OliveCulture

Holistic and Multi-professional Mechanism for a Pakistani Olive Oil Value Chain

A Brief Paper on Good Agronomic Practices, Integrated & Organic Farming Methodologies for the Olive Orchard Management

OLIVE PRODUCTION GUIDELINES

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However, the authors take responsibility for any shortcomings left in the report.

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FOREWORD

Italy, a prominent Mediterranean basin country, has long been at the forefront of contributing to social, agricultural, and other sector advancements in Pakistan. Over the past four decades, the Italian Government's contributions to the Agricultural Sector have been particularly noteworthy, including the olive promotion. In this latter area, the Olive Culture Project (Holistic and Multi-Professional Mechanism for a Pakistani Olive Oil Value Chain), through its experts from CIHEAM Bari (The Mediterranean Agronomic Institute of Bari Italy) and delivering on-field professional training programs, has played a crucial role in the development and sustainability of a comprehensive olive value chain in Pakistan. The Project encompasses a wide range of activities, including capacity building, research and development, technology transfer, market development, sustainability initiatives, and policy support. The Italian government's commitment to the olive sector in Pakistan is demonstrated through its support for the implementation of Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Points (HACCP) standards. These methodologies are crucial for ensuring high-quality production, maintaining safety standards, and optimizing processes in the agricultural sector.

"Good Agricultural Practices" (GAP) is the series of decisions that farmers make on related matters as they go along, like what to grow, how to prepare the soil, what plant nutrients to use, how to control weeds, pests, and diseases, how to harvest, irrigation techniques, how to preserve natural resources, how to safeguard the ecosystem, etc. All such decisions are now subject to a GAP analysis, which considers the choices' effects on the environment, food safety, labor and other social concerns, and the economy. Good Agricultural Practices (GAP), however, involve the application of existing knowledge to ensure the humane and sustainable production of safe, healthful food and agricultural products, including those not intended for human consumption. GAP also emphasizes social responsibility and economic sustainability throughout the production process. Good Agricultural Practices (GAP) have gained importance in many developing nations. The main challenge is how to make agriculture more sustainable in a world where food supply chains are becoming more globalized, placing a great deal of pressure on farmers' livelihoods, and where there are growing demands from specific markets on production processes.

The olive tree, symbolizing peace, wisdom, and prosperity has been an integral part of human agriculture for millennia. Recognizing its immense potential, this document **"Olive Production Guidelines,"** has been drafted as a dedicated effort to advance olive cultivation in Pakistan. This guide is an essential resource for technicians and olive growers, aiming to equip them with the knowledge and practices necessary to cultivate olives efficiently and sustainably.

Pakistan's diverse climatic regions, including the semi-arid Potohar plateau, the cool high-altitude areas of Khyber Pakhtunkhwa, and the varied landscapes of Balochistan, offer unique opportunities for olive farming. However, realizing this potential requires a deep understanding of good agronomic practices, integrated farming methodologies, and precise orchard management techniques.

This document meticulously details the critical aspects of olive cultivation, from the initial selection of suitable cultivars based on pedo-climatic conditions to advanced practices in pruning, nutrition, soil analysis, and foliar diagnostics. It provides a comprehensive fertilization plan tailored to olive trees' specific needs and offers sustainable strategies for pest and disease management. Water requirements and irrigation methods are thoroughly discussed to ensure efficient water use, while best practices for harvesting, storing, and managing soil fertility are outlined to optimize production and maintain orchard health. It underscores the importance of sustainability in olive farming by promoting environmentally friendly practices and integrating organic farming principles, to enhance soil health, conserve natural resources, and reduce the carbon footprint of olive cultivation. These practices not only improve the resilience of olive orchards but also contribute to a sustainable agricultural ecosystem.

Pakistan Oilseed Department extends its gratitude to the Olive Culture Project-CIHEAM Bari Italy, all contributors, and stakeholders who have made this document possible. Together, we look forward to seeing the flourishing of olive orchards across Pakistan, bringing economic growth and environmental benefits to our nation.

INTRODUCTION

The project "OliveCulture-holistic and multi-professional mechanism for a Pakistani Olive Value Chain" is an Italian scheme for empowering, strengthening, and assisting in the development of the Pakistani Olive Oil Value Chain on several levels in a holistic participatory and multi-functional way, involving institution businesses, farmers, youth, women, and consumers to improve productive economic and qualitative performance. The initiative is financed by the Italian Government and implemented by the Mediterranean Agronomic Institute, CIHEAM located in BARI, Italy in coordination with the Pakistan Oilseed Department (POD) of M/o National Food Security and Research (MNFS&R), the counterpart.

Scientific name: Olea europaea L.

Family: Oleaceae

Common names: English: Olive. French: Olivier. Spanish: Olivo. Italian: Olivo. German: Olive. Arabic: Zeitoun. Urdu: Zaitoon. Punjabi: Kahoo. Pushto, Khauna.

Olive cultivation dates back more than 6,000 years and is still flourishing today, not only in its countries of origin but also in most areas of the world. The olive is native to the Mediterranean region, tropical and central Asia, and various parts of Africa. It has a history almost as long as that of Western civilization, and its development was one of civilized man's first accomplishments.

BACKGROUND OF THE OLIVE CULTIVATION IN PAKISTAN

The olive was introduced in parts of Dera Ismail Khan (Now in present-day KP) in1866, and efforts have been made for long to grow olive for domestic and agronomic purposes. The first attempt was by Mr. Henderson, who imported 100 European olive plants and planted them in Rawalpindi. During 1907-1910, the program was restarted with the help of an Italian expert who established a small saplings orchard at Soon Valley, Garhi Dopatta, and Chattar in 1907. Plantations were also established at Khari Murat in the Attock District, Sakesar, and Rakh Chandia in 1910. All these plantations were handed over to the Agriculture Department in 1927 and eventually ended up with the Forest Department in 1935. The plantation was also done at the Agriculture Research Institute Tarnab Peshawar KP in 1912. In 1935 some of the saplings were imported from Palestine, the USA, and Italy. In 1950-1952, Olive plants were again imported from Syria, Egypt, and Turkey and planted in Rawalpindi and Faisalabad Region. In 1960 five thousand plants were procured from Italy and were planted at different locations of Pakistan.

The Pakistan Oilseed Developments Board (PODB) started work on Olives in the year 2000 and adopted a two-pronged approach for the promotion of olive cultivation in the country (i) conversion of wild olives into bearing species by top working (ii) establishment of new plantation. A five-year project (2000-2004) "Accelerated Promotion of Olive in NWFP and Potohar" was initiated. Another 5-year duration project (2005-2009) "New Plantation of Olive in NWFP, Potohar and Balochistan and maintenance of Orchards Established by PODB" was initiated.

The real development and commercialization were kicked off in 2012 with a PIDSA funded Olive commercialization project and then the Government of Pakistan funded a flagship olive cultivation project in 2014. Also, through provincial projects, the total number of olive trees planted is around

5.7 million. Along with this, a unique value chain including olive oil extraction units, table olive processing, and one olive certification Lab have been established.

The olive sector development in Pakistan was initiated some four decades ago through Italian financial and technical assistance since more than 5.7 million plants of mainly 21 different varieties, **Arbequina, Arbosana, Coratina, Koroneiki, Earlik, Gemlik, Frantoio, Picual, Ottobratica, Leccino, Pendolino, Chemlali, Ascolana, Manzanilla, Sevillano, Oliana, Chetoui, Souri, Nabali, Nocellara and Hojiblanca,** have been cultivated across the country on mainly marginal and undulated land.

However, detailed guidelines were altogether missing. Olive production is a complex process requiring particular attention to various agronomic practices to ensure high-quality yields. This comprehensive guideline covers every critical aspect of olive cultivation, from initial planting to final harvest and storage. Emphasizing the importance of adapting to pedo-climatic conditions, the guidelines ensure olives are grown in environments that maximize their potential. They provide detailed criteria for selecting the right form of farming and appropriate and climate-suitable cultivars, offer clear instructions on effective pruning techniques, and outline a comprehensive nutritional plan, including a tailored fertilization strategy. Effective pest and disease management strategies are included to minimize crop losses and maintain tree vitality. Efficient water management techniques are described to ensure optimal irrigation practices, conserve water, and enhance tree health. Best practices for harvesting and storing olives are provided to preserve quality and extend shelf life. Additionally, methods for maintaining soil fertility and implementing phytosanitary protections are detailed to safeguard against soil-borne diseases and pests. These guidelines equip olive growers of Pakistan with the knowledge and tools needed to produce high-quality olives sustainably and efficiently, ensuring the long-term success and profitability of their olive production endeavors.

ECO-FRIENDLY PRODUCTION METHODS

There is an increasing need to identify and apply agricultural production methods that are "eco-friendly", "climate-smart" and compatible - that is - both with the conservation needs of the now heavily anthropized natural environments, such as agricultural ones and with the requirements of safeguarding and protecting the health of the environment and the final consumer. Double attention is becoming increasingly crucial in the international production landscape, as well as in crops, such as olive growing, which have always been considered to have a lower impact both for the limited use of highly impacting inputs (pesticides, herbicides, chemical fertilizers, etc.) and for energy needs. The Olive tree production guidelines proposed in this document (Good Agricultural Practices) fall into this perspective. The choice, therefore, to differentiate three levels of "attention" to safeguarding environmental safety, first of all, responds to the need to adapt production activities to new trends and market demands while maintaining - however - the level of attention differentiated according to the peculiarities of the territory, of the production and business choices of individual farmers and in function - also - of the specific sensitivity towards these issues. For clarity, here below the following definitions:

Good Agricultural Practices are "the set of cultivation methods that a diligent farmer would employ in a particular region or context" (as per Italian Law).

Good Agricultural Practices (GAP) refer to the established cultivation methods and practices recommended or required for adoption by farmers in a specific region. These practices are designed to optimize agricultural productivity and sustainability while mitigating environmental impact and ensuring food safety.

Integrated Agriculture is defined as a method of fruit production aimed at achieving high-quality yields economically while prioritizing environmentally safe practices. It emphasizes minimizing the use of synthetic chemicals to reduce unwanted side effects and enhance safety for both the environment and human health.

Organic agriculture is a production method that prohibits the use of synthetic chemicals such as (pesticides, herbicides, fertilizers, auxiliaries for transforming and conditioning food products, etc.). This method is based on respecting and enhancing ecosystems, favoring the restoration of natural balances and corporate self-sufficiency.

1. Olive cultivation: main agronomic aspects

1.1. Pedo-climatic inclination

The complete knowledge of the characteristics of the territory where the farm is located is a fundamental step for the farmer who must make a series of primary choices for the proper conduct of the agricultural activity:

- choose the suitable cultivars (CV) based on the pedo-climatic characteristics,
- to restore the natural protective systems that will favor biodiversity and the maintenance of populations of beneficial insects, guaranteeing the protection of crops and soil from physical degradation actions (wind, erosive phenomena);
- optimize crop interventions (land preparation, fertilization, and phytosanitary treatments).

The complete knowledge of the following factors defines the characteristics of a specific territory:

- Pedological, fundamental for the choice of crops and agronomic practices related to soil management. Guaranteeing the best soil conditions means improving the intrinsic characteristics of the crops (development, resistance, production) and the properties of the soil;
- Climatic, essential for the choice of the varieties to be cultivated to obtain satisfactory productive results with the minimum use of technical means;
- Vegetation, is essential for creating natural protective systems and optimizing biological control through beneficial insects.

Planning agricultural activities based on the characteristics of the territory aims to optimize production while reducing reliance on external inputs such as (pesticides and fertilizers).

By **inherent suitability**, we refer to the innate capacity of an area to support and sustainably produce plants with minimal reliance on external interventions.

The main factors that determine the level of suitability of an area are the soil and the climate. Regarding the soil, some main parameters must be considered when evaluating a new orchard since they can be decisive in guaranteeing proper eco-compatible cultivation management.

Table 1: Optimal soil parameters of the planting site`

Pedological parameters	Optimal Values
Soil Weaving	Medium texture
Drainage	Good, there must be a quick draining of surface water.
Useful Depth	50 – 100 cm - The pitch must not exceed 100 cm from the surface
PH	Between 6 and 8.5
Active Limestone	Between 8 and 15 %
Salinity	Less than 6 mS/cm[1]

The olive tree demands specific environmental conditions such as climate, exposure, and position. The climatic conditions, **especially the minimum winter temperatures** (so-called chilling hours), represent the most critical limiting factor for the crop spread.

However, temperatures below -6 and -7 ° C are harmful in various ways, damaging leaves, branches, and trunks. A temperature of 2-3 °C below zero is dangerous in April and May, at the time of new foliation and the release of the little buds. The trunk also suffers damage below -10 °C zero; in this case, the plant must succumb.

The extent of damage caused by low temperatures varies with the duration of the thermal lowering, the plant's phenological phase, and the conditions of humidity, exposure, etc. (see the following table).

Table 2: Temperatures relating to the main phenological phases, below which the development of the stages can be significantly slowed down or compromised

Phenological phase	Average temperature (°C)	Optimal temperature (°C)
Beginning of budding	10,5 - 11	15
Beginning of blossoming	15	18
Beginning of the anthesis	18 - 19	20
Beginning of the fruit set	21 - 22	23
From blossoming to flowering	10	18 - 22
From the beginning of flowering to fruit set	15	23 - 25
From fruit set to veraison	20	21 - 22
From veraison to complete ripening	15	15 - 18
From complete ripening to the end of the harvest	5	7 - 8
From the end of the harvest to the blossoming	-5	0 - 5[1]

The olive tree is a heliophilous species, so it is advisable to have exposure to the **South and Southwest** and to adopt a form of cultivation that allows good light interception. By the book, the crop can be pushed up to 600-700 masl[2], especially in well-exposed sites. However, Pakistani experiences might indicate that olive trees can find a suitable microclimate also in extreme circumstances, such as in the height plateaus of Balochistan.

The oils of the lower areas are fatter, that is, richer in solid glycerides. In contrast, those of the high areas are relatively richer in liquid glycerides and, therefore, less fat, more digestible, and better from a dietary and commercial point of view. It should also be noted that the latitude, altitude, and exposure of the cultivation sites, through the climate's thermal factor, influence the oil's chemical composition and the proportion of its components during the maturation phase.

In addition to the factors mentioned, the crop yield is also influenced by wind, snow, and hail. A light breeze during the period of anthesis **facilitates the transport of pollen and the cultivars' self-incompatible** prevailing in the olive tree, while a constant and impetuous wind can cause the breaking of branches and the plants themselves. In arid regions, the persistent wind also greatly accentuates the aridity, favoring water evaporation from the ground and accentuating the plants' transpiration. Therefore, when an olive orchard has to be planted in an arid and windy area, it is necessary to create windbreaks using species suitable for the soil and climatic conditions of the site.

1.2. Olive Groves, Orchard systems and varieties

1.2.1. Olive Groves

a. Material to be used

Only self-rooted plants, in containers, must be used to establish new olive groves, as, by doing so, excellent roots are obtained, with homogeneous seedlings that enter early production. **Nursery material accompanied by genetic and sanitary certification must be used**, which certifies its local origin and good sanitary and agronomic quality.

b. Planting

It is advisable to carry out this operation in spring or early autumn with the orientation of the single North-South row to allow the best interception of the light energy.

c. Plant density

For the mono-cone training system, row spacing of 6 m and plant spacing within the row of 5-6 m is recommended. For the vase training system, spacing options include 6 x 6 or 5 x 6.

1.2.2. Form of farming

The orchard system must allow rapid plant growth, early entry into production, illumination of the entire canopy, high and constant productivity, and reduced pruning and harvesting costs.

The orchard system must support the plant's natural growth as much as possible, also to limit the pruning interventions.

It is recommended the simple vase and the polyconic vase training systems for olive plants intended for manual harvesting, whereas the mono-cone system is recommended for those intended for mechanical harvesting. It is noteworthy that during the initial growth phase, the mono-cone system promotes early entry into production, encourages crown development, mitigates alternate bearing, and notably increases olive yield during mechanical shaking for harvest.

1.2.3. Choosing the right Variety

The genetic features of the cultivars determine their resistance or susceptibility to adverse soil conditions and macro/microclimate, pests and diseases, early production, the quantity and quality of the harvest, alternate bearing, ripening, and Good Agronomic Practices applied. The selection of cultivars (varieties) represents a critical decision in planning an olive orchard. It involves choosing varieties that offer promising economic potential and are well-suited to the specific regional conditions of olive cultivation. When selecting varieties, that aim to preserve tradition and enhance the particularity of specific productions, growers may opt to use established cultivars alone or in combination with native varieties identified through scientific research. These selections prioritize not only productivity but also the quality of the final product (oil and/or table olives).

In monovarietal plantings, it is advisable to incorporate an appropriate proportion of pollinizer plants (typically around 10% of the total) where needed. Pollinizer plants are selected to ensure effective cross-pollination and optimize fruit sets in orchards where pollination by wind or insects may be limited for the primary variety. This practice enhances reproductive success and overall yield in monovarietal olive orchards.

1.2.4. Pruning

Pruning allows modification of the plant's spontaneous way of vegetating to adapt it to the chosen farming system.

Its primary functions include maintaining the overall efficiency of the crown, regulating the growth and positioning of fruiting branches (secondary branches) in relation to harvesting techniques, promoting a favorable ratio between crown foliage and woody structure, and enhancing air circulation within the canopy to mitigate conditions conducive to pest development. Pruning also facilitates optimal light exposure for fruiting branches, thereby managing excess production and minimizing the occurrence of alternate bearing cycles.

Initial training pruning

The training pruning which accompanies the juvenile period of the plant, has the purpose of forming the frame that must support the vegetative structures and production.

During the initial years, pruning should be conservative; excessive pruning can delay the plant's entry into production by slowing its growth.

How to do it:

i. After planting, the seedlings must be cut to about 100 cm, leaving all the twigs that will act as a suction pump.
ii. Third year: in the presence of stunted development, it will be necessary to eliminate all the branches competing with the main branches; if, on the other hand, the plant has developed, the twigs located below 50 cm and any suckers must be eliminated.
iii. Fourth year: the development of the main branches has already started, so it is necessary to eliminate the competing branches and those placed below them.

If there are no particular problems and the various operations have been carried out correctly, the branches will form acute angles with the vertical to resist the weight of the fruits and the climatic adversities; they will be well distributed around the trunk and adequately covered with twigs to ensure satisfactory photosynthesis.

a) Production pruning

Production or maintenance pruning is practiced in the plant's production phase to maintain the production capacity achieved over time.

Excessively drastic pruning in this phase compromises the plant's productive potential, as it alters the balance between the crown and the root system. The cuts must maintain the optimal volume of vegetation concerning the availability of water and nutrients. Overly developed foliage causes poor lighting and high water consumption, negatively affecting fruit development, oil yield, quality, and production quantity.

The intensity of pruning cuts should be adjusted according to the age of the plant and its current production capacity.

Concerning the latter, after a good harvest and anticipation of a year of discharge, it is advisable to prune slightly and vice versa. The cuts will have to be more severe if we wait an entire year.

It should be remembered that the purpose of pruning, in this phase, is to balance the vegetative function with the productive one, allowing the phenomenon of the alternate bearing of production to be contained.

This pruning should be conducted annually or biennially, preferably from late winter to early spring, following the year of full production.

b) Pruning residues

Pruning operations typically involve collecting and transporting the cut branches or burning them on-site. Alternatively, it is possible to leave the pruning residues in the field, which, after mechanical shredding, can be buried with subsequent processing. If the plants are healthy, the burying of pruning residues does not have any adverse effect either for the soil or for the plants; on the contrary, it determines the partial restitution of the elements removed from the soil and used by the plant for the production of leaves and branches.

This practice is possible and convenient, especially in young olive groves where the material removed with manual or mechanical pruning is of modest thickness, generally branches at most 2 - 3 years. Over the years, the surface layer of the soil becomes mulched.

c) Period of pruning

As a rule, olive tree pruning is carried out during the winter or early spring but always **after the period of severe frosts**. Low temperatures cause the death of the tissues responsible for healing, exposure to the cut, or delay the recovery itself, causing the wounds to widen. Therefore, in sites with a danger of late frosts, it is advisable to delay pruning to allow the plant a more excellent defense from low temperatures and to favour, as already mentioned, more rapid healing of wounds resulting from cuts.

Since pruning also affects the induction and differentiation of flower buds, it is good that in vigorous plants, it is delayed until the time when the little fingers are well evident. In contrast, it is advisable to do it before induction in those who are not vigorous or weak. That is, before February.

Excessive delay must also be avoided as it determines the plants' weakening and hinders the vegetation of the new shoots, which must replace the suppressed ones. If, on the other hand, the vegetation has begun, in addition to the previous year's branches, the buds in the formation process also fall, mainly resulting from the mobilization of reserves.

Pruning during summer is feasible, primarily limited to young plants during their establishment phase and to mature plants solely for removing water sprouts and suckers unless these are essential for partial crown regeneration. This is also the case for areas such as Punjab and Potohar, heavily impacted by extreme heat and dry waves in May/June and a hot and humid monsoon season. In this case, the recommendation is to have a two-step pruning approach, leaving some upper shoots to protect the plant against sunburn in June and pruning the upper/middle vegetative shoots at the beginning of monsoons to favour air circulation.

1.3. The nutritional needs of the olive tree

1.3.1. Soil analysis and foliar diagnostics

Adopting a rational fertilization technique is essential not only to maintain an adequate level of soil fertility but also to avoid nutritional imbalances affecting plants, including fruits, and to reduce the environmental impact.

The quantities of elements to be administered with fertilization to satisfy the olive tree's nutritional needs can be determined by analyzing the soil, foliar analysis, and measurement of the removals (restitution criterion).

The physical-mechanical and chemical analysis must precede the planting phase and is necessary to evaluate the quantity of elements to be distributed with the essential fertilization. It is good practice to repeat the analysis every 4 - 5 years.

Table 3: Reference values for the interpretation of soil analyses.

Assessment	pH in H2o 1: 2.5	Total limestone (CaCO3)	Total limestone (CaCO3) %	Organic matter (g / Kg =% 0)			Total Nitrogen (% 0)		
				Sand 60%	Medium	Clay 35%	Sand 60%	Medium	Clay 35%
Low	6.0 - 6.7	1-4	1.0-2.5	< 12	< 14	< 17	< 0,8	< 1,0	< 1,2
Normal	6.8 - 7.2	5 - 15	2.6-5.0	12 - 15	14 - 21	17 - 26	0,8 – 1,2	1,0 – 1,6	1,2 – 1,6
High	7.3-8.1	16 - 25	5.1-10	> 15	> 21	> 26	> 1,2	> 1,6	> 1,6

Table 4: Physiochemical Analysis of Soil

Assessment	Carbon Nitrogen Ratio (C / N)	Assimilable phosphorus (P)		Exchangeable Potassium (K)			Exchangeable Calcium (Ca) mg/kg	Exchangeable magnesium (Ca) mg/kg
		Olsen mg / Kg	Bray 1 mg / Kg	Sand 60% mg/kg	Medium Mg/kg	Clay 35%		
Low	6,0-6,7	1-4	1,0-2,5	0,60-1,00	1,00-1,50	1,25 - 2,00	< 1000	60-100
Normal	9,1-11,0	10-15	16-30	81-150	101-250	151 - 300	1000÷2000	100-150
High	11,1-20,0	16-25	31-50	151-250	251-350	301 - 450	> 2000	> 150

Table: 5 Nutrient Profile (Micro)

Assessment	Soluble boron	Absorbable copper	Absorbable iron (Fe) mg/kg	Sulfur (S) mg/kg	Molybdenum (Mo Index) pH + 10 mg / kgM o	Total soluble salts SST%	Cation exchange capacity

	(B) mg/kg	(Cu) mg/kg					CSC meq/100g
Low	0,20-0,40	< 1,0	< 5,0	5 - 10	< 6,3	/	6,0-12,0
Normal	0,41-1,00	1,1-6,0	5,1-130	11- 15	6,3-8,2	< 1,5	12,1-20,0
High	1,01-1,50	> 6,0	> 130	16 - 25	8,2	1,50-3,50	20,1-25,0

Foliar diagnostics can also ascertain the nutritional status of the olive grove. This method uses not only the evaluation of the vegetative aspect and the interpretation of the deficiency symptoms but also foliar analysis, which determines, through chemical analysis, the content of the nutritional elements in a representative sample of leaves taken at appropriate times and according to pre-established methods.

The below table shows the optimal percentage values by weight of the elements referring to the dry matter of the olive leaves:

Table: 6 Nutrient Profile (Macro)

NITROGEN	**2.10 %**
PHOSPHORUS	**0,35 %**
POTASSIUM	**1.05 %**
Total	**3,50 %**

Leaf and fruit analyses help establish the olive grove's nutritional status and highlight deficiencies or imbalances between the mineral elements.

1.3.2. The fertilization plan

a. Basic deep fertilization

It must be carried out before planting by distributing manure or other stabilized organic material (i.e., not producing toxic substances following its continuous decomposition) to improve the soil's physical-chemical and microbiological characteristics. However, it must be carried out according to the soil characteristics from the above analysis.

It is advisable anyway, if analyses are not yet done, to distribute 30 - 50 t / ha of mature manure or similar surrogates. The quantity of phosphorus and potassium shall be determined based on the analysis.

b. Plant growth fertilization

Rational nitrogen supplies in this phase are fundamental for the growth of young plants.

In the first year, it should be distributed in three interventions: the first as soon as the plant starts to vegetate, the other two after 15-20 days; from the second to the fourth year, the nitrogen must be distributed in two interventions at the vegetative restart (from March to July).

c. Production fertilization

Production fertilization aims to maintain a specific nutritional availability in the soil proportionate to the olive grove's vegetative-productive behavior. It varies from area to area and must be set according to the physical and chemical characteristics of the soil that can be deduced from the analysis. Observing some tree characteristics (e.g. length of the shoots, presence of suckers, width, and colour of the leaves, etc.) is essential for correct nitrogen fertilization.

For this practice, the chemical analysis of the soil is mandatory. It must be repeated every 4-5 years.

As for the nitrogen supply, dividing the fertilization into two or more distributions is advisable to allow the plant constant nutritional availability during the different phenological phases. **Avoiding nitrogen inputs during flowering is recommended** as they can cause dripping phenomena and, therefore, compromise fruit setting. It is also recommended to keep in mind that the excess of this element makes the plants more sensitive to cold and parasitic attacks and induces excessive vigor, resulting in poor production, delayed ripening, poor oil yield, and poor quality of the olives.

Regarding the nitrogen application rates for the olive grove, it is recommended to apply up to 3 kilograms per quintal of olives produced in the previous year or anticipated for the current year. This approach ensures optimal nitrogen management tailored to the orchard's productivity levels.

It is advisable to divide the fertilization into two phases, half at the vegetative restart and half at the stage of the advanced fruit set.

In a dry environment with no irrigation, the second fertilization of nitrogen is not recommended. Therefore, this element's contribution must be concentrated in the rainy season (late winter, early spring). As far as the nitrogen supply is concerned, this element should be given with quick-effect fertilizers (nitrates) at the vegetative restart, while in the other stages, it can be provided in different forms, such as ammonium salts, urea, etc.

Mineral nitrogen above 60 kg/ha should be administered fractionally, not in a single solution.

Regarding the contribution of **phosphorus and potassium**, it is advisable to administer them annually up to the maximum dose of 30 kg/ha and 40 kg/ha, respectively, or preferably every 4 - 5 years, only if the analytical values are lower than normal ones.

It is recommended to apply phosphorus and potassium fertilization in autumn, following harvest, to coincide with soil processing activities. Alternatively, it can be applied at the end of winter to early spring. Application of 20 tons per hectare of mature manure every 3 to 4 years is advised, with a corresponding 30% reduction in mineral nitrogen application in the year of manure application. In the absence of manure, green manure crops of legumes such as broad beans or lupines can be sown annually in alternate rows or every 2 to 3 years during fallow years, and incorporated into the soil at the beginning of flowering.

In the presence of localized irrigation (e.g. drip irrigation) and with the row kept free from weeds, it is advisable to intervene with distributions near the row, reducing the fertilizing units to be administered by 20%.

The olive tree is sensitive to the lack of calcium, magnesium, and trace elements: iron, manganese, and boron. The optimal Ca / Mg ratio is equal to 2, while the Ca / K ratio fluctuates between 2 and 3.5. In specific environments, it even reaches values of 7.7.

1.4. The main parasitic adversities

The olive trees, despite being native to the Mediterranean and historically resilient, now require specific care to ensure high-quality production. The mention of broad-spectrum pesticides contributing to the development of resistant insects and disrupting natural predator-prey balances is also accurate. This underscores the importance of adopting sustainable and integrated pest management practices in modern olive cultivation to maintain ecosystem health and optimize product quality. Furthermore, the higher use of pesticides increases the level of toxic residues in olive fruits/oil with a deep impact on human health and the environment. In this context, it stands to reason that the producer shall modify the plant protection method towards an Integrated Pest Management Program (IPM).

Concept of IPM: It is a pest control strategy that uses mechanical devices, physical devices, biological methods, cultural practices, and chemical management to maintain pests below the economic threshold level whose main goal is to reduce the use of pesticides and enhance the quality of the product.

Concept of Economic Threshold Level: ETL is an acceptable pest density at which intervention must be taken to prevent the pest from reaching the economic injury level and at which economic losses would exceed the cost of control measures.

1.4.1. Parasitic Diseases: Fungi

Peacock eye (*Spilocea oleagina*)

Symptoms: Peacock eye is a disease that causes damage of a certain intensity in very humid and rainy years, especially on young plants.

The symptoms are particularly evident on the leaves, where initially small and brownish spots appear, which subsequently expand, reaching a diameter of 10-12 mm. and take on a velvety appearance with a brown-greyish colour, darker in the peripheral part. In some periods (especially in summer), the spots are surrounded by yellow, green, or brownish-red zonings that recall the "eyes" of the terminal part of the peacock feather.

Other organs of the plant attacked are the petioles, the peduncles, the young twigs, and the fruits. On the latter, the spots are tiny, slightly depressed, and brownish, covered with a grey mold.

The attack causes phylloptosis (leaf fall), dropping, reduced differentiation of fruiting branches, and general weakening of the plant. The most severe attacks occur in early spring and autumn.

The parasite has a very long incubation period and develops exceptionally slowly. It does not have significant thermal requirements (cardinal t °: min. 0 ° C, opt 13-16 ° C, max 25 ° C), but those of humidity are high: it needs free water. It is localized exclusively in the cuticle. The thickness of the cuticle is taken as a parameter to determine the resistance of plants to the fungus.

Anthracnosis (*Colletotrichum acutatum*)

Symptoms: The incidence of anthracnose disease varies depending on the olive variety, environmental conditions, and the virulence of the pathogen. Initially, anthracnose symptoms manifest as small, dark olive-colored water-soaked spots on leaves. These spots gradually enlarge and turn tan in color. In favorable conditions for the disease, the lesions grow larger and more numerous, eventually merging and causing extensive damage, including the death of entire leaves and petioles. On mature fruit, symptoms appear as dark sunken lesions covered with orange spore masses. Infected fruits may either fall prematurely or mummify, leading to significant yield losses.

Total crop losses are not uncommon, particularly under specific agroecological conditions, combining high humidity and rainfall during the autumn, the widespread use of susceptible varieties, and the abundance of inoculum reservoirs (Talhinhas et al., 2011). If the diseased fruits are harvested, the quality of the olive oil produced is degraded (Moral et al., 2014). Defoliation and death of branches can also occur in severe epidemics, causing polyetic effects on the yield in subsequent years.

Control: The control of olive anthracnose is achieved through a combination of methods, from cultural practices to chemical or biological control. Concerning cultural practices, the selection of olive cultivars is of utmost relevance, as the susceptibility of cultivars to disease is very diverse (Cacciola et al., 2012; Moral et al., 2017) and dependent on the pathogen species (Talhinhas et al., 2015). In addition, appropriate cultivation techniques to maintain plant health are advisable, such as balanced fertilization, irrigation, and pruning (Moral et al., 2014; Sergeeva, 2011). Pruning can be effective in disease management by reducing inoculum (e.g. diseased twigs), by promoting unfavorable conditions to disease progress (e.g. sunlight infiltration and aeration within the tree canopy improves the drying of foliage and fruit surfaces), and by facilitating chemical treatments (Sergeeva, 2011). Infected pruning debris should be removed from the orchard or destroyed, as it is a source of inoculum.

In areas with high anthracnose incidence, disease control is mainly achieved by the employment of copper-based fungicides and/or a tight selection of harvest dates balancing maturation (i.e. potential oil and phenolic compound contents), meteorological conditions (harvesting in advance of rainy/wet periods) and agronomic constraints (e.g. immature fruits are difficult to harvest mechanically). Copper-based fungicides are recommended to be applied at the first autumnal rains before the emergence of symptoms. Sprays should be repeated depending on the cultivar susceptibility, the maturity/harvest date, and the frequency and intensity of rainfall (Moral et al., 2014). Nonetheless, under highly favorable conditions, such treatments may be ineffective because the product is easily leached by rain, and the opportunity to repeat the treatments can be postponed for long periods if the autumnal rains persist. Moreover, the use of copper-based fungicides may have long-term consequences because of their accumulation in the soil and water.

1.4.2. Parasitic Diseases: Bacteria

Olive Knot Disease (*Pseudomonas savastanoi*).

Symptoms: It is a typical disease of the olive tree, caused by a bacterium that penetrates, particularly into the tissues of young twigs, through injuries caused by insects (bites of oviposition by the olive fly), hail, frost, beating, pruning cuts. To this penetration, the plant reacts by forming, at that point, an initially greenish outgrowth, which then darkens and forms an irregular and cracked surface; these enlargements are caused by the enzymatic secretions of the bacterium, which stimulate the tumor reactions of the plant.

The bacterium also attacks the leaves, fruits, and roots. On the fruits around the lenticels, tumoral changes or notches of 2 mm in diameter can occur. The bacterium is preserved in tumors and is spread by rain.

Following the attack of this pathogen, the affected branches' deterioration and their drying up, global saddening of the plant operated by tumor cells, which subtract the nutrients necessary for their development from other healthy cells. The damage is more severe if the attack concerns the seedlings in the nursery.

1.4.3. Parasitic Diseases: Insects

Olive Psyllid (*Euphyllura olivina*)

Symptoms: Olive psyllid nymphs and adults produce a white, waxy secretion, which can cause premature flower drop during infestations. The waxy secretion completely covers the nymphs, most likely to hide them from predators or prevent desiccation. Nymphs and adults produce a white, waxy secretion and Honeydew can lead to sooty mold, which blocks stomata on leaves and stops photosynthesis.

It feeds by rupturing cells and ingesting sap, plant parts attacked include flower buds, young shoots, flowers, inflorescence, and fruit set. Feeding in this manner reduces nutrients that are essential for tree development and fruit production. Heavily infestation causes yield losses of 30 to 60%.

Host plants must be monitored for olive psyllid populations to prevent infestations from establishing in new locations. Monitoring methods include using sticky traps, agitating foliage to count fallen adults, and carefully inspecting plant parts for eggs, nymphs, and adults. Plant suckers (shoots) at the base of the tree should be inspected for olive psyllids if they have not been removed. Olive psyllids have three generations per year: the first generation begins feeding as nymphs in early March, the second generation feeds during April-May, primarily affecting flower and fruit sets, and the third generation occurs in September-October. Monitoring and controlling the first generation of olive psyllids in early March is crucial because reducing their numbers significantly mitigates the population of the second generation. Treatment is advised if more than ten olive psyllids are found per inflorescence. The life cycle lasts about three months depending on the temperature, with optimal conditions being between 20 and 25°C (68 and 77°F. The rate of mortality increases at temperatures above 32.2°C (90°F).

Cultural control: Olive psyllid populations may be reduced by pruning. Growers can prune infested areas, mainly suckers, along with center limbs to enhance air circulation, increasing heat exposure to olive psyllids.

Chemical control: Insecticides, should they become necessary, are best used before olive psyllids begin producing their waxy secretions, which can protect from chemicals. Because the secretions complicate control strategies, insecticides should target the first generation to avoid problematic second-generation infestations. Non-residual contact insecticides work against psyllids, such as neem oil, insecticidal soap, and horticultural oil.

Olive fly (*Bactrocera oleae*)

Description - Adult: Diptera of about 5 mm long, transparent and iridescent wings, dark thorax with light back, brown abdomen with black sides. It can make long journeys and has a longevity of three months. Females can lay more than 500 eggs.

Egg: elongated shape, white, placed in a cavity dug by the female in the mesocarp. Larva: 8 mm long, white apoda.

Pupae: enclosed in a cocoon (puparium) varying in colour from light yellowish white to brown.

Life cycle - The life cycle includes the following stages: egg,

larva I, larva II, larva III, pupa, and adult.

It overwinters as a pupae in the ground, but in mild climate regions, it can overwinter as an adult in trees or as a larva in drupes left on the tree. The adults will flicker from the pupae at the beginning of spring and oviposit on the young olives in June-July; this happens if the temperature does not exceed 30 ° C. The females lay one egg per fruit inside the pulp, which hatches after two days at 25 ° C; the larva feeds by digging a tunnel in the mesocarp. Reached maturity (10-12 days), the larva pupates in the fruit itself during the summer, while starting from September, the larva leaves the fruit and begins its nymphos in the ground. During the summer, nymphos last about ten days, and the complete cycle from egg to larva takes three weeks.

Others follow the first generation, the number of which depends on the climatic conditions; in the southern regions, *Bactrocera oleae* makes an average of 3-4 generations per year. In the summer, oviposition slows down and resumes in late summer and autumn.

Damage - The most significant damage occurs in humid summers and temperatures above 34 ° C and consists of:

- fruit drop caused by the presence of the larvae (rot-drop);
- decrease in olive yield due to the destruction of part of the pulp;
- the oil obtained is very acidic, dense, and reddish with an unpleasant odour;
- transmission of the agent of mange (*Pseudomonas savastanoi*) through oviposition punctures;
- finally, oviposition bites on olives intended for direct consumption make their marketing impossible.

1.5. Water requirements, methods, and techniques of water management

The lack of water in the soil during the entire vegetative season, particularly in summer, must be considered one of the leading causes of the low productivity of the olive tree and is undoubtedly the one that determines alternate bearing.

The provision of water regulates and accentuates the vegetative development, anticipates flowering, reduces the alternate bearing in production, increases the pulp/stone ratio in the olives, increases lipid synthesis (despite the increase in water in the drupes), improves the oil quality by reducing the sterol content and reducing the unproductive period during the rearing phase.

1.5.1. Irrigation methods

Irrigation can be performed in various ways, but localized (drip) irrigation is recommended.

In general, localized or drip irrigation is the most suitable method. In addition to presenting a high efficiency of water use equal to 90%, the process allows a more uniform water distribution over time with shorter shifts (2 - 4 days) and relatively modest irrigation volumes per plant (from 120 to 150 l per shift). The system also adapts well to soils with different orography. It implies low management costs by requiring operating pressures from 1 to 2 atmospheres. Compared to the old methods, which increase the development of weeds, drip irrigation allows for fertigation and using waters with a moderate salinity content.

1.5.2. Critical phases

The olive tree requires the most water from March to September, coinciding with the intense activity of the shoots and, above all, in correspondence with the following critical phenological phases: flower development, fruit set, and fruit growth.

1.5.3. Volumes of watering and irrigation shifts

For traditional olive orchards without fixed irrigation systems and with very variable plant distances between them, it is difficult to establish the intervention volumes expressed in cubic meters/hectares. Therefore, it is advisable to intervene with emergency irrigation in the critical phases previously reported at the rate of about 300 L / plant For specialized olive orchards (high density) equipped with micro-irrigation systems, the following table shows the irrigation schedules (irrigation shifts), referring to plants in total production. The data refer to production situations: vigor and density of medium planting, and the water table is irrelevant.

Table – 6: Watering volumes (water return) and irrigation shifts for micro-irrigation systems.

Month	Watering (mm/day)[3]	Interval (days)		Rain (mm)[4]
		Drip	Microjet	
April	1,0	3	5	2.0
May	2,0	2	3-4	2.0
June	2,5	2	2-3	2.5
July	2,0	1-2	3-4	2
August	2,0	1-2	3-4	2

Rainfall amounts below the threshold values that delay irrigation should be considered negligible. Similarly, excess rainfall beyond the following thresholds should also be considered negligible: 30 mm for sandy soil, 40 mm for medium-textured soil, and 50 mm for clayey soil.

2. METHODS OF HARVESTING AND STORING OLIVES

It is known that the olive harvest involves significant labor use, which represents, in Europe, up to 50% of the cost of oil production.

For this reason, many European farmers have found it convenient to increasingly turn towards mechanized harvesting, partially or fully. This does not apply to today's Pakistan, as labor does not represent a hindering cost for the production process.

In any case, it is good practice to take care not to damage the olives in any way (for example, not to step on the olives on the nets spread on the ground) because this would give rise to the fermentation processes responsible for many organoleptic defects of the oil.

2.1. Structure of the olive

The olive initially appears green. As it approaches maturation, it turns yellowish with patches of wine red. When fully mature, the olive becomes purplish or shiny black, depending on the variety.

The drupe (olive) - weighing approximately 1 to 8 grams - generally comprises 40 to 50% water, 15 to 32% fatty substances, and 25 to 35% solid residue.

The variety influences the olive's composition, the time of harvest, the seasonal climate trend, and the pruning and positioning of the land.

[3] Means the quantity of water to be returned to the crop based on its water needs.

[4] It is important to evaluate rainfall to irrigate only when necessary; the tool to use is the rain gauge.

It is essential to highlight that with the onset of superficial veraison in olives, oil formation begins, and the olives start to lose their distinctly green color. This process continues until the pulp takes on a color ranging from wine red to purple or shiny black, depending on the variety. It is crucial to avoid harvesting the fruit when the olives are overripe.

2.2. Early and late harvesting

Some objectives of the decision to postpone or advance the olive harvest can be:

- to have a very fruity oil; then, in this case, the harvesting can be brought forward;
- to obtain a less fruity, yellower, and fatter oil; so, in this case, it needs to be delayed;

In some cases, in particular years, it may be helpful to bring forward the harvest to escape the attack of the latest generation of the fly (*Bactrocera Oleae*).

However, harvesting early (compared to the ripe fruit) is always advisable to obtain a quality product. **Contrary to what is believed**, the oil yield (percentage in weight of oil on the weight of the drupe) remains the same at a certain level of maturation: the increase in yield is only apparent as the olives undergo a process of dehydration.

Furthermore, harvesting early positively impacts the oil's organoleptic characteristics, thus preserving typical aromas and aromas.

Therefore, harvesting should begin when approximately 10% of the fruits have darkened and should be completed before this percentage exceeds 50%.

2.3. Principal harvesting methodologies envisaged

Only those olive harvesting systems that guarantee the achievement of the quality of the oil will be taken into consideration:

- **Hand Harvest** (hand-harvested directly from the plant)
- **Facilitated** (through the use of rakes or pneumatic combs, or even through hooks shakers, operated on the ground by the operator)
- **Mechanical** (with the use of mechanical shaking arms applied to tractors or self-propelled machines and drupe interception systems)

It is, therefore, **not permitted to pick up olives from the ground that have fallen spontaneously due to natural causes**, as the oil obtained is of inferior quality due to rotten or moldy fruit and the over-ripeness of the olive, which falls spontaneously.

Knocking is not allowed, either. This is the most harmful system because beating the foliage of the plants with poles or canes causes wounds to the thinnest twigs (wounds to the plant favor mange).

2.3.1. Hand Harvest

It is the most rational collection system, even if it is costly regarding labor use and production costs. It consists of harvesting the olives by hand, directly on the plant.

The apparent advantages consist of:

- No damage is caused to the fruit and foliage of the tree
- Damage due to late fly attacks is avoided
- You save on peeling and washing the olives
- Quality and organoleptically better oil is produced.

2.3.2. Facilitated

Harvesting is conducted using nets or sheets spread on the ground, arranged appropriately under the plant's canopy. This is done by passing a "comb" with 6-8 teeth between the branches, causing the fruits to detach and fall onto the nets. Additionally, harvesting can be performed using shaking hooks attached to manually operated rods.

The hook shaker is equipped with a fuel or battery motor. This motor moves an arm, carrying a fixed clamp in the final part, using a connecting rod-crank kinematic mechanism. The operator holds the shaker over the shoulder using a shoulder strap, and thanks to cushioned handles, it is kept in the ideal working position.

On the other hand, the combs are made up of an aluminium extension rod placed on top of it with a mechanism that determines its reciprocating motion; the telescopic function of the rod is suitable for reaching the highest parts of the foliage. On the other hand, the lasher is equipped with a knob for opening and closing the compressed air.

2.3.3. Mechanical harvesting

For all farms with a significant surface area planted with olive groves, this operational solution is chosen to lower production costs and improve the oil quality by selecting the most appropriate machines. **In Pakistan, such machines are still complicated to find, and, considering the low labor cost, their spread is still regarded as pioneering.**

Indeed, the choice to carry out mechanical harvesting operations through shakers with vibrating arms implies an upstream choice of the right pruning system, which should guarantee the structural preparation of the plant's scaffolding suited to these choices.

That is, it is a question of being aware that the best results can be guaranteed through the creation of farming methods that develop as much as possible along a vertical axis, with a first scaffold no less than 70 cm from the ground, to allow an easy grip (non-traumatic for the plant) on the pliers placed at the ends of the shaking arm.

The machines that can detach the drupes are vibrating heads applied on self-propelled carriers or tractors. Interception, however, can occur using nets moved manually by operators, unrolled and wrapped by interceptor wagons, or inverted umbrellas mounted on the same tractor carrying the shaker.

The drupes are transported via interceptor wagons with an automatic loading system or on trailers with an automatic inverted umbrella loading system.

REGULATION ON GOOD AGRICULTURAL PRACTICES

3. Management of soil fertility

The regulation on GAP must optimize the management of nitrogen in the soil/plant system (existing, incoming, outgoing) in the presence of successive crops for which it is necessary to ensure economically and environmentally sustainable production and nutritional level to minimize possible losses with runoff water and surface and deep drainage. An in-depth knowledge of the agronomic context in which fertilizers are used is essential to obtain a correct relationship between agriculture, nitrogen fertilizers, and the environment. The impact of a particular type and a certain quantity of product used depends on a complex series of environmental and anthropogenic parameters that favor or hinder the mobilization of the various organic and inorganic substances from the surface towards the atmosphere through volatilization and, more often, by infiltration towards the deeper layers of the soil. To evaluate the risks of contamination of surface or groundwater, it is necessary to first establish the general climatic parameters. Subsequently, nitrogen fertilization should be based on a simple balance between the amount of nitrogen each crop needs to meet its physiological requirements and the amount of nitrogen available in the soil. If the natural supply of nitrogen is inadequate for crop needs, as is often the case, fertilization must compensate for this deficiency. This approach aims to maximize nitrogen uptake by the crops while minimizing its dispersion through runoff. Analytical data indicate the quantities of nitrogen absorbed for each crop and its absorption rate. For each soil, it is possible to estimate the supply of nitrogen that it can promptly supply and the seasonal rhythm. The amount of nitrogen provided depends on the stocks of this element present in the soil and any run-off. The rhythm is, in turn, dependent on the seasonally variable conditions of temperature and humidity and the aeration conditions of the soil, function of texture, structure, etc.

Reducing unwanted nitrate losses through percolation through appropriate land use management is possible. The potential operational lines range from adopting crop rotations that do not leave the land uncovered for long to the burial of straw crop residues and the correct management of soil cultivation.

Crop rotation in an olive orchard can be a beneficial practice, although it is less common compared to annual cropping systems. It can significantly enhance soil health, manage pests and diseases, and boost overall productivity. By alternating olive trees with cover crops such as legumes, soil fertility can be improved through nitrogen fixation. Cover crops also suppress weed growth, reducing the need for herbicides, and help manage pests and diseases by breaking their cycles. Additionally, these crops improve soil structure and prevent erosion. Implementing this practice involves introducing cover crops like clover or vetch during the off-season, planting annual or biennial crops between young olive trees until they reach full canopy coverage, and growing green manure crops to be incorporated into the soil. An example rotation plan might involve planting legumes for the first two years, incorporating them as green manure in the third year, rotating with cereals or other non-legume cover crops in the fourth and fifth years, and allowing a fallow period or reintroducing legumes in the sixth year. Timing rotations around the olive tree growth cycle and harvest period, choosing compatible crops that do not compete heavily with the olive trees for resources, and managing cover crops properly are crucial considerations. While traditional olive orchards may not typically use crop rotation, integrating cover crops and practicing strategic fallowing can provide significant benefits to soil health, pest management, and overall orchard productivity.

3.1. Grassing

A vegetative cover prevents the accumulation of nitrates by absorbing them through the roots. In addition to intercepting nitrates naturally present in the soil or introduced by fertilization, vegetative cover can also protect groundwater from nitrates of non-agricultural origin.

The olive tree is one of the most widespread species in the world, particularly in the Mediterranean basin, a land that has always been suited to its cultivation due to the soil and climate conditions favorable to its development.

Among the most environmentally friendly cultivation practices is **grassing**, namely the **release of a turf cover on natural or artificial agricultural land** which brings various benefits to the physicochemical and biological properties of the soil.

Naturally grassed olive grove - **grassing of tree crops** – provides for the maintenance of spontaneous or sown grassing in the inter-row of tree crops or, for tree crops not in rows, outside the vertical projection of the canopy.

Release of turf on the ground, with periodic mowing or shredding that creates a disturbance to their growth, first of all, creates a vegetal layer which, over time, will determine **a mulching action**, hindering germination in the seed bank contained in the soil.

Artificial grassing, the emergence of legumes - Another characteristic conferred by the permanent presence of the root hair of the weeds is that of **avoiding leaching of nitrates**, a well-known chemical fraction of the soil which is difficult to retain by the exchanger due to its negative charge (NO3-, etc.).
The high presence of weeds is also a factor **defense of the soil against erosion**, managing the intensity of rainwater, thus reducing its advancement, especially in steep slope conditions. At the same time, the weed layer represents a **photosynthesizing cover** that contributes to the removal of CO2 from the atmosphere with consequent storage in the soil.

The potentially achievable vegetative covers are the following:

- **spontaneous vegetation**: the natural grassing that occurs in late summer-autumn should be seen very positively in risk areas as a means of counteracting the percolation of nitrates; therefore, it should not be hindered but left to carry out its function for as long as possible; spontaneous grassing could be usefully applied on surfaces temporarily withdrawn from production (set-aside):
- **controlled grassing**: this agronomic practice, generally used in farms that apply the organic production method, consists of grassing the inter-rows by sowing different species, allowing soil coverage and avoiding leaching phenomena of very mobile elements (such as some forms of nitrogen) while allowing the preservation of the organic fertility of the soil itself.

The species to be considered suitable for this function should satisfy the following conditions:

- have low thermal needs to be able to grow in the autumn-winter period;
- have seed that is inexpensive, available, and easy to emerge;
- have low weed capacity;
- be consumers of nitrogen (therefore excluding legumes);
- do not create phytosanitary or infestation problems for the following crop.

The botanical families most responding to this model are the grasses, crucifers, composites, and *chenopodiaceae*. For all the families indicated above, the cultivation technique that appears technically and economically advisable is the following:

a) preparation of the land with the minimum tillage technique (harrowing)
b) broadcast sowing with plenty of seed at the first rains at the end of summer and burial with a plough;
c) fertilization: none.
d) Burial: upon exit from winter, by plowing at medium depth (0.20-0.25 cm), in any case, before the plants disseminate.

3.2. Tillage and soil structure

Impact of Tillage on Soil Structure: Traditional ploughing and non-working or grassing practices significantly influence the soil's pedological environment over time. Deep ploughing redistributes organic substances throughout the soil profile, potentially increasing mineralization and nitrate nitrogen production, which is beneficial for plant nutrition but can also lead to leaching. However, in arable olive orchards, excessive ploughing may decrease organic matter levels over time, affecting soil fertility and structure negatively.

Tillage Practices: Primary and secondary tillage operations alter soil porosity, primarily affecting the processed layer's macro-porosity while leaving smaller pores relatively unchanged. These changes in porosity influence water infiltration and runoff differently: tillage promotes runoff, while grassing enhances infiltration. For olive cultivation, minimizing tillage intensity can help maintain soil organic matter content and preserve soil structure, especially on sloping terrain where erosion control is crucial.

Water Management: Grass cover in olive orchards, particularly on slopes, plays a critical role in reducing surface runoff and consequently the movement of nitrates into surface water bodies. The turf's ability to consume water also reduces the soil's potential for rapid water percolation, enhancing water retention crucial for olive tree root uptake.

Conservation Practices: Adopting conservative cultivation practices like reduced tillage and maintaining grass cover can sustain soil health and fertility in olive orchards. These practices minimize soil disturbance, preserve organic matter, and optimize water infiltration and retention, all of which are beneficial for olive tree growth and productivity.

Adaptation to Soil Characteristics: The decision to perform tillage in olive orchards depends significantly on soil characteristics. For example, soils with specific texture types or poor structure may require more frequent interventions to maintain adequate macro-porosity for root development and water movement.

3.3. Land Management

Land management practices in hydraulic-agricultural systems play a critical role in optimizing olive crop cultivation, particularly concerning water management and erosion control. In sloping olive orchards, the primary goal is to mitigate surface runoff, which can be achieved through strategically placed ditches that slow down water flow. This helps prevent soil erosion and retains water on-site for olive tree uptake, essential in maintaining soil moisture levels and preventing nutrient leaching. Conversely, in flat olive orchards, effective drainage systems such as underground drains or open ditches facilitate excess water removal, reducing the risk of waterlogging and enhancing root health.

In plain lands, hydraulic-agricultural management provides significant environmental and agronomic benefits by swiftly evacuating water, along with dissolved nitrates, to surface hydrological networks. This rapid water disposal minimizes the time nitrate-laden water spends percolating towards aquifers, thereby protecting groundwater quality. Properly designed drainage infrastructure, tailored to soil texture, structure, and rainfall characteristics, optimizes water movement while safeguarding against erosion and nutrient loss. Techniques like field ballasting enhance surface water evacuation to ditches, further supporting erosion control and nutrient retention.

Regarding olive crop management, these practices ensure optimal soil moisture levels and nutrient availability, crucial for healthy olive tree growth and productivity. By integrating hydraulic-agricultural strategies tailored to local conditions, olive growers can sustainably manage water resources, prevent soil erosion, and enhance overall orchard resilience against environmental challenges. This approach not only supports agricultural productivity but also promotes environmental stewardship in olive cultivation.

3.4. Types of nitrogen fertilizers and their application

Using fertilizers and soil improvers to supply nitrogen to olive crops requires careful consideration of the chemical forms of nitrogen present in these products. The selection and expected responses must be calibrated based on how each form of nitrogen behaves in soil and contributes to plant nutrition. Nitrogen can exist in various forms such as nitrate, ammonium, and organic nitrogen compounds, each influencing soil fertility and nutrient uptake differently. For olive cultivation, understanding these nitrogen forms' dynamics helps optimize fertilizer application strategies to enhance both production outcomes and environmental sustainability.

Fertilizers with exclusively nitric nitrogen

The nitric ion is immediately assimilable by plants' root systems and, therefore, efficient. It is mobile in the ground and, thus, exposed to leaching and percolation processes in the presence of water surpluses. Nitric nitrogen must be used when crops have the most significant absorption (especially on the cover and better in split shares).

The main fertilizers containing only nitrogen in the nitric form are calcium nitrate (N=16%) and potassium nitrate (N=15%; K2O=45%).

Fertilizers with exclusively ammoniacal nitrogen

Unlike the nitric ion, the ammonium ion is retained by the soil and, therefore, cannot be washed away and/or percolated. Most plants use ammoniacal nitrogen only after its nitrification by the microbial biomass of the soil. Ammoniacal nitrogen, therefore, has a slower action and is conditioned by microbial activity. The main fertilizers containing only ammoniacal nitrogen are anhydrous ammonia (N=82%), ammonium sulphate (N=20-21%), ammonia solutions (minimum content: 10% N), ammonium phosphates (diammonium phosphate 18 /46 and monoammonium phosphate: 12/51).

Fertilizers with nitric and ammoniacal nitrogen

Fertilizers containing nitric and ammoniacal nitrogen offer a balanced approach between the characteristics of purely nitric and purely ammoniacal fertilizers. Depending on the ratio of nitric to ammoniacal nitrogen, these fertilizers provide flexible solutions for various stages of crop growth and specific field intervention needs. One prominent example of a nitro-ammonia fertilizer is ammonium nitrate, typically available in Italy with a nitrogen content of 26-27%, equally divided between nitric and ammoniacal forms. Additionally, formulations such as ammonium nitrate and urea are available, with nitrogen concentrations starting from 26% and commonly reaching up to 30% in commercial products.

Fertilizers with urea nitrogen

The urea form of nitrogen is itself not directly assimilable by plants. It must be transformed by the urease enzyme first into ammonia nitrogen and subsequently by the action of soil microorganisms into nitric nitrogen to be metabolized by plants. Urea nitrogen, therefore, has a slightly more delayed action than ammoniacal nitrogen. However, it must be remembered that the urea form is mobile in the soil and very soluble in water. The fundamental product is urea (N=46%), the solid mineral fertilizer with the highest nitrogen content.

Fertilizers with exclusively organic nitrogen

In organic fertilizers, nitrogen in organic form is predominantly in protein form. The structure of the proteins that contain it is more or less complex (globular or easily hydrolyzable proteins and scleroproteins) depending on the nature of the organic products of origin. Therefore, nitrogen availability for plant nutrition is more or less differentiated in time, from a few weeks to a few months. This availability passes through a series of transformations: from amino acids, subsequently to ammoniacal nitrogen, and then to nitrate nitrogen. They, therefore, find their best use in pre-sowing fertilization and for long-cycle crops. Among the main organic fertilizers are leather, hornwort, dried blood, meat and fish meal, manure, dried manure, etc.

Fertilizers with organic and mineral nitrogen (organo-mineral fertilizers)

They are products that allow the action of nitrogen to be activated over time; at the same time, they ensure a high-quality organic substance/nutrition element combination, increasing its availability for the plant.

Fertilizers with cyanamide nitrogen

Calcium cyanamide is the typical product containing nitrogen in the cyanamide (minimum nitrogen content of 18%). To be assimilated by plants, cyanamide nitrogen must also be transformed into nitrate nitrogen in the soil. The steps of this transformation are:

- Release of cyanamide by the action of humidity and carbon dioxide on the starting calcium cyanamide;
- transformation of cyanamide nitrogen into urea nitrogen through hydrolysis catalyzed by manganese oxides present in the soil;
- ammoniation of urea nitrogen by enzymatic action (urease);
- microorganisms, specifically in the soil, oxidate ammoniacal nitrogen to nitrate nitrogen.

For this series of steps, the action of the cyanamide N is slightly more delayed than that of the nitrogen of urea origin.

Fertilizers with slow-release nitrogen

The aim of obtaining products that can release nitrogen progressively over time and, therefore, present the positive economic aspects of fertilization in a single solution without or with reduced environmental losses has been achieved or approached mainly by two different technological ways. The first consists of preparing condensation compounds between urea and aldehydes. This family of products includes formula (N38%), isobutylenediurea (IBDU: N=30%), and crotonylidenediurea (CDU: N=28%). The second way covers traditional products with more or less porous membranes.

Livestock effluents

The diversity of effects that livestock effluents have on the agri-environmental system is justified by the variability of their composition, referring both to quantity and quality. Regarding nitrogen, the comparison between the different materials must be made based on the total content and its qualitative distribution. This element is present in the organic substance of zootechnical origin in various forms, which can be functionally aggregated into three fractions:

- mineral nitrogen;
- easily mineralizable organic nitrogen;
- residual organic nitrogen (slow-acting).

The salient characteristics of the different materials can thus be summarized.

Cattle manure

It is a complex material characterized by its high content of slowly degradable compounds, making it resistant to microbial breakdown due to polymerization during maturation. Its primary function lies in soil improvement, facilitating the aggregation of soil particles and enhancing the stability of soil aggregates. While it provides nutritional benefits, particularly nitrogen, these effects are relatively minor compared to its soil conditioning properties. The nitrogen released from cattle manure persists over several years following application, with approximately 25% of its total nitrogen content available in the first year of application. In Italian experiments, however, this efficiency was rarely found, often remaining below 20%. The residual effect assumes significant consistency up to several years after the cessation of the contributions, depending on the type of soil, the climate, the processing, the other fertilisations, and the crop that takes advantage of it.

Bovine slurry

It presents highly differentiated characteristics depending on the farming systems, ranging from actual slurry (7% of dry matter) to the more or less pasty consistency of the so-called slurry, which can reach a dry matter content of 15-20%. When litter is used at a rate of 3-4 kg per animal and per day, the structural effect can rely on almost half the quantity of slowly degradable nitrogen compounds compared to manure (40%). In contrast, the nutritional impact on the first year of mineralization can reach a maximum of 60%. Generally, it is a medium-efficiency fertilizer during the first year and has a good residual effect. Still, the variability of the material can cause the functional characteristics to differ significantly from the average ones just indicated. In particular, the more substantial presence of litter will bring the behavior closer to that of manure. At the same time, the separation and storage systems will influence the degree of maturation and stabilization.

Poultry Manure

In this case, almost all the nitrogen is already present in an available form in the first year. The result is a fertilizer with immediate effectiveness, comparable to synthetic ones. Even in this case, the residual effect can be considered mild, and the structural one is practically insignificant. However, it is tough to use correctly because it is not stabilized, is challenging to distribute, and is subject to solid losses due to volatilization, with problems of unpleasant emissions. However, these drawbacks can be considerably reduced or eliminated by using treatment systems such as pre-drying or composting, which allow you to enhance its nutritional and structural properties.

Compost

Composts are soil improvers obtained through an aerobic biological transformation process of organic matrices of different origins. Of particular interest for companies that have access to livestock manure is the composting of recovered lignocellulosic materials (straw, stalks, olive tree pruning residues, pomace, various crop residues), which are mixed with the manure as is or treated. Added to this significant variability of the starting matrices is that of the composting systems about the physical conditions and maturation times. It, therefore, becomes difficult to generalize the agronomic behavior of composts; however, it can be assumed that the average result of a composting process, correctly conducted for a sufficient time and with materials more typical of the agricultural company, generates a fertilizer similar to manure. It will, therefore, be characterized by low efficiency during the first year, compensated by a more prolonged effect; even the soil improver properties can be assimilated to those of manure. Again, in consideration of the heterogeneity of origin of the compostable organic matrices, the use of compost must be carried out with particular caution due to the possible presence of pollutants (mainly heavy metals), which can limit its use to defined doses, following analysis of the soil and of the compost to be used, based on the provisions of current regulations.

4. Phytosanitary protection

Good Agricultural Practices applied to olive tree protection involve the exclusive use of authorized phytosanitary products, adhering strictly to recommended doses, safety intervals, and all other instructions provided on the product labels. Furthermore, chemical control treatments must generally be carried out when the intervention thresholds are exceeded, where existing, for the control of animal parasites, or with preventive treatments, when predisposing conditions are established, and curative in the case of diseases: cryptogams and a certain number of diseases of bacterial origin. Virus control must be carried out through healthy propagation material that complies with current phytosanitary legislation and through the fight against vectors.

Therefore, given that, farmers who apply the GAPs must:

- Comply with the principles stated above;
- Always have the "campaign notebook" in which to make notes on the chemical control treatments carried out regularly, as well as any additional treatment, with the relative times, the fertilization interventions, and other cultivation operations carried out (pruning, ploughing, irrigation, etc.);
- Find out about the main phytosanitary problems arising in the farm and any chemical control treatments to be carried out. Regular meetings with the technicians responsible for the area, during which the main phytosanitary problems and the control strategies shall be discussed, control implemented and to be implemented, and through consultation with specialized magazines and Phyto pathological bulletins.

CONCLUSION

This document, titled "Olive Production Guidelines," presented in this study serves as a pivotal resource for advancing olive cultivation in Pakistan and has been prepared by the OliveCulture Project (Holistic and Multi-Professional Mechanism for a Pakistani Olive Oil Value Chain) under the supervision of experts from CIHEAM Bari (The Mediterranean Agronomic Institute of Bari Italy), to serve as a comprehensive resource for technicians and olive growers in Pakistan. It aims to transfer essential knowledge in a precise and accessible format, ensuring that the latest and most effective agronomic practices are readily available to those involved in olive cultivation. The guidelines cover a wide range of topics crucial for successful olive orchard management, including good agricultural practices, integrated and organic farming methodologies, and the selection of suitable cultivars aligned with local climatic conditions.

The guidelines encompass a wide array of critical aspects essential for successful olive cultivation in Pakistan's diverse climatic regions. From the initial selection of cultivars tailored to local pedo-climatic conditions to detailed practices in pruning, nutrition management, soil analysis, and foliar diagnostics, every aspect of olive orchard management is meticulously covered. The document emphasizes the importance of adopting integrated and organic farming methodologies to enhance soil health, biodiversity, and overall orchard resilience, sustainable pest and disease management strategies outlined in the guidelines promote reduced chemical inputs while ensuring effective control measures. The document also provides comprehensive guidance on water requirements, efficient irrigation methods, and best practices for harvesting, storing olives, and managing soil fertility. These practices collectively aim to optimize production yields, improve the quality of olive products, and mitigate environmental impacts.

Furthermore, this document aims to foster a community of knowledgeable and skilled olive growers who can share insights and innovations. Beyond these technical aspects, the guidelines emphasize the importance of sustainable and environmentally friendly farming practices. This includes promoting biodiversity, conserving natural resources, and reducing the carbon footprint of olive farming. The integration of organic farming principles not only enhances soil health and biodiversity but also improves the overall resilience of olive orchards to climatic variations and pest pressures.

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