against floods, providing it with drinking water, and so on. Less spectacular dams were built as well in Valencia, Murcia, and Granada. Archaeology also documented some weirs in the provinces of Jaen and Almeria. All of these dams, linked to a wide and complex network of seguias (canals), provided the main transport and distribution system of water for irrigation. These irrigation channels fitted with more or less sophisticated dispatching devices also provided for water mill operations. We also observe, besides these devices, the use of aqueducts and siphons for overcoming terrain difficulties. Beyond accumulation, transport, and distribution of water, the implementation of mechanical devices set Al-Andalus hydraulics apart from the rest of the Arab world. Textual and archaeological evidence demonstrate widespread use of waterwheels (*Norias*), the scoop-wheel (*saquiya*), or chain of pots, and the other hydraulic systems, such as *shadufs*. But the exploitation of underground water only reached a climax with the adoption of the Persian technology of *Qanat* (underground drainage galleries), introduced in Madrid at its foundation in the ninth century, which gave the impression of a city built on a fresh water sea. The study of *Qanat* is sufficiently advanced today. Mr. Barcelo and his team recently emphasized the great achievements in Majorca, where the network of collecting galleries reached its highest density. The upheavals brought by new water technologies reached beyond the plains and *huertas* (garden-suburbs), mountain zones, where the Arabo-Berber settlers introduced and developed terrace cultivation.[13] Such was, in outline, the course of progress of Andalusian hydraulics at the origin of new horticultural advances.

Diffusion of Plants and the First "Tropicalization": Botany and Garden Art in the Service of Horticulture

The Caliphate of Cordoba (929-1031) stands out as a period of medical, pharmacological, and botanical progress. Historical-biographical sources elicit the presence of botany and horticulture among the new branches of knowledge. Scientists' biographies often refer to the occupations of botanists *(nabâfi)* and horticulturists (*shajjâr*). The development of botanical knowledge in Andalusia was stimulated at its beginnings by travels to the East, reading of the *Treatise of Plants*, by Al-Dinawari (d. 895), and the translation from Greek to Arabic of the *De Materia Medica* by Dioscorides. A team of Moslem, Jewish and Christian scientists collaborated on this translation which was published in 948 and followed by a large number of revisions and

hundred hectares of orchards. The *Bouhayra* of Sevilla was built in 1171 by Abû Yaqûb Yûsuf. The size of this garden-making activity is striking. Hydraulic mastery allowed growing and rearing of tens of thousands of fruit and decorative trees.[16] Alongside the royal gardens the countryside gardens contributed to scientific activity. Allow me to pinpoint here that the variety of pomegranates, imported from Syria, was initially acclimatized in an agricultural village in the district of Rayyah (near Malaga) before being sent to the garden of the Al-Rusâfa Palace. Its name perpetuated the memory of Safar who was at the origin of its acclimatization and appears as a pioneer with respect to horticultural experimentation. The Aljarafe was one among a whole series of experimental stations that spread throughout Andalusia and brought about an agronomic revival and botany between the eleventh and twelfth centuries. Thanks to its natural assets and the vicinity of a large urban metropolis (Sevilla), this region became a center for horticultural research.[17] The plants that migrated from the Eastern parts of the Islamic world toward its most Western parts were numerous and varied (rice, sugar cane, cotton, banana tree, saffron, eggplant, spinach, watermelon, etc.). The sugar cane and the banana tree, for instance, were acclimatized along the Mediterranean coast of Andalusia, from Almeria to Gibraltar. In these warm and mild regions of Al-Andalus the Arabs could, thanks to their hydraulic mastery, carry out the first "tropicalization" in the history of Southern Europe, before the discovery of America would facilitate a second more diverse tropicalization.[18] Historical and geobotanical sources enable us today to better grasp this process, seemingly starting in the tenth century, that led to the creation of a tropical "environment" on an area ranging from the Mediterranean coasts to the valley of the Guadalquivir River.

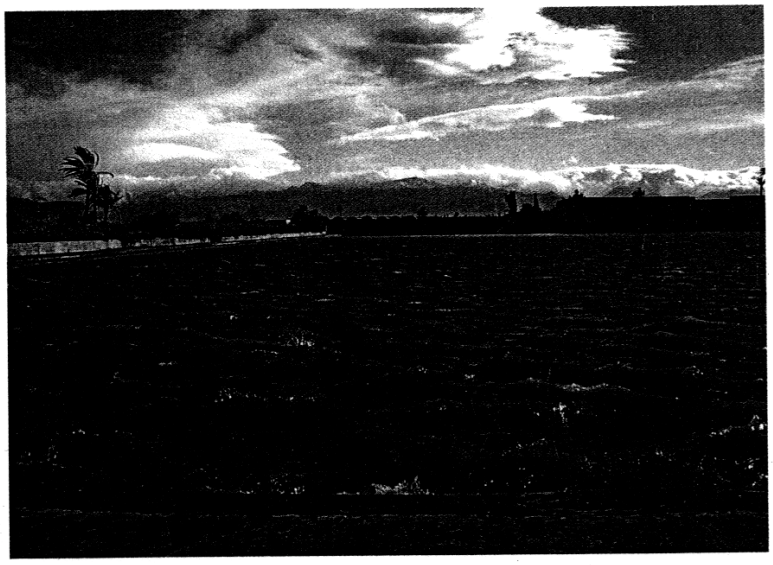

Fig. 1. Grand basin at the *Agdal* in Marrakech, also know as the "Bouhayra" or "Little Sea".

Classification of Trees and Citrus as "Sour Fruits"

Hispano-Arabic agronomists and botanists did not limit themselves to the description of the species of citrus. They also sought to integrate citrus fruits in a methodical classification. Ibn Bassâl succeeded at the beginning of the eleventh century, in classifying trees into four groups called the "mother of genres" (*ummahat Al-ajnas*): oleaginous trees (olive tree, common bay-tree, the Ben, lentish pistachio tree); gum trees (peach, apricot, almost trees); milky trees (fig, oleander . . .); and aqueous trees (apple, pear, quince, pomegranate, vine . . .). The author distinguishes, in addition to these capital classes, a fifth one, comprising evergreen trees with aqueous sap. Some of these trees, such as the pine and cypress, share gum tree features, others, such as the lemon tree, share aqueous tree features; and still others like the lime tree share oleaginous tree features; finally others like the rose laurel share milky tree features. Abû L-Khayr, who adopted the same system of classification, added to oleaginous

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Fig. 2. "Citron" from the ancient citrus fruit collection in Marrakech.

trees the oleander, the terebinth and the walnut tree; and the ficus sycamore, the caprifig tree and the mulberry tree to milky trees. Ibn Al-'Awwâm, building on the expertise of contemporary horticulturists, further refined the taxonomy worked out by his predecessors. He divided the aqueous trees into two categories: trees with heavy water (olive tree, common bay tree, oak, myrtle) and trees with light water that lose their leaves in winter (apple and quince trees, vine, pomegranate . . .). These texts thus outline a rational classification of trees (and more particularly citrus fruits) based on sap properties. (Fig. 2) Following this principle, Andalusian agronomists not only succeeded in integrating the various species of citrus in the kind of aqueous trees, but distinguished between those with purely liquid and those with oily sap.[19] It is worth nothing that G. Gallesio could, in the early nineteenth century, recognize in the writings of medieval Arab scientists the designation of citrus fruits by the common term of "acidic fruits." Contemporary information corroborates this fact. The agronomic treatise, by Ibn Luyun, composed in 1348, makes explicit reference to the species of citrus trees (lime, south orange tree, lemon tree, zanbu) as "sour fruit" trees (*dawat Al-khulul*). This discovery authorizes us to establish a link with the generic term "*agrumi*" (from the arabic radical for "sour," khal) that appeared in Italian in the sixteenth century. However, it is only in 1922 that Gallesio's wish came true and the word "*agrumes*" was adopted in French. Today, citrus fruits are still called in Arabic by their common name of "sour fruits" (*hawamid*), harking back to the middle ages. [20]

Citrus: Transplantation, Environmental Accommodations, Nurseries, Grafting and the Various Uses of Oranges and Lemons in the "Citrus Mania"

In the Middle Ages, generations of Arab agronomists and horticulturists met the challenge of transporting and transplanting various species of citrus from the Asian monsoon climate to the less lenient Mediterranean one in moderately dry and semiarid areas. How did this transfer take place? And, especially, on what ecological knowledge did the men engaged in the citrus fruits ventures rely on, not only to ensure transportation of unknown species, in the Western Muslim world, but to achieve an even more difficult acclimatization? Arabic geographers and historians account for various attempts (ninth and tenth centuries) at acclimatizing in the East new varieties either of citron tree (round citron) or of Seville orange. These attempts ended in half-failures in localities probably insufficiently prepared to receive them. Further inquiry into the causes of these half-failures always reveals a lack of attention to ecological factors. Given the major difference between the climate to the West and East of the Mediterranean sea—less rain fall that came mostly during the months of vegetative rest, long summer drought, and dangerous

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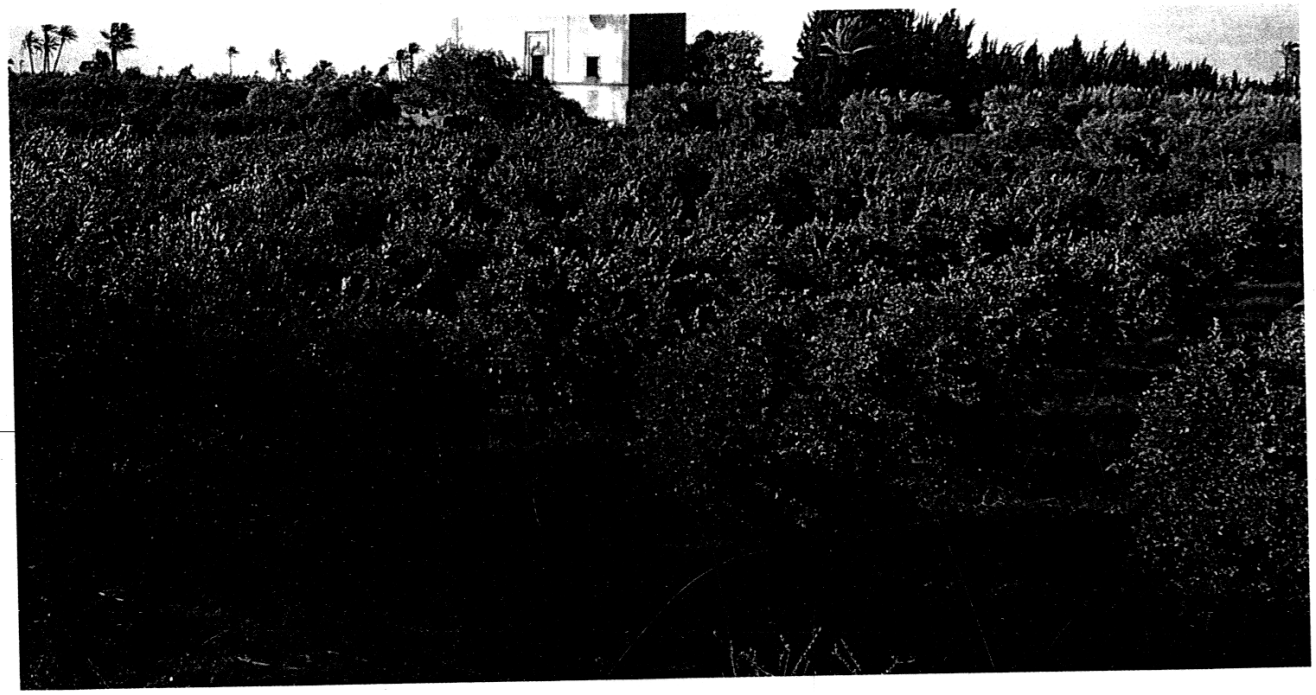

Fig. 3. "Tank of Dar al-Hana" (or Resting Pavilion) in the *Agdal* garden in Marrakech.

cold periods (especially in Andalusia)—numerous transplantation failures could be expected. Such would have been the case if the Andalusian agronomists had not elaborated from the very beginning an adequate system of information on citrus fruits ecology. Ibn Bassâl, an agronomist well informed of the environmental circumstances of Eastern agronomy, established the basic premises for citrus fruit ecology. Taking stock of the seven climate areas that the various species of citrus can thrive in, he identified the third climate (India, China, Persia, Iraq, Syria, and North Africa), and noted that their culture is practically excluded in the fourth climate (France, Northern Spain, Roman provinces). Abû L-Khayr recommended avoiding mountainous areas for the lime tree and Seville orange cultivation because "if one plants them in these regions," he says, "they will not be very productive and will fail more rapidly." Elsewhere he adds that "The citrus owes its life to water." This sentence expresses in a pithy way an awareness of new ecological realities, in which citrus fruit trees demand an artificial cultivation to which men must provide as much water as possible. (Fig. 3)

To protect citrus fruits against freezing and the cold, enemies no less dangerous than drought, Andalusian agronomists recommended sheltering them with plaits and covering their feet with leaves and ashes of courge. To succeed in cultivating the new species of citrus and other water-demanding plants, the Arabs of the Western world launched into a huge endeavor for the mastery of river and underground water. But this leap would not have been thinkable in the absence of some initial understanding and capacity for control of the new plants' ecology. Arabic historical sources generally mention transportation of citrus seeds from one place or one country to another. This is probably the privileged form, although not the only one, through which citrus fruits traveled from East to West in the Muslim world. Hispano-Arabic agronomists contribute to the

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Fig. 4. "Citron Tree" from the ancient citrus fruit collection in Marrakesch.

improvement of the methods of selection and multiplication of the various aspects. Their teaching embraced all phases of citrus fruit tree cultivation from transportation up to tree-fructification and product transformation. Ibn Hajjâj must be credited with clarifying the terminology of nurseries and their function. The word for nursery "*Al-tarmidanat*," is borrowed from Yunius, who claims it is derived from a Greek word. It applied to places where subjects are first planted before they are taken away and replanted elsewhere. There cannot be a better definition for nurseries that remains: a place where young plants are grown before being transplanted. From an agronomist's point of view, the nursery is twofold: the seed bed and the nurturing bed for cuttings and young seedlings. Pips are first raised in newly made clay pots (*qasari*) or large pots with a hole in the bottom. The transportation of the citrus pips is forwarded directly to these pots or large clay vases. But, before engaging in plant propagation, one should find a site and prepare the nursery. The nursery for citrus fruits must be established on a piece of ground uncultivated for at least two years. It must, moreover, be very well protected from winds. The use of special tools, smaller and better suited to the care of young seedlings often laid out in tight rows is also recommended. The multiplication of citrus fruits by sowing of seeds is certainly "good and efficient" as explains Ibn Bassâl, but it takes too much time, hence the use of cuttings. Several ways of transplanting from nursery to orchard were experimented with; when the plant could not be removed with all its roots, horticulturists used cuttings by bed (*takbis*) and of cuttings out of pot or funnel (*istilaf*) for their transplantation. Grafting was employed both to multiply and to improve the various citrus varieties. Often graftings were transported from one country to another or covered great distances between two regions. For the voyage, the grafting shoots were stored "in a vase with a narrow opening that had never contained oil, but only salt water before this use." The graftings were placed dry in these vases and locked up to prevent being harmed by the wind.

It is likely because of these precautions that citrus graftings could make increasingly long voyages and spread more quickly to new grounds. Besides farming technique progress, Arab citrus cultivation developed in the Middle Ages a practical sense of nurture. The agronomists' teachings provide for each variety of citrus a kind of technical guideline containing all of the useful elements relative to the choice of soil, tilling method, manuring, irrigation, and shearing size of citrus fruits.[21] Thanks to the progress of horticultural techniques, Muslim Spain during the eleventh and twelfth centuries went through a kind of citrus mania, similar in intensity to the "tulipomania" that seized Dutchmen a few centuries later (seventeenth century).[22] Arabs at this time engaged in horticultural luxury, cultivating citrus fruits not only for using their fruits, barks, and pips, but also for

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decorating and embellishing their gardens. (Fig. 5) The number of known uses of the different citrus varieties defies the imagination. Nabatean agriculture reckoned with twenty-one uses of the citron tree: thirteen for its fruit, six for its leaves, and two for its branches and roots. The Sevilla orange tree was appreciated for the beauty of its foliage, the quality of its juices and syrups, the fragrance of its flowers used to manufacture perfumed essences, and for the use of its bark in medicine. An anonymous botanist of Sevilla (eleventh century) wrote the first description of lemonade and showed the value of lemon essence to treat "cold illnesses," especially those striking fishermen and navigators. Yet the most complete description of the various uses of lemons is to be found in the *Treatise of Lemon* by Ibn Jami, translated as of 1602 into Latin. This fruit described six varieties of drinks, ranging from sweetened lemonade to lemon liquors and vinegars.[23] Uses of citrus fruits spread and diversified so much that all means to multiply them and improve their production were sought. This fever that we call the "citrusmania" could only be alleviated by creating gardens used not only for acclimatization places, multiplication, and amelioration of citrus fruits, but also as places where the creative imagination of Arab agronomists and gardeners could indulge in the quest for the strangest grafted trees, for fruits with extraordinary forms and for ornamental uses of the different citrus species and varieties. Botanical gardens, beginning in the eighth century, sponsored by huge fortunes and stimulated by a deep desire to propagate the new plants, provided the initial impulse. These gardens demonstrated possibilities that spread like fire to the social elite first and later to an increasingly broad population that could not resist the temptation to propagate citrus fruits in their gardens, and even later the courtyards of modest dwellings.

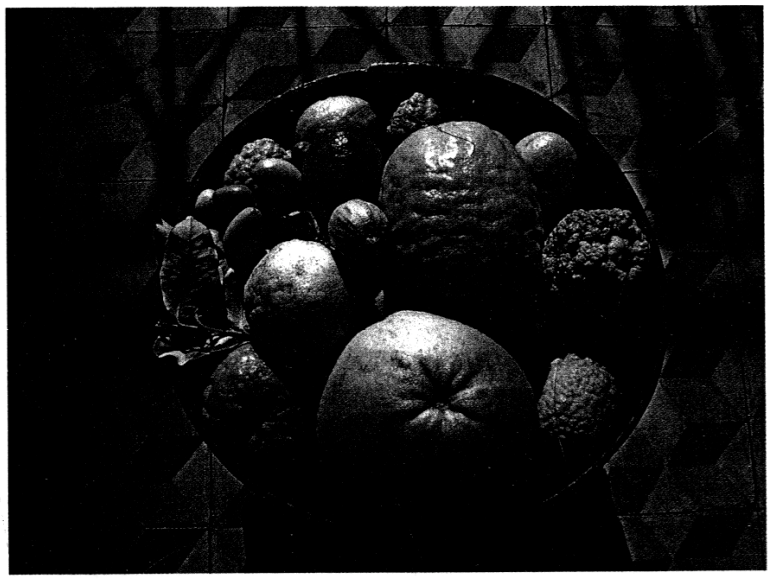

Fig. 5. Ancient citrus fruit collection, Marrakech.

Conclusion

Reaching the end of this study, we can gauge from the topics covered how much the history of horticulture would gain from being reexamined. Can we think today of the Mediterranean world without its citrus landscapes, sugar cane, and rice plantations? Can we imagine it without the innumerable plants that the Arabs introduced in the south of Europe (Andalusia, Sicily) in the Middle Ages? Yet these horticultural changes did not prevail without conflicts and resistance. These innovations grew to such an extent that they did not fail to stir opposition not only from traditionalists, but also from some scientists. Al-Tighnari, the most brilliant agronomist of Granada, fell prey to the folk superstition that attributed all the misfortunes of Andalusia in the eleventh century to the propagation of the Sevilla orange tree. According to him, whenever it grows it brings

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only ruin and desolation to its owners. Yet he was the author who wrote with the greatest competence about citrus cultivation. Superstitions about the Sevilla orange tree in Al Andalus in the eleventh century call to mind the misfortune of the potato in sixteenth-century Europe. The plant of American origin will be made responsible for all evils. We may come to believe that all of these resistances of a psychological and mental nature are the tribute that horticultural innovations must pay, throughout history, to succeed in changing food practices and our cultural landscapes.

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NOTES

[1] Mohammed El Faïz, "La révolution agricole dans l'Espagne musulmane est-elle mesurable?", in *Histoire et Mesure*, vol. XIII, 1998, édition CNRS, Paris; A. M. Watson, *Agricultural Revolution in the early Islamic World* (Cambridge University, London-New-York, 1983).

[2] Mohammed El Faïz, "L'apport des traités agronomiques hispano-arabes à l'histoire économique d'Al-Andalus," in *Ciencias de la naturaleza en Al-Andalus. Textos y estudios* III, ed. Expiración Garcia Sánchez (Granada: Consejo Superior de Investigaciones Cientificas [CSIC], 1994), 406.

[3] Victor-Donatien de Musset Pathay, *Bibliographie agronomique* (Paris: édition Colas, 1810), 97.

[4] El Faïz, "L'apport des traités agronomiques hispano-arabes à l'histoire économique d'Al-Andalus," op. cit. 412.

[5] Ibn al-Awwâm, *Le Livre de l'Agriculture, trans. J.J.* Clément-Mullet, revised edition with an introduction by El Faïz (Arles: Edition Actes-Sud, 2000), 15.

[6] L'Emir Moustapha Chehabi, *Dictionnaire des termes agricoles arabe-français* (Le Caire: Imprimerie Misr, 1957).

[7] Ahmad Y. al-Hassan and Donald Hill, *Sciences et techniques en Islam, trans.* Hachem el Husseine (Paris: Edifra, UNESCO, 1991), 7-9.

[8] El Faïz, "L'apport des traités agronomiques hispano-arabes," op. cit., 416-17.

[9] Ibid., 419.

[10] El Faïz, *Histoire de l'hydraulique arabe* (Paris: Actes Sud,, 2005), 317.

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[21] *Il Giardino Delle Esperidi*, op. cit.118-21.

[22] D. Onno Wijnands "Commercium Botanicum: the diffusion of plants in the 16th century," in *The Authentic Garden: A symposium on gardens*, op. cit.,79.

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