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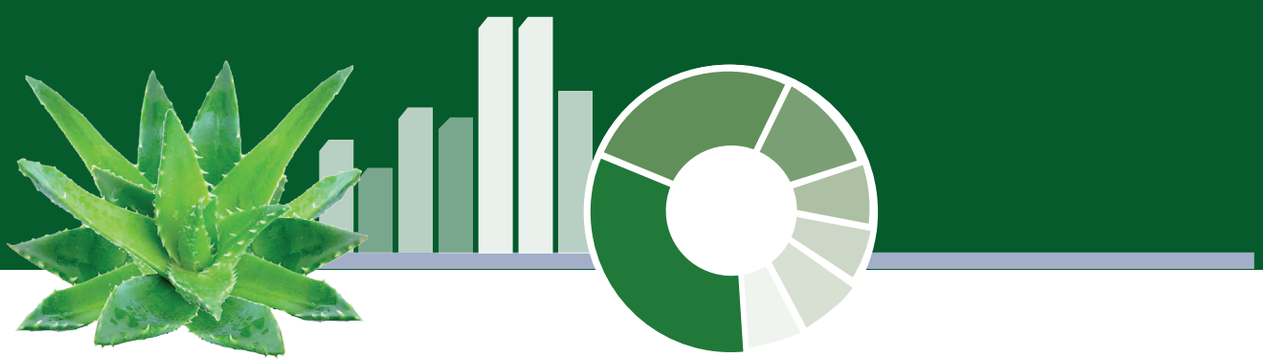
Report

AGROECOLOGICAL AND BIOCULTURAL ANALYSIS OF AGRICULTURAL SYSTEMS IN JORDAN



SMALL FARMERS

ALOE VERA

Jordan

John Paul II Foundation
for dialogue, cooperation and development - Onlus

FONDAZIONE GIOVANNI PAOLO II ONLUS

REPORT
AGROECOLOGICAL AND BIOCULTURAL ANALYSIS OF AGRICULTURAL SYSTEMS IN JORDAN

Edited by: Giuseppe Russo, Marco Ciolfi, Marco Lauteri National Research Council (CNR), Research Institute on Terrestrial Ecosystems (IRET)

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John Paul II Foundation Projects Department

The Foundation, with funds of the Italian Agency for Development Cooperation, coordinates a network of high-profile academic partners: from scientific research area, largescale distribution and national and international institutions, relies upon the work of a qualified team of economists, agronomists and market experts. It promotes a partnership-based approach supporting small farmers in reorganizing their production in a quality-oriented perspective to favour access to international markets.

REPORT AND GUIDE LINES

Guides and Reports Small Farmer is a series of publications edited by the John Paul II Foundation Projects Department, which aim is to contribute to the knowledge and diffusion of the results obtained by the scientific-technical partners over their activities of technical assistance in the economic development and social inclusion programs of rural areas. The series is aimed at a systematisation of both, the theoretical and methodological aspects, in order to support their replicability and it's intended for small producers, cooperatives, agricultural enterprises and stakeholders.
The Guides and Reports share a precious scientific-technical know-how and they are intended to promote the human, social and economic development in the most disadvantaged communities around the world, thus supporting the fight to poverty.

Report. This series aims to present the main outcomes and outputs of the researches and analysis elaborated within the project, reporting also the methodology applied. It is a summary of the documents produced by all the experts and research institutions involved. The aim of the document is to make the strategy known and to give clear indications for its replicability and dissemination of the results to all interested beneficiaries. At the same time, it intends to offer a complete summary document to systematize the information and make it clearly usable to all partners and relevant stakeholders.

The others series:
- Guides
- Systematisation documents.
- Product promotional brochure

SMALL FARMERS Quality Management System

The Quality Management System is a system of quality standards applied to agricultural production from plant cultivation to post-harvest management.
The QMS is part of an overall framework direct to promote synergies among several products as, from plant Dates, Cherries, Apricots, Aloe vera and to foster network and cooperation between Small Farmers engaged in the application of a re-organization strategy.
The QMS is based on:

- An agroecological production approach promoting a Quality Management System, which focuses on product quality enhancement to respond to the international market demand while protecting the delicate balance between trees and surrounding ecosystem.
- The promotion of cultivation-related traditions and local plant varieties, ensuring delivery of a high-quality and sustainable product.
- Ethical principles to enable inclusive and efficient agricultural system for farmers and workers involved in the value chain, which aims to provide support for access to more profitable markets by promoting economic and social development in the most disadvantaged communities.

01 BIBLIOGRAPHIC RESEARCH

1.1 Botanical and plant physiology aspects

Aloe vera L., sinonym: Aloe barbadensis Miller; order: Liliales, family: Asphodelaceae, is a succulent, aromatic and officinal plant, whose biologically active products are used in cosmetics, pharmaceuticals and food production (Chandegara and Varshney, 2013).

From a botanical point of view, aloe is a xerophyte (Rahda and Laxmipriya, 2015), characteristic of subtropical or temperate climates; it grows in South-East Africa along the river Nile and it was introduced in North Africa and in the Mediterranean countries by ancient civilizations before the V century BC, as in 4000 B.C. it had already been painted on the walls of some Ancient Egypt temples. It is a thermophilic species, sensitive to cold. Each plant usually has 12-16 leaves that can reach a weight of 1.5 kg and a length of 25-30 cm, while the central juvenile ones measure 3-10 cm. The leaf margins are indented and aculeate. In dry-humid tropical climates, A. vera blooms from October to January, with inflorescences that range from yellow and orange to red. The development of the fruits, which contain many seeds, takes place from February to April. Its propagation is basically vegetative and the plant has a life-span of about 12 years.

A. vera does not have high water requirements and is a good choice for hot areas with drought problems (Manvitha and Bidya, 2014). However, although economically attractive, the processing of aloe requires high technical skills and specialized work. Generally, the leaves harvest begins when the plant is 4-5 years old, although it is also possible to have a first crop after 7-8 months from the planting.

Aloe produces two types of exudate: a reddish yellow one ("aloin"; Manvitha and Bidya, 2014) from the pericyclic cells under the cutinised epidermis of the leaves and another one from the tubular thin-walled cells in the central part of the leaf, that is the aquifer parenchyma. The first exudate is a laxative, it can be used for sunburns and as an immunostimulant (source: research conducted by the University of Padua since 2000). The second one, a real transparent, mucilaginous, tasteless and odorless gel (Pal et al., 2013), is not a laxative because it does not contain anthraquinones but it is rich in vitamins (Lissoni et al., 2017; Sanchez-Machado et al., 2017). This gel, also called pulp, is mostly used for several purposes thanks to the medical effects of its polysaccharides (Rahda and Laxmipriya, 2015).

Like all species in its family, A. vera is characterized by leaf succulence, acid metabolism of crassulaceae (CAM), and the presence of a thin, waxy cuticle, all of which are common in plants with "succulent plant syndrome" (Grace et al., 2015).

1.2 Ashemite biogeography

Jordan is characterised by four distinct biogeographical zones: Mediterranean, Irano-Turanian, Saharo-Arabian and Afrotropical (Amr et al. 2004).

Since the Neolithic age, these areas have been very rich in wildlife as evidenced by the images on the walls of some historic palaces on the borders of the desert and in some churches (see Madaba ones). Even if we do not know much about the relationship between man and nature in the Neolithic age, in the previous 14 centuries of Arab-Islamic civilization it is possible to have relevant information on the importance recognized to natural resources. In fact, Islamic religion and culture paid so much attention to the preservation and conservation of nature, that they took in the concept of hima (conservation system) from pre-Islamic societies. The word hima means protected or forbidden. Hima is a resource protection system in line with pre-Islamic and Islamic culture, in which the use of pastures, crops and forests could be denied by the owner (Irini et al., 2013).

1.3 Nature conservation

In the last 40 years, the importance of the natural environment and its ancient and beneficial relations with men, has led the Jordanian authorities to launch a series of initiatives for the conservation of nature. Not surprisingly, until the 70s, Jordan had not undergone any particular environmental emergencies. However, the demographic increase and modernization of the country have led to an overexploitation of natural resources. But then the surge in the use of water resources brought to the beginning of a crisis whose problems and effects still persist (Hadadin and Tarawneh 2007). Even if today Jordan can boast at least 27 non-governmental organizations (NGOs) with objectives of conservation and protection of the environment, only the Royal Society for the Conservation of Nature (RSCN) has a full mandate from the Government of Jordan. In particular, the RSCN is concerned with a) strengthening the laws on nature protection and the Convention on International Trade in Endangered Species (CITES) and b) monitoring and controlling the hunting activities.

The Jordanian Government, through the work and supervision of the Ministry of the Environment (MOE), is a model for the other Arab countries of the Middle East and has participated in 33 international conventions as well as 3 regional ones. Moreover between 1946 and 1992, it has established 23 Reserves inclusive of important desert, pre-desert, grassy and forest biocenosis, among which the Dana Nature Reserve and that of Mujib stand out; others are still being proposed, like some high-naturalness areas in the Governorate of Feifa. An acceleration of conservation activities has resulted from the extinction or alarming decrease of animal and plant species. The Reserves have therefore carried out programs of reintroduction and protection of endemic or naturalized species, also starting a collaboration with local agencies as in the case of the RSCN. Both these actions and attentions have made it possible not only to sensitize the local populations but also to improve their living standard and quality of life.

1.4 Scenarios and potential of the Aloe supply chain in Jordan

The interest in A. vera is shared by both the scientific community and global industry, as demonstrated by the existence of an International Aloe Science Council (IASC;www.iasc.org). Although A. vera is cultivated in many countries, at a commercial level Greece and the Middle East have become important players, both as areas of cultivation and development of the production processes. The aloe leaf mesophyll was first marketed in the 1930s in the United States. In 2004 the trade of aloe extracts on a global scale was worth 125 million US$. Today this turnover exceeds 300 million US$, with an annual increase of about 35% (Grace, 2011). Globally, according to IASC, about 24000 ha are used for the production of aloe.

It is important to know that Aloe vera is a worldwide sustainable cultivation and it is not mentioned by CITES (Convention on International Trade in Endangered Species) as vulnerable species unlike other species classified in the Aloe genus.

In particular, even if there are several standards of production, Aloe vera has always been cultivated following management criteria that are compatible with or similar to those adopted in organic farming. In fact, this species has few natural predators and parasites, it is resistant to many cryptogams if cultivated in suitable conditions and can grow naturally without the use of pesticides.

The association JEPA (Jordan Exporters and Producers Association for Fruit and Vegetables) and RSCN (Royal Society for Conservation of Nature) as well other local actors in Jordan, will have to carry out a productive and commercial policy able to create sustainable realities from a productive and environmental point of view, as it actually happens in other production areas in the world. The main standards of organic certification are: USDA-NOP (National Organic Program); European Union Organic Farming Program; COR (Canada Organic Products Regulations). Other relevant certification bodies are: CCPB, a certification and control body for agri-food products and "no food" in the field of organic, eco-friendly and eco-sustainable production; Bioagricert, recognized by the EU as a Control and Certification Body.

02 PERFORMED BIOCHEMICAL, BIOCULTURAL AND AGROECOLOGICAL ANALYSES

1.1 Phyto-ecological analysis of Aloe vera in Jordan

According to experts from the Herbarium of the University of Yarmouk (HKJ) and the Royal Botanical Gardens of Kew (UK), A. vera is present in the Wadi Musa, at the ancient ruins of Petra (Taifour and El-Oqlah, 2017) in the Governorate of Ma'an. A visit to Petra allowed to verify the actual presence of numerous specimens of A. vera grown in nursery for decorative purposes. However, it was not possible to verify the origin of these specimens and to identify the nursery they had come from. Otherwise, according to some literature (Brandes, 2010), A. vera is naturalized in the most inaccessible wadis, on the edge of the tourist route. Most likely, A. vera is an allochthonous species introduced to Jordan by the Nabataeans (VI century BC) for medicinal purposes that is today a relict crop.

However, Jordan does not have a homogenous flora on a national scale and its biogeography is influenced by the phytocoria (botanical spatial characterization based on plant taxonomic composition) of two large areas: Irano-Turanian and Saharo-Sindian. Even if the genus Aloe is not endemic in these two areas, some literature supplies information on the characteristics of those areas in Jordan where this species is cur-

rently naturalized: mixed shrubs with altitudes from 600 to 1500 m. and annual rainfall of 100-300 mm.

In 2014 the King Abdullah II Development Farm in the South Jordan Valley planted 3,000 plants of A. vera; since 2018 most of these plants have been moved to small Jordan farmers associations in the Ghor area. Since 2019, many other small associations have been involved with small plots, less than a donum (0.1 ha), that are scattered throughout the country in locations which have very different pedoclimatic characteristics. However, the origin of these plants is not clear: some farmers of the King Abdellah Development Farm claim that there are at least two groups of aloes, the local one and the one provided by the British nursery with plants of Indian origin. Another local source claims that the specimens of the nursery come from Thailand. In order to clarify this uncertain information, it will be necessary to first verify the purchase documents and, if necessary, to receive direct information from the nursery of origin. Moreover, to understand if there is a diversified local population of aloe, it would be necessary to make a genetic comparison between different groups of aloe coming from Thailand, India and Jordan in order to trace back to their reintroduction. When they were moved to the plots of beneficiaries, these plants had not been fertilized but only irrigated with a regime of 2 l/ plant every 7 days. In addition, some of the plants had visible wounds due to abrasion and fungi caused by both sand storms and an inadequate irrigation regime.

Jordan 's rainfall (about 200 mm per year) is not able to meet its water needs. Most of the available water resources are mainly allocated to agricultural needs (77.5%) and secondly to industrial and domestic ones (Hadadin and Tarawneh, 2007). The scenarios envisaged in the near future by the IPCC, based on the effects of the present climate change, are not so comforting for the Middle East bioclimatic region. In particular, in the last decades, we have been witnessing a worrying increase in droughts. Paradoxically, this trend is accompanied by an increase in hydrogeomorphological risk, due to the increased frequency of extreme weather events. This leads to high mortgages for the sustainable management of any rural development activity, in particular socio-ecological development. Restoring an ecological network with endemic, highly adapted species that can give the ecosystem emerging properties of a holistic nature is part of an integrated approach that has been too often ignored by the land-use management.

1.2 Biocultural analysis

The name Aloe derives either from the Arabic alloeh or from the Hebrew halal both meaning "bitter shining substance" (Sanchez-Machado et al., 2017). Compared to other plants that characterized the environmental history of the Middle East, there is no scientific literature that has studied in depth the case of Aloe vera from an historical-cultural point of view.

The first historical reference dates back to the IV century BC and it refers to the use that doctors of the ancient Greece made of this plant. In particular, aloe was imported from the island of Socotra in the Indian Ocean (Manvitha and Bidya, 2014).

The medical use of A. vera is also reported in a collection of Sumerian clay tablets dating back to 2100 B.C. This species is also mentioned for its use as a laxative in the Egyptian Ebers papyrus in 1552 B.C. In Egypt aloe was used by the ancient Kemet civilization in the Nile Valley and it is said that even Queen Nefertiti used it (1353 BC).

It is also narrated that the philosopher Aristotle, as a mentor to Alexander the Great, suggested him to conquer Socotra in 333 BC because of the local abundance of aloe species, that were considered strategically important by the pharmacopoeia of the time as they were used during the war to heal the soldiers' wounds. It is said that Alexander the Great, during his military campaigns, used fresh aloe that had been previously planted on his chariots. However, it should

be noted that the endemic aloe species of Socotra and Yemen should be A. perryi (Schoff, 1912). Queen Cleopatra VII (69-30 BC) is also believed to use A. vera for both cosmetics and medical purposes (Manvitha and Bidya, 2014).

In the Naturalis Historia by Pliny the Elder (1st century AD) we can find several references to aloe: the merchants of the time already counterfeited the colour and flavour of the aloe derivatives (Liber VIII - 68); aloe was considered a remedy to stop severe bleeding (Liber XXI - 44); it was used with the Costaceae (aromatic plants botanically close to ginger) to treat the skin (Liber XXVI - 38); aloe is similar to the sea squill or sea onion (Drimia maritima L.), a plant typical of the Mediterranean coastal areas that has cardiotonic properties, a bitter taste and a strong smell (Liber XXVII - 5); aloe is said to be a species coming from India and used in Asia only to treat recent wounds with the precious liquid produced by its leaves (Liber XXVII - 5).

In De Medicina by Celso, that belongs to the same age as Naturali Historia, there are other references to Aloe: it was used together with leek, plumbum combustum (lead sulphide) and aqua Lycium, a juice extracted from Asian plants that had astringent properties (5,1); there is also a reference to incense aloe (Aloes turis), which recalls the medieval definition of white aloe, that was used with fissile alum.

In the Middle Ages, Matthaeus Silvaticus (XIII-XIV century), a physician that worked at the famous Schola Medica Salernitana, spoke of aloe and myrrh mixed with mumia, that were used as a mummifying balm as they had characteristics similar to the tar. The mumia was previously mentioned by the physician Constantine the African in the 11th century as a remedy for head fractures and was extracted from Egyptian mummies in the 16th century.

One of the most important texts on the trade of products during the Late Middle Ages is La Pratica della Mercatura, by Francesco Balducci Pegolotti (1340; in Evans, 1936), from the powerful company Compagnia dei Bardi in Florence. The Bards were highly active bankers and merchants throughout the Old World; this enabled Pegolotti not only to be a witness of every trade of goods of the time, but also to access all sorts of correspondence and commercial documents. This work mentions A.vera on sale at the markets of Constantinople and Galata ("Pera"). In this case there is a reference to the "wood" of aloe as merchandise also traded in the markets of Alexandria of Egypt, Cyprus and Majorca. In Italy, the author cites Venice, Naples and Genoa, while in France aloe is present in Nimes ("Nimisi") and Montpelleir ("Monpolieri").

To explain the various products ("mercatantie") Pegolotti wrote that there were several types of aloe: Cetrino (medium quality, yellow to red, from Yemen), patico (hepatic, darker than Cetrino, opaque, considered a kind of socotrine), cavallino (black aloe, the worst quality of aloe, black color), socoltrino (socotrine, coming from the Island of Socotra that was considered the best quality aloe and was often counterfeited because of its high value in the Middle Ages.

The author also writes about aloe white, sold in a box ("cofetto", i.e. box) in the form of a walnut. In particular Pegolotti refers to the use of the aloe white wood, which once bitten, despite its bitter taste, gives off a pleasant scent.

According to Evans (1936) it is not clear whether aloe white can be considered a variety of aloe or another species, the Aquilaria agallocha Roxb. coming from Malaysia and Indochina, that had been used since ancient times as a component of incense. So, according to this theory, wood was nothing more than resinous duramen. For the Arabs, aloe with white wood or simply aloe white was known as al qhschur. According to La Pratica by Pegolotti, Aloe white looked like a paste ("rassembra la sua pasta a pasta di pece navale") that had a part lighter than the other and a very bitter taste.

The Pan-Mediterranean spread of aloe and the strong demand for the original one coming from the Indian Ocean area, highlighted the importance of this cultivation in the Near East, where Jordan was most likely a forced passage to the Mediterranean markets. However, it should be noted the absence of the North African countries west of Egypt (e.g. Morocco, Tunisia) in the trade routes listed by Pegolotti in relation to aloe, despite the fact that they were demanded for other products of Middle Eastern origin, such as the manna extracted from trees of the genus Fraxinus.

Pegolotti mentioned Transjordan for its "sugar powder", whose extraction took place in Cyprus, Rhodes and also in Syria ("Soria"), in particular, Kerak ("Crac-

co", "Cranco of Monreale") situated on the eastern heights overlooking the Dead Sea. The sugar of Kerak, a famous fortress of the Crusader period, was considered inferior to others, as it was dark and grainy. Jordan was an important hub for the routes that departed from tropical Asia (country of origin of the sugar cane). We should also consider that the commercial value of sugar was quite high, especially before the discovery of the Americas. The cited "Amano of Soria", is referable to Amman in Jordan, since the Emirate of Transjordan, founded by Abdallah I, did not exist in the XIV century and Amman was an obligatory passage along the route from Damascus to Mecca. According to Pegolotti in Amman they traded "Maputo cotton" or "wool-cotton", so also in this case we cannot trace a commercial endemicity in the history of Jordan as far as A. vera is concerned, although today the most accredited hypothesis is that it is a relict crop introduced as an exotic species by the Nabataeans (Ruben et al., 2006).

It is also said that Christopher Columbus departed from Palos with numerous pots of A. vera saying that "Four vegetables are indispensable for human health: wheat, vine, olive and aloe. The first one nourishes, the second one refreshes the spirit, the third one brings in harmony, the fourth one heals ". The Genoese explorer is said to call aloe "potted doctor" (Cumo, 2013).

1.3 Technical and agronomic measures

The National Research Council (CNR) and Fondazione Archeologia Arborea (FAA)[1] researches have been aimed at the establishment of new plantations through studies of technical-agronomic nature.

From a strictly agro-ecological point of view, the inspections carried out in the Feifa area and in the environmental context of the Dead Sea depression, have highlighted an extreme vulnerability of their socio-ecological systems, whose habitats are dominated by the randomness of rainfall, by temperature variations, by the soil salinization and alkalinization, by the groundwater depletion, by hydro-geomorphological instability, soil erosion, as well as biodiversity erosion due to overexploitation of resources, general anthropogenic impact and consequences of climate change.

A few weeks after the mission in October 2018, intense rainfall generated a flood in the Jordan Valley, especially in the Feifa area, with damage to the ongoing aloe planting. Hence the need for a deep overall environmental restoration, starting from the adoption of ecological micro-networks concerning the farm and getting to large-scale forestation programs and fight against desertification. Such restoration and

1 Fondazione Archeologia Arborea (FAA) is an Italian technical partner of the project. It is mission is to research on old local varieties of fruit plants to save these plants from their final disappearance.

conservation actions must be directed to the recovery of a network of ecological complexity on different geographical scales. On a small scale it is important to focus on a strategy concerning plantations, that are the object of technical-practical guidelines intended for operators interested in growing aloe. Basic criteria, whose objective is to increase the organic substance of the soil and to produce soil conditioners and fertilizers, will necessarily concern the combined cultivation of nitrogen-fixing species of the genus Medicago or other Leguminosae, but also the creation of natural windbreaks aimed at windbreaking and shading. On this purpose, the most suitable tree-shrub species are the Ziziphus spina-christi, Tamarix spp., Acacia spp. as well as the species Calotropis procera ("Apple of Sodom") and other species to classify, which can occasionally be found at field margins and edge areas.

1.4 Identification of native areas and species

The Nature Reserves of reference that can support the activities proposed by this study are Mujib and Dana in the south and Ajloun in the north.

The most suitable species for this experiment were identified in a farm involved in the project in Feifa. The first plantation, 6 dunums (=0.6 ha) large, was widened by 19 dunums (=1.9 ha) and the planting operations included the use of a shade cloth to protect the propagation material. The spacing adopted for the current plantation is 1.5 m on the inter-row and 1 m on the row, with a density of 666 plants per dunum.

The proposal to create innovative agroforestry models and systems, based on the cultivation of aloe in association with essences to re-establish a micro-ecological network on a large- scale, has involved other realities in the northern cluster of Jordan. Female cooperatives or associations have been chosen in accordance with the priority social objectives of the project actions. The first association chosen in the Plateau is in the Mafraq Governorate, which has supplied a sandy-clay soil that is adjacent to its headquarters. The presence in this area of the Opuntia ficus-indica cactus species gives general indications on the compatibility of crassulacea aloe with pre-desert environmental conditions with strong seasonal temperature variations that characterize the Mafraq area. The field selected for this experiment covers an area of about 200 square meters and requires a planting layout of 1 m x 0.5 m for about 400 plants. Then 200 plants will be distributed to the association's 48 women and they will be used both for the spread of aloe and for a potential income on a small scale.

Finally, the RSCN has supplied a plot of land near Azraq, in the East of Jordan, close to the Azraq Wetland Reserve, the wildlife reserve of Shaumari, both for ornamental and scientific purposes (that is assessing the adaptability of aloe in a desert area with soil extremely poor in nutrients and subjected to significant temperature variations).

03 EXPERIMENTAL PROJECTS IN JORDAN

A preliminary analysis of data collected from the plantations of Aloe vera in Jordan, has been reported in a document for Mutah University and then deepened to contribute to the Quality Management System of the supply chain, through a comparison of a) morphometric parameters of plants; b) three soil types: Red Soil (RS), Clay and Sand (CS) and Sand (SD); c) three types of treatment: control, fertilizer (organo-mineral fertilizer; 20g application per plant) and manure (organic fertilizer; origin: chicken, cattle, sheep and goat); 200g application per plant).

The performed growth analysis has led to: 1) acquisition of best practices for the supply chain of Aloe vera in Jordan, meant as productive improvement and setting of a management system; 2) collection of data and experiences useful to the follow-up experiment carried out in the laboratories and greenhouse at CNR IRET in Italy.

3.1 Morphometric measurements of plants and sampling frequency

A. NUMBER OF VISIBLE LEAVES

B. SUMMARY ASSESSMENT OF THE PLANTS' CONDITIONS (LEAF GREENING, DAMAGES, ETC.)

C. LENGTH AND WIDTH OF LARGER BASAL LEAVES: MEASURES BY MEANS OF FLEXIBLE TAPES ACCURATE TO 1 MM

D. THICKNESS OF THE LARGEST BASAL LEAVES IN THE MIDRIB, BY USING A CALIPER WITH A PRECISION OF 1 MM

E. HEIGHT OF THE PLANT: FROM THE GROUND TO THE APEX OF THE LEAF

F. EVALUATION OF THE PROJECTION OF THE PLANT TO THE GROUND: MEASUREMENT OF THE TWO LARGEST DIAMETERS OF THE TWO LARGEST PAIRS OF BASAL LEAVES

G. CALCULATION OF THE CIRCULAR AREA OF THE PLANT BY AVERAGING THE TWO DIAMETERS AND USING THIS VALUE TO DETERMINE THE AREA OF THE CORRESPONDING CIRCLE

H. SAMPLING DATES: EARLY SPRING AND LATE AUTUMN

3.2 Experimental areas

The experimental macro-areas identified are mainly the Highlands and the Jordan Valley. However, the classification of experimental sites should also include the Hills, which are 14 in total:

- Highlands: Amira, Basma, Um, Jimal, Kohm el Ahmar, Madaba.
- Hills: Diara, Jazzaza, Nahla.
- Jordan Valley: Sammar, Maamoura, Ghor Safi, Ghor Mazraa, Feifa.

3.3 Results and discussion

The statistical analysis was carried out with the softwares R (R Core team, 2018) and Wizard, while the graphics were processed with the help of DataGraph.

The projection diameter of the plants indicates a high coefficient of correlation (R2) with morphometric variables, for the choice of leaves that are suitable for the production of gel.

For example, the correlation between diameter projection and larger leaf at basal level is evident (R2 = 0.66). The same projection diameter does not correlate significantly with the thickness and width of the basal leaf (R2 0.42 and 0.49 respectively).

The morphometric variables measured in A. vera plants are significantly different in the test areas except the leaf thickness, as evidenced by the Variance Analysis (one way ANOVA) that shows significant differences ($p<0.001$). The 2-way ANOVA, which correlates area, soil and type of treatment showed significant differences in the number of leaves (area and treatment interaction), in the length of the basal leaf (area-soil), the width (area-soil and soil-treatment), plant height (area-treatment and soil-treatment) and projection diameter (area-soil). Similarly to the 1-way ANOVA, the thickness shows no significant differences, while in the case of basal leaf width, plant height and projection diameter the significance is lower ($p<0.01$) than for number of leaves and length ($p<0.001$). There is a higher median in the areas at higher altitude with regard to the length of the reference basal leaf (Highlands). In Jazzaza (Hills) the number of leaves, usually 15, is significantly higher than in other areas.

As for soil types, the sandy soil affects less the length of the basal leaf than the other two types. Width, thickness and number of leaves are not significantly influenced by the type of soil. Other characteristics of the plant, such as height and projection diameter, have respectively the lowest average values in Red Soil and sandy soils. The number of leaves and the length of the basal leaf grows with decreasing salinity (Rahimi-Degolan et al., 2012). The Red Soil is typically not very fertile as it lacks in nitrogen, humus, phosphoric acid, magnesium and silt but it is rich in potassium, with a pH from neutral to acid. Moreover, the texture of the Red Soil is sandy and porous, especially in the superficial layers and this does not favor fertility (Dekwedi et al., 2017).

The treatment that most favorably affects the length of the basal leaf is the use of manure, especially if compared to fertilizers that are related to lower average length values, also in relation to control. Furthermore, the width, the thickness of the basal leaf and the height of A. vera. plants are affected favourably by the use of manure. This is due to the fact that A.

vera can grow in all types of soil, even if the most favourable condition is warm-humid climates, high rainfall and well drained soils rich in organic matter (Manvitha and Bidya, 2014). In the pre-harvest phase, the manure had the dual- purpose of increasing the organic substance but also improving the texture of the soil and its ability to retain water, as we can see from the Project Sharing Report of the second year. The process of decomposition of manure, due to the temperature but also to the particular conditions of the soil, causes the release of water and minerals (Zwert et al., 1996) that provides A. vera plants with the correct water supply. In fact Aloe vera has very complex physiological mechanisms in terms of efficiency of water use, whose combination enables a fine modulation of the water balance: large storage of water, like CAM metabolism plants and an efficient CO2 fixation, like C4 metabolism plants; synthesis of cytoplasmic accumulation osmolytes (especially proline) for water retention that, in their turn, originate from glucose synthesis (Delatorre-Herrera et al., 2010). This highlights how the interaction irrigation regime/ treatment is fundamental for the best performance of the supply chain production

According to the data collected, the use of manure has favored the growth of Aloe vera, a plant with great adaptive plasticity (Silva et al., 2014)

A. vera meets the best conditions at high-medium altitudes, where there is a balance between rainfall and a soil texture that is able to retain the right amount of water in favor of the rhizosphere activities. Manure applications allow A.vera to find or facilitate the achievement of the most productive soil-plant balance .

04 EXPERIMENTATION IN ITALY

4.1 Morphometric measurements of plants and sampling frequency

In March 2021, young plants of Aloe vera and A. arborescens were transplanted in 20 l pots filled with a mixture of sand and compost in the volumetric proportion 3:1.

In line with the measurements previously carried out in Jordan, the experiment at the greenhouse of the CNR IRET has considered the following variables, that have been measured weekly:

01. NUMBER OF LEAVES (N)
02. LEAF GREENING (RANGE: 1-5)
03. LEAF DAMAGE (RANGE: 1-5)
04. MAIN LEAF LENGTH (IN CM)
05. WIDTH OF MAIN LEAF (IN CM)
06. MAIN LEAF THICKNESS (IN CM)

07. HEIGHT OF PLANT (IN CM)

08. PROJECTION OF THE DIAMETER (IN CM)

Three experimental theses and a control one were planned, each consisting of 11 plants of Aloe arborescens and 16 plants of Aloe vera, classified as follows: control; *; M; L. The three theses (*, M, L) were subjected to bacterial inoculation; respectively: *, genus Burkholderia; M, genus Rhodococcus; L, Biodynamic Basalt + Lactobacyllus.

Isotopic measurements of soil and leaves of all plants have been carried out on a monthly basis.

At the end of the experiment, in August 2021, an extensive sampling was performed, enclosing 4 plants for each treatment. The plants were harvested and dissected in their different organs, which were collected into paper envelopes: leaves, shoots and roots. The samples were oven dried at a temperature of 60°C. Leaf gel and cuticle samples were independently sampled from the central leaf of other replicates and immediately freeze-dried.

Overall, the results of this test in a controlled environment were not enlightening. The plants showed excellent growth and productivity in all the compared theses. To explain the mild effect of growth-promoting bacteria, a likely hypothesis is that the commercial compost, used in 1:3 volumetric mixture with sand as substrate in pots, had already been inoculated with bacterial and/or fungal populations. This would explain the excellent crop results observed in the control pots, the ones where no inoculation had been performed. However, an accurate statistical analysis allowed to detect a significantly better production in aloe inoculated with the population of Rhodococcus in thesis M. This bacterial population was selected in Mali and this could suggest a possible co-adaptation of the succulent and the bacterial strain. However, this moderate increase in production, cannot be considered a significant result, otherwise there would be the risk of speculative conclusions. What is worth mentioning is the relevance of the combination "aloe-soil rich in organic substance", a binomial that is strengthened both by the tests carried out on site in Jordan and by the excellent general results of greenhouse cultivation. The desirable objective would be the selection and production of bacterial strains, which are plant promoters, on site, directly in Jordan, in order to start a farm production of humic compost from local residual crops. The use of such composts would however be a form of circular economy, internal to the farm or the rural area, able to counteract the loss of soil fertility. Such a loss, on the contrary, is normally increased by the wide use of mineral fertilizers and monoculture farming, which unfortunately are more often adopted as deleterious agronomic solutions imported by western forms of management.

05 CONCLUSIONS AND PERSPECTIVE

The next step towards agro-environmental protection and the restoration of ecological networks in Jordanian rural landscapes will be a careful floristic analysis of local biocenoses, aimed at the design of sustainable agroecological systems, resilient to biotic crises caused by incipient extreme climates. Finally, for a better integration of aloe in a sustainable socio-economic framework enclosing a biocultural perspective, it seems important to investigate the aloe ecotype of Wadi Musa. Here, in fact, the ecosystem hosts relict populations of Aloe vera and its floristic analysis can facilitate the selection of native combined species in experimental plantings.

Sharing completely the Jean Paul II Foundation virtuous objectives of safeguarding and restoring natural resources, the CNR-IRET in this long series of missions in Jordan and of exchange missions with Jordanian technicians in Italy, has pursued activities of contextualization of local rurality aimed at agroecological, biocultural and best practice objectives, by following a universally sustainable perspective.

Priority should be given, in particular, to the development in the Hashemite country of a renewed rurality, a sort of neo-ruralism strongly suited to the past traditions of an agrosilvopastoral and oasistic ecosystem management. However, such a cultural (rather than economic) effort, can only originate from the awareness of the environmental upheavals that are affecting the entire biosphere. The Near East is an area deeply affected by the impact of global changes, where desertification is advancing and the socio-ecological resilience of the human-environment system is strained. In this situation, a farm becomes a defensive trench, provided that innovative systems, based on good agroecological practices, are developed towards agroforestry and oasistic farm structures. The neo-rural renaissance keywords must be: greening of soils, increase of organic matter and fer-

tility, agricultural and natural biodiversity, agricultural consociation, agroforestry, circularity in the use of environmental resources, protection of aquifers, water harvesting strategies, water use efficiency, renewable energy, equity, sharing and social inclusion.

All the strengths highlighted by the project will help to lay the first foundations for the creation of a traditional product brand, especially at level of quality certification. Behind this brand, there will be several virtuous characteristics (sustainable management, organic production, agroecological balance, social equity and recovery of ecosystem services) that will allow to enter the growing Middle East and Mediterranean Aloe vera markets.

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Contact

info@fondazionegiovannipaolo.org
www.fondazionegiovannipaolo.org

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AICS - Agenzia Italiana per la Cooperazione allo Sviluppo Sede di Amman Business Avenue building 77, Islamic College Street, 11180 – Jabal Amman, Amman Jordan
Tel: +962 (0) 6 4658668 - www.amman.aics.gov.it

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