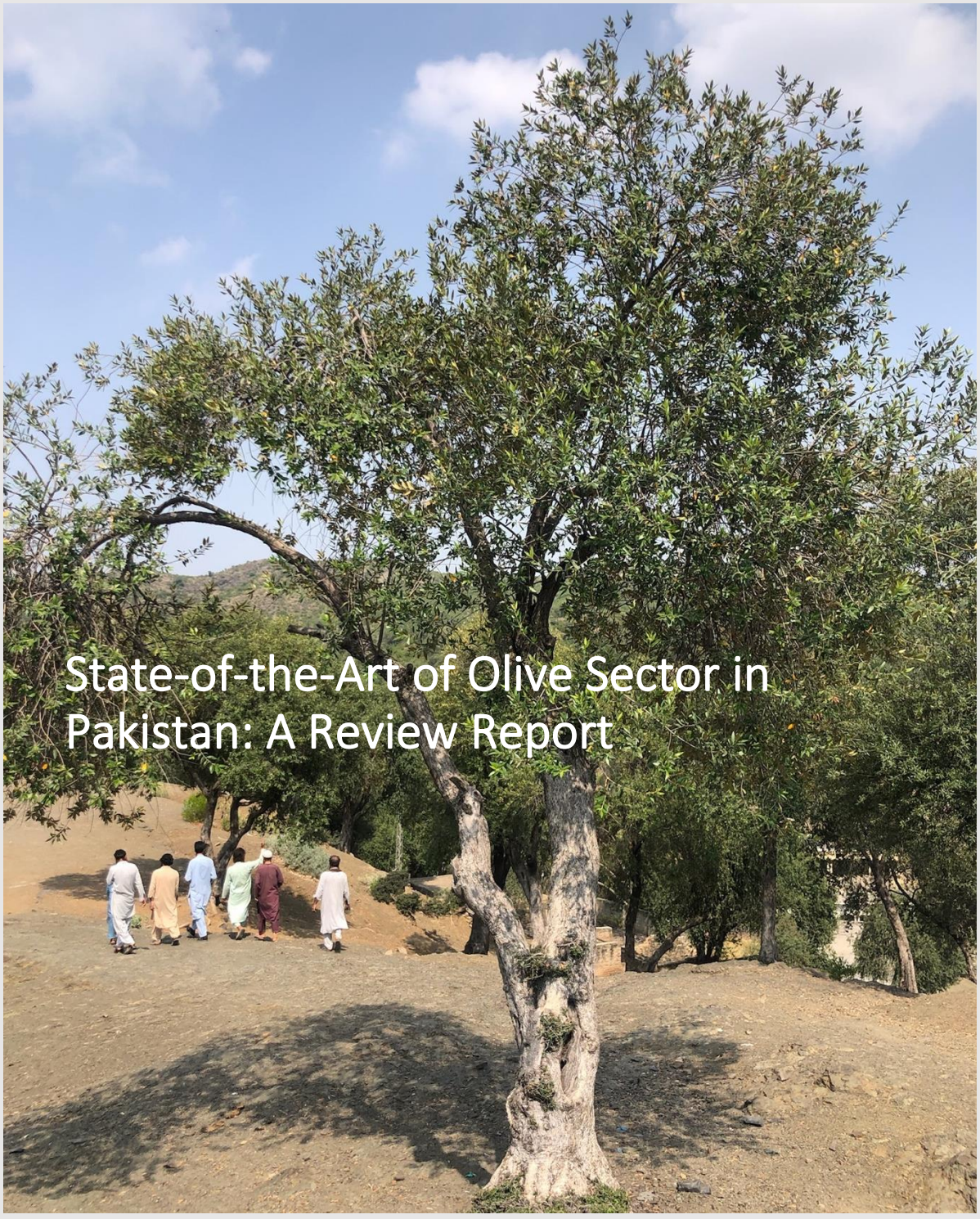

State-of-the-Art of Olive Sector in Pakistan: A Review Report

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The Authors take the responsibility of any shortcoming left in the Report.

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ACRONYMS AND ABBREVIATIONS

AFLP	Amplified Fragment Length Polymorphism
AJK	Azad Jammu & Kashmir
ARI Quetta	Agriculture Research Institute Quetta Baluchistan
ARI Tarnab	Agriculture Research Institute Tarnab KPK
BARDC	Balochistan Agricultural Research & Development Centre
BARI	Barani Agricultural Research Institute
BIT	Board of Investment & Trade
BUETK	Balochistan University of Engineering and Technology, Khuzdar
CABI	Pakistan and Centre for Agriculture and Biosciences International
CEFORT	Centre of Excellence for Olive Research and Training
CIHEAM Bari	Centre for Advanced Mediterranean Agronomic Studies Mediterranean Agronomic Institute Bari
CPEC	China–Pakistan Economic Corridor
ECNEC	Executive Committee of the National Economic Council
FATA	Federally Administered Tribal Areas
FBR	Federal Board of Revenue
FSC&RD	Federal Seed Certification and Registration Department
GB	Gilgit Baltistan
GOP	Government of Pakistan
GRASP	Growth for Rural Advancement and Sustainable Progress
HACCP	Hazard Analysis Critical Control Point
HEIS	High Efficiency Irrigation System
IAO	Instituto Agronomico Per L'Oltremare
ICT	Islamabad Capital Territory
IMF	International Monetary Fund
IOC	International Olive Council
IOOC	International Olive Oil Council
IPM	Integrated Pest Management
ISO	International Organization for Standardization
KPK	Khyber Pakhtunkhwa
MNFSR	Ministry of National Food Security and Research
MoC	Ministry of Commerce
NARC	National Agriculture Research Center
NGOs	Non-Government Organizations
NTHRI	National Tea & High Value Crops Research Institute
PARC	Pakistan Agricultural Research Council
PCP	Planning Commission of Pakistan
PCSIR	Pakistan Chemical and Industrial Research Laboratory
PIDSA	Pakistan Italian Debt for Development Swap Agreement
POCCSP	Promotion of Olive Cultivation on Commercial Scale in Pakistan
POD	Pakistan Oilseed Department
PODB	Pakistan Oilseed Development Board
PPAF	Pakistan Poverty Alleviation Fund
PSDP	Public Sector Development Programme
R&D	Research and Development
RAPD	Randomly Amplified Polymorphic DNA
SME	Small and Medium Enterprises
SMEDA	Small and Medium Enterprises Development Authority
SPS	Sanitary and Phytosanitary
SSR	Simple Sequence Repeat
STPF	Strategic Trade Policy Framework
SWOT	Strengths, Weaknesses, Opportunities and Threats
UET	University of Engineering and Technology
UPGMA	Unweighted Pair Group Method
VOO	Virgin olive Oils
ZTBL	Zarai Taraqiati Bank Limited

INTRODUCTION

Pakistan is a major importer of edible oil since the early 1970s because its domestic production is less than consumption and about two-third demand for edible oil is met through imports, which is a vulnerable burden on the foreign exchange of the country. The edible oil seeds in Pakistan is a policy failure because their production as edible oil has declined despite numerous initiatives. The domestic production contributes only 13 to 15 percent of the whole consumption whereas 85 to 87 percent is met through imports. Per capita consumption of edible oil has risen from 5.31 kg in 1973-74 to 20 kg in 2018 and is probably going to rise to 22 kilograms by 2028 projecting the total consumption to 6.5 million tons against current local production of than 0.5 million tons, widening the demand-supply gap more. The import bill will move upward accentuating the need for well-thought-out policy and planning (Business Recorder Report June 9, 2022).

The olive is an evergreen tree that can live and bear fruit for hundreds of years and is native to the Mediterranean region, including the coasts of southeastern Europe, West Africa and North Africa. Moreover, this species is also grown in regions like northern Iran and areas west of the Caspian Sea. Efforts are also being made to cultivate this tree in many other countries. According to the Food and Agriculture Organization (2018) of the United Nations, olive trees covered an area of 10,513,320 hectares in 2018, which was 26 percent higher than that in 2000. Moreover, the total yield obtained from these trees in 2018 was 21,066,062 tons, 35% more than in 2000. According to several projects on olive, reports, research papers and articles, it has been portrayed that in Pakistan, there is a considerable scope and potential for Olive cultivation as a source of edible oil.

Olive fruit is an important agricultural produce in the Mediterranean region. They can be green, purple, dark brown, black and even pink in color. An olive contains 20-30 percent of oil. That is why almost 90 percent of olive production is used to extract oil while the remaining ten percent is used for other purposes. An olive tree produces, on average, 20-30 kg of fruit while one liter of olive oil is produced from the pressing of 4-6 kg of olives. Olive trees can be planted in harsh climatic conditions. Almost 70 percent of olive orchards are rainfed; in parts of the Mediterranean some olive trees are planted in areas having less than 200 mm of rainfall. They are a source of income for a large number of people (Atif 2020). Spain is the world's top producer of olive oil and it has the largest area under cultivation, and, thus, the largest production of olives. According to the Observatory of Economic Complexity (OEC), the world trade of olives in 2018 amounted to US$ 604 million, showing an increase of 22.1 percent compared to 2017. Similarly, according to OEC (2020) the latest trade data of Olive oil virgin in 2020 was the world's 448th most traded product, with a total trade of $6.54 billion, representing the 0.039% of total world trade.

In Pakistan, the concerted efforts are underway to develop Olive sector keeping in view its value chain development from production to marketing. At federal level, the Pakistan Oilseed Department (POD), previously "Pakistan Oilseed Development Board (PODB)" till June 2021,

has to provide coordination and policy formulation as well as to promote research on oilseed development including cultivation of olives.

In the current scenario, there is an immense need to promote and revamp the cultivation of oilseeds in a transforming mode, utilizing both conventional and non-conventional oilseed crops including olives. It is essential to mention that promotion of Olive cultivation is a potential alternative for edible oil source as Pakistan has many areas with a climate, land and soil that are suitable for the plantation and cultivation of a variety of olive trees and olive orchards.

The Italian Government has played a pivotal role for the olive promotion in Pakistan since 1980's, and currently, through the OliveCulture Project implemented by CIHEAM Bari in partnership with POD, is aiming to strengthen the olive value chain through adoption of holistic and multi-disciplinary approach, involving the stakeholders. The Project is being implemented in the suitable olive cultivation areas of Baluchistan, Khyber Pakhtunkhwa, and Punjab. It aiming to provide technical backstopping for strengthening the olive value chain in all aspects covering nursery, orchard, harvesting/post harvesting management, youth and women involvement, marketing/ market development, branding and standardization, complying with international standards, in collaboration with federal and provincial endeavors.

For the purpose of pragmatic implementations of the various components of the OliveCulture Project, it has been deemed appropriate to carry out a comprehensive analysis of the existing olive sector/industry, evolved from previous national and international initiatives, and assess its level of state-of-the-art development, as a result of the capitalization of the bilateral cooperation initiatives activated by the Pakistani and Italian Governments.

Keeping this in view, in addition to the various available reports studied/reviewed, information has also been searched in the press regarding the Olive cultivation, Olive oil processing and trade.

The review of the current scenario of olive sector linked to the past, including the introduction of exotic cultivars and their adaptability tests and performance, would help whoever is dealing with the olive development to structure to integrate the current activities, when possible, and for their future planning keeping in view the history and lessons learnt.

NATIONAL AND INTERNATIONAL INITIATIVES[12]

The Government and a number of International donors played a fundamental role to promote olive cultivation and it's processing in Pakistan. Public sector organizations hands in gloves with international agencies have assisted in financial and technical backstopping and capacity building of scientists, academia, farmers, and industry in the olive value chain development mode, and provided state of the art technology, high-yielding olive varieties, tools, and olive oil extraction machinery.

The details of the multiple projects executed during the last almost two and a half decades in the country to promote olive cultivation and develop its value chain are given hereunder, whereas the chronical of the significant projects, mostly related to federal financing, are listed in Table 1:

a) Keeping in view the large presence of wild olives in different ecological zones of Pakistan with various morphological and ecological types, the M/o Food, Agriculture and Livestock (MinFAL), through the Pakistan Oilseed Development Board (PODB launched in 1986 a project to graft about 5.5 million wild plants, but less than 1% plants went into production).

   Due to the failure of the grafting, as some olive plants that were randomly imported on occasional basis by the Research, Officials and travelers from the Mediterranean countries showed a good harvest under certain conditions, this was considered a proof that olive could be introduced in the Country for production.

b) The pioneer structured initiative was taken in 1986 with the assistance and funding from the Italian Government of the "*Fruit, Vegetable and Olive Project.*" (1986-1989), implemented by AGROTEC with the Pakistan Agricultural Research Council (PARC). Some experimental trials with the exotic olive germplasm were established in the provinces and at the National Agriculture Research Center (NARC). It is worth to mention that Olive was not a main component of the project, nevertheless the basis was laid down for introducing the cultivation by exploring the suitability of country's agro-ecology zones. The scientific and technical response was positive, but the real outcomes would have been ensured by a regular follow-up post-project.

c) PODB during 2005 launched the project captioned as "*New plantation of Olive in Khyber Pakhtunkhwa, Potohar and Balochistan, and maintenance of Olive orchards established by POD"* at the cost of Rs. 39.185 million.

   PODB also developed 150 acres of model Olive farm at Sangbhatti, Mardan and planted about 20,000 Olive plants. It also established germplasm unit on 10 acres comprising of 1,000

[1] Assessment of the main activites done by the PIDSA & AFNEPAK Projects are included

[2] Only significant activities have been included

Olive plants of different varieties imported from Italy and other countries, incurring a cost of Rs. 38.0 million.

d) The Italian Government resumed the dedicated support for the development of olive on modern way, in consideration of the relevant failures of the grafting, and financed the project "*Promotion of the production and marketing of olive oil in Pakistan*", implemented by the Istituto Agronomico per l'Oltremare & Pakistan Oilseed Development Board (PODB) from 2007 to 2008, The Project identified suitable areas for olive growing and published the "Atlas of suitable areas for olive growing in 14 Districts in NWFP (now a days KPK) and Balochistan". And a Market Study to understand the oil consumption and market dynamics.

e) The Pakistan Italian Debt Swap Agreement (PIDSA) awarded in 2012 to the Ministry of National Food Security& Research the project captioned as "*Promotion of Olive Cultivation for Economic Development and Poverty Alleviation*". The project, with the cost of PKR 382 million, was executed through PARC coordination system in KPK, Baluchistan, FATA and Punjab provinces.

   The project represents the first significative investment in the Country for the development of the olive sector, aiming to increase the local production of edible oils by cultivating olive specially to utilize culturable waste lands and expand the cultivation of olives in selected / identified areas through new plantation in these provinces. Main outcomes are the followings:
   - Plantation at farmer fields: a total of 520,867 olive plants, covering an estimated area of about 2,018 hectares i.e., 120,140 plants in Balochistan, 138,949 plants in KPK, 14,207 plants in Punjab, 101,200 plants in FATA, and 11,105 plants in Federal area of Islamabad.
   - Plants Propagation and nursery management: a total of 671,092 cuttings were distributed as follows: 49,000 in Balochistan, 193,200 in KPK, 328,437 in Punjab, and 5,000 at NARC.
   - Training and Field Days: 31 and 20 respectively.
   - Maintenance of Mother Orchards, Rehabilitation of previously planted olive orchards and infrastructure: were done as per plan.
   - Adaptability study/Varietal trails: were planted in all the provinces at 118 different locations and would have been regularly followed up at the end of the project by the relevant Institutions and Departments.
   - Media Advertisements: Media campaign remained continued as a regular activity through print and electronic modes, as there was no awareness of the farmers and Country about olive.

   The Project was, in conclusion, very successful in introducing olive in farmer fields, in the Agriculture Research system, in the relevant public institutions and policy makers, in the consumers, in the donors, and ultimately in paving the way for future investments.

f) The Italian Government, extending the support for the development of olive sector in a consequential and consistent manner, financed the regional project "*Technical assistance and support to line ministries in the agricultural sector with emphasis on olive production/AFNEPAK*" (in Pakistan, Afghanistan and Nepal) implemented by the Istituto Agronomico per l'Oltremare (IAO) & PARC, from 2012 to 2016. He was approved with

the General Objective of strengthening the development of the agricultural sector, in particular olive-growing and production of olive oil, and to improve the standard of living of the rural population. He targeted following Specific Objectives:

- The 1st Objective "*Definition of the areas of agro-economic interest for users*" had to lead to the completion of the detailed mapping of the areas with a natural vocation towards olive-growing, which began under the project "Promotion of the production and marketing of olive oil in Pakistan". There was also the plan to develop opportunity cost models relating to the possibility of cultivating olive trees in areas which have no infrastructure or services, so as to support the task of the decision-makers in the relevant Ministries. Moreover, it was planned to create a national registry of olive-growing and a network for the collection and handling of meteorological data obtained in the trial orchards set up by the Project. A market survey was also planned to ascertain the different uses of olive products, their diffusion in the market and market prospects for them.

- The 2nd Objective "*Training of technicians and farmers*" focused on providing capacity building to a substantial number of agricultural experts and farmers' professional in a broad range of subjects, so as to satisfy the diverse requirements of a supply chain industry as is that of olive-growing.

- The 3rd Objective "*Technical support for the setting-up of production lines on farms and for small farms in association with one another"* aimed to study the adaptability of the cultivars thus far introduced to the country, so as to be able to supply information not only regarding the areas to cultivate and the relative cultural techniques, but also the selection of the best cultivars for obtaining oil or table olives, according to the characteristics of the soil and climate of the different areas for cultivation.
  +
- The 4th Objective "*Setting up and consolidating farmers' associations*" was deemed essential for ensuring the development of a sustainable olive industry in vast areas of the country, particularly where the majority are small holders and the purchase of machinery and management of the infrastructure would be done through organized groups of farmers (already existing or new ones).The training was therefore also offered to Non-Governmental Organizations (NGO)s and Community Based Organizations (CBO)s. The Project was also encouraged to promote collaboration with research institutes and supporting them with equipment when needed.
-
- The 5th Objective "*Increasing income-producing activities: enhancement of oil quality*" aimed to enhance the quality of the oil both for food, cosmetic and medicinal use. It was included training for technicians of laboratory.

- The 6th Objective "*Support to Production through Promotional Activities"* was aiming to provide technical assistance to farmers by supporting activities undertaken or promoted by the counterpart M/o NFS&R in favor of the beneficiaries and directed towards the diffusion of olive-growing and promoting olive products in the Country. The activity had to include NGOs, communities and private investors.

Results

The objectives were only partly achieved, as the counterpart had to suspend the activities - in fact the project is not yet administratively closed - which were developed in support and integration with the PIDSA's Olive project. The most noticeable outcomes, besides the provision of training of trainers and technical assistance, are a market study, "Market analysis for value chain and olive oil consumption in Pakistan", done by the Punjab Economic Research Institute, and mapping of the olive plantation.

g) Under the PIDSA's financed project" *Early recovery of Agriculture and Livelihood Program for conflicted areas (Malakand)"* implemented by the Provincial Disaster Management Authority/Provincial Reconstruction and Rehabilitation Authority (PDMA/PaRSA) of Khyber Pakhtunkhwa, from March 2010 to July 2012 at the cost of Rs 713 million, were planted in Swat 24,000 imported Olive plants over 71 hectares of rangeland, barani (rainfed), with the assistance of PODB. Training sessions were conducted as well as the follow up. Grafting on wild olive was also done on 247,878 plants. Later on, it was assessed that the percentage of plants survival and growing was low, due to several constraints, which were taken in due consideration by PODB.

h) Inspired by the positive response to the Olive project financed by PIDSA at all levels in the Country, the Public Sector Development Programme (PSDP) financed the megaproject "***Promotion of Olive Cultivation on Commercial Scale in Pakistan"*** (POCCSP) with total cost of PKR 2444.545 million, to be executed by PARC. This initiative was considering the majority of the virgin lands of Pakistan suitable for olive cultivation, encouraging research results on series of adaptability experiments on exotic varieties, and taking benefit from prevailing huge population of wild olive trees in various parts of the country. The main objectives of the project are to culminate the real potential of olive farming in the country including Baluchistan, KPK, Punjab, AJK, GB, and Southern Punjab.

The first phase (2014-2021) has been completed, while Phase-2, worth Rs. 6410.229 million, started during 2021-22 under the implementation of the POD, and will be completed by 2024. During the span of project life, it will target Olive plantation on 75,000 acres through providing exotic and indigenously produced olive plants to farmers and develop infrastructure/capacity of the public and private sector for mass-scale production of true to type, disease-free olive nursery plants as well as providing mother orchards development for bud wood provision. Drip irrigation systems are being installed over 16,000 hectares and 3.6 million olive trees. The public and private sectors currently maintain 25 olive oil extraction plants of different capacities. The project will also train youth and gender on olive culture. This project also has the mandate to provide Olive oil extraction units and value addition equipment to facilitate processing. The project is being implemented by Pakistan Oilseed Department (POD) of MNFSR. Overall in the country the project has nine (9) components located at Federal, Punjab, Baluchistan, KPK, GB and AJK level.

An overview of the achievements is reported in the Chapter "*Assessment of the agronomic studies done with the PSDP project from 2014"*

i) The Institute of BARI (Barani Agriculture Research Institute) at Chakwal has been trying to cultivate olive since 1991 and in this regard more than 50 varieties have been tested. With the support of Punjab Agriculture and Meat Company (PAMCO) in 2012 a project was launched by importing 13,100 saplings to prepare mother blocks**.** Then, thanks to the PIDSA financing, the province could start the olive development transforming Potohar in "Olive Valley".

   The Institute had also carried out, from 2010 to 2014, with the Punjab Agricultural Research Board (PARB), an *Adaptation study of new cultivars of olive and standardization of its propagation and value addition techniques on the barani areas of Punjab.*

j) In continuation to the activities done through the POCCSP, Punjab launched a provincial project, from 2015 to 2020, worth Rs. 2629.786 million. The major objectives are to achieve Olive cultivation on 15,100 acres of land with provision of 2,038,500 certified nursery plants, capacity building of private sector for acclimatization of nursery plants, provision of technical assistance to olive growers for layout, plantation & orchard, improve water source development and drip irrigation system management. The project was supported by USAID, which greatly helped in establishing BARI as Centre of Excellence.

   To further enrich the Olive promotion, the project has financed the establishment of the *Centre of Excellence for Olive Research & Training (CEFORT)* at BARI Chakwal with total cost of PKR 283.121 million. The CEFORT will develop capabilities and capacities for olive cultivation, management, post-harvest and processing and value addition/product development. It will also develop & adapt technologies for development of olive sector in Punjab through on-station and farmer participatory research and will act as a repository of olive genetic resources management and undertake socio-economic research in olive crop.

k) The "*Program for Poverty Reduction*" (PPR) financed by Italian Government and executed by the Pakistan Poverty Alleviation Fund (PPAF) on behalf of the Government of Pakistan, had introduced the olive crop for the adoption by the Communities. Between 2016 and 2020, as much as 53,608 olive saplings were planted covering and approximate area of 560 acres, with 692 beneficiaries. The PPR also established n.3 (three) olive oil extraction units/processing plants, one in KPK and two in Balochistan, which are managed by associations of communities together with PPAF and other relevant partners. The plant of Lower Dir is also equipped with a unit for the processing of Table olives.

l) The European Union is financing the project *"Growth for Rural Advancement and Sustainable Progress/GRASP*" in selected districts of Balochistan and Sindh, which is implemented by the International Trade Centre, from 2019 to 2024. The objective is poverty reduction and sustainable, inclusive growth through development of rural small and medium-sized enterprises. Olive development has been identified as an eligible crop for the

project in Balochistan, therefore synergies may be developed with the other on-going initiatives. The field activities are being handled by FAO (agriculture) and PPAF (for the SMEs).

It may be recalled that European Union had financed in the past olive oil activities in Swat under the Programme for Economic Advancement and Community Empowerment (PEACE), implemented from October 2012 to March 2018, and that the current project will certainly build on that experience, which encouraging, for instance, the constitution of an Interest Group which manages an olive mill.

m) Keeping in view the olive cultivation success story, but also the complexity for reaching a viable vale chain, the Government of Pakistan through Economic Affairs Division requested to Italian Agency for Development Cooperation (AICS) to further support the process of olive development.

Positively, the Italian Government has financed the Project **"OliveCulture - Holistic and multi-professional Mechanism for a Pakistani Olive Value Chain"** which has been designed to strengthen the Pakistani olive oil value chain on several levels in a holistic, participatory, and multifunctional way, involving institutions, businesses, farmers, youth, women and consumers, to improve productive, economic, and qualitative performances.

The Project is funded by the Italian Ministry of Foreign Affairs and International Cooperation – Italian Agency for Development Cooperation and jointly implemented by CIHEAM – Bari and the Ministry of National Food Security and Research, through the Pakistan Oilseed Department (POD). The POD and its national project "Promotion of Olive cultivation on commercial scale in Pakistan – Phase II" are the main partners, encouraging herewith a holistic and multi-professional mechanism for strengthening the Pakistani quality olive value chain.

The Project has started on the 17th of January 2022, and will terminate in March 2024. The Synopsis of the Project is attached as Annex-1.

Table – 1 Public Sector/Partnership Projects Executed for the Promotion of Olive Cultivation and Development of its Value Chain					
N0.	**Title of the Project**	**Project Time Span**	**Executing Organization/Sponsor**	**Project Domain**	**Project Cost PKR (Million)**
1	Grafting wild olives into bearing species	1986	Pakistan Oilseed Development Board PODB	Pakistan Oilseed Development Board	-
2	Fruit, Vegetable and Olive Project	1986 to 1989	AGROTEC & Pakistan Agriculture Research Council (PARC)/Italian Government	Punjab, KPK, Baluchistan, FATA	-
3	Accelerated promotion of olive cultivation	2000 to 2004	Pakistan Oilseed Development Board (PODB)	KPK and Potohar	24.055
4	Rapid conversion of wild olive into oil bearing species	2004 to 2008	Pakistan Oilseed Development Board (PODB)	Punjab, KPK, Baluchistan	186.379
5	Development of olive model farm for R&D activities	Not Available	Pakistan Oilseed Development Board (PODB)	Not Available	-
6	Development of olive production and processing in Baluchistan	Not Available	PODB - M/o Food and Agriculture and Livestock (MINFAL	Baluchistan	190.00
7	Promotion of the production and marketing of olive oil in Pakistan.	2007 to 2008	Istituto Agronomico per l'Oltremare (IAO) & Pakistan Oilseed Development Board (PODB)/ Italian Government	KPK, Baluchistan	0.8 M. Euro
8	Adaptation study of new cultivars of olive and standardization of its propagation and value addition techniques	2010 to 2014	PARB, Punjab and Barani Agriculture Research Institute (BARI), Chakwal	Barani Areas of Punjab	21.97
9	Technical assistance and support to line ministries in the agricultural sector with emphasis on olive production (AFNEPAK)	2012-2016	Istituto Agronomico per l'Oltremare (IAO) & Pakistan Agriculture Research Council PARC)/Italian Government	Afghanistan, Nepal and Pakistan	2.4 M € (0.8 M for Pakistan)
10	Promotion of olive cultivation for economic development and poverty alleviation	2012 to 2015	Pakistan Italian Debt Swap Agreement (PIDSA) and PARC /Italian Government	Punjab, KPK, Baluchistan, FATA	382.15

N0.	Title of the Project	Project Time Span	Executing Organization/Sponsor	Project Domain	Project Cost PKR (Million)
11	Developing Potohar into an olive valley	2015 to 2020	Punjab Agriculture Development Program, BARI Chakwal	Punjab Barani regions	2629.79
12	Plantation of Five million of olive saplings in KPK and maintenance of model farm at Sangbhatti	2013 to 2019	Agriculture Development Program. Agriculture Research Institute, Peshawar	KPK and FATA	1154.17
13	Development of olive production and processing in Baluchistan	2016 to 2019	Baluchistan Agriculture Development Program. Agriculture Research Institute, Quetta	Baluchistan	190.00
14	Promotion of Olive Cultivation on commercial scale in Pakistan. Phase-1 (POCCSP)	2014 to 2022	M/o National Food Security and Research (MNFSR) - PARC	Punjab, KPK, Baluchistan, FATA and AJK	2320.27
15	Promotion of Olive cultivation on commercial scale in Pakistan. Phase-2 (POCCSP)	2021 to 2024	PSDP MFSR Pakistan Oilseed Department (POD)	Punjab, KPK, Baluchistan, AJK, GB, and Southern Punjab	6.41 Billion
16	Project OliveCulture "Holistic and multi-professional mechanism for a Pakistani Olive Value Chain"	2022 to 2024	CIHEAM Bari & Pakistan Oilseed Department (POD)/ Italian Government	Baluchistan, Khyber Pakhtunkhwa, Punjab, Sindh, Gilgit-Baltistan and Islamabad Capital Territory	€ 1,500,000
Source: Various reports published by Projects and internet					

ASSESSMENT OF THE AGRONOMIC STUDIES DONE WITH THE PSDP PROJECT FROM 2014[3]

In order to evaluate the activities done in the field of agronomy and olive crop production by the national project "*Promotion of Olive Cultivation on Commercial Scale in Pakistan*" POCCSP, 2021) it is required to provide an overview of the initiative. The project, which has been shortly described in previous chapter, was approved in 2014 with an allocation of Rs. 2320.27 million to harness the real potential of olive farming. The Ministry of National Food Security & Research (MNFS&R) entrusted to PARC the implementation. The project had two phases, and its domain spreads with its components in Baluchistan, KPK, Punjab, AJK and GB. Phase – I was completed in 2019.

Whereas "*Promotion of Olive Cultivation on Commercial Scale in Pakistan (phase-II) - National program on Olive Deepening"* was approved in the Executive Committee of the National Economic Council (ECNEC) meeting on 1 June 2021 by Ministry of Planning Development & Special Initiatives; the MNFS&R) has entrusted the implementation to POD. The phase-II envisages olive cultivation on an area of 75,000 acres and grafting of 5 Million wild olive plants throughout the country on public and private land/forests. Further it will provide 6 olive oil extraction units, 10 table olive processing units and 10 nursery tunnels on 50% matching grant basis to private sector. Phase – II was launched during 2021-22 and will be completed by 2024 (POCCSP, 2022). The combined PSDP-funded project (phases I and II) is mainly meant to provide services, resources, structures, equipment and inputs facilities for the development of the olive value chain in various ecologies of the provinces and assigned the following objectives to be accomplished during the scheduled timeframe of Phase I:

- Plantation of olive plants on 50,000 acres (POCCSP, Project Report, 2014-21)
- To develop infrastructure/capacity of the public and private sector on mass-scale production of true-to-type, disease-free olive nursery plants
- Provision of Exotic and Indigenously produced olive plants to farmers
- Human resource development through training on olive culture involving youth and gender
- Provision of oil extraction units and value additional equipment to facilitate processing
- Mother orchards development for budwood provision

The project interventions were to encompass state-of-the-art technological backstopping to uplift the olive value chain stakeholders from production to processing.

The project interventions and their follow-up progress and achievements for the period 2014-21 (POCCSP. 2022) are summarized as follows:

Intervention – 1: Provision of certified, true-to-type olive plants (all imported)

[3] Sub-activity 3.1.2 Assessment of the Agronomic Studies done with the PSDP project from 2014

Progress: 13,354 acres (1.719 million olive saplings) have been planted across the country, i.e. Baluchistan 56%, KPK 24%, Punjab 15%, AJK 3%, and GB 2%, benefiting around 3,884 small and large farmers in the specified areas of the country. More than 17% of these plantations have started fruiting.

Intervention – 2: Installation of drip irrigation systems at the farmer's site
Progress: Granted and installed HEIS / drip irrigation systems on 1,686 acres for 124 farmers in three provinces (75% of the targeted), i.e. Baluchistan 35%. KPK 45% and Punjab 20%,

Intervention – 3: Specialized double-shaded olive nurseries for plant propagation
Progress: 12 nurseries have been established under the grant i.e. Six (06) in Baluchistan, three (03) in KPK, two (02) in Punjab and one (01) in ICT which are producing plants for the farmers. The nurseries established have an in-built irrigation, heating, cooling system with temperature controls, and all other facilities to produce olive saplings on a largescale.

Intervention – 4: Olive oil extraction units
Progress: Under the grant, nine (09) olive mills of varying processing capacities have been established as follows: MORI TEM Oliomio Gold 100kg/hr. are operational at NARC, BARI, AO Lower Dir, NTHRI Mansehra, AO Zhob, and AO Barkhan, whereas PIERALISI 600kg/hr. are operational at BARI Attock, ARI Loralai and BARDC Quetta.

Intervention – 5: Support to provincial departments for conducting adaptability trials
Progress: The target of 25 trials for exotic varieties has been achieved, and data collection from the trials is in progress for registration and certification from relevant authorities.

Intervention – 6: Support for the establishment of olive mother blocks (GPUs) at public sector institutions
Progress: The GPUs were developed for all project components, including GB and the AJK.

Intervention – 7: Plant propagation locally
Progress: A total of 1.856 million cuttings have been planted so far at the components

Intervention – 8: Training to the value chain stakeholders
Progress: During 63 training sessions out of 91 as per the total target, more than 4,370 farmers/stakeholders received hands-on training on olive farm best practice, pruning, nursery establishment, and fruit processing, packing, and marketing.

Intervention – 9: Installation of weather stations
Progress: Installed five weather stations at various locations, i.e., BARI Attock, NTHRI Shinkiyari, ARI Quetta, UET Khuzdar, and Loralai.

Intervention – 10: Up-gradation of olive value-addition labs

Achievements: The project has supported the up-gradation of olive oil and value-added products labs for conducting evidence-based research at BARI Chakwal Punjab, ARI Tarnab KPK, and ARI Quetta Baluchistan. These labs are meant for the standardization of olive oil and recipes of value-added products. The labs were improved through upgrading infrastructure with the provision of equipment and tools to help in the preparation of standardized products for R&D and training to the stakeholders.

In addition to the progress mentioned above, it may be mentioned: (i) 20% - 30% of the olive fruits are used in preparing value-added products, pickles, jams, sweets, and syrups which have increased demand, and (ii) joint research, development, and training of olive value chain stakeholders have being conducted through specialized dedicated institutions such as CEFORT (Center of Excellence for Olive Research and Training) established by the Government of Punjab at BARI Chakwal with technical and financial support of USAID Pakistan, and (iii) the intellectual property rights for marketing olive oil and value-added products, a trade mark and logo as *"Pak Olive"* has been approved by the intellectual property organization, Government of Pakistan.

The project has organized an "Impact Assessment" released in April 2022 by the firm Khaity. Pk prepared on the basis of a formal questionnaire-oriented survey of about 670 olive growers representing the project domain areas of the country. A comprehensive evaluation of the project-assigned intervention has been studied. The results have shown that the overall project intervention implementation activities have portrayed tangible outcomes and positive impacts to foresee that the country has real potential to progress in developing the olive value chain. It is vital to note that the report shows the scenario of the period from 2014 – 21, when about 20% of the olive plantation by the project have started fruiting; the existing outcome will be different when the olive plantation will be bearing fruit to their full potential after almost 10 years.

The salient features of the Impact Assessment Study are summarized as follows:

- About 45% of irrigated and 35% of rainfed land is used for olive plantation.
- The average survival rate of the plantation on farmer's land varied from 80-90%. Death rate up to 50% was also reported mainly due to drought/water shortage.
- About 73% of farmers reported that they have been informed by the project about the cultivar to be planted. Widely used variety are Arbequina and Arbosana.
- 37% of farmers possess wild varieties, native in land varying from 1-10 acres.
- 59% of farmers used pesticides to control insects, pests and diseases over olive plantations mainly once or twice a year. Cost ranging 1,000-10,000 Rs/acre
- Around 86% of farmers used fertilizer to provide nutrition to the olive plantation, majority once a season, at the cost of Rs10,000/acre; 13% were not using any fertilizers; 90% of farmers were using organic fertilizers, i.e. animal manure (81%) and poultry waste (6% of organic fertilizer)
- Out of 670 surveyed farms, only 19% of the orchards has started production, and about 7% olive farms have reached 50% production level.

- The primary method used by 99% farmers for harvesting olives is manual; only 1% used some tool for mechanical harvesting. The unavailability of proper machine is a constraint. Generally, harvesting costs varying around Rs 10,000 per acre.
- The project installed Drip Irrigation System on 1,686 acres of olive fields across the country, whereas on other olive plantation farmers are irrigating using conventional methods.
- 91% of farmers expressed that olive plantation benefits the soil.
- 77% of livestock manure is used as fertilizer in all provinces.
- In most cases, the distance from the olive farm to the market is more than 5 km.
- 35% of farmers are preparing olive value-added products at their farms
- Farmers who are preparing olive value-added products and are selling to markets are from Baluchistan 53%, KPK 14%, Punjab 28%, and from ICT/Federal 5%.
- Regarding olive extracting unit accessibility, 63% of farmers have not, 78% have no access to government-provided olive oil storage facilities, 69% do not even own olive oil storage facilities, and 90% want to establish it with government support 80-100% subsidy.
- Regarding the value-added lab established by the government, 48% of farmers mentioned no to have access, 35% did not respond, and 9% had no knowledge about the lab.
- Regarding establishing a weather station, 74% of the farmers have said they do not have a weather station nearby or are unaware that 11% have access to it.
- Regarding the farm/orchard maintenance cost, 21% of farmers' estimates are around Rs. 5,000 per acre, while 76% did not respond.
- Transportation cost of olive to market is dependent on distance from farm to market and reported by the majority of farmers to vary between less than Rupees 20,000 (46% farmers), 20,000 to 50,000 (9%farmers) and 50,000 to 100,000 (43% farmers).
- Training on the olive plantation and production was availed by 54% of farmers, while 11% were unaware of it. Those who benefited from training expressed a positive impact of exercise on their capacity building. Almost all the farmers are in favor of training programme in future, also in agronomic management practices and cost reduction.
- Overall, 58% of farmers said that training improved their knowledge about olive cultivation. 37% did not respond, and 4% had no impact of exercise on expertise.
- 84% of farmers think that olive plantations have a positive impact on other vegetation and wildlife.

ASSESSMENT OF THE AGRONOMIC STUDIES

Olive tree vegetative and reproductive growth characteristics strongly respond to light availability, canopy differences, and architecture of different cultivars (Schneider et al., 2012; Cherbiy-Hoffmann et al., 2013; Rousseaux et al. 2020). The Olive varieties Arbequina, Coratina and Frantoio were considered as most suitable for cultivation based on their productivity, the leaf area distribution, canopy architecture, leaf anatomical characteristics under Mediterranean climate (Tous, 2010; Neri et al., 2020).

Adaptability trials of olive varieties were conducted at 93 different locations in the country for the evaluation/selection of suitable olive variety, appropriate for the given climatic conditions (Awan et al., 2014; Pulido-Fernández et al., 2019). Similarly, according to Promotion of Olive Cultivation for Economic Development and Poverty Alleviation (POCCSP) project report (2014-21), Pakistan imported more than 100 olive cultivars and their adaptability trials were conducted in various ecological zones by BARI Chakwal and ARI Peshawar. The results showed that most of the varieties under study were suitable for oil extraction whereas some varieties proved best for table purposes. However, it is pertinent to mention that comprehensive information on various olive varieties compatible with various regions is not readily available in any structured form that could prove helpful for farmers to take decision regarding selection of suitable varieties keeping in view the productivity and other physical and chemical and quality characteristics. The availability of true-to-type disease-free plants of certified varieties was one of the issues that farmers had to face in the past however, currently POCCSP is supporting the establishment of nurseries as well as is offering certified commercially viable olive plants free of cost.

In case of Pakistan climatic conditions, these are not exactly like the Mediterranean countries, rather there are in certain case the opposite. A number of olive varieties are being cultivated in Pothwar region, Baluchistan and Khyber Pakhtunkhwa. The olive (Olea europaea L.) is a worldwide famous tree crop having valuable commercial role due to nutritional as well as therapeutic benefits obtained from its edible oil. Eight varieties of Olea europaea L. fruits were obtained from three Agricultural research institutes located in different areas of Pakistan including Quetta, Loralai and Zhob to extract and determine their oil contents by conventional method as solvent extraction (Soxhlet apparatus). Statistical analysis showed significant ($p = 0.002$) difference in oil composition of collected plants. Highest amount (percentage) of oil was obtained from Gemlik variety (65%) from Loralai and lowest oil content from Dolce Agogia variety (17.5%) collected from Quetta. Gemlik variety proved to be the dominant varieties regarding oil recovery percentage among Dolce Agogia, Moraiolo, Coratina, Leccino and Uslu, whereas Arbequina and Frantoio contained the significant amount of olive oil. Further research is under consideration to rule out best suitable factors including some soil and environmental factors to obtained more potential cultivars of Olea europaea in Pakistan (Khaliq et al., 2020).

The influence of agro-climatic conditions on the performance of Olive varieties Coratina, Pendolino and Leccino for fruit yield and oil contents at two locations, Sangbhatti and Chakwal, during 2008 and 2009 was studied by Azmat and Rab (2014). Olive cultivation at Chakwal resulted in higher number of fruits per tree, fruit set percentage and oil content percentage, whereas higher fruit size and fruit yield was recorded at Sangbhatti. Cultivar Leccino was higher in number of fruits per tree, and higher fruit yield and oil content percentage. Pendolino resulted in higher fruit set percentage. Coratina produced fruits of bigger size with poor oil content.

Four olive cultivars i.e. Frantoio, Moresca, Biancolella and Leccino were looked into for most suitable drafting time and its effect on olives productivity by Ibrar et.al (2016). The grafting times chosen were June, July and August and the study were completed at Agriculture Research Institute Tarnab, Peshawar during 2012. The various growth parameters recorded were

sprouting percentage, number of sprouts, sprout length, number of leaves and days to sprout after grafting. The highest number of sprouts, sprouting percentage and days to sprout was observed in plants grafted in July, whereas, the maximum length of sprouts and leaves per sprout was noticed in plants grafted in June. The variety Biancolella grafted in August took less days to sprout compared to other drafting times and varieties. Overall olive cultivar, Frantoio performed well among the other cultivars it is concluded that Frantoio is a good scion to be grafted in July in the climatic conditions of Peshawar.

Fatty acid profile of selected Olive cultivars i.e. Coratina, Pendolino and Leccino was investigated by Azmat et.al (2015) to find out impact of climatic zones i.e., Sangbhatti and Chakwal. The results showed that climatic conditions do affect the fatty acid and polyphenol contents of olive oil in these cultivars. Olive plantation at Chakwal performed well regarding Palmitic acid, Palmitoleic acid, Stearic acid and Linoleic acid as compared to plants grown at Sangbhatti. These differences among the fatty acids might be due to the temperature, relative humidity and altitude of the Chakwal region. Higher content of Oleic acid and Linolenic acid was recorded at Sangbhatti as compared to plants grown at Chakwal. Sangbhatti is famous for wet summer and that might be the reason for the variation in the fatty acid contents. The highest content of polyphenols was observed in Sangbhatti as compared to Chakwal depending on various factors such as cultivar, climate and environmental factors, ripeness and processing, after storage of the oil. These results show that the climatic conditions, in particular the rainfall during growth influenced the concentration of phenolic compounds. The PV of the oil was below 20 meq of oxygen/kg, which is an acceptable limit for quality of virgin olive oil as per International Olive Oil Council standards. However, the limit was exceeded at Chakwal, which may be attributed due to the environmental conditions of that area. The variation in PV can be explained by dissimilarity in the activity of lipoxygenase enzyme in these cultivars.

Olive pollen viability and germination tests are the key factors for final productivity (M. Azhar; et.al. 2020), hence studied and characterized pollen and phenological aspects of 18 olive cultivars at Barani Agricultural Research Institute, Chakwal. Pollen viability was tested through Acetocarmine while germination was analyzed in the culture media having water, boric acid, sucrose and agar. The evaluation and performance of these exotic olive genotypes, established that olive phenology and pollen parameters are not only genotypic characteristics but there are also other a biotic and biotic factor especially temperature might have pivotal role. All parameters showed variation in each variety, however, overall varieties Gemlik, Coratina, Frantoio, Nabali, Hamdi, Moraiolo, Chietina could be recommended for olive orchard establishment. The variety Ottobratica could be used as pollinator on the basis of good pollen viability and germination capacity. The study also found a strong variation in pollen viability and germination capacity between cultivars and indicated that varieties showed poor performance regarding parameters on our climate compared to olive grown in Mediterranean climatic condition and it might be due to high temperature, dry winds and poor conditions of soil in our case that resulted in poor fruit set.

The Olive final fruit yield is significantly correlated to fruit set which is directly dependent upon self-incompatibility, pollination ability, extent of cross-compatibility among cultivars, and

prevailing environmental conditions especially suitable temperature regimes during anthesis Iqbal (M. A. et.al 2020). Keeping this in view, during the years of 2017 and 2018 four Italian cultivars viz. Coratina, Frantoio, Ottobratica, and Leccino were studied under Pothwar agro-climatic conditions. Each variety exhibited different values for the initial fruit set, final fruit set, number of shot-berries and extent of self-incompatibility index. The results of the study depicted that the varieties Coratina, Frantoio, and Leccino possessed partial self-incompatibility while Ottobratica was self-incompatible in agro-climatic conditions of Pothwar region. Cross-pollination or open pollination in varieties Coratina and Ottobratica can enhance the economic yield. All the cultivars can act as good pollinizers as the fruit set percentage in all the crosses were more than 2% except for the cross Ottobratica × Leccino which also produced good fruit set (> 1% fruit set percentage). The results shows that these cultivars could be used to establish olive orchards in the arid climate of the country.

The physical and chemical characteristics of Pendolino, cultivar for oils, were evaluated by Ata Ullah; et.al (2018); for this study they collected olive fruits samples from four locations of Bajaur, Karak, Lower Dir and Peshawar to identify and compare the oils with standard defined by International Olive Oil Council (IOOC) for virgin olive oil. Virgin olive Oils (VOO) extracted by pressing and centrifuging of olive fruits with three-phase vertical decanter. The extracted virgin olive oil was studied for various physiochemical properties and fatty acid profile. The results verified that the oil quality of samples studied from above four locations are free from any flaws and the results were within the limits fixed by IOOC. Accordingly, these samples were classified as virgin olive oil. Peroxides and Acidity values were according to standard limits for virgin olive oil although small differences exist among the physiochemical properties of olive oils samples. Overall, the samples have good properties of low percentage of acidity. Phenolic compounds have strong antioxidant activity; inhibit lipid oxidation, which are responsible beneficial effect in human body and the stability of oil. Among the four analyzed samples the Lower Dir olive oil has the highest content of chlorophyll and antioxidant and suitable as source of eatable oil for human consumption.

Based on adaptability trials conducted in Potohar and adjoining plains of the Punjab by the Barani Agricultural Research Institute (BARI), Chakwal, two (02) olive varieties named as Zaitoon-1 and Zaitoon-2 were released during 2011 (BARI 2022). These varieties have been developed through selection from exotic germplasm imported from Italy. The olive trees have medium plant vigor with spreading nature of growth along with profuse branching. These are medium to late maturing cultivars which starts fruiting after four years of planting. Flowering starts in the month of March and fruit mature in the month of September to October. The fruit is of medium size having elongate shape. The average fruit weight has been recorded to be 2.8 g with medium width of stalk cavity which is elliptic in shape. The color change of the fruit starts from apex and attain dark violet color at full maturity. The average yield of each variety is around 23 kg/plant with oil content of 19.34%. These Olive varieties have also shown fruit bearing, in Lahore, Kasur, Sahiwal, Faisalabad, Layyah, Bhakkar and Mianwali showing great potential for its expansion in the Punjab.

Eight table olives varieties i.e. Ascolana, BARI Zaitoon-1, Earlik, Gemlik, Hamdi, Hojiblanca, Manzanilla and Picual were studied by Sumrah et.al. (2021) during 2017-19 to evaluate their performance based on growth and yield behavior at Barani Agricultural Research Institute (BARI), Chakwal. The adaptability trial was conducted using randomized complete blocks design (RCBD) with three replications. It was found out that Olive varieties respond differently regarding the growth and yield parameters in Pothwar climate. The results exhibited morphological trait differences among the olive varieties under study. The table varieties like Ascolana, Earlik, Gemlik and Hamdi performed well under the climatic condition of Pothwar area and produced maximum fruit yield (22.66 Kg), fruit weight (6.29 g) and oil recovery percentage (24.66%) respectively, and based on their growth and yield performance, these varieties are found most suitable and have potential for massive scale promotion, commercial processing and product development in this region. The proposed selected olive varieties can be recommended for commercial cultivation in Potohar region and the adjoining areas of Punjab for better yield and oil recovery.

Under arid sub-tropical conditions of Quetta, Asif. M. et.al. (2022) studied five olive varieties i.e. Kalamata, Leccino, Pendolino, Arbosona and Arbequina and appraised the impact of climatic variations on these olive cultivars to select the suitable genotypes based on fruit productivity and oil composition. The results revealed that the highest oil production percentage was observed in olive cultivars Kalamata 21%, Leccino 20%, and Arbiquina 17%. The lowest oil production percentage was detected in the cultivars Pendolino 16% and Arbosona 10%. Tree canopy, the staminate height, fruit set percentage and yield per plant showed significant differences among cultivars. However, fruit size (Length and width), canopy and height of trees and 100 fruit weight of each plant did not show significant variation among the cultivars. Oil extraction percentage and total fruit weight per plant showed extreme variability among all the characters. Based on these results it is concluded that the olive cultivars tested Kalamata, Leccino and Arbiquina are suitable for oil extraction under the climatic condition of Quetta, Balochistan.

Local and exotic olive genotypes growing in Salt Range of Potohar region were characterized by M.Q. Saad. et.al. (2020). Studies were conducted on eight olive genotypes BARI Zaitoon-I, Earlik I, Earlik-II, Frantoio, Mariana, Nocellara, Naqvi and Sorani, collected from different locations of Potohar. On the basis of morphological attributes, maximum leaf length was observed in genotypes Mariana (6.26 cm) and BARI Zaitoon-1 (6.24 cm), while maximum leaf width was observed in genotypes Frantoio (158 cm) and Naqvi (153 cm). Regarding fruit weight, maximum fruit weight was measured in Mariana (5.41 g) while the minimum fruit weight (0.93 g) was observed in genotype Earlik-II. In all these eight genotypes biochemical assessment of fatty acids composition was ranged as palmitic acid (13.80 - 10.12%), palmitoleic acid (2.08 -1.03%), oleic acid (77.14-70.47%) and linolenic acid (1 - 0.21%). Similarly, total polyphenols and peroxidase value found in genotypes ranging as 321-144 mg kg-1 and 15-3.03 meq of O2/kg, respectively. The study revealed that biochemical profiling of olive genotypes could be helpful for olive oil processing industry and for breeders to conduct their future breeding programs. The morphological agronomic traits observed in this study are helpful for breeders to evaluate and develop elite olive genotypes. Overall, the genotype Mariana showed

highest fruit weight and maximum fatty acid composition which is an indication that this genotype has a greater potential for cultivation semi-arid climatic conditions of Potohar.

There are about 86 varieties and 19 cultivars of Olive that are being planted in the country but no comprehensive olive adaptability trials data is available for comparison in the agro-ecologies of Baluchistan especially Loralai have been reported by Palwasha. et.al. (2022). Hence, study was conducted at Katvi Farm Loralai, in which five promising olive exotic and local varieties i.e. Sorani, Carolea, Biancolilla, Koronieki and Kaissy were included for evaluation of qualitative characteristics and quantitative traits. The results depicted that Kaissy is the largest sized fruits 26mm with thickest pulp amongst the five tested varieties followed by Carolea 25mm whereas, Koroneiki produced higher number of fruits with smaller size of 13mm and thinner pulp. Biancolilla gave highest yield/tree 23.3 followed by Carolea and the lowest yield was in case of Kaissy variety. The Oil contents percentage were highest in Sorani (11.67%), followed by Biancolilla (9.33%). Chemical analysis revealed that acidity of oil samples of all five cultivars was <0.3, peroxide value of 20 except for Kaissy >20. Maximum Polyphenols contents were found in Sorani. K270 value was lower in all cultivars. Sorani was found to be most productive in terms of higher yield and highest oil content, while Kaissy is recommended for dual purposes owing to its bigger sized fruit and moderate oil production. It is recommended that Sorani variety is most suitable among the tested ones for cultivation under Loralai environmental conditions.

Adaptability trials including eighteen olive cultivars under arid sub-tropical conditions of Pothwar region to select suitable genotypes on the basis of fruit yield and oil production were conducted by Iqbal. M.A. et.al. (2019). Longest period for pollen donation was observed in olive cultivars Ottobratica, Frantoio, and Hamdi. The shortest pollen production or dissemination time was observed in the cultivars Azerbaijan and Nocellera. Tree canopy, staminate flower, number of flowers per twig, initial and final fruit set percentage, number of shot berries and yield per plant varied highly significant among the cultivars. However, leaf size, pistillate flower, fruit size, fruit weight and oil recovery percentage did not show significant variation among the cultivars. However, final fruit set percentage varied highly significant among all cultivars. The results depict that five olive cultivars including Coratina, Gemlik, Moraiolo, Nabali and Hamdi were found most suitable for oil and fruit yield under the climatic condition of Pothwar region on the basis of fruit set percentage, fruit yield and oil productivity. The study also illustrated that on basis of morphological diversity among olive cultivars, findings will serve as a reliable tool for conservation and preservation strategies of olive germplasm and also it will be helpful in improving the oil quantity and quality and market opportunities. However, it is recommended that for perfect and most reliable knowledge qualitative traits and molecular marker could be used in future studies. It is also envisaged that cultivar specific study for phenological traits including numerous olive cultivars will generate better understanding for selection in whole districts of Potohar.

Adaptability trials on three olive cultivars Pendolino, Coratina and Leccino grown over various ecological locations i.e. Olive Model Farm (OMF), Mardan and Barani Agriculture Research Institute (BARI), Chakwal were conducted by Azmat et.al. (2020) to assess the oil quality during

two consecutive years, 2008-09 and 2009-2010. Means for peroxide and acid value of olive oil were significantly influenced by cultivars and locations. The cultivar Coratina had the highest peroxide (18.50 milli eq/kg) and acid value (2.65%). In contrast, the least peroxide value (12.75milli eq/kg) and acid value (2.49%) was recorded in oil extracted from cultivars Pengalino and Leccino, respectively. The interaction of olive cultivars and location revealed significant influence on both the two parameters under study. The peroxide value which was lower in oil of cultivars Leccino and Coratina (7.53 and 9.80 milli eq/kg respectively) but increased to 23.11 and 27.21 milli eq/kg in oil obtained from Chakwal location, while the peroxide value of cultivar Pendolino behaved non-significantly. The acid value of olive oil was the least (0.85%) in cultivar Leccino and the highest (2.89%) in Pendolino at OMF farm. The research depicted that the cultivar Coratina had the highest peroxide (milli eq/kg) and acid value (%) than rest of the cultivars. The peroxide value which was lower in oil of cultivars Leccino and Coratina increased in oil obtained from Chakwal location. The acid value of olive oil was the least in cultivar Leccino and the highest in Pendolino at OMF farm.

Alam. R. et.al. (2021) evaluated phenological, carpometric and yield characteristics of olive cultivars i.e. Frontoio, Manzanilla, Ottobratica, Pendolino and Picual at different harvesting stages (Lemon green, Semi-ripe and Ripe) during 2014 and 2015 under irrigation condition at Olive Model Farm Sangbhatti, Mardan. Pendolino started early flower opening on 12th April, taken as baseline for phonological attributes and took more days (9.50) to fruit set, while less days (6.33), started from 18th April were noted for Ottobratica. The cultivars Manzanilla and Picual attained lemon green maturity after 193.50 (25th October) and 192 (22nd October) days respectively, while 202.17 (2nd November) and 201.33 (1st November) days were taken by these cultivars to reach semi ripe stage and 214.17 and 210 days to ripe stage of harvesting respectively. Frontoio, Ottobratica and Pendolino attained semi ripe stage after 180.17 (11th October), 184.50 (20th October) and 193 (22nd October) days respectively, while 188 (19th October), 195 (30th October) and 203.67 (2nd November) days were taken by these cultivars to attain ripe stage of harvesting after flower opening. The cultivar Manzanilla produced heavy fruits (4.34 g), however large sized fruits (4.48 cm3) with more pulp: stone (4.94) were yielded by Picual. High fruit yield (35.81kg tree-1) and more oil percentage (14.66%) were determined in the oil extracted from fruits of Frontoio. Yield and yield components enhanced from lemon green to semi-ripe and ripe stage of harvesting, also the percentage of oil increased with the ripening process of olive fruits. Olive cultivars Frontoio, Manzanilla and Picual are recommended for high yield and production of olive oil. However, cultivars; Frontoio seems to be promising under the local conditions of Sangbhatti and merits more attention for early ripening, high productivity and production of oil. The cultivar Manzanilla is categorized for high productivity (at par with Frontoio) and good oil recovery. The oil content from the fruits of Picual was statistically at par with Manzanilla, also large sized fruits having more pulp: stone were yielded by Picual. The performance of Ottobratica in terms of yield and oil recovery was not satisfactory. The olive cultivar Frontoio is recommended for early ripening, high productive and oil production potential under the local agro-climatic conditions of Sangbhatti, Mardan and other similar environments. Manzanilla and Picual both are recommended for cultivation due to their large sized fruits, more pulp: stone, optimum yield and good oil recovery. Pendolino is also recommended that marginally qualifies for the studied attributes, while Ottobratica is

recommended to be tested in other ecologies. Oil content increased with the ripening process of olive fruits but further investigation is needed to find out the appropriate stage of harvesting that determines the equilibrium among olive oil recovery and quality.

Seasonal variation of Calcium (Ca) and Magnesium (Mg) contents in olive leaves because their variation in olive is pertinent for healthy plant growth (Farhat A. et.al. 2021). To explore this intervention, six olive varieties BARI Zaitoon-1, PS-1, VP-1, Balkasar, Moraiolo and Chitina were included for analysis of leaf nutrients on monthly basis during 2017 for one year growing season from field selected at University Research Farm, Chakwal. Preliminary soil sampling was done for initial analysis of fertility status, soil texture, soil pH, EC, total organic matter, $CaCO_3$, NO_3^-, available P, extractable K^+, soluble Ca, Mg and Ca. Soil was categorized as alkaline having no salinity issue and it was found weak to moderate calcareous, soil texture sandy loam to loam with little organic matter. The results revealed deficiency of N, P whereas K, Ca and Mg were adequate in olive orchard. In olive, highest Ca peaks were noticed in summer season during the initiation of leaf development. The varietal comparison shown that Ca concentration in each olive variety was above the sufficient level. In winter highest Mg peaks were noticed from fruit growth to the end of dormancy. There was no Mg deficiency among olive cultivars. Seasonal changes of magnesium content in different olive varieties showed different trends in each variety. The outcome of the study provides information for the development of nutrition management guidelines of olive orchards for potential quality yield. It is also recommended that flower and fruits samples should also studied to understand the nutrient status of orchards.

Olea ferruginea Royle (Oleaceae), locally known as Kahu, is native to Northern part of the country, and the fruit of this tree is currently not being utilized for any useful purpose (P. Anwar, et.al. 2013). To explore this native source of virgin olive oil (OWOT), they conducted studies on chemical composition and quality parameters. The fruits from wild olive trees were collected from different locations i.e. Bhara Kahu, Kotli Sattian and Dir Swat, whereas a reference sample (OCOT) of a local variety (Zaitoon II) Olea europaea L. was collected from Barani Agricultural Research Institute, Chakwal for comparison. The basic quality characteristics of oils such as free acidity, peroxide value, specific UV absorptions and sensory analysis demonstrated that the oils belong to the "lampante olive oil" commercial category due to low quality of processed olives. Some minor discrepancies with respect to the standard olive oil composition (linoleic acid slight exceeding 1% and traces of erucic acid and brassicasterol) were found and it should be further studied to understand their etiology. Concerning minor compounds, tocopherols were found in low quantities whereas higher amounts of β-carotene and lutein were observed in OWOT compared to OCOT. Finally, OWOTs showed a relatively low quantity of hydrophilic phenols that proportionally expressed three times less antioxidant activity compared with OCOT. Careful control of fruit quality and good practices before olive milling could improve not only quality of the product, but also provide a new promising source of edible virgin oils.

IDENTIFICATION OF MORE IMPLANTED VARIETAL TEST IN THE COUNTRY[4]

Varietal tests and performance

As described in previous chapters, thousands of olive plants were imported from various source countries where it is predominantly cultivated as commercial crop. The priority was to promote olive cultivation in Pakistan. These exotic plants/varieties were planted in various ecologies in the country to identify the most promising cultivars as well as suitable areas for olive cultivation. Simultaneously, multiplication of the promising olive varieties was initiated by establishing mother blocks in the suitable ecologies of the country. Whereas nurseries did not develop; adequately. The suitable varieties that were recommended for dissemination to promote olive cultivation in the country are mainly exotic and fetched from various European Mediterranean countries (i.e. Italy, Spain etc.), and North African countries. However, it must be understood that Olive varieties do not perform evenly in all climatic conditions in every olive producing country.

Based on consolidated research paradigm, evaluation/selection system for adaptability trials are a prerequisite to identify acclimatized varieties to be recommended for cultivation in a given climatic zone. It has been noticed by the experts that olive varietal performance under sub-mountainous agro-climatic conditions ensures success to promote commercial olive cultivation as well as development of olive industry in these parts of the countries, provided that other conditions are satisfied.

The establishment of a significant number of varietal tests/trials under the PIDSA's project was meant to provide at the earliest reliable data, but the required follow up and monitoring did not take place as required.

Olive varieties genetic characterization studies

In Pakistan, little is known about the diversity and divergence in cultivated and indigenous wild olives and assessment/exploitation of indigenous genetic diversity which is important for crop genetic improvement (Safia N. et.al. 2019). Studies have been conducted to assess the diversity and divergence between cultivated and wild olive collection from Buner, Bajaur, Malakand and Upper-Dir regions of Khyber-Pakhtunkhwa. Based on 30 olive genotypes using eight Randomly Amplified Polymorphic DNA (RAPD) primers, polymorphic single bands were considered as a single allele/locus for all genetic analysis of these olive genotypes. A total of 36 loci were amplified, scored as dominant markers (present or absent). When considering 30 genotypes, all the markers were polymorphic. A minimum number of loci was recorded for OPA1B1, OPB2B1 and H20B1 while the maximum was recorded for OPA1B7 and OPR3B7. Maximum gene diversity 0.515 was recorded for loci OPA1B3 and OPR3B2, while the minimum gene diversity (0.067) was recorded for loci OPR3B7, OPB2B5, H07B4, H20B1, H20B2 and A14B2. The results revealed an overall high diversity within 30 olive genotype as each possess a distinct multilocus genotype. The RAPD based FCA analyses shown a clear

[4] Sub-Activity 3.1.3

divergence between the cultivated and wild genotypes under study. Individuals sampled in Buner, Malakand and Bajaur were relatively closer to each other, than those sampled from Upper Dir. The findings on divergence and diversity in this study could be useful for exploitation of local and exotic olive genetic resources. The wild olive clearly diverged from the cultivated olive genotypes. Among the wild olive genotypes, Malakand genotypes were closer to Buner and Bajaur, while Upper Dir were the most divergent. Overall, there was a high diversity in the germplasm, which could be exploited in further olive cultivation and improvement breeding programs, development of olive cultivars and transformation of wild olive into cultivated plantation. It is also inferred that a more extensive sampling and more powerful genotyping tools to further elucidate the wild olive population structure in comparison with exotic collections.

Sequencing of plastid genome of the olive flaunts high resolution Cp markers for olive DNA fingerprinting and using this information tool, Noman. M. et.al. (2015) designed a combination of chloroplast markers to amplify genes recruited in photosynthesis, ribosomal and NADH energy metabolism for varietal identification of olive plants. Concatenated DNA sequences of more than 100 unknown and 10 reference plants samples were analyzed using various bioinformatics and phylogenetic tools. Conserved blocks of nucleotide sequences were detected in multiple alignments. Phylogenetic reconstruction differentiated the unknown plants into various clusters with known varieties. Further narrowing down of the samples through UPGMA tree clearly separated the plants into Arbosana, Frantoio and Koroneiki as the major varieties. Multiple alignments of these clusters revealed important variety specific SNPs including G and T nucleotides at specific positions. Sequence identifying at intra cultivar level was more than 98.79% while it dropped to 97%, and even to 96% at inter varietal level. Furthermore, a neighbor net network analysis separated these three clusters, thus validating the results of UPGMA tree. Overall, out of 100 plants samples, 49 plants were identified that fall into 10 varieties including Arbosana, Carolea, Chetoui, Coratina, Domat, Frantoio, Gemlik, Koroneiki, Leccino and Moraiolo. The maximum number of known plants belongs to Frantoio and Gemlik (8 each). The least number of samples was identified from Carolea, Domat and Moraiolo with 2 samples each. However, 51 plants could not be identified, as plants were not clustered with any of reference control. The results have implications in on-farm conservation of olive germplasm and provision of genuine material for multiplication of authentic varieties. This strategy can be extended to varietal identification of other plant species. The results depicted that the Cp5 primer used successfully identified 49 varieties out of 100 unknown olive plants through mutations detection by alignment of the marker region sequences followed by the phylogenetic reconstruction with different bioinformatics software. This strategy can be further extended to characterize the olive tree germplasm reliably and efficiently with low costs which is distributed throughout the country in search of the better varieties. After the better varieties have been identified, this will enhance the olive oil and fruit production in Pakistan by the on-farm preservation and provision of the authentic germplasm to olive growers for the establishment to new olive orchards.

Olive population structure and genetic diversity and developed DNA fingerprints of 13 olive varieties using 63 Simple Sequence Repeat (SSR) markers was revealed by Iqbal. M. Z. et.al.

(2021). In a study 618 alleles were amplified among which 582 were polymorphic and 36 were monomorphic. High allelic diversity per locus was found among 63 SSR markers, i.e., one for GAPU-12 to 23 for UDO099-008 and GAPU-47 with an average 9.80 alleles per locus. On the basis of cluster analysis genotypes were grouped into two clusters. Cluster I contained varieties Manzanilla, Sohawa-selection, Koroneki, Bulkasar-selection, Arbequina, Arbosona, Chugtai-selection, whereas cluster II was comprised of varieties Bari-Zatoon, Coratina, Gemlik, Frontaio, Pendolino and Ottobratica. UDO-24 marker alone identified seven olive varieties. Similarly, DCA-07 and EMO-02 identified six olive varieties each. The study findings will be helpful for future studies related to DNA fingerprinting and genetic diversity assessment for choice of SSR markers and identification of olive varieties.

The genetic relationship in wild and cultivated olive populations growing in Azad Jammu and Kashmir was explored by Hussain et.al. (2017) using four primer combinations during Amplified Fragment Length Polymorphism (AFLP) analysis. Genetic relationships were displayed in a dendrogram based on Unweighted Pair Group Method (UPGMA) and Principal Component Analysis (PCA). Four clusters were clearly separating wild and cultivated olive populations from each other indicated that the Olea cuspidata (wild) which is an Afro-Asiatic species found particularly in this region and Olea europaea (cultivated) were divergent. The insightful difference between wild and cultivated populations and the close relationship among Olea europaea accessions had confirmed that the cultivated olive did not develop locally but were introduced from abroad, propagated by grafting on local wild olive. Moreover, analysis of cultivated olive showed that they are probably from same population with common ancestry. The results of this study are useful for genetic improvement of olive because these molecular evidences were describing important differences between both species in a given area and given population and molecular genetic analysis provides new insights regarding the extent of diversity of individuals within and between populations. The present study determined the relatedness and obtained information on population structure and genetic diversity of wild and cultivated olive using AFLP. The AFLP analysis appeared to be efficient in verifying its variety status. In the actual application, the measurement of genetic differences among these populations is needed to guide the on-going grafting of Olea europaea while ensuring that a substantial genetic diversity is preserved within the study areas. For the Olea europaea nursery industry, this study can be useful to eliminate duplication of the clones and ensure the diversity of the propagated clones for grafting on Olea cuspidata.

Evolutionary relationship among olive cultivars growing in orchards at different locations in Pakistan was delineated by Ramazan and Ali. G.M. (2014) through phylogenetic reconstruction to identify unknown cultivars of olives using DNA markers and Genome sequence analysis. As a result, 965 unknown olive plants resulted in identification of 515 plants differentiated into 27 varieties, out of the identified plants 140 were from Ternab and 375 from Sangbhatti olive orchards. A total number of 2071 of leaf samples of olive plants were collected from Sangbhatti, Ternab, Chakwal and NARC olive orchards that include 71 known and 2000 unknown plant source. These samples were used for DNA extraction, PCR amplification and sequencing and also to optimize an efficient, cost effective, rapid and reliable DNA based protocol for the large-scale commercial identification of unknown plants of olive. Employing this protocol more than

53 % unknown plants have been identified. These results depicted that chloroplast DNA marker-based protocol developed can efficiently be implicated for the identification of unknown plants of olive. Sequencing data and bioinformatics analysis of 965 annotated samples, however, more than 47% (450 out of 965) of the plant samples could not be identified as these were not clustered into any of the known sequence clade, the reason by that there exist other varieties in these orchards for which any reference genome sequence was not available. To find out the solutions to this problem, it needs to sequence more known olive varieties growing in the country or to acquire the DNA of these varieties from other olive growing countries to be used as reference known genome and also need to sequence another nearby marker gene region. It was found out that joining both the sequences is referred as concatenation of the sequences and it has more resolving power than a single sequence. It is important to mention that present studies have ensued availability of huge repository of DNA sequences of indigenous olive plant that could serve as reference genomes for future comparisons as well as setting of plant diagnostic lab at NIGAB for olive and other unknown plant identification services through DNA based markers.

Population structure, genetic diversity and developed DNA fingerprints of 13 olive varieties using 63 Simple Sequence Repeat (SSR) markers was studied by Iqbal. M. Z. et.al. (2021) Overall 618 alleles were amplified among which 582 were polymorphic and 36 were monomorphic. High allelic diversity per locus was found among 63 SSR markers, i.e., one for GAPU-12 to 23 for UDO099-008 and GAPU-47 with an average 9.80 alleles per locus. On the basis of cluster analysis genotypes grouped into two clusters. Cluster I contained varieties Manzanilla, Sohawa-selection, Koroneki, Bulkasar-selection, Arbequina, Arbosona, Chugtai selection, whereas cluster II was comprised of varieties Bari-Zatoon, Coratina, Gemlik, Frontaio, Pendolino and Ottobratica. UDO-24 marker alone identified seven olive varieties. Similarly, DCA-07 and EMO-02 identified six olive varieties each. It highlighted that findings could be helpful for future exploration of DNA fingerprinting and genetic diversity assessment for choice of SSR markers and identification of olive varieties.

Using Randomly Amplified Polymorphic DNA (RAPD) markers system developed DNA fingerprints and assessment of genetic diversity among seven olive varieties at Genetically Modified Organism Testing Lab, Agricultural Biotechnology Research Institute, AARI Faisalabad during 2015 (Iqbal. M. Z; et.al. 2019). It found out that out of total 62 RAPD markers used, out of which 59 were highly polymorphic (95.2%) whereas only three RAPD markers were monomorphic and out of total 583 alleles were amplified by 59 markers and 85 were monomorphic and 498 were polymorphic. Number of alleles varied from 3 (for I-4, I-18 and R-10) to 19 (for G-16), with an average of 9.85 alleles per marker. A combination of three RAPD primers (A 13, Q-1 & R-15 or I-3, R-13, R-15 or I-2, A-13, I-17) can distinguish all seven olive varieties under study. RAPD primers Q-1 can individually identify four olive varieties among seven under study whereas locus I-1, I-14, I-2, I-5, R-13, G-13, I-7, R-15, G 18 and A-13 each alone can distinguish three olive genotypes individually. Variety specific alleles were not found for Bulkasar selection and Arbequina. Further statistical analysis using estimation of confusion probability (Cj) and primer efficiency [discriminating power (DL), Discriminating power (Dj)] also endorsed these findings. Clustering analysis at 70% similarity as base line

produced seven different clusters indicating different genetic background of these varieties. Genetic similarity varied from 0.548 to 0.728. The RAPD molecular markers were found useful for the identification of olive varieties and propagation of certified nursery. The seven varieties under study are genetically different from each other and can be distinguished with three or more RAPD markers.

CONSIDERATIONS

Promotion and cultivation of olive as an alternate oilseeds crop for edible oil production is potentially a viable intervention in Pakistan. The agro-ecological conditions across the country and mainly areas which are not under the cash crops and marginal areas are highly suitable for olive cultivation. Policy support and extensive awareness is required for consumers and industry partners to adopt olive crop and olive oils as potential replacement of other vegetable oils or as an alternative healthier choice.

The review of the Olive sector has indicated that there were a number of initiatives taken by government at federal and provincial levels as well as initiatives by the international donors, in particular Italy, and at community level (through NGOs and local organizations). With these broad-based involvements of stakeholders, huge financial investments and backstopping from research and development have been delivered, but apparently these interventions have not resulted in substantial breakthrough in promotion of Olive cultivation and its oil production in the country.

The review has also depicted that a number of institutes are working on Olive varieties evaluation and performance through adaptability trials as well as performing analysis using genetic characteristics based on DNA markers, Polymorphism and Simple Sequence Repeats techniques. It has been noticed that there does not exist a uniform data collection format/system for adaptability trials and genetic analysis in accordance with international standards as well as coordination at federal and provincial level is lacking to follow required data parameters. The Olive cultivars adaptability trials need to have uniform evaluation system in each area compatibility for various varieties. Similarly, the certification of Olive plants/varieties as well as Olive plant nurseries (imported or locally developed) are not certified through an accredited agency to comply with international standards. Measures related to the genetic improvement of olive crops in order to increase their productivity, resistance or tolerance to diseases and plagues, adaptation to the environment and/or the quality of their products require legislation and policy framework at national and provincial level.

It clearly emerges that the coordination between national and provincial level concerning the Olive promotion activities is weak, and this lack of coordination system leads sometime to duplication of activities and inefficient use of resources. The technical support and coordination between technical arms like breeders, pathologists, data management and marketing experts etc. is not well established at national as well provincial level. There needs to be established supporting system on technical aspects between federal and provincial stakeholders such as growers, scientists, extensionists, processors, commercial partners and policy makers. This system may also function in the capacity building of the stakeholders involved in the Olive value chain from production to processing and value addition. The Creation of the Pakistan Olive Oil Council or similar organization as a tool to support the Pakistani olive oil value chain is of prime importance to monitor and address sector specific consumer, producer and trade-oriented reforms and policy measures to bring the country out of oil crisis.

Economic competition of developing Olive orchards with cash crops due to absence of crop zoning regulations and cluster-based transformation approaches, volatile market prices and marginally developed market infrastructure lack of a sustainable olive and oil development policy, weak industrial linkages and farmer's adoption of non-recommended agronomic technology packages are challenges to enhance olive and olive oil production. Sustainable and long-term impacts in olives productivity enhancement can be gained by identifying and developing Olive producing agro-ecological clusters. These clusters should be facilitated with extensive market linkages, public and private investments for value chain development and specialized agronomic technology packages to maximize the benefits. Targeted subsidy regimes can be extended to such clusters and consolidating small holding farmers at village level and consolidation of villages at a regional cluster level will greatly impact on efforts being carried out to promote olive and olive oil value chain.

Does not exist any national policy, legal framework that includes rules and laws regarding the regulation and standardization of Olive value and supply chain from production to processing and marketing complying international methodology and standards. The National Food Security Policy (2018) emphasizes the need to shift agricultural production focus from conventional crops to promote cultivation and utilization of oilseeds as alternate crops for import substitution. It is inevitable to formulate a comprehensive and consistent Olive policy framework in consultation with all the stakeholders that addresses the institutional as well as policy constraints including competitive pricing and marketing in the olive value chain. The policy should clearly define the federal and provincial responsibilities and goals as it is a devolved subject under the 18th Constitutional Amendment. A national olive and olive oil policy framework for innovation, provincial integration, industrial collaboration and national implementation roadmap is indispensable.

Policy, financial and infrastructure support strategies should be devised to organize small farmers/growers into cooperative arrangements for the processing of oil and its marketing. Effective policy interventions, re-oriented at levels of consumer, producer and trade are required to bridge up the gap in olive production, processing, reduction in edible oil sustainable consumption. It should foster strong linkages with olive oil extraction and solvent industry producing olive oil and the Olive producers to prioritize and channelize locally olive oil extraction on priority. Sustainable Olive crop intensification policy following an integrated approach is needed at provincial and federal level for horizontal expansion of olive cultivation, adaption of high yielding and multiple stress tolerant cultivars, and integrated olive crop and oil technologies, keeping in view the value chain and value addition management that shall be adopted.

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