

Potential of the Medicinal Flora in Pakistan and the Risk of Extinction: The Need for a Conservation Strategy



Ijaz Rasool Noorka, Mohamed Behnassi, Zafar Iqbal Khan, Hafeez-Ul-Hassan, Emran Manzoor, and Syed Shujat Ali

Abstract The medicinal flora has a prime importance from ancient times. 10% of the known plant species are used to cure human and animal diseases. In Pakistan, a large population depend on plants for the cure of major and minor diseases. These plants are wild, and some are cultivated like field crops. The livelihood of a large segment of population is connected with them. However, the important therapeutic flora species are going to extinct in the country due to many factors, particularly the over-collection by unauthorized people and the lack of a conservation strategy and a proper maintenance system. Therefore, local populations should be sensitized on the importance of growing essential medicinal flora. The present raw utilization of medicinal herbs in Pakistan and their prime conservation as income resources should be a key concern for research, business, and policy making.

Keywords Conservation · Health · Livelihood · Medicinal flora · Pakistan

1 Introduction

Medicinal plants are an important source of pharmaceutical agriculture. Such plants have a large importance, especially for desert and hilly areas and the coast. They

I. R. Noorka (✉)

Professor, Department of Plant Breeding and Genetics, Ghazi University, Dera Ghazi Khan, Pakistan

e-mail: ijazphd@yahoo.com

I. R. Noorka · Hafeez-Ul-Hassan · E. Manzoor · S. S. Ali

Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Sargodha, Pakistan

M. Behnassi

Economic Social & Environmental Council (ESEC), Center for Environment, Human Security & Governance (CERES), Rabat, Morocco

e-mail: behnassi@gmail.com; m.behnassi@uiz.ac.ma

Z. I. Khan

Department of Botany, University of Sargodha, Sargodha, Pakistan

e-mail: zafar.khan@uos.edu.pk

are commonly used by local populations for curing diseases from pre-historic times. Synthetic medicines reduce the use of medicinal plants, but over time they may have serious residual effects. Indeed, the allopathic medicines' action is quick, but after curing a chronic disease, they may cause other health issues like blood pressure fluctuations and stomach and liver problems. In some cases, microbes develop a certain resistance against synthetic medicines whose prices are often inaccessible for the poor. Recently, many peoples all over the world are turning toward natural resources for cure given their potential as a source of vitamins, antioxidants, and other medicinal virtues.

Presently, the medical research showed that the study of medicinal plants' biological activities is essential. Therefore, the production of new molecules from herbs that may be effective tools for curing dangerous diseases is expected. Indeed, many scientists have reported that some diseases like cancer can be cured by the use of natural resources. *Terminalia arjuna* and flavonoids, for instance, have shown effectiveness against cancer. *Eugenia jambolanare*, *Trigonella foenum*, *Allium sativum*, and *Allium cepa* are hypoglycemic herbs or shrubs with an effective result against diabetes mellitus, which affects many peoples in developing countries. Heart and vessels-related diseases are more common these days and cause more deaths all over the world, whereas herbal medicines are more effective against them. Arthritis and aging effects can be reduced by the use of herbal medicines given their enzymatic actions. Many plants are used to cure ulcer given their antioxidant and antimicrobial potential (Ali and Qaisar 2009). Scientists commonly separate phytochemical compounds (such as morphine, atropine, aconitine, nicotine, and atisine) from medicinal herbs; the latter are very active against a number of diseases.

With the progress made in herbal medicine research, this becomes an alternative effective source of health care in today's allopathic era marked by the science-based, modern medicine. The reason behind the use of medicinal plants is that they have a combination of side-effect neutralizing and synergistic combinations. Different plants are harvested commercially for the extraction of active ingredients. For the preparation of compounds and extracts, eastern medicines are largely based on Unani methods.

According to the World Health Organization (WHO), the use of herbal medicine is globally increasing. In developing countries, about 80% of peoples depend on these herbs to cure basic health issues. In developed countries, up to 65% of populations like to use alternative natural herbal medicines. More specifically, the percentage of people using herbal medicines in developing countries is, for instance, 60% in Tanzania, 80% in Benin, 70% in India, 90% in Ethiopia, and 60% Uganda, while the percentage in developed countries is 60–70% in Japan, 49% in France, 40% in The United States, 70% in Canada, 48% in Australia, and 31% in Belgium.

In present time, the global market of herbal medicines is US \$60,000 million that may grow by US \$5 trillion up to 2050. The growing trend to use herbal medicines has enhanced the acceptance of WHO rules about herbal medicines by governments. In The United States and Germany, for instance, the establishment of herbal medicine research institutes entails promising perspectives for this field in the future.

Many peoples are involved in the collection (especially women), processing, and marketing of such plants globally (Elisabetsky and Castilhos 1990). The medicinal flora is also an important source of income, especially in vulnerable rural areas.

Against such a background, this chapter highlights the importance and the scope of medicinal plants both globally and at the level of Pakistan, identifies the main factors threatening the sustainability of such plants, and assesses the progress made in herbal medicine research in Pakistan. The chapter concludes by developing some recommended measures to protect medicinal plants in the country given their growing social and economic importance.

2 The Global Demand and Supply of Herbal Medicines

There is an increasing interest for the natural medicine production and research, especially from pharmaceutical companies and research centers. Globally, the use of herbal medicine increases according to a growing trend and its active role in R&D and the culture of the community is also enhanced. This increasing consumption of herbal medicines shows the importance of using natural ways of cure.

In The United States, the botanical market is estimated at approximately US \$1.6 billion per annum, which includes medicinal plants and herbs. The European countries import medicinal flora from Africa and Asia (around 400,000 tons annually costing about US \$1 billion). The European Union (EU) utilizes 3000 kg *Glycerrhiza* annually. To secure such amount, 400 tons in the active plant parts and plant roots are required. China and India are the leading exporters, respectively. In China, during 2000, the output value of the pharmaceutical industry was US \$28 billion. In 2010, the share of Chinese herbal medicine in the world market has reached 15%. In India only, the Lucknow produces medicinal plants of Rs. 90 millions annually. The Russians use 50,000 tons of medicinal plants annually, from which 50% are cultivated and the rest is widely collected. All these examples show that the cultivation medicinal plants are becoming globally essential to meet increasing demands. However, in Pakistan, the situation is reverse because there are no innovations in the area of cultivation of medicinal plants at both commercial and domestic levels.

Research projects running by different organizations in Pakistan regarding the conservation and utilization of plant genetic resources are playing a key role. The World Wide Fund for Nature (WWF) is playing leading role in this regard. It is also dealing with the conservation of endemic knowledge. In this area, there is a potential for agricultural production by the cultivation of medicinal plants of high value like Safran, which is an important and costly medicinal and aromatic agent, a sacred plant among many Muslims. In recent era, the annual yield and price of Safran have increased manifold. Its production per year was increased from 70,000 to 200,000 flowers yield. Qarshi Herbal Industries utilize 20 kg in 2002 in the medicines compared to 35 kg in 2009. One acre of land may yield a profit of >Rs. 100,000. Safran, often grown in tropical climate, is a very high profit crop for farmers in northern areas.

For all the reasons mentioned above, through the development of herbal medicine sector, many developing economies may access to promising market opportunities. To satisfy the increasing demand in this sector and exploiting new resources, new research programs and surveys are being undertaken.

3 Medicinal Plants in Pakistan and Their Scope

The total area of Pakistan is 796,096 km², and its climate varies from glaciers to desert. There is a large diversity of medicinal flora present from 0 to 8611 m altitude. It has been reported that 70% spp. of total species are climate specific, while 30% are multi-climatic. The country has four medicinal phytogeographical zones: Irano-Turanian (45%); Sino-Himalayan (10%); Saharo-Sindian (9.5%); and Indian element (6%) (Ali and Qaisar 2009).

Indeed, the geographical structure of Pakistan is very rich with a variety of medicinal flora due to a range of different climates and altitudes from glaciers to deserts and the coast. Such medicinal flora is well grown according to their ideal climate, and they are playing important roles in the agriculture of hilly areas and desert. The main regions of herb production are the northern areas, Murree Hills, Mansehra, Abbottabad, Sindh, Azad Kashmir, Baluchistan, Punjab, and KPK of Pakistan.

Many medicinal plants from the northern areas of Pakistan had been identified and listed by Gilani et al. (2009) and Hamayun et al. (2006). Similarly, there are 70 spp. of medicinal plants studied and reported from Mansehra, KPK province, by Haq and Hussein (1993). In Ayubia National Park, Nathiagali, and Swat, ethnobotanical studies of medicinal were conducted by Shinwari et al. (2003). 83 species, that were locally used in Chitral areas of Hindukush range, were scientifically studied by Ali and Qaisar (2009). In addition, 114 spp. with ethnobotanical uses had been reported from Balochistan and in Kharan. With the listing of such plants, their chemical and ethnobotanical properties, along with their medicinal uses, had been identified (Kirba et al. 2009).

Generally, it was observed that there are 6000 species of plants found in Pakistan (Stewart 1972), 4200 of which are used as medicinal plants, 75 unprocessed drugs are exported, and 200 species are processed within the country. Hazara and Malakand are the leading producer with a potential of 500 tons of medicinal plants (24 tons in Northern Areas, 38 tons in Azad Kashmir, and 16 tons in Murree Hills).

In Pakistan, the demand for medicinal herbs is 20,000 tons/annum while the production is low. This gap is either met by imports or by increasing domestic production through incentivizing farmers to grow medicinal plants at commercial scales. However, the imbalance between import and export of medicinal plants is still very substantial. To reduce this gap, the Central Board of Revenue (CBR) announced in 2001 the duty-free import of medicinal plants.

12% of Pakistani medicinal plants are used as medicines, and about 300 species are exported. Ten leading *Dar-ul-hikmats* in the country use more than 2 million kg annually of 200 species during 1990s, and the consumption has increased manifold at

present time. According to a survey, 22 spp. of plants with a value of USD 0.8 million were traded in 1990, and in 2002, the value has reached USD 6.95 million, that is 8.5 times increases. The consumption has increased 6 times (Shinwari et al. 2003).

Moreover, even if Pakistan is endowed with rich medicinal herbal sources, that are used for aromatic and medicinal purposes, some plants are well studied while others are still under process. As a developing country, Pakistan needs to enhance the herbal research and its applications for medical purposes.

4 Threats to Medicinal Plants in Pakistan

Environmental and climatic changes greatly affect the life on earth. Pollution, deforestation, industrialization, and population growth are factors that globally cause the decline of natural resources in quantity and quality. As a consequence, many plant and animal species are at the risk of extinction. The efforts to conserve natural flora and fauna through national parks, by providing natural habitats to wild organisms, are effective at the zonal level.

In Pakistan, 10% of the medicinal flora has been reported by Shinwari et al. (2000) two decades ago to be endangered species due to many factors such as poverty, population growth, and the lack of social institutions, planned cultivation, and interest and awareness about raising medicinal plants. Urbanization, rapid construction of roads, industry, pollution, and industrial farming are also important factors threatening natural medicinal resources. Moreover, the increased demand for land to meet the needs of livestock, timber, fuel wood, and fodder causes deforestation. With the decline of forests, the habitat of herbal plants is also decreasing (Saxena et al. 2001). In the same vein, the country gives shelter to thousands of Afghan refugees over many years despite being an over-populated country. This community is suffering from poverty and unemployment; thus, storing and sailing important plants are an alternative source of income.

In addition, the commercial collection of medicinal flora for consumption in the country causes an increasing danger to their sustainable availability (Gilani et al. 2009). Two major companies (Qarshi and Hamdard) produce herbal medicines and use wild flora extensively from all over the country. This situation causes the extinction of costly plants from wild flora and also increases the prices of related products. On the other hand, areas from which plants are collected are backward and the local populations are often unable to improve their livelihoods because the revenue generated from these plants is mostly at the benefit of a few persons.

In Pakistan, all medicinal plants are collected from wild resources. In most cases, those who collect such plants are unexpert and do not know the efficient way of collection. From the site of collection to national and international markets, each medicinal product or drug passes through many middlemen; this speculation often causes the increase of the cost and the final price manifold (Shinwari 2010).

5 Herbal Medicine Research in Pakistan

The local population of different zones have an indigenous knowledge about the medicinal uses of many plants, and this knowledge is often transferred from a generation to another (Bhardwaj and Gakhar 2005). However, when this knowledge is limited to a group or a person, it may be lost, hence the need to preserve it properly. The modernization and decline of traditional cultural values often cause the wastage of such a precious knowledge about medicinal plants (Martin 1995). Ethnobotany is the science of gathering and arranging the local indigenous knowledges about the conservation of medicinal herbs by local peoples for curing (Shenji 1994). It is highly required to transfer the essential ethnobotanical knowledge about herbs, which is disappearing very fast, to younger generations. This will make transmitted knowledge and data beneficial for future medicinal studies (Qureshi et al. 2001).

Herbal drugs are extensively used against various diseases. There is an abundant flora provided by nature for human and other living beings with several benefits (Bhatti et al. 2001). However, many plants are not explored yet and there is a need to find out their medicinal potential (Baquar 1989). Meanwhile, the harvesting of medicinal plants should be regulated, and there is an urgent need to conserve such plants and to reduce the harvesting rate according to the regeneration rate of each plant. In this perspective, Shinwari and Qaiser (2011) reported that local farmers and people of Pakistan marginally contribute to the conservation, rearing, and stability of medicinal plants.

Keeping in view the pivotal role of medicinal plants in our daily life, in case of direct use, indirect use, herbal medicine, and as by-products, it is highly needed to conserve the potential flora. Conservation strategies may be in situ and ex situ and should cover as well the cultivation process for a sustainable use of medicinal plant resources. Furthermore, plant breeding and genetical approaches should be utilized for the improvement of medicinal flora and proper long-term preservation of plant propagules in gene banks (seed bank, DNA libraries, etc.).

In Pakistan, the research on medicinal plants is very limited and often done by universities. However, advanced research in this area is still unconventional despite the fact that the country has a large diversity of medicinal herbs. Indeed, there are a few institutions where research and study of medicinal herbs are done and scientific laboratories and chemical analysis are still lacking. At present time, only traditional knowledge is transferred from generation to another with research projects undertaken in the country by some scientists. Some examples are presented below.

Baluchistan and northern areas of Pakistan are not only rich in medicinal flora, but also the center of origin and diversity of many Generas—e.g., *Cousinia*, *Allium*, and *Astragalus*. Some of them are near extinction, and the rest is explored and studied for medicinal purposes. There is a large diversity found in more than 13 Natural Regions from alpine to mangrove forests (Shinwari et al. 2003). They are alternative sources of cure; e.g., an active ingredient from peppers (*capsaicin*) is used as anti-pain without affecting other sensations (Binshtok et al. 2007). Malik et al. (1990) work in six districts of Baluchistan and gather useful information in the area of herbal

medicine. Goodman and Ghafoor (1992) had done a comprehensive ethnobotanical survey in the areas of Baluchistan, gathering and studying 114 plant species used by local peoples as herbal medicine. Leporatti and Lattanzi (1994) undertook their study in the region of Makran and focused on 27 important plants by reference to their ethnomedicinal potential. Qureshi and Bhatti (2007) stated the effective uses of wild gourd (*Citrullus colocynthis*) from Nara Desert, Sindh, while demonstrating its taxonomic traits and medicinal uses. Qureshi and Bhatti (2008) reported as well, by reference to the same study area (Nara Desert, Sindh), 51 plant spp. from 43 genera and 28 families used by local peoples for medicinal purposes. They also explored 21 species that are not recorded in the Indo-Pak medicinal history.

6 Protection of Herbal Medicines: Recommended Measures

To conserve the medicinal flora, the control of access to plant resources and the plant protection are to be planned with long-term effects. For a practical implementation of the management strategy, a comprehensive knowledge about the ecological parameters and socio-economic trends is required.

Although the profession of pharmacy in Pakistan is steadily advancing, the country's healthcare system has to recognize the pharmacist's role in the cure. This lacking recognition is due to the limited interaction among pharmacists and customers. In Pakistan, pharmacists are concerned with their professional role and they do not think about the future prospects of the healthcare system. Moreover, there is a shortage of pharmacists in pharmacies. They are concentrated on management more than customers. Thus, the pharmacist's role is not familiar with the public needs as a healthcare professional. By enhancing both the knowledge and the collection of local nursery-based stocks, a substantial reduction of pressure on wild medicinal plants may be achieved. The knowledge about the cultivation and growing of medicinal plants is not reaching farmers in effective ways, so that they can understand easily who actually utilize it practically. Then, the focus must be on the larger use of ex situ management and on the growing and establishment of nurseries with the aim to conserve important plants. Within a range of climatic zones, it is necessary to select ideal sites for the establishment of nurseries. The main criteria for the selection of species to be studied are the degree of extinction in the wild, the economic importance, and the availability of information about them. Sophisticated harvesting of medicinal plants, training of collectors, expertise in nursery techniques, and skipping middlemen between producers and consumers throughout the trading process are essential measures to be implemented.

There is currently an urgent need to develop rules about the collection and conservation of endangered species. These steps are necessary for the best use and conservation of a threatened diversity to avoid the depletion of such precious natural resources. Unfortunately, there is currently no management structure in Pakistan with relation to the area of medicinal plants.

7 Conclusion

Wild medicinal plants are an essential source of medicine in traditional systems. They are used as curing agents for human and animal health from times immemorial (Sher et al. 2000). Even in recent times, they keep their importance with similar uses as in the past. Many plants from forests and mountains are collected from the northern areas of Pakistan and Rawalpindi and are used as a cure of different health problems (Arshad and Akram 1999; Khan 1985, 1991). Herbal medicine has a well-established market, which facilitates the import and export of targeted plants.

10% of the known plant species is used to cure human and animal diseases. In Pakistan, a large population depend on such plants as medicines and source of income. These plants are wild, and some are cultivated like field crops. Children and women play important roles in collection and processing, and the livelihood of a large part of the population depends on these plants. The marketing of medicinal plants is handled by the local (Pansar) system.

Some important species are endangered in Pakistan due to many factors, including the over-collection by drug smugglers and the lack of conservation programs and a proper maintenance system. This is a gateway for interested researchers, businesses, and decision makers to plan research and action programs aiming at the production and conservation of medicinal plants with the objective of boosting income generation, especially for poor collectors and farmers.

References

- Ali H, Qaisar M (2009) The ethnobotany of Chitral valley, Pakistan with particular reference to medicinal plants. *Pak J Bot* 41(4):2009–2041
- Arshad M, Akram S (1999) Medicinal plants of University of Arid agriculture Rawalpindi. *Hamdard Med.* 40(3):46–50
- Baqar SR (1989) Medicinal and poisonous plants of Karachi, Pakistan. pp 95–96, 184–185, 248–241, 337–440
- Bhardwaj S, Gakhar SK (2005) Ethnomedicinal plants used by the tribals of Mizoram to cure cut and wound. *Indian J Tradit Knowl* 4(1):75–80
- Bhatti GR, Qureshi R, Shah M (2001) Ethnobotany of Qadanwari of Nara Desert. *Pak J Bot* 33(special issue):801–812
- Binshtok AM, Bean BP, Woolf CJ (2007) Inhibition of nociceptors by TRPV1-mediated entry of impermeant sodium channel blockers. *Nature* 449(7162):607–611
- Elisabetsky E, Castilhos ZC (1990) Plants used as analgesics by Amazonian cabocols. *Int J Crude Drug Res* 28:309–320
- Gilani SA, Kikuchi A, Watanabe KN (2009) Genetic variation within and among fragmented populations of endangered medicinal plant, *Withania coagulans* (Solanaceae) from Pakistan and its implications for conservation. *Afr J Biotech* 8:2948–2958
- Goodman SM, Ghafoor A (1992) The ethnobotany of southern Baluchistan, Pakistan, with particular reference to medicinal plants. *Fieldianc Bot* 31(4):1–84
- Hamayun M, Khan SA, Kim HY, Leechae IJ (2006) Traditional knowledge and ex-situ conservation of some threatened medicinal plants of Swat Kohistan. *Pak J Bot* 2(2):205–209

- Haq I, Hussein Z (1993) Medicinal plants of Manshera District, NWFP Pakistan. *Hamd Med* 34(3):63–69
- Khan M (1985) Report of participatory rural appraisal on agriculture at Bayun, Kalam, Swat. A Joint Pak/Swiss-Govt venture, pp 11–20
- Khan AA (1991) Marketing of herbal drugs and its problems. In: Proceedings of the national workshop on appropriate use of medicinal plants in traditional medicine, NIH, Islamabad, pp 69–72
- Kirba SS, Zengin F, Kursat M (2009) Antimicrobial activities of extracts of some plants. *Pak J Bot* 41(4):2067–2070
- Leporatti ML, Lattanzi E (1994) Traditional phytotherapy on coastal area of Makran (Southern Pakistan). *Fitoterapia* 65(2):157–161
- Malik SM, Shan M, Marwat Q (1990) Ecotaxonomical evaluation of valuable plants of Balochistan, Pakistan. Project Rep. No. 123. Pakistan Science Foundation, Islamabad
- Martin GJ (1995) Ethnobotany: a people and plants conservation manual. Clapham & Hall, London, New York, Tokyo
- Qureshi R, Bhatti GR (2007) Wild gourd: a green medicine. *Hamdard Medicus* 50(1):156–162
- Qureshi R, Bhatti GR (2008) Ethnobotany of plants used by the Thari people of Nara Desert, Pakistan. *Fitoterapia* 79:468–473
- Qureshi R, Bhatti GR, Shah M (2001) Ethnomedicinal properties of *Aloe barbadensis* Mill with particular reference to the people of Nara Desert. *Hamdard Medicus* 44(3):46–50
- Saxena KG, Rao KS, Sen KK, Maikhuri RK, Semwal RL (2001) Integrated natural resource management: approaches and lessons from the Himalaya. *Conserv Ecol* 5(2):14 [online]. <http://www.consecol.org/vol5/iss2/art14/>
- Shenji P (1994) Himalayan biodiversity conservation strategies. Himavikes Pub. No.3
- Sher H, Ahmad M, Iqbal CM (2000) Market survey of medicinal plants in major cities of Pakistan, their use and future prospects. Swiss Purred, Development Cooperation, Berne, Switzerland, pp 33–47
- Shinwari ZK, Gilani SS, Kohjoma K, Nakaike T (2000) Status of medicinal plants in Pakistani Hindukush Himalayas. In: Proceedings of Nepal—Japan joint symposium on conservation and utilization of Himalayan Medical Resource, pp 257–264
- Shinwari ZK, Khan AA, Nakaike T (2003) Medicinal and other useful plants of district Swat-Pakistan. WWF-Pakistan
- Shinwari ZK (2010) Medicinal plants research in Pakistan. *J Med Plants Res* 4(3):161–176
- Shinwari ZK, Qaiser M (2011) Efforts on conservation and sustainable use of medicinal plants of Pakistan. *Pak J Bot* 43:5–10
- Stewart RR (1972) An annotated catalogue of the vascular plants of west Pakistan and Kashmir. Fakhri Press, Karachi, p 102

Dr. Ijaz Rasool Noorka is Professor and Chairman at the Department of Plant Breeding & Genetics, Manager Research Operations & Farms and diversified administrative assignments at Ghazi University, Dera Ghazi Khan Pakistan. Prior to this, he served in Government of Punjab agriculture sector in multiple positions and University of Sargodha as Principal, Director Public Relations & Publications, Chairman PBG and member Syndicate. Prof. Noorka received an early education from countryside school of District Jhang, Pakistan and lastly the Post-Doctorate from the United Kingdom (UK). He was honored with Roll of Honor (Twice), University Color (Thrice). He is recognized as international scientist, innovative thinker with practical solutions-oriented outlook. Prof. Noorka was invited to represent his research findings throughout the globe, particularly in FAO (United Nation), Japan, China, Morocco, Iran, Turkey, Egypt, South Africa, India, Abu Dhabi (Twice), Saudi Arabia (Thrice), Sri Lanka, Italy, France, Singapore, Malaysia, Sudan, Dubai (Thrice), United Kingdom etc. His credit includes, international player, project collaborator

(University-Industry linkage programs), radio, TV anchorperson, having, 250 National & International publications and thirteen book chapters mostly published by Springer and CRC Taylor and Francis.

Dr. Mohamed Behnassi is a Full Professor and Head of Public Law in French Department at the College of Law, Economics, and Social Sciences of Agadir, Ibn Zohr University, Morocco. He is a Senior Researcher of international law and politics of environment and human security. He holds a Ph.D. in International Environmental Law and Governance (2003), a MSc. in Political Sciences (1997), and a B.A. of Administration (1995) from Hassan II University of Casablanca. He obtained a Diploma in International Environmental Law and Diplomacy from the University of Eastern Finland and UNEP, 2015. He is also an Alumnus of the International Visitors Leadership Program of the Department of State, United States of America. Dr. Behnassi is currently the Founding Director of the Center for Environment, Human Security and Governance (CERES). From 2015 to 2018, he was the Director of the Research Laboratory for Territorial Governance, Human Security and Sustainability (LAGOS). Recently, he was appointed as Expert Evaluator for the National Center for Scientific and Technical Research (CNRST/Morocco), and selected twice (2019-2024) as an Assessment Scoping Expert and a Review Editor by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and Member of the Mediterranean Experts on Climate and Environmental Change (MEDECC). He was also selected by The Intergovernmental Panel on Climate Change (IPCC) as Expert Reviewer of the 1st Order Draft of the Synthesis Report (SYR) of the IPCC VI Assessment Report (AR6). Accordingly, he was among the Lead Authors of the 1st Assessment Report (MAR1): *Climate and Environmental Change in the Mediterranean Basin - Current Situation and Risks for the Future* (MEDECC, 2021). Dr. Behnassi has published considerable number of scientific papers and book chapters in addition to 20 books, including recent ones on: *Food Security and Climate-Smart Food Systems - Building Resilience for the Global South* (Springer, 2022); *The Climate-Conflict-Migration Nexus from a Human Security Perspective* (Springer, 2022); and *Social-Ecological Systems in the Era of Risks and Insecurity - Pathways to Viability and Resilience* (Springer, 2021). Dr. Behnassi serves as a reviewer for many global publishers (such as Routledge and Springer) and scientific journals with high impact factor. He has organized many international conferences covering the above research areas, managed many research and expertise projects, and is regularly requested to provide scientific expertise nationally and internationally. Other professional activities include social compliance auditing and consultancy by monitoring human rights at work and the sustainability of the global supply chain.

Dr. Zafar Iqbal Khan is a Professor of Botany in the Department of Botany, University of Sargodha. He is HEC Approved Ph.D. Supervisor and registered as the Productive Scientist of Pakistan for the year 2008 by the Pakistan Council for Science and Technology. He published more than 280 research articles in reputed national and international journals by securing impact factor >350. The main area of his research is the bioavailability of toxic and trace metals in soils to crops, animals, and humans, considering all of the properties of soils that modify this bioavailability. Ultimately, this research project has several goals, including the protection of food crops from toxic metal contaminants, the minimization of trace element deficiencies, and the development of methods for testing and remediating contaminated soils.

Mr. Hafeez-Ul-Hassan is the final year student of M.Sc. (Hons) on Plant Breeding and Genetics, Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Pakistan.

Mr. Emran Manzoor is the final year student of M.Sc. (Hons) on Plant Breeding and Genetics, Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Pakistan.

Mr. Syed Shujat Ali is the final year student of M.Sc. (Hons) on Plant Breeding and Genetics, Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Pakistan.