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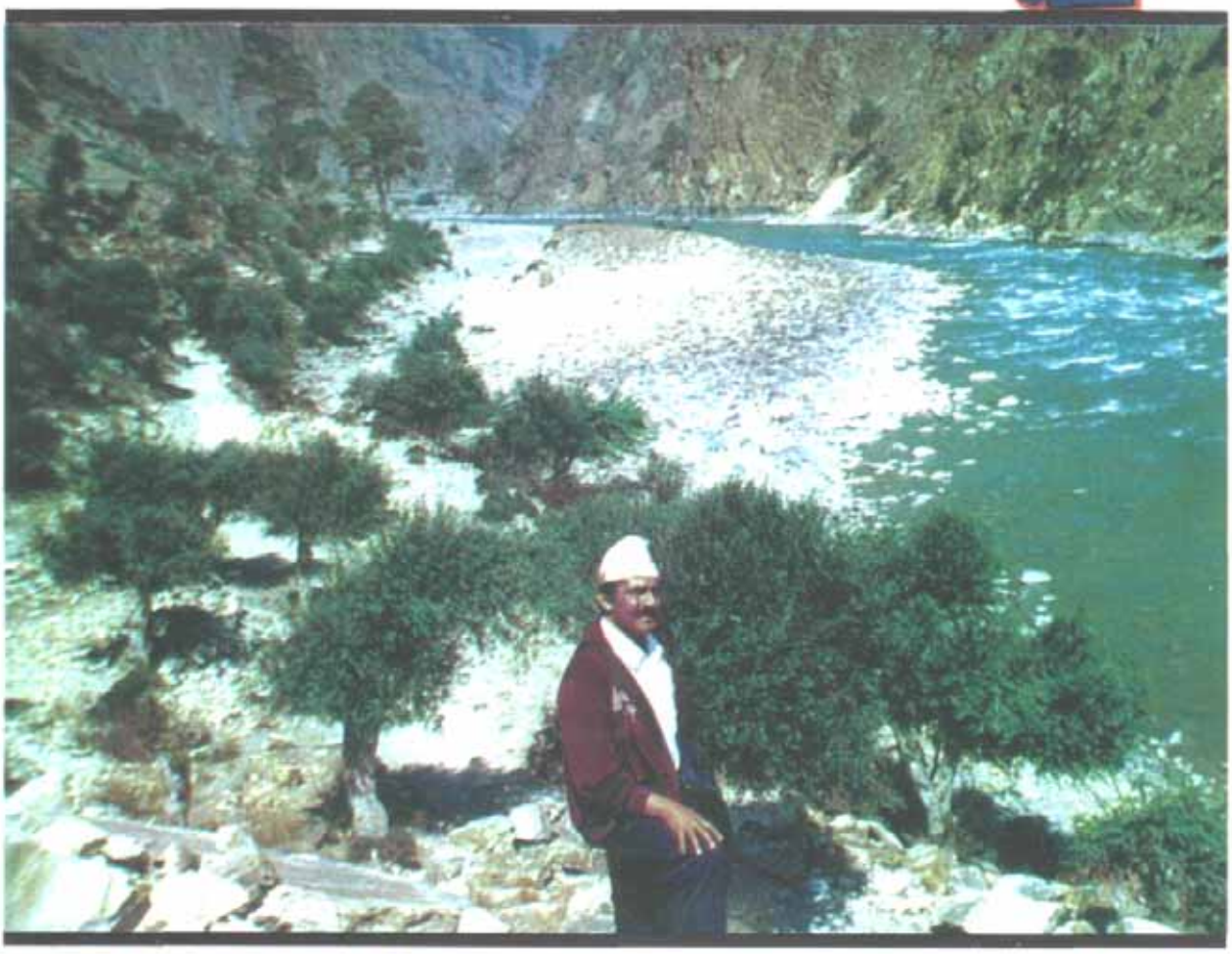
Prospects for
OLIVE GROWING IN NEPAL



His Majesty's Government

Department of Agriculture, Fruit Development Division Olive Production Development Project, TCP/NEP/6713
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Cover Page

Wild Olives (Olea cuspidata) along the Bheri riverside in Dolpa district

PROSPECTS FOR OLIVE GROWING IN NEPAL

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FOREWORD

This document produced under the auspices of Olive Production Development Project (TCP/NEP/6713) is expected to be of use to those who are interested in the subject of Olive Production in Nepal.

Kathmandu, August 1999

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I. HISTORY

Olive is a tree with endless history. From some olive tree pieces and seeds discovered in Spain it was recognized that olives existed from the XII millennium B.C. In the book of Genesis (Old Testament) we read that it was an olive twig that Noah's dove took back to the Ark (a ship) after the deluge (great flood). Tn the Greek Mythology, in a game between Athena and Poseidone, God Zeus originated a new tree "the olive" to premiate Athena. This tree was regarded as a holy plant to symbolize peace and abundance.

Olive was beleived to be originated in Pamir and Turkestan. It slowly occupied lands from East to West crossing Armenia and entering into the Mediterranean region. In this region, olive received maximum importance and started cultivating from 6,000 years ago. During the Roman empire some famous experts prepared an olive-oil classification: *Oleum ex albis ulivis (*this could be compared to the extra virgin olive-oil available in these days) and *viride, maturum, caducum, cibarium* (to be considered olive-oils of secondary importance).

During the Renaissance period olives received again great importance. With the discovery of America inl492 olive trees from Europe reached Antille and consequently the American continent. By the 16th century olives are already in Mexico, Peru, California, Chile and Argentina where it is possible to find famous Arauco's olive even today.

Recently, olive has started to influence other areas of the World such as South Africa, Angola, Australia, China, and others. Its production extended even to a geographic area with monsoon characteristics that was considered unsuitable few years ago.

In pre-himalaya regions of Northern Pakistan, Jammu & Kashmir, Himachal Pradesh (H.P.) and Uttar Pradesh of India, and Nepal, olive cultivation is being studied. Some significant results have been obtained for possibilities to exploit olive production. Olive is known as "Jaitoon" in Sanskrit, Arabic, Hindi, and Nepali . *Olea cuspidata* is a species locally known as "Lotto" in Dolpa and "Launtho" in Bajura districts of Nepal and "Kahu" in Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh States of India.

In Pakistan and India the cultivated olives *(Olea europaea L.)* were introduced in fifties as evidenced by the existing plantations in Mingora (SWAT), Rawalpindi, and Pinjore in India, where olive cultivation started 40 years ago. The first olive orchard was established at Jidhari in Solan District by the efforts of Maharaja Patiala's Family. In sixties and seventies, the H.P. government established olive plantations and launched a top-working programme of *Olea europaea* with *Olea cuspidata.* Tehnical Cooperation Programme of FAO/UNDP was launched to provide necessary technical support from 1975 for several years. With the Bilateral Agreement between Indian and Italian Governments from 1984 to 1993, India has extended commercial olive plantation activities and olive oil industries in Himachal, Jammu and Uttar Pradesh.

From the 1965 survey reports and other evidences of HMG Royal Botanical Garden, Godawari it appears that olives were introduced from India to Nepal probably by some Nepalese. These olives were recorded at Matyalo of Bajura district on both the deforested and cultivated areas along the Karnali river. During the survey, one of the trees was 12 m high. Three commercial olives such as Nuovo, Nabali, and Manzanilla were introduced from Israel in 1978 during the implementation of a *Hill Agriculture Development Project (Nep/73/004).* These olives were planted at Horticulture Centers located at Kirtipur, Jumla, and Marpha. In 1992, the Himalaya Plantation Private Limited (HPPL) introduced some olive varieties from H.P. (India) and Italy; these were planted at Thaiba of Lalitpur district. The same company again brought in about 15 varieties from Italy, France and H.P. (India) and planted 2400 trees in Chitlang area of Makawanpur district during 1996 and 1997.

During the Phase IT of Horticulture Development Project supported by JICA two cultivars of olives such as Mission and Rakka were introduced to Nepal in 1994 and these olives were planted at Kirtipur Horticulture Center. Mr. Ram Chandra Paudel, then Agriculture Minister in 1995, brought 4 olive cultivars from Egypt namely, Toffahi, Hamed, Picual and Manzanilla; they were planted at the center in 1996. The FAO supported TCP project also introduced 18 cultivars of olive from the Olive-World Germplasm Bank, Cordaba, Spain in 1998 and planted at Horticulture Center of Godavari, Lalitpur both for germplasm collection and establishing mother plant block. For varietal adaptability studies they have been planted in Juphal of Dolpa district, Ghasa of Mustang district and District Agricultural Development Office of Dadeldhura district in 1999. From Syria, B.R, Dhakal and B.D. Karmacharya also brought with them 3 cultivars namely, Sorani, Zeity and Kaissy in 1998 and planted at Godavari, Ghasa and Juphal in 1999.

For plant multiplication, a mist propagation unit is built at Godavari in 1998 to supply enough olive saplings to mid-hill districts of Western Development Regions.

II. BOTANY

Olive belongs to the botanical order, *Ligustrales* and family, *Oleaceae;* this family includes 30 genus including *Olea* and has 600 species. Olive is botanically called *Olea eurovaea L.* This species has two subspecies : *oleaster* and *sativa.*

Recently, the common olive is botanically called *Olea europaea* var. *sativa* (*O. sativa* Hoffm. & Link) and the Euro-mediterranean sub-species, a wild type is called *Olea europaea* var. *oleaster* (*O. oleaster* Hoffm & Link). *Olea europaea* var. *sativa* is the most cultivated olive tree in the world. There are other olive subspecies, they are :

1. *Laperrini* Batt. and Trab, a native to North Africa, has small inedible fruits.

2. *Cuspidata* Wall, *(or Ferruginea Royale),* a native to Pre-Himalaya Range, has small fruits with few oil percentage.
3. *Glandulifera* Wall.is native to Pre-Himalaya Range; it has glossy and wider leaves as compared to others.
4. *Verrucosa* Link is native to Austral Africa.

5. *Crysophylla* Lam. is native to Tropical Africa.

In Nepal, *Olea europaea* var. *sativa* is distributed in different locations from Far-west to Central Development Regions. The two subspecies of this *Olea* genus, *0. cuspidata* or *ferruginea* (the under surface of leaf in these plants is of rosy colour) and *O. glandulifera* are also present in Nepal.

Table 1. Two Olea species and their availability in different localities.

Species	**District**	**Locality**	**Elevation (m. a.s.l.)**
Olea cuspidate	Dolpa	Parang & Thuli Bheri Dunai, Upper Bheri Bheri, Tallon, Parakya Logne Karnali,	1100 - 1800
	Rukkum	Godamkot	1150
	Humla	Darma, Simikot	1800
	Bajura	Kaligad, Kolti, Boldhik	2192
Olea glandulifera	Bajhang	Chainpur, Manakot, Baru Ganga	1530-1566

Olive is an evergreen tree. Leaves are replaced every after 2 - 3 years. Tree height varies from 5 to 20 m. The plant has either spreading nature or bushy habit in its natural state (basiplastia); but can be trained to a tree. Root system is strong; distributed almost all over top soil but with roots having capability to hint rocky soil. Horizontal growth of roots is almost three times the canopy width. The trunk is cylindrical, tortuous, sometimes with characteristic knot-like swellings; the trunk diameter can be more than two meter with a light gray bark. It is a long-lived tree; some trees have been lived for 1000 years. The olive wood is very hard and delicately grained. Leaves are lanceolate, thick, leathery and opposite. Leaf color is green-grey on the upper surface and silver-green on the lower surface. Leaves have stomata nestled in peltate trichomes on their lower surface (star-like hairs) that restrict water loss due to transpiration and make the olive relatively resistant to drought.

III. FLORAL AND FRUIT BIOLOGY

Flower bud inflorescence is borne in the axil of each leaf. Usually, the bud is formed on the current season's growth and gives visible growth in the next season. There are hundreds of flowers per twig. Each inflorescence contains 15 to 30 flower buds which are small, round and white yellow in colour. The flowers are white or whitish; the calix is short and 4 - toothed; the corolla is short-tubed with 4 valvate petals; the stamens are 2 , each bearing 10.000 to 15.000 small and light pollen grains. The ovary is 2- loculed, bearing a short style and a capitate stigma. The pistil has two carpels, each containing two ovules but only one is fertilized and thus produces one-seeded drupe.

There are two types of flowers: perfect flowers that contain stamen and pistil , while the staminate flower contains aborted pistil and functional stamens. Large commercial crops occur when 1 to 2 perfect flowers are present among 15 to 30 flowers per inflorescence. The perfect flower has large pistil which almost fills the space within the floral tube. The pistil is green when immature and deep green at the time of full bloom. Olives are monoecious ; the same tree bears perfect and imperfect flowers.

The reasons for flower and young fruit drop are not well known. However, pistil abortion is often involved. Stress from lack of water and nutrients during floral development can lead to pistil abortion. Flower buds begin to form by winter and full bloom occurs during April to May depending upon the cultivar and the latitude. Flower drop can also be due to a) a sudden decreasing of temperature, b) continuous rainfall, c) thick fog, d) strong winds, e) too low Relative Humidity, and f) nutrient deficiency

The biological fruiting cycle starts with the flower bud differentiation (Feb. -March) and ends with fruit ripening (Nov. - Dec.) i.e. it takes about 9 months duration. The main phonological phases are a) flower bud differentiation, b) panicle / raceme formation, c) blooming, d) pollination, e) fertilization, and 0 fruit set and fruit development

Flower bud differentiation:

The time of bud formation are neutral; they can develop into vegetetive buds (shoot) or flower buds. Olive tree can have also mixed buds, they produce floral organs and shoots. A floral behaviour study performed in India (Indo- Italian Olive and Fruit Dev. Project) in 1992 at Basht and Govindpora of Jammu & Kashmir by Dr. Ivano Giannotti and it was showed that buds, containing the relative primordia of so called "mixed buds" are insignificant in number (i.e. less than 1% on the average). In the olive , as in all common evergreen plants, the differentiation of buds starts in one-year old twig during the year of flowering. Eccessive growth, unfavorable climatic conditions, heavy pruning, etc. can reduce the number of differentiated buds.

Panicle /raceme formation:

Floral organs are ready to open one month after the flower bud appearance. The inflorescence is composed of one main rachis bearing a flower of first order which has several

secondary rachis with flowers of second order. There are flowers of third order also. On each rachis or axil, flowers are borne opposite to each other. Some cultivars have only one axel and all flowers of second order are attached to this one. The difference in the inflorescence structure is a typical character of olive cultivars.

Blooming:

When floral organs are completely developed and formed then blooming starts. In this stage flowers are ready for pollination and fertilization. Each flower cluster bears 15 to 30 small, roundish and white-yellow blossoms. The flowers are also small, may be imperfect due to pistil hypotrophy and consists of 2 stamens each bearing 10,000 to 15,000 pollen grains. These pollen grains are carried by wind upto a distance of 12 km.

Pollination:

Pollen grains reach the stigma, which is receptive for several days with some exceptions. In cultivar "Luques", the stigma receptivity is of 8 days but the pollen tube growth requires four days; so the total pollination period is only four days. The cultivar "Picholine" has eight days of pollination period. In most of the olive cultivars flowers of one tree/cultivar are pollinated by pollens of other tree/cultivar. There are exceptions; the cultivars such as "Frantoio" and "Ascolana Tenera" have self compatible pollens, but even these cultivars perform better with cross pollination.

It is very important to find proper cultivar for pollination and their placement in the orchard is also important. Pollinators in new olive plantations should be around 20% of the total trees and they are to be located in the field towards the prevailing wind. Cultivar combination may also be important for good production. "Pendolino and Sevilano" are good pollinizers for many cultivars. "Pendolino" is a commercial pollinizer variety for Frantoio and Leccino cultivars.

Flower fertilization:

When fertilization takes place there is a growth of flower tissue for fruit formation. There is also some sterility phenomenon that does not allow fertilization to take place. Fruit formation may take place without fertilization or with partial fertilization. In such cases, fruits are small called "Olive passerine or shot berries" Other factors of sterility in olives are lack of nutrients and climatic factors.

Fruit set and fruit formation:

Fruit set is considered normal when 2 to 4 % of flowers become fruits. Fruit formation start with pericarp formation followed by epicarp (skin), mesocarp (pulp) and then endocarp(stone) development. One month after fruit formation, about 20% of fruits drop in normal condition. From September (in Northern Hemisphere) there is a change in the colour of epicure (from green to red-violet, black) and such change indicates ripening process occurring inside the fruit.

At Bajaura of Himachal Pradesh, India, Pietro Bartolucci, Gaetano Tassone and one Indian Horticulturist studied fruiting behavior of 16 cultivars in 1992. They observed that

fruit drop was equal to or less than the standard value recorded in common olive growing areas during monsoon. Weekly observation of fruit branches and twigs showed that the average fruit set decreased from 47. 4 % (soon after full bloom period) to 2. 9 % (at ripening stage).

Alternate bearing:

This phenomenon occurs often in olive trees. In this case the tree bears heavily in one year and scanty or no fruits the next year. This creates many economical and technical problems to the olive growers. Even if we are agreed for a good yield one year and less yield the following year, it has been demonstrated that the total yield will be anyway less in comparison with constant year production.

Nutritional problems, lack of water, pest and diseases, frost in spring season are some of the possible factors favouring the alternate bearing.

Alternate bearing is an overlapping of the biological fruit cycle of one year to the next year. The year of no fruits on the tree due to unfavourable conditions, there is a nice vegetative growth, this vegetative growth allows many buds to differentiate in flower buds and consequently there will be a good crop. But, this heavy crop does not allow the formation of well developed branches and in the following year the crop will be again scanty,

Olive fruit:

The fruit is an oblong or ovoid drupe weighing 1 to 10 g. or even more according to the cultivar. The skin of fruit is green when immature and dark blue, blue-violet, black when ripe with sometimes many lenticels. The pulp of fruit becomes soft at the full maturity stage. The oil is present in all skin (pericarp), pulp (mesocarp) and the seed (endocarp). The fruit is horticulturally matured in October- November and the seed by October. The fruit is physiologically matured in January or February. Fresh and . unprocessed olives are inedible as they are extremely bitter. The bitterness of the pulp is due to a hydrosoluble glucoside called the oleuropein. The glucoside is neutralized with sodium hydroxide while pickling and goes with water at the time of separation of oil from the fruit juice. Fruits of some cultivars have very low oleuropein; they are called sweet olives.

IV. USE OF THE OLIVE

Olive growing plays an important role in the economy of the country. It can be grown in marginal and waste land where the soil is unsuitable for other crops. It increases the land value. It contributes to soil conservation and helps to combat problems of the environmental degradation and desertification. It provides employment opportunities to the rural population and thus helps in poverty alleviation. A large number of olive groves are owned by smallholders in the olive growing countries; they earn enough for the betterment of their livelihood. Moreover, olive products help to satisfy the nutritional needs of the population.

It contributes to establish agro-industries for manufacturing filter discs, olive crushers, packaging materials, etc.

Ripe olive fruits are pressed for rich oil which is the best oil available in the world for edible purposes. The olive oil has twice energy value than that of sugar. The fruits contain around 20% oil and has very less cholesterol. It contains 80% unsaturated fatty acid against 20% saturated ones. It contains oleic acid in high percentage which is very essential for our body. The oil is used for cooking, salad dressing, food preparation, massage, and for the manufacture of cosmetics, Pharmaceuticals, toilet preparation, etc. Matured fruits are also eaten after being processed and preserved in vinegar or salt solution.

The extract from leaves, bark and fruits has medicinal properties. Its wood is used for carving, to furnish houses, to prepare vessels and tools for the kitchen as well as for the field purposes and is an excellent firewood. Leaves are given to the animals as fodder, oil cakes are fed to livestock or is used as manure and is again excellent firewood. The olive juice soon after extraction of oil is good as manures.

Olive trees are also planted for beautification. Generally if an old olive tree is uprooted, other olives take its place.

V. PEDOCLIMATIC REQUIREMENTS

Nepal a hilly country, is situated on the Southern side of the Mighty Himalaya. The hills and mountains are stretched from the East to the West along with the Himalaya. Although it is located in between 26° 22' to 30° 27' North latitude and 80° 4' to 88° 12' East longitude, Nepal is a cool country, especially the Northern parts, due to the higher altitude and the presence of close Himalayan range. The Northern sides of the mountains are more cooler than the Southern ones. Nepal has diverse climatic conditions with many micro-climatic pockets. It receives plenty of rain from the Bay of Bengal of the Indian Ocean during summer and less rain from the North - West side in the winter. There are some areas in the Western part of the country which are suitable for olive growing. This has proven also by the presence of wild species of olive at altitudes ranging from 1500 to 2000 meters above sea level (asl.)

Factors that are to be considered for olive growing are 1-Atmospheric temperature, 2-Precipitation, 3-Atmospheric humidity, 4-Sunlight hours , and 5-Soil.

Temperature:

The olive requires a warm temperate climate, the most suitable cliamtic areas for growing olive in the Mediterranean region fall in between 30° and 45° North latitude. The areas below 30° latitude in the Northern Hemisphere can also fulfil the chilling requirement due to the higher altitudes for olives to bear fruits; olive trees need winter rest period for 60 - 80 days to differentiate flower buds. Average temperature of 7° C for about 500 - 1000 hours is required in the winter depending upon the cultivars to develop floral buds and break dormancy. The

maximum absolute temperature should not exceed 20°C during November to February. The temperature below -5°C for longer period is detrimental to the plant although it can tolerate gradual drop of temperature up to -10° C for a short period. Temperature, after the chilling is met, should nse gradually. The tree should not be in vegetative state when it is freezing. Summer temperatures even upto + 40°C are not harmful to olives. The best olive production and fruit quality occur in areas having mild winter and long, warm, and dry summer .

Table 2. Temperature requirements for olive development stages,

Development stages of flower	Temperature required
l.Bud differentiation in winter	Absolute minimum to - 10 °C is tolerated.
2.Bud differentiation in February	Absolute minimum to-5° to-7°C is accepted.
3. Sprouting in February/March	Average temperature + 9 °C to + 10 °C.
4.Blossoming (bud growth) in March/April	Average temperature + 14 °C to + 16 °C.
5.Blooming and pollination in April/May	Average temperature + 18 °C to + 19 °C.
6.Fertilization (fruit set) stage in May	Average temperature + 21 °C to + 22 °C.

Pollination occurs in late April in between 5 to 7 days period. It takes 3 to 4 days from pollination to fertilization. The ratio of male and female flowers should be 1:6. Heavy rain during flowering and pollination period is harmful. Nitrogenous fertilizer should be given one month before flowering, but as foliar application it can be sprayed one week before blooming. It helps in pollination and fertilization.

Precipitation:

Olive plants require rainfall less than 1000 mm. Areas receiving 400 to 700 mm. annual rainfall are most suitable for olive growing. If the annual rainfall is below 400 mm, irrigation must be given to have good production; in any case, irrigations during summer increase fruit yields by 30 to 50 %.

The precipitation requirement depends on the type of the soil and the cultivar. Clay soil needs more rainfall than the sandy and silt loam soil. Well distribution of rainfall throughout the year is favorable to this crop. All olive producing countries in the Mediterranean region receives major amount of rainfall during winter and less amount in summer but there are observation and experimental evidences that summer rain from June to September helps to increase the yield. Reports from "Olive Production in California" indicated that the precipitation is positively related to olive yield. Similarly, FAO publication " Improvement in Olive Cultivation" states that the periods from flowering to fruit growth and stone hardening are very sensitive to water. The Official Magazine of the International Olive Oil Council "Ohvae" reports that China which receives summer rain, produced greater olive growth , which is conducive to bigger harvest (more growth with long shoots and thus have more fruit set).

Atmospheric humidity:

Olive has developed drought resistant characteristics from the physiological and structural points of view. The Department of Biology of Yunnan University (China) has reported that the stomata shut earlier, closing at 10.0 a.m. and gradually opening at 04-05.0 p.m. This is the way

in which olive adapts to arid conditions. The appropriate atmospheric humidity should be between 40-65 %. as found in olive growing areas elsewhere in the world; but China has adapted olive growing in the areas of 61-63 %. Relative Humidity, over 80% is not suitable for olive growing.

Sunlight hours:

Olive likes sunny and warm environments. It is a long-day plant and benefits from the strong sunlight. The plant receives 2400 to 2700 hours annual sunlight in the main olive growing areas of the world. China is successfully growing olives in areas that range from 1000 m. (a.s.I.) to 1900 m altitudes and 1900 to 2400 sunshine hours.

Annual sunlight hours in some olive producing areas are 2493 (Southern Catania, Italy), 2783 (Jaen, Spain), 2756 (Crete, Greece), 2685 (Southern -Valona, Albania), 1912 (Wudu, China), 2431 (Xichang, China), 2711(Binchuan - Yunnan, China), and 2518 (Bajaura -H.P., India).

Annual sunlight hours in some selected places of Nepal are 2205 (Makwanpur of Central Development Region), 1961 (Marpha of Western Development Region), 2357 (Dunai of Mid-western Development Region) and 2464 (Dadeldhura of Far-westem Development Region)

Soil:

Soil is a complex mixture of soil particles, soil solution, organic matter, and biological organisms. Plants obtain most of their mineral nutrients from the soil solution. Climatic factors are important when considering adaptability to olive growing. The physical properties of the soil are also very important than the chemical properties. The olive has a shallow root system and does not tolerate excessive water in the soil. The physical and chemical properties of soil for olive are required as follow:

Soil texture:

It is the relative proportion of sand, silt, and clay particles. Each soil particle has its own particle size which may vary from less than 0.002 mm (clay) to more than o.o2 mm (sand). The relative proportion of these mixtures determines soil type, soil permeability and even the action exchange capacity.

Table 3. Proportion of different soil particles in a soil for olive growing-

Soil texture	Particle size proportion
Sand particles	45 to 65 %
Silt particles	10 to 35%
Clay particles	10 to 35 %

If a soil contains more than 35 % clay or the soil layer is shallow and has a clay pan horizon under the tillage layer, then the soil is not suitable for olive growing. The optimum permeability should be 80 to 150 mm/hr.

Chemical properties:

The neutral and light saline soils are suitable for the olive. The best soil pH range is 7 to 8. It should not be less than 6 and more than 8. The olive is a plant that likes nitrogen and is addicted to calcium. The olive is sensitive to boron also. Boron deficiency in soils can cause a serious problem in haulting the growth of growing points. The soil that suits for olive culture should contain nitrogen (1 to 1. 5 %), phosphorus (0. 60 to 0. 75 %), potassium (0. 4 %), organic matter (2 to 3 %), and water soluble salt (4 to 5 g. /kg. soil).

Olive trees are sensitive to poor drainage and water logging. The root growth is poor under stagnated conditions thus reducing nutrient uptake. There is a chance of root decay in poorly drained soils.

Irrigation water:

Although olives are drought tolerant , adequate water must be available throughout the season for the growth and maximum production. Irrigation water with high nitrogen promotes excessive vegetative growth that impedes fruit production. Excess of sodium salt in water accumulation in the soil creates water penetration problem. Hence, analysis of irrigation water is also an important tool for selecting olive plantation sites.

The drought resistance of olive plants is due to the well developed root system (which become wider if the soil is dry), the particular tree form and leaf function. There is a correlation between soil humidity and biological fruit cycle. There are periods in the year that olive require enough humidity in the soil. The first critical period is bud differentiation and blooming period. Lack of water in this period can reduce the amount of (lowers, increase ovary abortion and induce poor fruit set. The second critical period is during the development of fruits, especially during stone formation. In this period, it is possible to observe fruit drop that will be more intense if the soil is dry.

Since olive trees require water in orchards for economical production, it is necessary to provide irrigation as and when necessary so that water is adequately available during the critical periods. In Nepal where rainfall are abundant but concentrated in a short period of time the available water decreases faster; thus in such conditions irrigation must be given to the trees before blooming.

VI. GEOGRAPHIC DISTRIBUTION

Warm-temperate climate is considered best for olive and three main geographic areas are suitable for olives in the world; they are: (1) the Mediterranean Region where there is the maximum concentration of olives in the world, (2) between 30° and 45° latitude in both the Hemispheres, and (3) higher altitudes at lower latitudes.

Recently, Chinese scientists have become successful to grow olives starting from 27° N latitude in a monsoon climate. For fulfilling chilling requirements, olives should be

cultivated in higher altitudes at lower latitudes. It seems that there is a correlation between latitude and altitude. The olive is cultivated at 1200 m. a.s.l. (above sea level) at Jaen in Spain; at 1600 - 1700 m. a.s.l. in Morocco; up to 2000 m.a.s.l. in some parts of Argentina

Rainfall is another important factor. Olive is a xerophytes species; it survives and bears fruits in Sfax (Tunisia) where annual rain is only l80 mm. It also performs well in Wanxian (China) having an annual rain of 1185 mm. under monsoon climate. Thus, this fruit species has a wide range of adaptation with respect of rainfall requirements. The variation in summer rainfall regimes is the chief ecological difference among China, Nepal, India, Pakistan, and the main olive producing areas in the world. Olives in a monsoon climate result in intense growth during June, July, August and the tree become comparatively bigger than those in Mediterranean countries. But the monsoon climate is related only to the middle and high mountains belts in Pre-himalaya range because, at lower altitude, olive is producing continuous growth and no flower bud differentiation occurs. In the middle and high mountains where monsoon rainfalls arc around 60% of the total and no severe cold winter, olive trees perform well.

Experience has shown that in Mediterranean countries when olives are irrigated during summer the yield raised from 30 to 50%. With optimal irrigation the cultivar Leccino recorded yield increase of 2.8 tons per ha. Olive-oil quality was also high after irrigation . Thus, olives can grow succesfully in varied climatic conditions of pre-Himalaya range also. It is important not to exceed in some meteorological parameters like Relative Humidity (more than 75%) and rainfall (possibly stay within 1200 mm. per year). The poor soil drainage, insufficient sunlight, lack of chilling requirement, etc. are also important factors that govern success in olive cultivation..

Olive trees distribution in the world:

There are many countries where olives are commercially grown. Mediterranean countries produce largest amount of olives in the world. Spain, Italy, Tunisia, Greece, etc have maximum acreage under olive cultivation.

Table: 4. World distribution of olive fruits and its production area in hectares.

Country	Area (ha)	Country	Area (ha)
ALGERIA	195530	GIORDANIA	16360
ANGOLA	400	LEBANON	32000
EGYPT	25200	SYRIA	405000
LIBIA	100000	TURCHIA	877700
MOROCCO	412000	PALESTINA	95000
TUNISIA	1538000	ALBANIA	45000
REP.OF S. AFRICA	1345	SPAIN	2127000
ARGENTINA	28670	FRANCE	20000
BRAZIL	840	GREECE	690800
CHILE	2955	ITALY	1141350
U.S.A.	12150		(specialized orchards)
MEXICO	6000	MALTA	200
PERU	5605	PORTUGAL	316000
URUGUAY	890	OLD YUGOSLAVIA	29960
CHINA	19230	AUSTRALIA	2000
CIPRO	7500	Mediterranean countries	7955340
IRAQ	10000		
IRAN	5355	TOTAL WORLD AREA	8187300
ISRAEL	17300		

SOURCE "L'OLIVO L'OLIO VOL1VA « CONSIGLIO OLEICOLO INTERSAZIONALE Principe de Vergara ,154 - 28002 Madrid (Spain)
by Prof. Luis Civantos, Josi F.Lamas, Yolanda Martinez, Sergio Diaz-AUDICOM, S.L. (1998).

Climatic characteristics of Nepal:

In Nepal there are four main geographic regions such as Terai Region, Shiwalik Region, Middle mountain Region and High mountain Region.

The country is affected by concentrated monsoon rains during June to August. The Climatic and Hydrological Atlas of Nepal" published by ICIMOD gives altitude classification as below 1.000 m. (asl.) ; 1.000 to- 2.000 ; 2.000 to- 3.000 ; 3.000 to-4.000 4.000 to- 5.000 ; and above 5.000 m (asl.). The Horticulture Master Plan Document with reference to the Agro- ecological Zone Map gives different possible crops for varying altitudes where climate changes are noted. The cool temperate zone is most suitable for apple, pear (from 2.100 up to 3.000 m. asl.) whereas the warm temperate zone (from 1.500 up to 2.100 m. asl.) can be considered good for stone fruits and olive. This zone is characterized by less rain during monsoon (rain -shadow areas) with compatible soil pH.

As for the soil is concerned, it is observed that in those olive trials performed in soil condition at pH 5.5 (Makwanpur Dist)., application of lime (3kg /tree) along with irrigation (the water from local channels is having pH around 8) raised the soil pH up to 6.5. In such cases, olive is performing quite well even at low soil pH value.

VII. CULTIVARS

Many olive cultivars exist not only in the Mediterranean region but also in other countries. In Italy alone there are over 600 cultivars or cultivar groups with 200 million trees . There are other 700 million trees totalling 900 million trees in the World. In each country, there are cultivars or cultivar groups suitable for each particular geographic area. The recent FAO Publication "OLIVE GERMPLASM - CULTIVARS AND WORLD-WIDE COLLECTIONS" has given all the information including the description of their characteristics and germplasm distribution in the world. There is certain procedure while selecting cultivar or its groups for a specific geographic area (ecotype). They are:

a) Selection is made due to different growth habit, for productivity and production efficiency.
b) Cultivars having 'dwarf characteristics are better for high planting density, when high production per tree or per hectare is not required and when harvesting is done manually or with the help of other hand-tools.
c) Vigorous cultivars are better for well spaced plantations, give high production per tree and are better for mechanical harvest.
d) Cultivars having up-right growth are suited for "monocono" training form, but for square or rectangular plantation cultivars may be different.
e) Select three or more cultivars for a single block to effect pollination and production may be affected by one or more cultivars due to unfavorable climatic conditions.
f) Search and plant olive cultivars belonging to the same area as cultivars belonging to other areas may suffer due to poor growth and pollination problems.
g) Cultivars selected should help each other in cross pollination. If a single cultivar is planted in an orchard it needs 20 % pollim'zer. Pollinizer is required for self-fertile cultivars also because they give better yields with cross pollination.
h) Select pollinizers having capability to produce many flowers with abundant pollen grains (cv. Pendolino for example).
i) Select resistant cultivars against frost.
1) Plant those cultivars recommended, selected and authorized by the Government for a specific and protected geographic area.
m) Select drought resistant cultivars for rain-fed conditions or rocky soil and other cultivars for clay soil or irrigated ones.
n) Select cultivars having different ripening period to facilitate. The harvesting operations and to allow processing of a special quality olive oil (olive oil "of a single cultivar or special combinations sometimes is preferable).

The study of each cultivar is made after collection of detailed information which consists of: a) filling a form specially prepared for olive following the indications given by U. P.O.V.

and their modifications (made by Barranco et al. 1984; Cimato et al.1993), **b)** photographic documentation strictly related to the form filled for each cultivar, and **c)** identifying the chemical components of the olive-oil for the better classification of the cultivar under study. Recently other scientific methods are used for the classification of the olive cultivars which are performed by Bogani et al., 1994; Fabbri et al., 1995; Cresti et al., 1996; Trujillo et al., 1995 from the technical analyses of DNA (RAPD) and ANN (Artificial Neural Network) by P. Fiorino and S. Mancuso, Florence, Italy.

VIII. PROPAGATION

Olive propagation is made today mainly through semi-hard wood cuttings (60% of the total) and by grafting the desired cv. on olive seedlings (40%). Nowadays micro propagation is also used in olive.

The asexual propagation of plants is called vegetative multiplication whereas the term reproduction is used for sexual propagation. The offspring of sexual reproduction (seed) never show the complete characteristics of the parent plant and remain unproductive for a long initial periods. The propagation in olive is carried out exclusively by the asexual method. The propagation by using the plant parts such as roots, ovules, layering, cutting or stem, is called direct multiplication. The rootstocks should be considered an intermediary between the soil and scion. Direct multiplication produces olive plants on their own roots.

Olive plantation in Nepal is a new adventure. Only in the Nineties, a few olive orchards have been established to test the adaptability of the cultivars in different agro climatic zone of the country. The plants produced by cuttings were imported from Spain, Italy, France and India. Although wild species of olive which are available in the Western part of Nepal have spread naturally by seeds, the modem method of propagation by using mist propagation technique has been recently initiated in Nepal. The description of propagation methods used in other olive producing countries is briefly given.

Modern techniques (Micro propagation or tissue culture):
Olive micro propagation can be used for:

1) to programme for better production,
2) to produce micro propagated cultivars in mass,
3) to allow competitive price and overcoming of export problems,
4) to get planting materials free from insect pests and diseases, and
5) to export olive 'genotypes' in environments geographically far away from the native place.

Micro propagation requires the availability of well equipped laboratory where explants are prepared in media with a combination of chemical nutrients, plant hormones and other compounds for their multiplications at specific light intensity and temperature. Micro

propagation of olive is made in 4 phases: 1) preparation of explants (uninodal explants), 2) proliferation of the explants in 'vitro', 3) rooting of explants in 'vitro', and 4) acclimatization.

Actually there are 25 cultivars already micro propagated and are under study for their performance (Leva 1999- CNR Scandicci Florence). Because it is a 'Basitona' species, olives are not able to produce attached new shoots in 'in vitro' from the bottom part of the explant as it happens in other species (apple). Therefore olive multiplication 'in vitro' is given by prolongation of main axis and number of internodes produced. The prolongation of the main axis vary from cultivar to cultivar and its adaptation to 'in vitro' conditions.

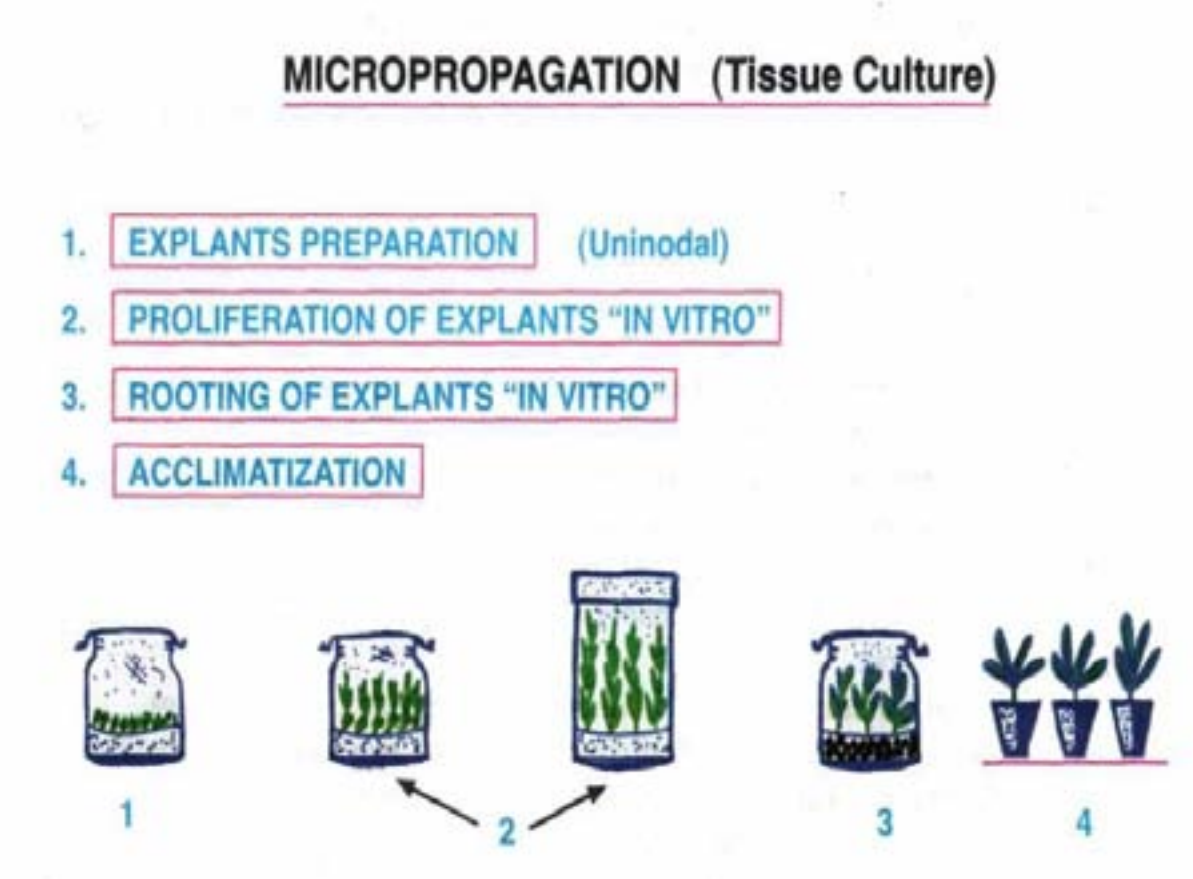

Fig. 1. Micropropagation of olives by tissue culture

Glass containers used for olive micro propagation are of 785 cm3 in which 150 ml of 'substrate' and 16 uninodal explants are placed; the top is closed with thin P. E. film. If each uninodal explant is able to produce 8 intemodes, from each glass pot is possible to obtain 128 explants. Pratically it is possible to obtain 12,800 explants every 40-50 days in one square meter surface. The 'substrata' for the explants for example was made by Rugini in 1984 and called OM (Olive Medium). It is characterized by the presence of Ca, Mg, S, P, Cu, in better quantity than the MS substrate (Murashige and Skoog, 1962) and a balanced proportion of Ca: N of about 1:11 suitable for new coming shoots. Others compounds along with auxins combinations are used and tested for this type of multiplication.

Acclimatization of the explants rooted 'in vitro' is quite delicate operation because they are transferred from an environment with high relative humidity, aseptic and reduced light intensity to the glass-house that generally is in opposite condition. Practically ,'on live' conditions it is necessary for the olive to produce the normal leaf, which is not case in 'in vitro' condition. Hardening and acclimatization of explants follow the same proceeding for self - rooting olive cuttings.

Propagation by cutting:

Multiplication of plants by semi-hardwood cuttings under the intermittent mist spray is a common practice in olive growing countries. The technology of mist spray in propagation was introduced by Hudson Hartmann in 1954. The mist spray reduces transpiration, leaf temperature and increases relative humidity and keeps cuttings in turgid condition throughout the process of root induction.

Steps in producing cuttings:

1) Take cuttings from well developed and vigorus mother plant.
2) Take cuttings from the middle or bottom parts of the tree
3) Avoid taking cuttings from the fruited buds. Vegetative buds are highly capable of forming roots.
4) Choose a shoot of 6 to 12 month old, 45 to 60 cm. long and 3 to 8 mm. in diameter.
5) Remove the tender portion from the top and hard portion from the base of the shoot.
6) Make 3 cuttings (basal, medial, and apical) from the shoot, each measuring 10 to 15 cm. long. The apical (terminal) cutting results better in Spring while the basal and the medial cuttings perform better in Summer and Autumn, due topresence of more carbohydrate and hormones on them.
7) Give a slant cut on the top and straight cut on the bottom of cuttings to mark the correct polarity. The bottom cut is made just below a node, otherwise it will not root.
8) Remove all leaves except 2 to 3 pairs on the top portion of the cuttings
9) The cutting should be fresh (not more than two days from the day of detachment) and be kept in the shade and moist condition.
10) Do not take cuttings during very hot and very cold seasons.
11) Cuttings can be put in the benches or beds 2 to 3 times each in Spring and Autumn

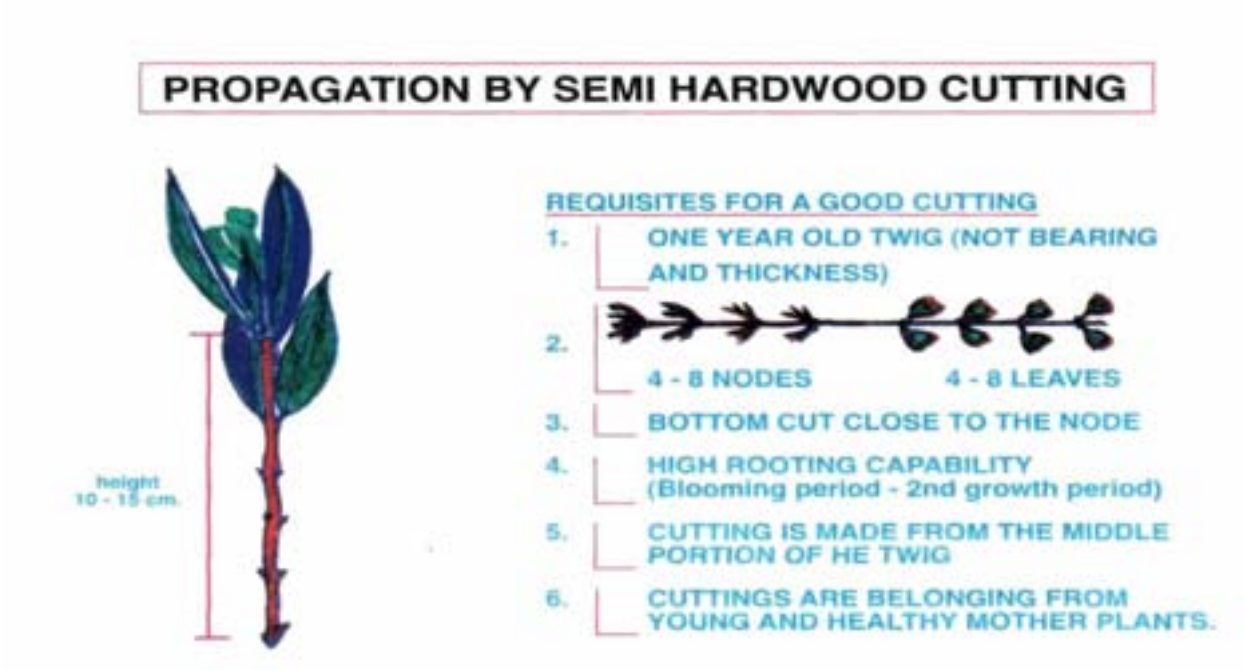

Fig. 2. Propagation of olives by semi-hardwood cutting.

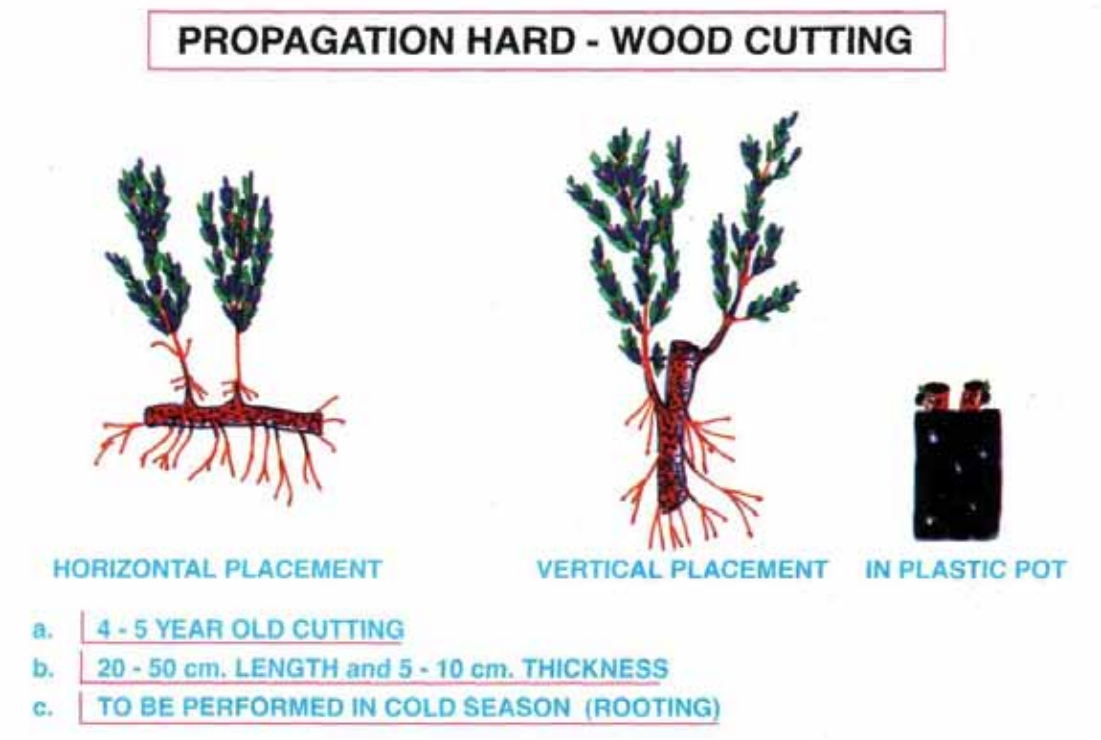

Fig. 3. Propagation of olives by hardwood cuttings (Old method).

Preparation of IBA solution:

Since IBA solution is commonly used rooting hormone for cuttings, its preparation should follow the given procedures as listed below:

1) Weigh 4g of indol-3-butyric acid (IBA). IBA is the most commonly used synthetic hormone in propagation, but similar results can also be obtained with indol-3-acetic acid (IAA) and naphthalene acetic acid (NAA).
2) Dilute it in 500 ml of 50% alcohol solution in a tube.
3) Add distilled or boiled water to the tube to make a total volume of 1000 ml.
4) Stir it to make uniform concentration.
5) The concentration in alcohol solution ranges from 2500 to 5000 ppm with an immersion time from two to five seconds.
6) The prepared solution can be kept for two days in a refrigerator at 4° to 6° C and away from the light.
7) Pour the solution into the flask after preparation and cover it with black polyethylene to save from light.
8) One liter solution will be enough for 15000 cuttings.

Preparation of IBA paste:

To prepare the IBA paste the following procedures are used carefully.

1) Weigh 5 g IBA.
2) Dilute in 500 ml pure alcohol.
3) Weigh 995 g Talc (baby) powder.
4) Mix the solution and powder,
5) Spread it under shade until the alcohol is completely evaporated.
6) IBA is ready for use.
7) The powder is kept in a tight container.

Treatment of cuttings:

1) Dip the basal part, about 2 cm, usually in a bunch of 25 cuttings, into IBA solution for 5 seconds.
2) Remove the cuttings from the solution and leave them exposed for 15 minutes to evaporate alcohol. The drying action of the alcohol can sometimes produce necrosis of the bark immersed in the solution.

Putting cuttings into the media:

1) Put agri-perlite or volcanic aggregates or other media (peat moss, sand, gravel or brick aggregates, vermiculite, coal and saw dust, etc.) in the beds up to 15 to
2) 30 cm thickness. Agri-perlite is the best media for cuttings.
3) Level the beds and make loose for easier insertion of cuttings.
4) Make lines at 5 cm apart.
5) Insert basal parts of cuttings 2 cm deep; insert 5 cm if there is no bed heating system
6) Maintain the distance 2 cm between cuttings.
7) Maintain atmospheric temperature at 20° C and media temp, at 24° C with the help of cooling and heating system.
8) Maintain atmospheric humidity at 80% or above with the help of intermittent mist spray.

Mist propagation unit:

Propagation by cuttings requires a special environment where these cuttings are induced to root. With this process, the parenchyma tic cells become meristematic and division of cells starts. The indegenous auxins and other components available in the cutting stimulates root formation (Went and Thiman -1934). This stimulation is possible only when determinate environment parameters are satisfied as a) temperature around 20° to 25° C, b) high relative humidity 80° to 100°, and c) rooting 'media' with good water holding capacity, porosity, good drainage (needs to keep for long time),and adequate density. To satisfy these parameters it is necessary to have a bench with bottom heating system, mist spray system (MSS), and cooling system. All these systems including the rooting bench, where cuttings are normally placed, is called 'Mist Propagation Unit'(MPU).

In other olive growing areas there are glasshouses or plastic houses which are well equipped and authomatized; these structures are able to produce more rooted cuttings at one time. Italy, for example, produces four to five million olive trees per year in Sicily, Apulia, Calabria and Tuscany; out of this, 60 % are propagated by cuttings.

In those countries like Nepal where olive cultivation is at infant stage, we need small type of MPU but with same characteristics of the bigger ones. Past experience says that, to obtain good results with small MPU in different climatic conditions where infrastructures are lacking it however is not so easy. There are four determinate periods of climate such as a) hot and dry, b) hot and wet, c) cold and wet, and d) cold and dry.

Moreover the local nurseries have two main sources available: water from channels and electricity. Other facilities are not suitable for this kind of activity (Solar energy , gas cylinders, etc.). But even these two sources can be used to some extent (the water from channal is having multipurpose functions, electricity is for houses or for small electric engines.). In this condition it is necessary to find a MPU that should be simple, cheap, and able to give good results.

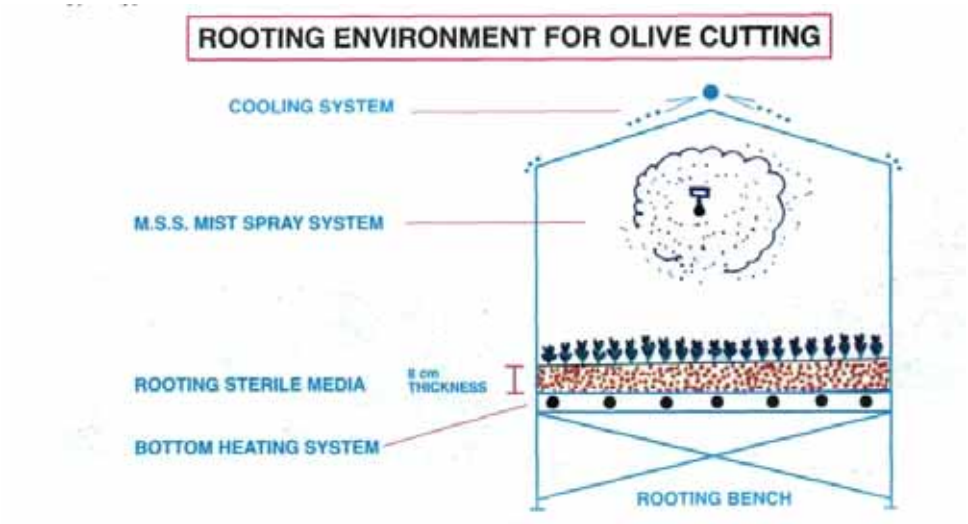

Fig.4. Rooting environment for olive cuttings

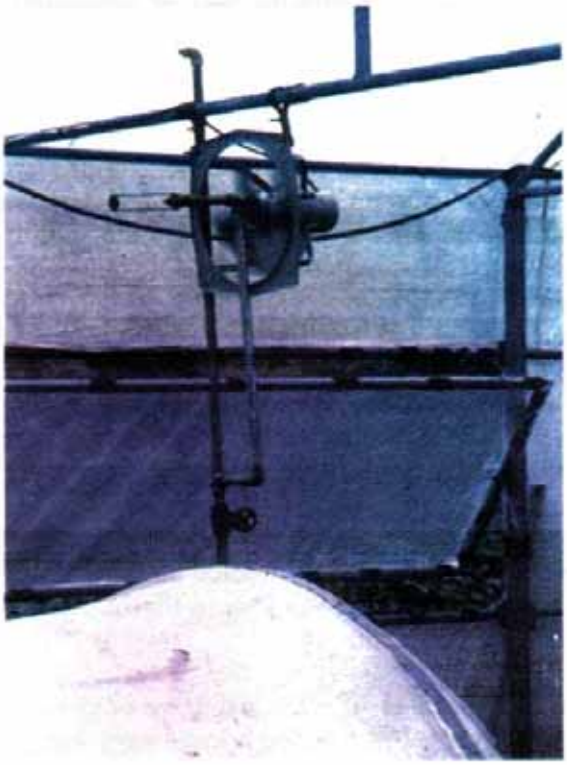

Plate 1. Cooling system

Plate 2. Pressure tank for mist spray system and boilder, and circ. water pump heating system

Plate 3. Mist propagation unit bench with checking panel

During monsoon season the best way is to propagate in the open, as to say in plain air' as the natural conditions are favorable for a relatively good result. In other periods the required environment for rooting of cuttings needs to be created with technical devices.

Considering the information given above, it is necessary to develop MPU structures which satisfy the following parameters:

1) A well near the channel for deviation of water and water intake,
2) Sedimentation tank cemented (four tanks connected together ; the first with gravel and the others for sedimentations of small particles only),
3) Plastic tank (to store clean water , 500-1000 liters capacity , coming from sedimentation tank),
4) Electrical engine with pressure switch and pressure balance like a model: (Pkm.60-1, a 5 - 40 l/min H° 38 - 5 , V. 240, Hz. 50, 2900 min. , Kw. 0,37HP 0,50, IN 2,5 A. , 550 W. max, C 10, VL. 450 , r.cl.B I.P. 44) suitable forthe MSS.
5) Pressure tank (with pressure gauge from 0 to 5 A.), adjusted to the MSS requirements.
6) Heating system (boiler with circulation hot water pump).
7) Cooling system (a fan and a jet sprinkler placed just in front of the fan at its center to reduce the temperature as and when required); if it is necessary ashade net may be placed above the plastic/glasshouse to reduce further temperature down but it is not good to have shade more, i.e. not more than 40% shade for the cuttings.
8) Bench (a frame possibly of aluminum and equipped with mist spray system (MSS), heating pipes, control panel composed of a general switch, heating switch, mist spraying, general switch, thermostatic thermometer, sound alarm for temperature, hygrostat to control and operate MSS by time span.

There are indications for reducing some technical devices further but all of them should be tested for operational functions, because one method used in a particular place may not be functional in another place.

Potting of rooted cuttings:

1) The basal area of the cuttings starts bumping after 20 to 25 days and callus is formed. The appearance of callus indicates the rooting activities. The first root starts appearing after 40 to 45 days and most of the roots develop within 60 to 65 days after the insertion of cutting into the media.
2) At random sampling of about 25 cuttings from different places is made and rooted cuttings are counted. If 50% of them are rooted, fill them in the plastic pots. The cuttings which have only callus, should be replanted after dipping once again into IBA solution.
3) The size of poly bag for filling rooted cuttings should be 22 cm in length and 13 cm in width. The black poly bag is preferable, because there is less chance of forming algae or green stain. Poly pots or jiffy pots are better for transplanting rooted cuttings.
4) Fill the pot upto half with a moist mixture containing equal part of soil, sand and manure; place the rooted cutting in such a way that the roots are spread

and fill the remaining part of the pot with the mixture leaving 1 cm. space on the top of the pot for watering.

5) Water the plants immediately after potting with a can. Give shower irrigation every day, in summer and once in two days in winter.
6) Keep the pots with plants in lines in an intermediately (between controlled conditions and outside atmosphere) plastic house for hardening or adaptation. The plastic house should have temperature 2° C more in winter and 2° C less in summer than the outside temperature.
7) Spray, mineral fertilizer 100-150 ml/gr per 100 litters of water on plants once every 3 weeks. A half gram urea per pot can be given and watered.
8) Hand weeding is necessary at weekly intervals.
9) Transfer plants in larger sized poly bags (15 X 30 cm) when roots are seen in the bottom or side holes in the pots or bags and keep them outside.
10) Water the plants before transferring to the larger size bags
11) The adaptation stage lasts for 30 to 45 days depending upon the season (30 days in Spring and 45 days in Autumn)

Steps in transferring plants to the larger poly bags:

1) Prepare the soil mixture comprising 30% sand or even more, 30% manure and 40% soil. Add 2 kg of Potassium Sulphate and 4 kg of Super Phosphate (P2O5) in one cubic meter of soil mixture. Mix thoroughly and take out all stones and garbage's.
2) Wet the soil mixture before filling into the bags of 3 kg. capacity.
3) Fill the poly bags of 33 x 15-17 cm size with soil mixture half to two third part of it, then transfer plants from small pots to these larger poly bags and fill with soil mixture leaving some space (2.5 cm) on the top of bags for watering.
4) Prepare the land for keeping plants in the open space outside or in the shade house by broadcasting Furadane and ploughing the land 2 to 3 times.
5) Keep lines of 8 bags in width and lenght as needful. Give 50 cm gap for the path between two beds of plants.
6) Weed out grasses and control insect pests and diseases. Give 3 g Furadane per bag if nematode is a problem.
7) Apply nitrogen fertilizer 0.3 g N for small plant and 0.5 g for larger plant through urea or ammonium nitrate at monthly interval.
8) Give shower irrigation once in a day for 5 days and then once in every 3 days.
9) Sell the plants when it is 50 to 100 cm tall.

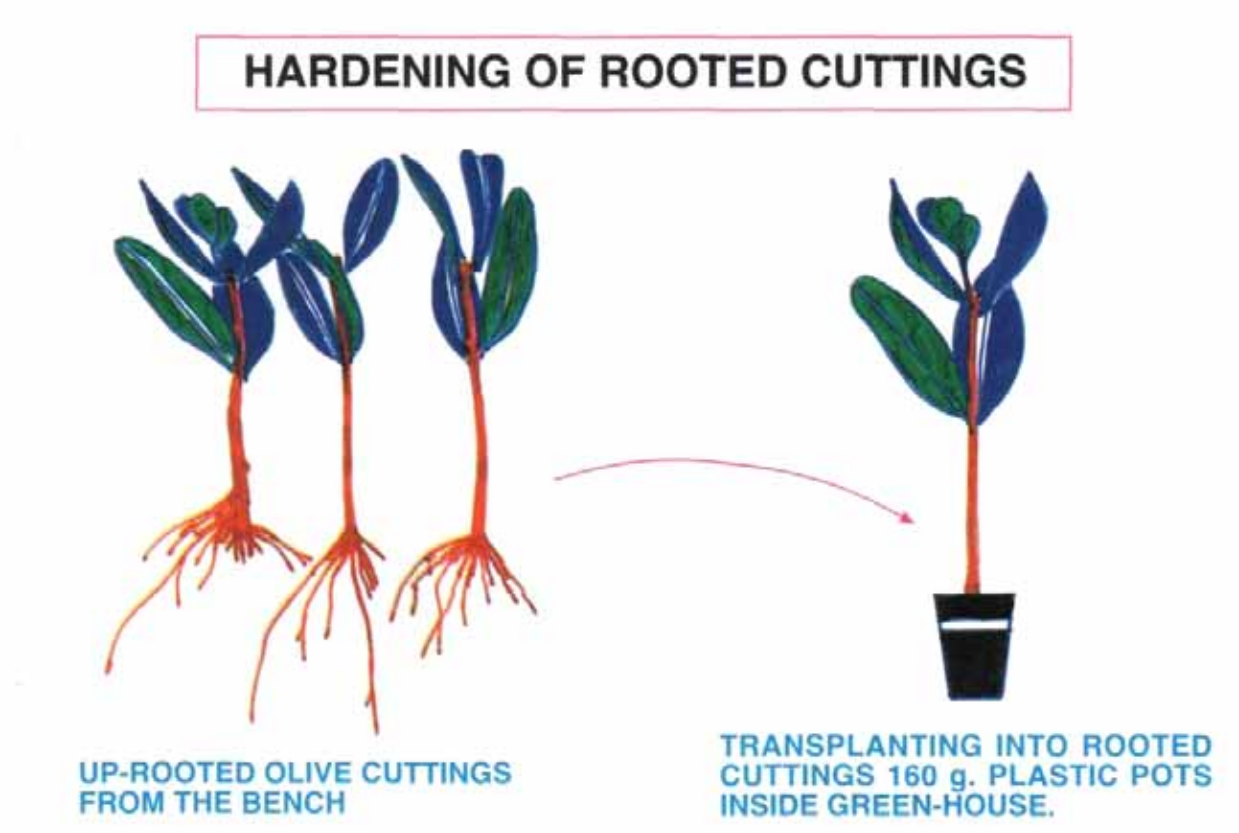

Fig. 5. Hardening of rooted cuttings of olives

Substrate (media) for root formation:

The rooting media for keeping cuttings may be peat moss, sand, gravel, stone or brick aggregates, burnt coal, saw dust, vermiculite, perlite, etc. Perlite alone, or mixed with peat moss is the best medium for rooting. It has almost neutral pH, good porosity to assure sufficient circulation of air; it retains the necessary quantity of moisture and drains out excess water; it impedes the formation of algae and can be sterilized easily.

These characteristics favour the formation of numerous roots in the cuttings and plants. This alone or mixed with soil and sand is also a good medium for potted plants.

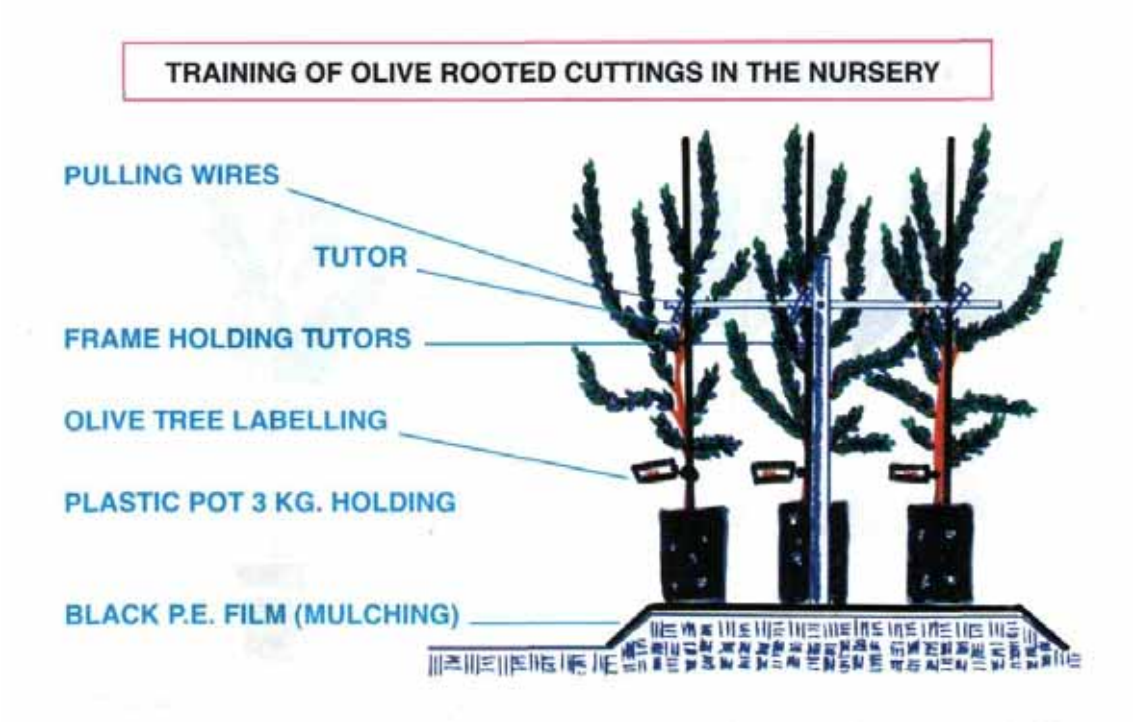

Fig. 6. Training of rooted olive cuttings in nursery.

Criteria for selecting propagation material:

1) It is essential to study the morphological, physiological and agronomic characteristics of the strain or clone that it is desired to propagate.
2) Only moderately vigorous branches must be selected for scions and cuttings. They must not have juvenile characteristics that prolong the non-producing phase of the future plants.
3) The selected material should be absolutely healthy, i.e. free from insects and diseases.

It is desirable to set up plots of selected mother trees close to each nursery and attention must be given to its biological measures and sanitary controls. Where there is no mist propagation facility, the desired plants can be produced by adopting other methods such as budding, grafting and planting stem or roots in the nursery beds or directly at the permanent site.

Mother plant plot:

The system of training mother plants depends on individual's choice. Some nursery men prefer bushy mother trees from the ground level and some others like to develop shoots a bit above on the single stem. However, it is advisable to adopt maximum planting density per unit area compatible with cultivation practices and with sufficient light reaching the top of the mother plants. The rapid development of mother plants is necessary to obtain maximum number of cuttings. The mother plants should be well identified and sure of the variety. The

mother plant plot should be situated near the propagation unit and should have irrigation facility. The site for mother plant plot should not be located at extreme hot or cold place. The soil should be friable and tillaged according to the density of water.

The way to establish a mother plant block:

1) Plough the land and level the soil.
2) Dig 45 to 60 cm deep and wide pits at2x2mor2x3mor2x4m distance depending upon the planned methods of cultivation and training system of the plants.
3) Mix the top soil with 7 kg of manure, 200 g supper phosphate, 200 g potassium sulphate for one pit. Put normal soil into the bottom part, mixture in the middle part and again normal soil on the top portion of the pit. If insect is a problem, apply 40g Furadane per pit.
4) Plant one vigorous, healthy and well identified sapling in a pit and press the soil around the plant to remove air.
5) Irrigate plants immediately after planting and then 4 times at 15 days interval. Irrigation once in a month during dry season is necessary.
6) Give staking to the plant to protect it from wind.
7) Plough or hoe the soil 10 cm deep, 4 to 5 times in a year i.e. during November, April, May, June and September.
8) The weeds around plants should be removed by hands. The weeds harbor insects, disease and compete with the plants for nutrition and moisture.
9) Do not prune mother plants at all for two years, cut the stem at ground level in the third year. A number of shoots will arise at the ground level and the plant will develop a bushy form.
10) Apply following fertilizers for 1000 sq. m area of the plants every year; half dose in Autumn and other half during early Spring:
    - **i)** 21 kg. urea (46 % N), **ii)** 15 kg. ammonium nitrate (33 % N) in) 15 kg. Supper Phosphate (46% P2O5), iv) 15 kg. potassium sulphate (50% 2O), v) add manure 3 cubic meter in every two years, and vi) give foliar sprays 4 times in a year , 2 times in Autumn and 2 times in Spring to accelerate vegetative growth.
    - **ii)** This condition will give good shoots, good carbohydrate and root age percentage. The cutting can be taken all the year round except in very cold or very hot season. Cut whole scion shoots of appropriate size at surface level for putting in nursery leaving only thin branches for next season. The cuttings should be kept under shade.

Genetic(germplasm) collection block:

1) Vigour, branching habit, fruits, yield, oil percentage and other characteristics of the varieties are studied
2) Spacing 8 to 10 m. both ways is maintained
3) Give more spacing to the plants in dry conditions
4) Results does not differ with the variety only but with soil and climate also
5) Some varieties can be grown in dry conditions while others need irrigation.
6) Irrigate plants to reduce cold and frost effects in winter.

Indirect multiplication (Budding and Grafting):

This kind of propagation method is still in use in most commercial nurseries. Many table olive varieties are propagated by grafting only and this technique gives often 95 % success; even today, this is a quite economic technique.

In the international market the demand of grafted olive plants is increasing because: 1) grafted cuttings perform better in windy areas, 2) they have better performance in sandy and loose soils, 3) they show better anchorage to the soil, and 4) in the pots, a grafted olive grows faster in comparison to self - rooted cuttings. Because of these reasons, as in other fruit species, a clonal rootstock series should be introduced in Oliveculture to effect on olive growth, productivity, olive-oil content and fruit characteristics.

Raising seedlings as rootstocks:

The seedling rootstocks can be obtained from wild-olive stones or from stones of cultivated varieties. A greater percentage of germination and more vigorous seedlings are obtained from the former. The wild species, *Olea cuspidata* available in the Western Mountains of Nepal has proven successful for using as rootstocks. The followings are the steps for raising the seedlings:

1) Collect ripe fruits from the tree for seeds during October to December.
2) Smash or crush the fruit gently to remove flesh (skin and pulp) within 6 hours after picking.
3) Clean the seeds with sand and water to remove the sticky materials or with a solution of NaOH and water (250 g of NaOH for 100 kg seeds and 100 litres of water).
4) Store the cleaned seed in a dry place in a layer 4 to 5 cm thickness, covered with paper sheets and free from mice.
5) Soak the seeds in water for 15 to 20 days before sowing in the beds. Change water two times every day while soaking; you may add in the water 5 ml NAA (Naphthalene acetic acid) in 10 liters of water for 10 kg seeds to stimulate germination.
6) The pits can also be scarified (cracked or clipped) and stratified (soaked in water and put in most sand) for quicker germination.

Nursery soil and bed preparation and seed sowing:

Mix equal part of sand, manure and soil. Sieve it and put in the bed (6 m x 1 m in size). One square meter of bed is enough for 4 kg of seeds. One kilogram of seeds contains 1500 seeds. Put these seeds closely in the bed or box and cover them with 1 to 2 cm thick layer of sieved mixture. Irrigate seed - bed once in every 3 days. Cover seed bed with plastic sheet to save it from cold and rain. Remove the cover sheet during sunny days. Seeds germinate within 3 months after sowing (Jan.- Feb.). Successful results in the nursery depend largely on atmospheric humidity, available light, and heat. The temperature required for germination of seeds is 13° C.

Potting of seedlings:

While seedlings are being potted it is necessary to consider following points:

1) Uprooot the seedlings at 6-8 leaf stage.
2) Cut the tip of tap root before putting them into pots or bags.

3) Main root of the seedling should be straight while planting.
4) Press the soil around the plant after transplanting.
5) Transplant them in beds or pots on the cloudy day as far as possible, usually in April.
6) Keep poly bags with plants 4 in number in width side for easier budding or grafting.
7) Give periodical irrigation, fertilization, plant protection and shade for the plants.
8) Seedlings become ready for grafting or budding after one year (i.e., next April).

Budding and grafting:

Grafting is different from budding; in budding we take scion wood with one bud while in grafting the scion wood contains two or more buds. Therefore the operation of these practices are different. The following points are to be considered in budding and grafting operations.

1) Take one-year old scion wood. Remove the top and bottom portion and also the leaves but keep petioles intact to make the bark movable.
2) Take bud from the scion wood and insert into the T-cut or patch cut on the rootstock.
3) Bud it at 15 cm height of seedlings from the soil level.
4) Wrap the bud tightly with the plastic ribbon.
5) Budding should be done in April
6) The scion wood should be of pencil size (1 cm diameter) for grafting.
7) Side or tongue grafting is done during January or February and can be done in Autumn also.
8) The unproductive varieties or wild species can be improved by top working or side grafting or budding.
9) Budding is preferred when there is scarcity of scion shoots for grafting. It takes 2 to 3 years to prepare grafted or budded plants.

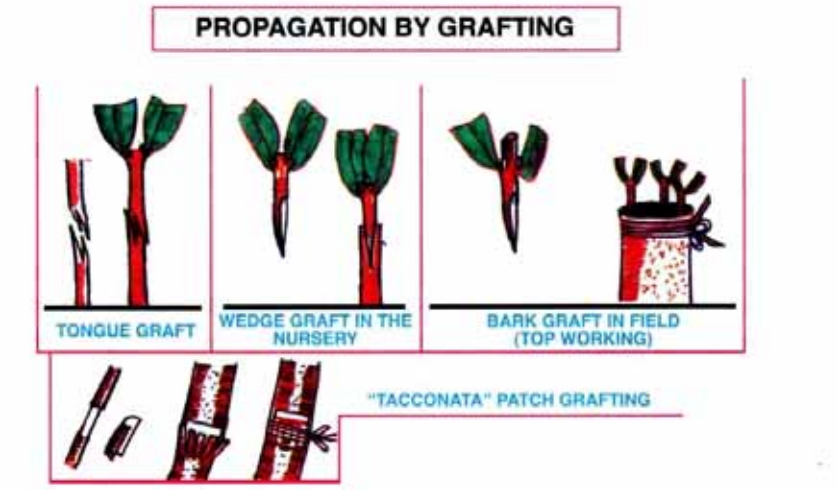

Fig. 7. Propagation by grafting.

Grafting of Qlea europaea cultivars on Olea cuspidata:

Promising results were obtained in Himachal Pradesh (India) by grafting *Olea europaea* cultivars on *Olea cuspidata.* There are different ways for grafting:

1) Raise the seedlings of *Olea cuspidata* in the nursery to graft selected olive cultivars.
2) Cut the olive tree at the lower end to allow new growth from soil level. The new shoots will be grafted (bark graft) with selected olive cultivars.
3) Head back the main branches and perform bark grafting on them.
4) 'Tacconata' patch grafting (modification of the patch budding) can also be done. This is used in those areas where we are not intending to provoke dangerous imbalances in the topworked trees.

From the information available for 30 years, it is possible to affirm that grafting of 30 olive cultivars on *Olea cuspidata* appears to be satisfatory under both physiological and production points of view. In the grafting sometimes and only for some cultivars it could be possible to observe a conspicuous overgrowth of the scion; it may look like a kind of 'ovules' formation..

Traditional methods of propagation:

Root piece:

A pit of 1 m x 1 m size is dug out at the permanent site one month before planting. A well fermented manure is mixed with the soil and filled the pit. Root pieces of about 5 to 10 cm in diameter, each weighing 2 to 5 kg are put into the soil at the onset of rainy season, Autumn in case of Syria. Small shoots emerge from those pieces of the roots.

Root cuttings:

The roots weighing 200 to 400 g are put in the plastic bags. These root cuttings are developed as planting materials for the supply to another area. This is modified method of the root piece technique.

Branch piece:

A piece of branch measuring 5 to 7 cm in diameter and 30 to 40 cm in length is taken. The pit is dug and rilled it after one month with a mixture of soil, and well rotten manure or cowdung. The two-third parts of the branch is buried below the soil level at the permanent site and one-third of the top portion is exposed above the soil. This method is also applied during Autumn and sprouts during Spring. The shoots emerged are kept as such for 2 years and then, only one shoot is selected to grow by removing all other shoots.

Stem piece:

During Autumn, a piece of stem of two year age with 1 to 2 cm diameter and 20 to 30 cm long is taken. Two or three such stem cuttings are put in the plastic bags containing sand, soil and manure and irrigated once a week when there is no rain. Separate the plants when they develop good roots and put them in individual pots to grow. The plants in this way are developed for another area

Ovules:

The ovule is a protuberance (composition of meristematic tissue) formed in those plant parts where a build-up of sap or a slowing down of sap circulation occurs. The "tubers" are formed mostly at the base of the trunk where the roots join. The ovule or the "tuber" has capacity to produce shoot and root. It is covered with soil to exclude light after separation from the mother tree. The ovules are separated from the stock at the base of old but healthy trees. If the ovule has already the root and the shoot, then it can be transplanted at the permanent site. The ovule can also be divided into pieces, if it has more number of shoots and roots. To preserve for longer period, ovules should be cared as for the cuttings in the nursery. The size of the ovules varies from less than 0.5 to 5 kg depending on the environmental conditions. The multiplication by ovules gives the best results.

Suckers:

Suckers are shoots that are originated on ovules or basal parts of trunks of the older trees. Instead of removing the ovules, they can be induced to produce rooted suckers, even when they remain in situ. The rooted suckers can be produced by another way also. The base of tree is covered with a light layer of soil, or strongly binding the base of the tree with one or two turns of wire, or ringing the bark of the trunk. The suckers removed from the mother tree can be taken to the nursery for further development, or they can be planted directly in their permanent site. This method of propagation is not a healthy practice as it weakens the mother tree and plants produced in this way show juvenile characteristics.

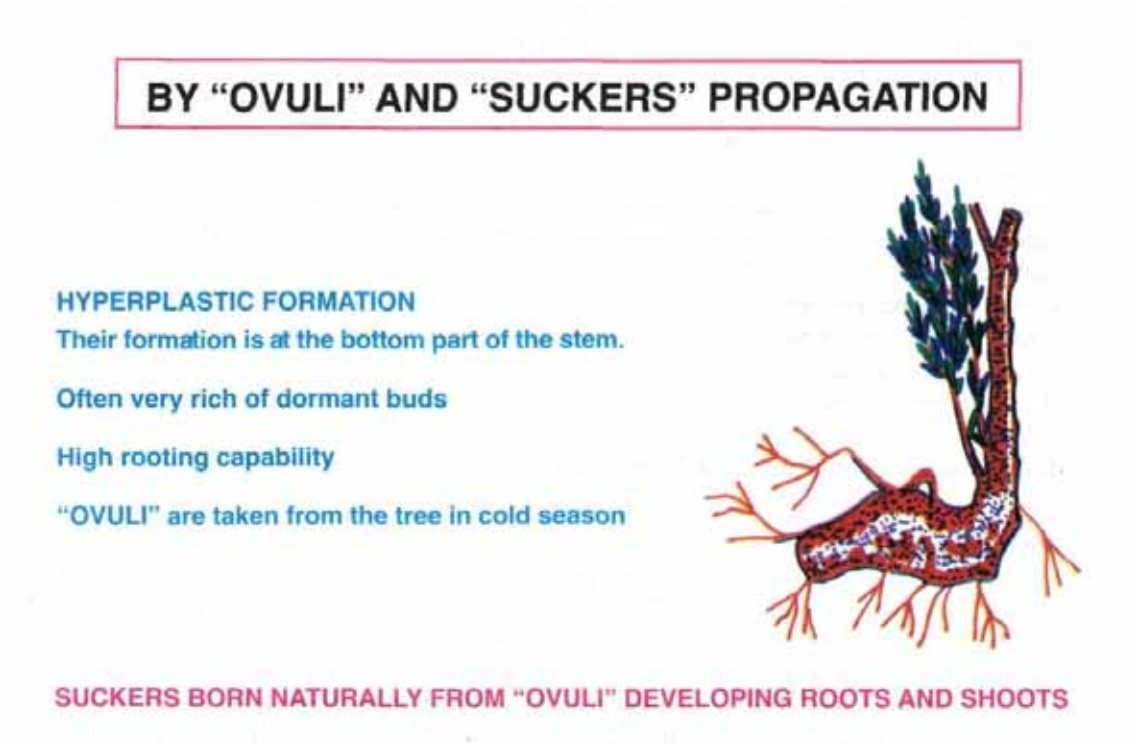

Fig. 8. Other propagation by ovules and suckers.

IX. ORCHARD ESTABLISHMENT

A well established orchard must produce a large quantity of fruits annually to fetch a good profit. A newly established orchard must reach its economic bearing stage as early as possible after planting; this helps to meet the operative cost and produce high yelds regularly in the consecutive years for long time. Olive being a long term crop, a minor mistake at the time of orchard establishment creates a big problem later and makes a considerable loss of investment. Proper planning and careful attention in site selection, land preparation, orchard design, selection of cultivars , spacing, planting, and initial training of trees are critical. These factors determine the fate of an orchardist to attain good profit. The proper pruning of the tree to regularize fruiting habit and plant protection measures are also equally important.

Site selection:

The production capacity of a plant and profit from an orchard are greatly affected by the site. The climatic factors, soil conditions, irrigation facilities, availability of labour and materials, road access and nearness to the market are important elements to be considered while selecting a site for orchard establishment.

Olive is a long lived permanent tree crop with high adaptability and resistance to the most adverse conditions. It can be cultivated in neglected, unfertile soil and drought, conditions. Olive trees recover easily from damages caused by bad weather and poor soil conditions. It produces good yield in regular manner under fertile soil, suitable climatic and well managed orchard conditions. Olive plantations can be made in different ways. They are planted only in the periphery of the cultivated land, or along the field path, sometimes as intercropping or associated to other fruit species (grape).

Plants density vary from place to place: in Tunisia (Sfax) there are only 17 trees per hectare due to dry conditions while in specialized orchards, trees are accommodated up to 1000 per hectare. For making plantations in new area, it requires suitable pedoclimatic conditions, like proper geographic areas with suitable microclimate. When the plantation is made at the bottom of a valley keep in mind that olive does not tolerate water-logging. It is also an anemophilous species. Instead, when we want to plant on the top of the valley, it must verify that particular place(s) are not subjected to frost, strong winds, hail stones and the terrain is having gentle gradient. The better places for olive growing are those areas like plateau in between the top and the bottom parts of the valley facing North- South direction so that the rows are better exposed to sun-light. Selected area and cultivars should be free from disease-causing organisms such as Verticillium, Tuberculosis, Armillaria, Rosellinia, etc.

Land preparation:

The land for establishing a new grove should be cleared by removing bushes and stumps. It needs leveling and deep ploughing. The terracing in the sloppy land is necessary. Digging and ploughing operations are done to break the compact layer of soil, and thus facilitating to enrich it in oxygen and easy movement of water in the soil profile. The root system of olive is distributed at a depth from 20 to 80 cm depending on the soil texture and fertility. The absorption of both water and nutrients has been carried out through the younger portions of the roots-called root hairs. It is important to create a favorable environment for the absorption system of the tree by improving the soil layers physically and chemically.

The improvement of soil up to deep layers is possible only before plantation in fruit crops. It is advisable to enrich soil by scattering 40 to 80 tons manure, 200 to 400 kg phosphorus, and 300 to 600 kg potassium per hectare on the surface and turning them quite deep (70 to 100 cm) into the soil using deep overturning plough. If such powerful machines for overturning soil deeper enough are not available, the pits should be dug out and fill the pits with top soil mixed with manures and fertilizers. The most of soils contain relatively large quantities of potassium and phosphorus but on account of their low solubility, a supplemental application of these nutrients deep in the soil layers is desirable.

After levelling and ploughing , drainage is vitally important in order to get rid of excess moisture in soil. Drainage system can be developed by using stones, or bricks, or perforated plastic tubes underneath the plantation area. A deep drainage channel, as per the slope gradient, can also be helpful.

In areas where natural run-off is available, drainage is not necessary. Development of water supply system to all olive trees in orchard is necessary to achieve maximum production. Levelling of land is required in orchards where water is supplemented by flood or furrow irrigation.

Olive plants are placed in the plane soil with ball of earth minimizing transplanting shocks. Olive plants of one to two years old (from one meter and above in height) are placed in the soil soon after a pit is dug (40 x 40 cm). In rainfed conditions it is necessary to irrigate the trees at the time of plantation and also 150 g of nitrogen fertilizer is applied.

Spacing:

It is not possible to give precise figures for the spacing of trees, as it differs according to the systems of lay-out design, forms of trees to be maintained, climatic and soil conditions, cultivars, irrigated or unirrigated conditions, etc. The traditional system of spacing was quite wide, 10 to 12 m between plants and rows, even more in semi-desert area upto 24 m each way. Most of growers these days keep closer spacing such as, 6 x 5 m or 6 x 6 m distances to accomode about 300 plants per hectare. Some orchardists in cold regions follow planting two trees per pit doubling the plant density, in view of one tree may be killed by cold injury, at least another will remain alive for production.

Plant density is related to plant productivity. Olive trees remain unproductive for the first three to four years after planting. Increasing production through the years depends upon plant density. Higher the plant density, earlier is the yield but the economical life of the orchard is shorter.

New olive orchards often have high density plantation and it has dwarfing effect of the cultivars. These parameters permit to reduce unproductive periods, aim to obtain production costs and to make easy cultural practices. The olive trees bear fruits on one- year wood located at its outer periphery in the presence of adequate sunlight. Olive shoots do not flower and do not produce fruit in full shade. If trees are planted too closely, shading eventually reduces orchard productivity. Olive orchards are sometimes planted with filler trees at high density to use the sunlight most efficiently and reach maximum production before the trees reach full size. Such filler trees are removed when their shading interferes with the permanent trees to produce fruits.

Orchard design:

Olive grove, as for other fruit crops, may be designed and laid out in several ways, but attention must be paid in providing maximum sun exposure over the trees in all ages and in allowing for efficient orchard equipment operation.

The square, the rectangular, and the hexagonal or triangular systems are some popular designs of lay-out for olive. The hedgerow and quincunx system are also followed by some growers. The contour pattern seems easy and more practicable to layout in the slopy terraces of hills and mountains. For this, a contour line must be allocated by using either the A-frame or other survey equipmqnts.

Pollinizer placement:

The transfer of pollen grains from anther to stigma is exclusively operated in olive (anemophilus species) by wind. The most effective dissemination of the wind blown pollen occurs within a 30 m radius of the pollinizer. Hence, the pollinizer rows should be spaced at every 60 m distance in the orchard.

Most of olive cultivars need cross-pollination because the olive is considered self-unfruitful. Some self-fruitful cultivars are also benefited from cross-pollination. Pendolino, an Italian cultivar, is considered an effective and universal pollinizer.

Pollinizer percentage and layout scheme in an olive orchard

OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
OOXOOOXOOOXOOOXOO	OOXOOOXOOOXOOOXOO
OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
OXOOXOOXOOXOOXOO	OOXOOOXOOOXOOOXOO
OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
OXOOXOOXOOXOOXOO	OOXOOOXOOOXOOOXOO
OOOOOOOOOOOOOOO	OOXOOOXOOOXOOOXOO
lP/oPoIlinizer	23% Pollinizer

O = main varieties

X = pollinizer

Digging and filling the pits:

The pit size for new plantation of olive should be large (lmxlmxlm size) to facilitate root spread of plants at the younger stage. Care should be taken not to glaze the sides of the pit that will hinder lateral root growth and water movement. The sides at the pit are chopped with a spade or shovel to destroy the glazing parts before filling the pit. Fill the pit with a mixture of 50 kg well rotten cowdung manure , 500 g diammonium phosphate, 250 g potassium sulphate, one kg agriculture lime (CaO), 40 g Furadane or other soil insecticides and top soil. It is wise to fill the pit with normal soil down at the bottom, mixture in the middle part and again normal soil on the top of the pit. The level of this filled soil should be 15 cm higher than the ground level. Digging and filling of pits should be completed about one month before planting.

Selection of plants:

When selecting plants for new plantation, the points to be taken into account are the genetic characteristics and health of the young plants. Plants should be well developed, with branches over the whole length to the trunk down to the base. The cultivars chosen should be well adapted to the local conditions and according to the purposes of oil extraction or table olives. The saplings prepared from grafting or cuttings do not make much difference in their performance. Plant height should be 50 to 100 cm or even more. Two to three years old plants are preferable to one-year old plants.

Time of planting:

The best time to plant is in March or April at the start of growing season, when the threat of frost is over. The areas with moderate climates have more flexibility in planting time and October to December are preferred. In areas with light sandy soil, any time of the year is suitable for planting provided water is available for irrigation. The olive saplings are planted before or after the rainy season, preferably in the spring in dense, cold and ill-drained soils. Bare-rooted saplings, trained to one trunk, are planted during February and March, before the onset of new growth.

Planting:

Take out the soil-ball from the plastic tubes and prune off any broken or long roots that do not easily fit into the hole; loosen earth ball, if it is too hard/Take out the soil from the pit making a hole. Place the earth ball with the plant into the hole to*the same depth as that was in the plastic tubes or in the nursery, or a few centimeter lower . Both too shallow and too deep planting is harmful. It impedes the root development of the plant. A correct planting depth should vary from 10 to 20 cm in heavy soil and 25 to 40 cm in light soil. The grafted part of the plant should be above the ground level. Fill the hole with top soil and press the soil firmly with feet little by little to remove air pockets and save roots from drying out. Irrigate the soil around plant immediately after planting. A two-meter tall staking which can last for two years is erected into the pit along the planting center towards the wind direction before plantation. The main stem of the plant is tied with the stake.

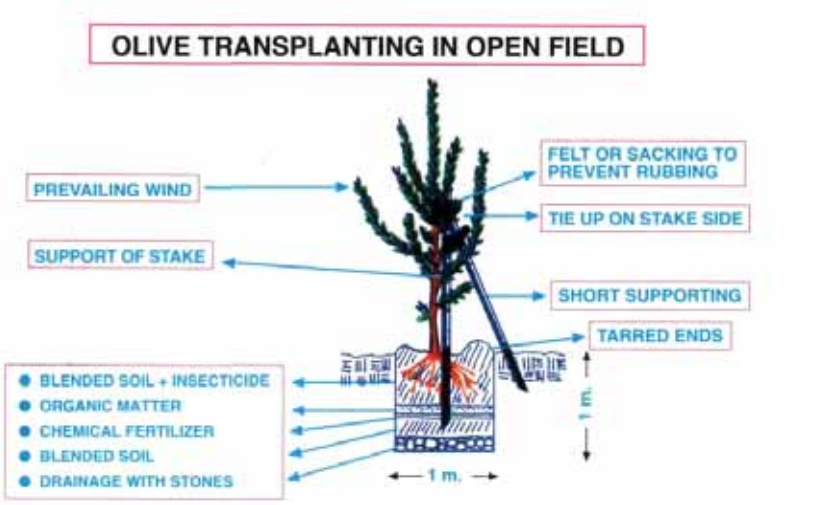

Fig. 9. Olive transplanting in open field

X. ORCHARD MANAGEMENT

Intercropping and tillage:

Intercropping may be done only for a few years when plants are young and intercrops are additionally supplied with nutrients and moisture. The care must be taken to keep the intercrops at a reasonable distance from the trunks of olive trees. The solanaceous, cucurbits, cotton, peach, plum, pear and other wild crops should not be planted as intercrops. These crops serve as host plants for Verticillium wilt. If olives are planted on a contour line in a terraced area, grapes may be cultivated together "grape married to olive" keeping the grapes and olive trees one to one and half meter away. In this case, olive must be trained to the "Open centre" and the grapes to the "Guyot system", Unilateral and bilateral horizontal Cordon, Kniffin, Chautauqua, Umbrella systems.

The olive groves are tilled two or three times in winter- the first is immediately after harvesting in December, the second in February/ March, and the third in April/ May. The summer tillage operation is carried out in June or July. The tillage operation should be shallow (5 -15 cm deep).

Soil and plant fertilization:

Fertilizing the plants depends on many factors such as soil, climate, tree age, growth, variety, nature of the plants, etc. These factors are to be critically observed before deciding the amount of fertilizer dose to the plants. The mechanism of the transfer of ions in solution to the roots is very complex and a little has been understood. The recommendation of fertilizer dose is generally made on the basis of soil analysis, systematic experimentation, and analysis of the plant tissues. The recommendation based on "foliar diagnosis" is the most acceptable and reasonable.

Table 5. Variation percentage of macronutrients (g/dry matter) and micronutrients (vvm) in the olive leaf.

Nutrients	Minimum	Maximum
N	1.00	3.00
P	0.08	0.80
K	0.10	2.80
Mg	0.02	0.70
Ca	0.70	4.40
S	0.02	0.30
B	2.00	33.00
Mn	5.00	160.00
Fe	40.00	400.00
Cu	2.00	75.00
Zn	4.00	80.00
Na	0.01	0.03
Cl	0.05	0.60

The soil pH has a definite effect on nutrient availability to tree roots. A soil pH ranging between 6.5 and 7.5 is the best for overall nutrient availability to most plant species, but pH 7 to 8 is the best for olive. Soil pH should be checked regularly. The olive tree takes up modest quantities of the nutrients in order of calcium, potassium, nitrogen and phosphorus.

It will be worthwhile to know that one ton of olive fruits uptakes about 9 kg of nitrogen, 2 kg of phosphorus and 10 kg of potassium from the soil. The uptake per hectare of an olive grove may range from 17 to 33 kg of nitrogen, 8 to 20 kg of phosphorus and 20 to 50 kg of potassium. Consequently, the average uptake of nitrogen, phosphorus and potassium ratio is about 2: 1 : 2.5.

The studies on foliar - diagnosis indicate that optimal main nutrient content in olive leaf vary, i.e. 2 - 2.5% nitrogen, 0.3 - 0.5 % phosphorus and 1 to 1.5% potassium.

Table 6. Application seasons and quantities of major nutrients

Season/month of Application	Non bearing olive tree (2-4 years after plantation)	Bearing olive (after 4 years of plantation)	Critical stage for nitrogen
December	0.1-0.3 kg N 0.05-0.1 kg.P_2O5 0.1 - 0.2kgK2O	0.3-0.5 kg N 0.1 - 0.25kg$P2O_5$ 0.2-0.4kgK2O	Differentiation of buds and shoots (March)
Spring Time	0.05 - 0.1 kg. N	0.1 -0.2 kg. N (after bloom)	Fruit setting (May-June)
Autumn Time	0.05-0.1 kg. N	0.1 -0.2 kg. N	Hardening of stone in fruits (August)

The time of fertilizer application may differ according to the availability of irrigation water or moisture content in the soil, and also in dry or cold areas. Fertilizers, especially nitrogen , should be given at its critical stage by means of foliar spray in a difficult situation. Fertilizers are to be scattered outside the vertical projection of tree-top on the ground and turned under at a 10-15 cm depth by means of a tillage.

Nitrogen:

It accelerates the vegetative growth and development of the plant, increases the quantity of chlorophyll and thus increases the plant's capacity to assimilate photosynthetic materials. The tree reacts quickly to the addition of nitrogenous fertilizers and its production increases but it should not be forgotten that the plant becomes more susceptible to cold and fungal diseases with excess application of nitrogen.

Phosphorus:

It favours flowering and setting of fruits. It accelerates maturation. It acts as antidote to an excess of nitrogen. It should be applied in Autumn, when soil is in the best condition and damage less to the root system.

Potassium:

"Olive trees require potassium in the greatest quantities after calcium. Potassium moves to fruit at ripening time and thus it contains a great quantity of potassium. Its consumption increases with rainfall. Potassium makes the plant more resistant to Peacock Spot *(Cycloconium oleaginum)* and other fungal diseases. It makes the plant more resistant to drought and cold. In potassium deficiency, trees have underdeveloped fruits.

Trace element:

Deficiency of boron can be easily corrected by applying 200 to 400 g of borax per tree to the soil or on the leaves as foliar sprays. This treatment should be sufficient for many years. Foliar sprays may aid the current season's growth, but the effect does not last as long as the soil application.

Dusting of sulphur, two or three weeks before flowering, helps in better fruiting. Dusting of boron alone or mixed with sulphur, also increases flowering.

Organic matter:

Organic materials improve soil conditions, cohere the loose soils, improve texture of heavy soils, control soil pH, increase ion exchange capacity in the soil, retain soil humidity, activate the micro-organisms, assimilate the nutritive elements present in the soil, etc. The organic materials should be applied in Autumn and buried as deeply as possible. The application of manure 5 to 10 tons per hectare in the dry climate should be made in every one to two years and in humid climate in every three or four years; green manuring with legume crops is an excellent practice.

Irrigation:

The olive tree can grow in drought condition and has very less water requirement but it produces a bumper crop if it has been irrigated at its critical stages. They are:

1) two to three weeks before flowering (March- April)
2) immediately after flowering and fruit setting (May-June)
3) at pit hardening (July-August), and
4) when the fruit reaches its full size and fruit turns color (September)

In less rainfall recovering areas like Tunisia (400 mm) two irrigations are given - one in March and another in when fruits turn colour. This can increase yield by 3000 kg per hectare over non-irrigated conditions.

Sandy soils have little capacity to retain water for use, approximately 4-5 % of their volume, While heavy soils can provide upto 15 and 17%. Sandy soils become saturated with low quantities of water (400 to 500 m^3 /ha per irrigation) and thus require frequent irrigation , whereas heavy soils require more water (1000 to 1200 m^3 / ha per irrigation) and hold

moisture for longer period of time. Irrigation in heavy soils should be given for long time until water reaches quite deep to the root zones. Water permeability in heavy soils is slow and in sandy soils it is rapid.

Permeability is the velocity of penetration of water, while the capacity is represented by the depth dampened by given quantity of water. A close attention should be given to the depth of penetration of water while irrigating the grove and a good irrigation system for proper distribution of water over the surface should be adopted. Invisible irrigation under the soil surface is more important that the visible soil surface.

Important points to be considered are 1) irrigate at critical stages of plants, 2) irrigate when plants show wilting symptoms in the morning time, and 3) use auger to find out the depth and area moistened with water. Calculate the time required to moisten whole root zones or soil area in each plot by using auger, keep records and irrigate accordingly next time.

XI. TRAINING AND PRUNING

Olives require training and pruning like all the other cultivated species; these operations are intended to enforce trees to give a good yield every year and at the same time to maintain a good balance of fruit /leaves/wood ratio. Good economical results are obtained if we exploit the potentiality of the varietal characters of each olive cultivar.

Olive tree is a 'basitona' species and therefore, there is a better development of bottom shoots against the terminal ones. A young olive tree, if its leaves detached in the field soon after plantation, will generate a well developed branches at low height and poor response from apical buds. If we bend a olive twig, it is possible to observe a better development and growth of the shoots coming from the bottom part of the twig and this growth will be more intense, according to the closer degree of bending operation performed. These basic information need to be considered at the time of training and pruning.

The olive tree canopy and its geometry is given by number and distribution of scaffold limbs and by development and direction of the apical bud as well as the development of the laterals.

Inside the canopy we can observe two type of growth: the first is related to the development of the tree structure, with branches having intense upright growth, the other is characterized by small branches with drooping habit, with wide crotch, placed in the side lateral and having bearing attitude.

Tree structure and its canopy change naturally with the age of the tree due to: "self-tree pruning"; water shoots are formed from dormant buds and the canopy become dense.

Climate has its influence on pruning because olive is cultivated in different climatic zones and they may have to be pruned differently. Some authors, for example, say that pruning may be done severely in tropical and subtropical climates because the growing conditions favour an excessive amount of growth.

Training:

"Pruning is a science which in one way or the other controls the building up and the regulation of development in plants in order that they shall fulfils to the utmost the purpose for which they were planted" (J.C.Bakhshi, D.K.Uppal, H.N.Khajura).

When we make a cut on the tree for pruning purpose, we remove an organ or part of the organ of the tree; this interrupts nutrient flow toward the cut. The direction of the other organs near to the cut may also be changed or modified. Bigger is the cut, more intense will be the tree reaction.

The best way to prune the tree is given by the knowledge pertaining to its physiological principles of the tree, objectives of pruning, cultivar characteristics, agro-climatic conditions, etc.

It is reminded that 'pruning' is only one of the several cultural practices required in an orchard. For the hand-harvesting or using special combs working with pressed air, it is necessary to maintain tree canopy as low to the ground as possible and to allow the tree to grow freely so that the tree should reach its final size in a shorter time and to bear fruits as earlier as possible.

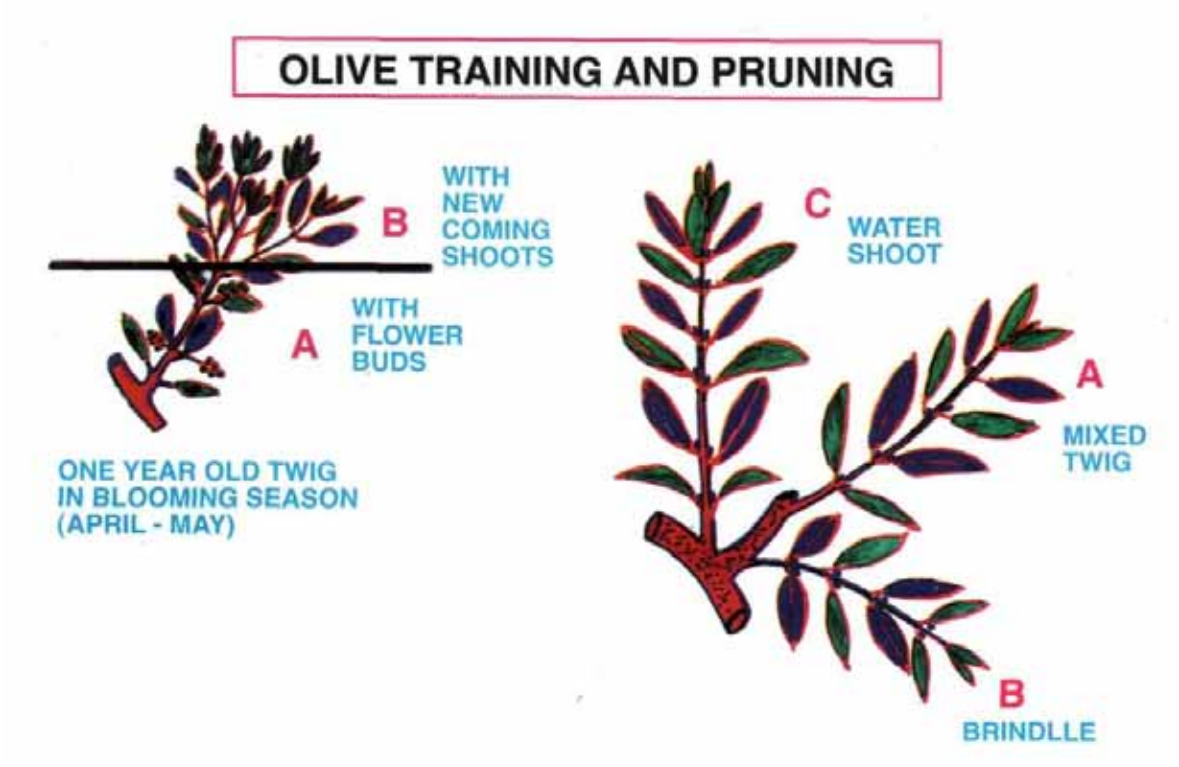

Fig. 10. Olive training and pruning.

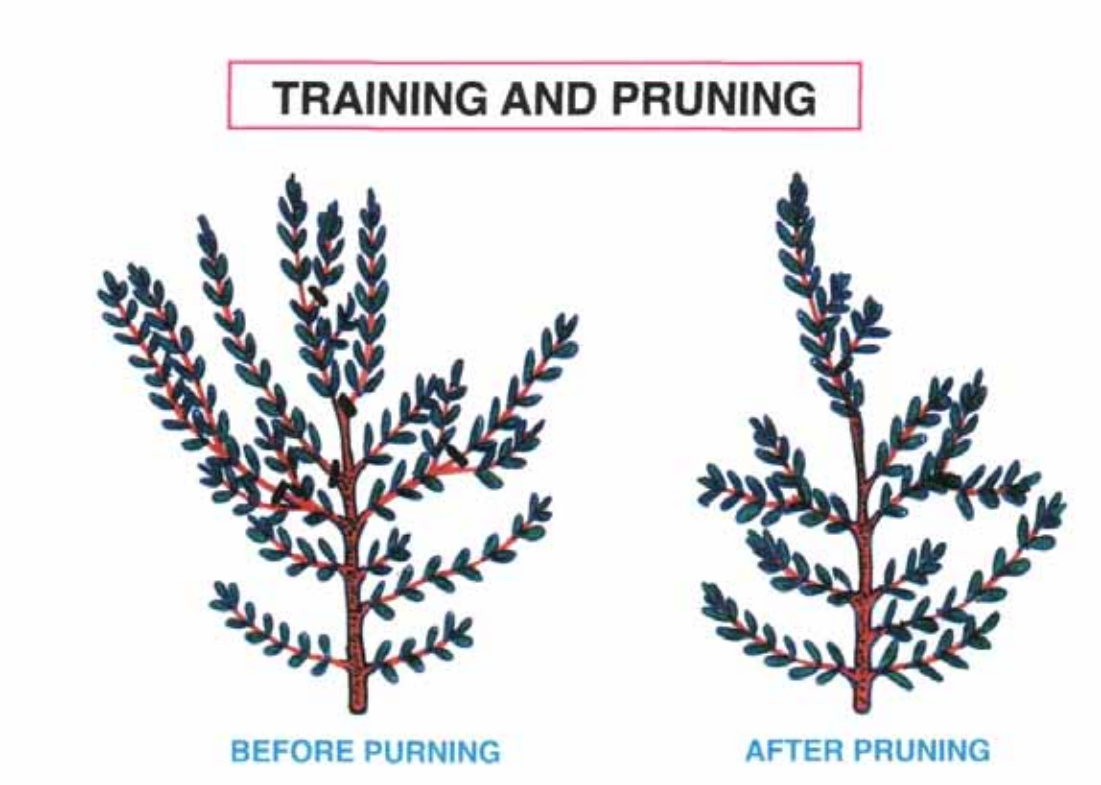

Fig. 11. Pruning of terminal branches.

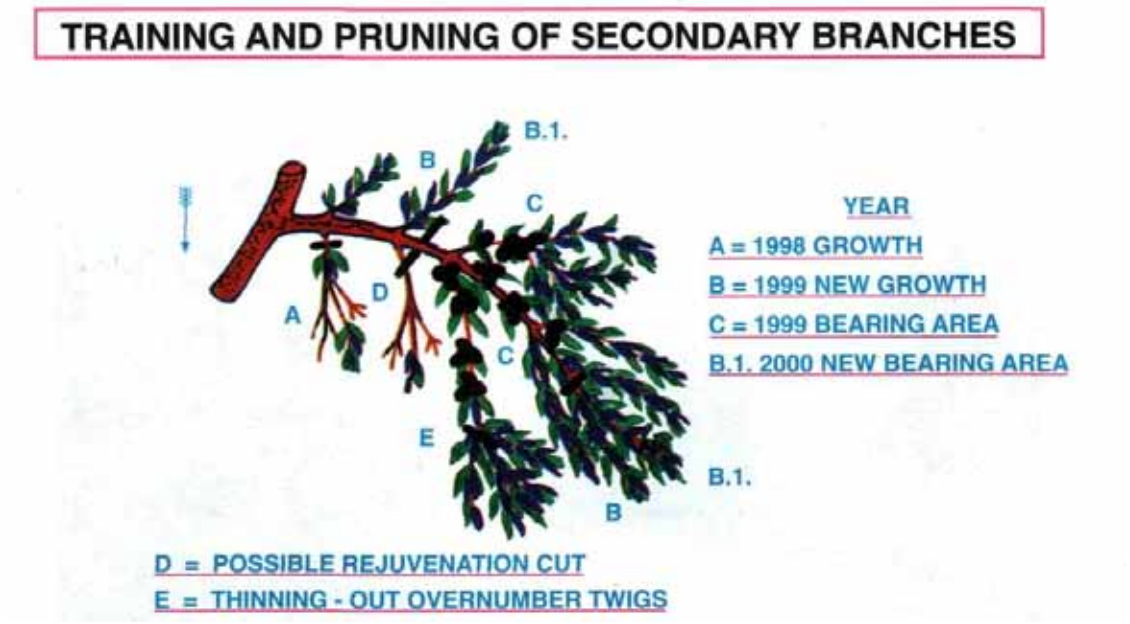

Fig. 12. Training and pruning of secondary branches

It is the best form for hand-harvesting. No pruning is required soon after the time of plantation for this form, because the natural behavior of olive trees is to grow in this as it is bastions species. This is the way to obtain early bearing and high yield from the tree in a few (three to five) years.

This form can remain untouched for some years and occasionally it may be pruned only the inner branches including the water sprouts which may allow the tree to grow upright.

Some problems for this tree form may be seen after some years (from 8 to 15) because in the lower part of the canopy branches start loosing their vigour due to overlapping and cris-crossing of twigs; the tree is more affected by pest and diseases. Nevertheless the top portion of the canopy try to re-place the lower weak portion; the yield decreases thereby increasing production costs. To avoid these problems it is necessary to a) select cultivars having less tree vigour, b) go for low density plantations, c) find suitable environment, and d) head-back the main branches with severe cuts.

Plate 4. Tree trained to a bush form

Training to open centre (vase -with a cylindrical or truncated -conical top):

This form is better for hand harvesting with combs working with air pressure. In this form, we delay the beginning of fruits production. The canopy is having a trunk of 80 to 120 cm and three to four main branches having conical shape. The object of this form is to give every part of the tree a large and equal amount of light and air. To obtain this form, we select three to four well placed new shoots (which will form the main branches) and tie them to a tutor (bamboo sticks) having 45° inclination. We can avoid to tie the selected shoots if we do:

a) At plantation time the tree maiden is tied to a support or stake in a position that we find suitable for the main branches

b) During the growing period the maiden will bend alone due to its weight (if not is better to pinch-out the tip) and many new and vigorous shoots are formed at the bending point.

c) All coming shoots must be well checked and need to prune the internal shoots (shoot thinning) , water shoots and need instead to keep the shoots bending towards the external part of the tree.

d) In between the selected shoots, we choose three to four well placed branches for the formation of the main branches

e) In two to three years the trunk will be formed; then it is necessary to remove the shoots arising along the stem to avoid competition for nutrients, space, etc.

f) Annual pruning operation (the tree structure is formed with a maximum height of 5 m) is done to allow the tree to increase in volume but not in height, expanding its canopy along with the side laterals of each main scaffold branch.

Plate 5. Open center of trees in old olive orchard.

Plate 6. Open center of "Dwarf trees" in olive orchard

Training to low headed open centre:

This form is almost like the previous one (Vase) with the exception that the trunk is very short. The tree at the time of plantation is headed- back to 30- 50 cm height and those shoots originated near the cut will be selected for the formation of the tree structure. A special care is required for developing shoots, as in the open centre form. This is a half-way form between the bush and the open centre; so it carries some problems of the bush (partially) and the requirements /benefits of the open centre.

Plate 7. Low headed open center trees in olive, orchard

Training to monocono (spindle type of tree) system:

This form is related to modern olive orchards where mechanical harvest method is required and high density plantation is followed. The olive is trained to a single axil, with lateral branches decreasing in size from the bottom to the periphery , with a portion of trunk (60 to 80 cm and close to the soil) free from shoots or branchlet formation to permit the operation of the shaker. Since the fruits are placed relatively near the axil, the detachment of the stalk from the twig is easier at the time of shaking the tree. This form, however may have several problems, such as:

a) Cultivars having spreading or drooping habit are difficult to train.
b) It requires constant and qualified pruning operations.
c) It requires long stakes or supports and wires.
d) Trees become too high and is difficult to control.
e) There is competition between the canopies because they try to touch each others.

Plate 8. Monocono system (Central leader system).

Overall consideration on pruning:

There is no exact explanation about a form which is better than the other. Often times, it has happened that the good performance of olive orchards was not depended upon the pruning system adopted, but simply following regular cultural practices. At the time of plantation it is important to take into consideration the characteristics of the cultivar and its

vigour because high density plantations is preferable only for olive cultivar having 'dwarf characteristic.

Olive is a "Basitona" species and following the apical dominance theory , in a branch, the bottom shoots are resulting to have better development in comparison to others that grow at in the middle and in apical portion. But if there is no enough chilling requirement, the branch behaviors changes towards "Acroplastia " instead of "Basiplastia", practically the apical buds remain dormant for less period; thus, they are sprout earlier.

In this context it is advisable to perform pruning in Autumn or before Winter season or soon after harvesting time. This type of pruning consists of heading back the one year shoots and activates the growth of dormant buds of the one year twigs. These dormant buds (neutral at pruning time) can develop to flower buds instead of vegetative buds because they were mature enough for flower induction.

Pruning of bearing trees:

Pruning of bearing trees is made starting from the top of the terminal branches and slowly coming down and rotating for 360° around the tree. There are some important operational considerations:

1) Pruning of the terminal branch and branch lets: Terminal branches before pruning often are crowded of new shoots and 'debushing' is necessary to restore the branch , to facilitate sun light penetration in the canopy and to maintain the maiden. Pruning is made according to dichotomous branching system.

2) Pruning of secondary branches with laterals adequately placed: These branches are fruit bearing and it is possible to find: the growth of the past year, the bearing area or one year growth and the new bearing area or new vegetative formation. The new vegetative formation is the prolongation of the one year old twigs and the formation of new twigs (branches) arising from the bending portion . Pruning is to remove the old and unproductive twigs, to thin-out the prolongation of the branch , to select new bearing twigs borne on the bending portion of the branch. If we need to make a rejuvenation cut, remove or head back all the bearing area to let new branches developed on the bend portion.

3) In a particular branch, there are three types of vegetative development: a) mixed twigs that are the best for flower/fruit formation and for prolongation of bearing tree life, b) brindle or very small twigs with fruit bearing but completes vegetative cycle within a year, and c) water shoots always up-right and to be removed because they bring the tree to an unbalanced condition. Rarely water shoots are maintained to restore tree canopy

4. If the tree has crossed a desired height, it is good to head back to develop side laterals, which are the axes of prolongation of main branches . The point near to the cut has to be constantly checked in the future because there will be always new and strong vegetative formation

5) All cuts made to olive trees must be close to the node; the secateurs must be sharp and the cut is well-polished.

XII. INSECT PESTS AND DISEASES

The damage to olive trees by pests reduce the value and quality of the oil or table-olives and make the orchard more expensive in terms of production costs.

The explanation in this chapter of different pests and diseases has to be considered incomplete because in Nepal olive cultivation is in the beginning stage, some pests, quite common in main producing areas are not active in Nepal, while other kind of local insects can be of more dangerous. Integrated Pest Management can be applied when there is a clear knowledge of all insects and diseases affecting olive-growing area; the biological cycle of pests and diseases must be known adequately to find out the proper time for treatments or any other controlling measures.

It is important to know the 'threshold' of pest population for economic losses; if the parasite is not crossing the 'threshold' it means that the damage is less and the treatment cost may be high and uneconomical. If the parasite population has already crossed the 'threshold' level it means that the damage is becoming more severe causing economical losses; thus treatments to reduce or control pests are required.

Insect pests:

Olive fly, *Bactrocera (Dacus) oleae* Gmelin:

This insect is not observed in India and Nepal. This olive fly breeds in the fruit pulp, and larvae damage fruits. There can be 3 to 5 generations in a year depending upon climate. In winter, the olive fly make an interruption of the biological cycle leaving underground and coming again in spring. Control measures include:

a) collect fruit samples to ascertain the number of damaged fruits (the 'threshold' is 5% of damaged fruits).
b) capture flies with sexual and/or chromo tropic traps.
c) Apply insecticides before they breed in the fruit pulp. Foliar applications of two to four lip soluble methyl parathion during summer and hydro soluble dimethoate later on.
d) This insect may be controlled by biological method using *Opius concolor* in Spring - Summer.

Black scale, *Saissetia oleae* Bern:

This scale is observed in India and Nepal. This insect causes several damages: leaves drop, vegetative growth reduces, twigs become shorter and less number of flower buds are formed. Injuries to the tree is made by sap suction and indirect through honeydew production with further development of the sooty mould. Black scales attack olive trees, citrus and other fruit crops. They live in winter as larvae and become active (adults) in spring season and specially in summer. As soon as the new generation is formed they start to migrate towards fresh green leaves and tender twigs. Dry and warm climate reduce the growth and population increment of this insect.

There are many natural enemies of this insect such as, *Cocophagus, Methaphycus, Scutelistas, Coccinelidus, Crisopidas* but none of them seems capable of repressing it. *Methaphycus barletti* looks more effective than others against this insect. The economic threshold is when there are 10% of twigs holding larvae and adults. Chemical spray is made in summer (one or two applications) with petroleum-oil (related to agriculture) combined with methylparathion or parathion.

Olive psylla, *Euphyllura olivina* Costa:

This phyla is observed in commercial olive varieties available in India and Nepal and also found in wild olives, *Oiea cuspidata.* This insect is not considered very harmful to olives but is largely spread in most olive growing areas. Chemical spray is based on the same strategy as against black scale.

Tingid bug, *Gryllodes sigillatus* Walk:

This bug is observed in India only. It is a very injurious insect to olive trees. The injury consists in stinging leaf lamina and sucking leaf sap. Leaves thereof become yellow loosing their function. The tree, with severe attack can be totally defoliated. There are several generations and if the tinged attack is associated with other insects, trees show a severe decay and it may take two to three years for the recovery. Natural enemies are unknown and several treatments are necessary to control this insect: Parathion, metylparathion, permethrin, azinphos-methyle from Spring to Autumn.

Olive kernel borer, *Prays oleae* Bern :

This borer is not observed in India and Nepal. In Mediterranean countries this insect is very dangerous. There are three generations within a year : the first attacks leaves, the second attacks flowers and the third attacks fruits. Third generation makes fruits drop and a small outlet nearby the peduncles cavity of fruit is seen

This insect can be controlled by biological method with *Bacillus thurigensis,* chemical control with spray of different insecticides such as, permethrin, triclorphon, and fenitriothon. The economic 'threshold' is given when 100 insects have been captured in the sexual traps or more than 10% of olives are damaged with eggs.

Other insects:

There are many other kind of insects migrating from soil to the olive foliage climbing the stem. Sometimes they make serious injuries to the tips, to the inflorescence and to the leaves, twigs and bark. Recently a ring of synthetic wool above the stem is considered a good barrier against these insects. Application of non- poisonous glue for killing rats is also a good barrier to stop insects from climbing up the stem.

Diseases

Olive nodes or tuberculosis, *Pseudomonas savastanoi* Smith: (olive knot)

This disease is not observed in India and Nepal. It is a bacterial disease and appears on branches and twigs with formations of thick and hard nodes. These nodes reduce the development of the affected olive organ and the full branch may dry-up. The disease find its

way to develop through injuries made by hail stone, pruning operations, frost, insects and harvesting by beating the tree with wooden sticks.

It is important not to use infected secateurs for pruning on a non-infected tree. Cuttings from infected trees have to be treated with Streptomicine sulphate before propagation.The nodes need to be removed from the diseased tree and the cut must be well done removing the entire swelled part of the twig or branch. The cut has to be protected and disinfected with Bordeaux mixture and its combinations. On new olive plantations, olive cultivars that show particular resistance to *Pseudomonas* should be used.

Peacock leaf spot or olive blotch, *Cycloconium oleaginum* Cast:

This leaf spot is observed in India and Nepal. This disease is caused by the fungus. It grows on leaves and fruits. Sometimes this fungus causes intense defoliation on affected trees. Olive growing areas with high relative humidity and in bottom of the valley, trees are more exposed to olive blotch. High defoliation affects flower bud differentiation significantly. Olive blotch forms spots about 10 to 12 mm in diameter on upper leaf surface; spots are composed of concentric rings of different shades and resembling the spots of a peacock's tail. . . . . .

Treatments with Bordeaux mixture is effective at concentration of 1 - 1. 5 % . Before winter season or at beginning of rainy months it is advisable to make a treatment with captafol, or with copper ox chloride.

Sooty mould:

This is caused by many causal organisms such as, ***Spilocaea oleagina*** Hugh, ***Capnodium elaeophilum*** **Prill,** ***Cladosporium erbarum*** Link, ***Alternaria tenuis*** Nees, ***Limacinula oleae*** **Sacc**. et Trotter. This mould is observed in India and Nepal. Sooty mould is a disease formed by the action of different fungus; it consists of a black coating on leaves, fruits and branches. The excretes of black scale *{Saissetia oleae Bern.),* the attack of Aspiditus and other sugar substances produced by the tree due to unfavourable weather conditions (sudden temperature variation, relative humidity, strong winds) are excellent food for the above cited fungi.

Sooty mould does not penetrate the tissues of olive tree; the disease appears due to shutting off light and air to the leaves causing leaf drop. Olive fruits of table cultivars are severely damaged and oil quality can also be affected.

The disease can be controlled with copper ox chloride, Bordeaux mixture, captafol treatments after harvesting. During the cold season it is possible to make a treatment with 1% white mineral oil and/or NaOH.

VerticiHium wilt, *Verticillium dabliae* Kleb.

This fungal disease is observed in Nepal. *Verticillium dabliae* penetrates olive trees through roots and invades the xylem. The first symptoms are seen with curled leaves and then drying of twigs, branches and sometime the tree as a whole. "Apoplexy" and "Slow decay" are two terms given to the disease according to the intensity.

There is no satisfactory control for this disease. However, the following are some possible preventive measures to avoid its incidence.

1) Choose verticillium-free soil for plantation.
2) Use resistant cultivars such as Frantoio.
3) Uproot and burn infected trees,
4) Avoid olive intercropping with Solanaceous and other species that are known as *Verticillium* carrier.
5) Eliminate the infestants below the projection of the canopy.
6) Provide localized irrigation.
7) Use herbicides to control weeds.
8) Disinfect secateurs and other tools before pruning healthy trees.
9) Soil solarization to minimize or destroy the disease-causing soil fungi.
10) Adopt integrated control measures with *Talaromyces flavus* as natural antagonistof *Verticillium dabliae* and soil solarization.

Olive anthracnosc or fruit mummification, *Gloeosporium olivarum* Aim:

This disease is observed in India and but not in Nepal. This fungus penetrates the skin of healthy fruits and its action expands at the distal part of the drup. Treatment with Copper oxychloride in summer should suffice.

Fruit spot, *Sphaeropsis dalmatica* Thum, ***Macrophoma dalmatica*** Thum, Gig:

As observed in India this fungus attacks fruits in summer; it makes roundish rotten-like spots which turn to suberized and marked the fruit. Infected fruits are totally damaged and are not good for table-purpose. Fruits are also poor for oil quality. The fungus is having one insect helper 'a cecidomya, *Prolasioptera berlesiana'* which is a natural enemy of *Bactrocera oleae* (olive fly). It can be controlled with Copper ox chloride sprays in summer treatment.

XIII. OLIVE PROCESSING

Olive -oil processing:

Nowadays oil extraction is made by powerful and complex type of machinery with capacity to process up to 20 tons/hour; thus it means a special branch of the oil-industry. There are others of medium capacity which vary from 0.3 tons/hour up to 1.5 tons/hour. The mini oil-plants are also able to process oil from 50 to 150 kg/hour. Recently, these type of mini oil-mill have been found quite useful for small scale farmers who want to extract oil at their home. Moreover in the beginning stage, specially in those areas of the world where olive
is a new crop (Australia, New Zealand, Tasmania, India, Texas, California etc.) these mini oil-mills become quite popular because they are easy to operate, easy to buy, and they satisfy the farmer's requirements.

The old type of oil-mill operated by hand are no more in use and they are replaced with new oil-mill models. The quality of a good olive-oil and the capability to extract oil from fruits depend upon the knowledge of these oil machinery also. Since they have been

used for centuries making the history of olive-oil industry, a sample of such mills should be available in those countries which are interested in oliveculture.

Nevertheless, these "old oil-mills" can still find a place to operate in some remote areas and villages. The olive-oil is present in the pulp and seed; olive paste prepared from ripe olive fruit is used for extracting oil. The oil extraction is relatively a complex process. In Nepal olive culture is at its beginning stage; if the olive plantation starts this year (1999) fruits will be ready by 2004 only and olive culture will have to be introduced in selected specific small localities. In such situations, only small oil-mill can be operated. The kinds of transport facilities available in the country do not allow maintenance of the olive fruit quality if they have to be transported to a distant place for processing. The availability of small, simple oil mill at farm or cooperative level can facilitate the processing and then the oil can be easily transported to main centres for bottling and marketing.

Characteristics of **old model and hand operated oil-mill:**

It is composed of four individual machinery:

a) Washing machine (to separate olive fruits from stone, leaves, soil, twigs etc.)
b) Crusher (to make the olive paste)
c) Batcher- (optional) - (to facilitate the separation of oil from the olive paste)
d) Oil-press (for separation of juice from the olive paste)
e) Oil settlers or centrifugal separator (for separation of olive-oil from the juice)

Washing machine: Commonly the olives at their arrival are submerged in a tank with cold water and soon after they are lifted to the crushing machine. Other type of washing machine are made with a cylindrical metal sheet holding many holes and fixed on the central axil slightly inclinated on the horizontal. The olives are allowed to cross the rotating cylinder and water is sprayed to separate olives from other impurity. New technology brings new products day by day; for small fanners, for example a kind of wheelbarrow is in use for small quantity of olives. Before crushing it is important to wash olives.

Crusher _

It is composed of the following parts:

1) Four legs that are well fixed on the ground.
2) Horizontal granite crusher 25 cm thick and 1.60 m diameter (fixed).
3) Metal basin, supported on and around the granite crusher. This basin is havingtrunk conical form, the outer part is 2.50 m diameter and the inner part 1,60m; it isfixed to the four legs and it is joined in pieces with stirrups and bolts. A small door ismade outside the lateral of this basin to facilitate expulsion of the olive-paste.
4) Two vertical granite wheels of 30 cm thick and 1.20 m diameter. The wheels areinserted on a horizontal axis that passes in the lodgement specially created in th buttof the upright axis. The granite wheels are assembled at different distance from the upright axis because they are able to cover more crushing area.
5) Raspers for crushers and basin to keep clean from the paste.
6) Shovels (two) for batching.
7) Shovel for dough expulsion.
8) Power - supply for rotating the wheels (man-power, animal-power, water -mill, petrol/diesel engine, electrical engine).

The crushing operation and preparation of the paste should be done within 30 and 45 minutes. The crusher should not be overloaded. If the paste is too juicy, and the black olive skin and the pulp skids to the outer part of the crusher; it means too many olives have been loaded at one time. In this condition the stony-seeds will be powdered under the granite wheels, and good paste is not formed. If olives are too juicy then it needs to modify shovels and rappers accordingly.

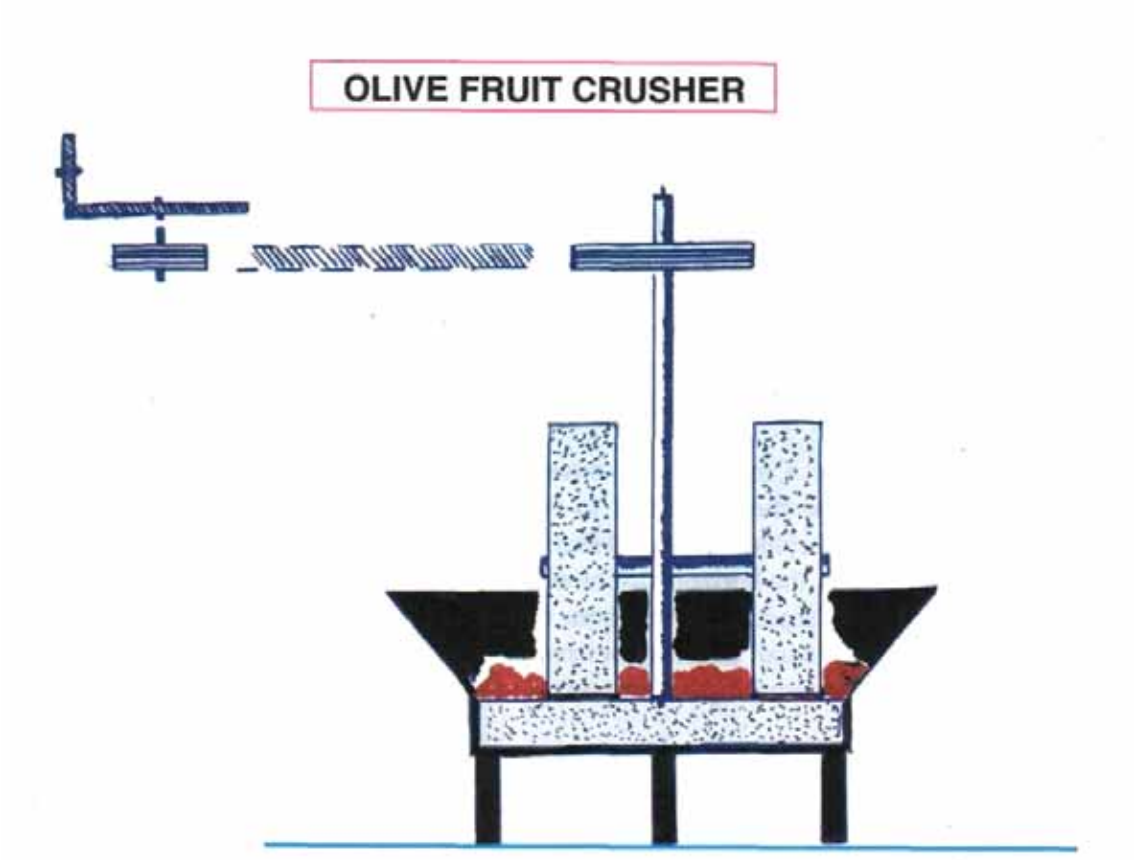

Fig. 13. Olive fruits crusher

Sony-seeds are having a mechanical function only . The seed contains a little oil whereas pulp has more oil.. They are broken in several parts by the granite wheels and consequently the pulp is also lacerated. The oil from the seeds and pulp comes out easily. Shovels and raspers should permit a good mixing of paste and lacerating effect in the pulp.

Oil-press: There are vertical and horizontal oil-presses. The vertical one is composed of:

1) Main frame (wood or iron) holding the piston, horizontal pressing disc, a pile of several
matts holding the olive paste, basin for collecting olive juice.
2) The piston is screwed (for manual operating presses) and its diameter is 30 cm.
3) The height of the pile of several matts should not exceed 1.50 m. .

It is important to know for the olive press the impact of work and, the area on which effectively the pressure is released. The impact of work is the number of atm. (atmosphere) that is possible to reach without damaging the press. (1 atm. is equal to 1 kg per square cm of the surface under pressure). The power of the press is given by the diameter of the piston and the normal impact of work in atm. So, if the press has a piston of 30 cm diameter and work at normal pressure of 400 atm, its power is given by following formula:

$$\text{Power of the press} = \frac{\text{atm. n.: X 3,1416 X square diameter (30 x 30 cm.) of the piston}}{4} = 282744 \text{ kg}$$

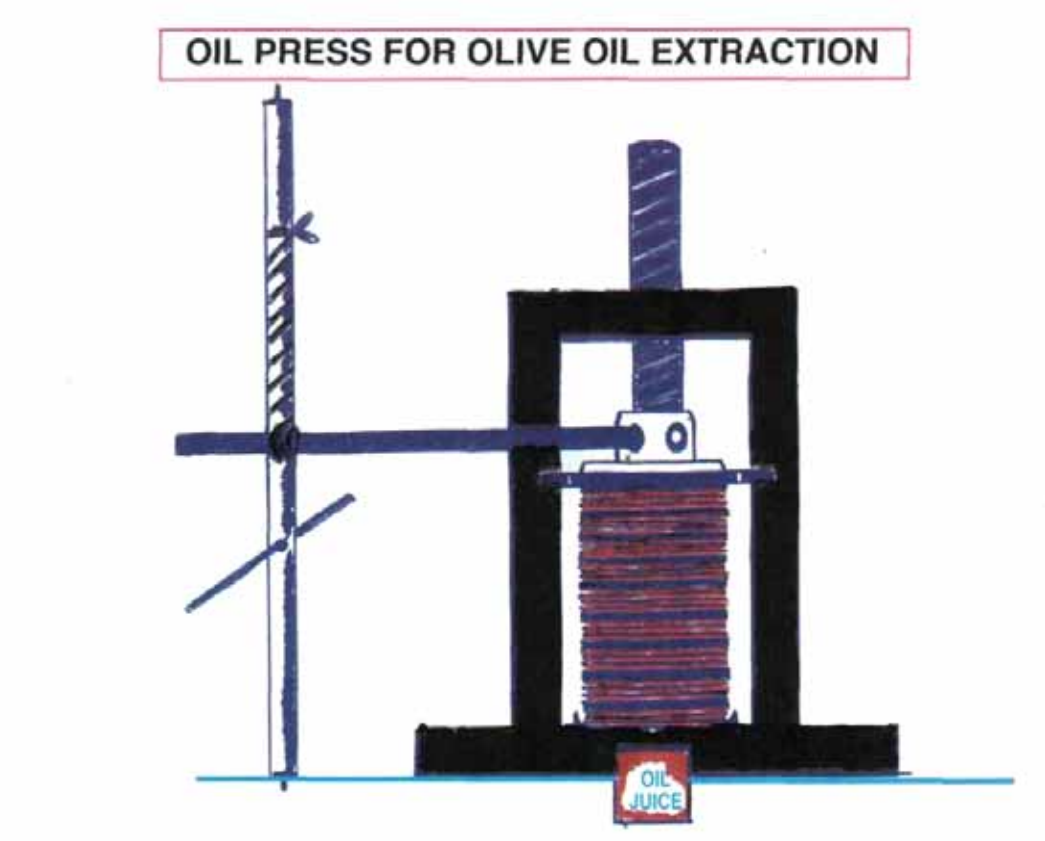

Fig. 14. Oil press for olive oil extraction.

The above calculation is related to the power of the press but not to the impact of work really done on olive paste. So, it is necessary to know the area of the pile of matts made with the olive paste, pile, and discs under pressure. More the resulting area of the pile under pressure, less will be the pressure released in each square centimeter of the same. The pressure is expressed in kilogram.

The useful effect of impact of work is given by dividing the power of the press (282744 kg) and the area of the piles under pressure . The area of the crown of olive paste which is under pressure is given by the total area of the pile, minus the area of the internal hole. Example, the wider diameter of the olive paste is 62 cm and the area is 3 1 X 3 1 X 3 . 14 = 3017.54 sq. cm; the smaller is 21 cm; thus, 10.5 X 10.5 X 3.14 - 346.185 sq. cm.

(3017.54 - 346.85) = 2670 sq. cm. Now, we divide 282744 : 2670 = 105 kg per sq. cm.

If we release the same pressure to two matts having different sizes, it will receive more pressure and the oil cake will be more dry in piles of matts having less diameter. Other parameters to be taken into consideration are:

a) The speed of the piston while pressing and releasing the olive cake (more is the
speed, less oil is obtained),
b) Methods of loading the piles,
c) Metal discs,
d) Kind of matts used, and
e) Kind of olive paste used. Normally the olive paste should not be more than 2.5 cm.
thickness between the matts.

Oil-settlers;

In place of centrifugal machines that are related to the oil-industry at higher level, it is possible to separate olive-oil from the juice simply by force of gravity. Minimum two tanks are needed to make this operated. One tank is positioned at higher level than the other and is filled with water. The second one (40-50 cm diameter x 100 - 120 cm height) is placed below the first one and is filled with the olive juice coming from the press. With rubber atossic pipes, we make communications between the two tanks with tape to control the water flow towards the juice. The juice is decanted naturally inside the tank for 20 - 40 minutes; soon after, the oil appears on the upper tank then add water from the lower tank. The olive oil will exit from an outlet positioned on the top of the tank and it is collected in a stainless steel vessel/ container or glass/ earth jar with a pipe.

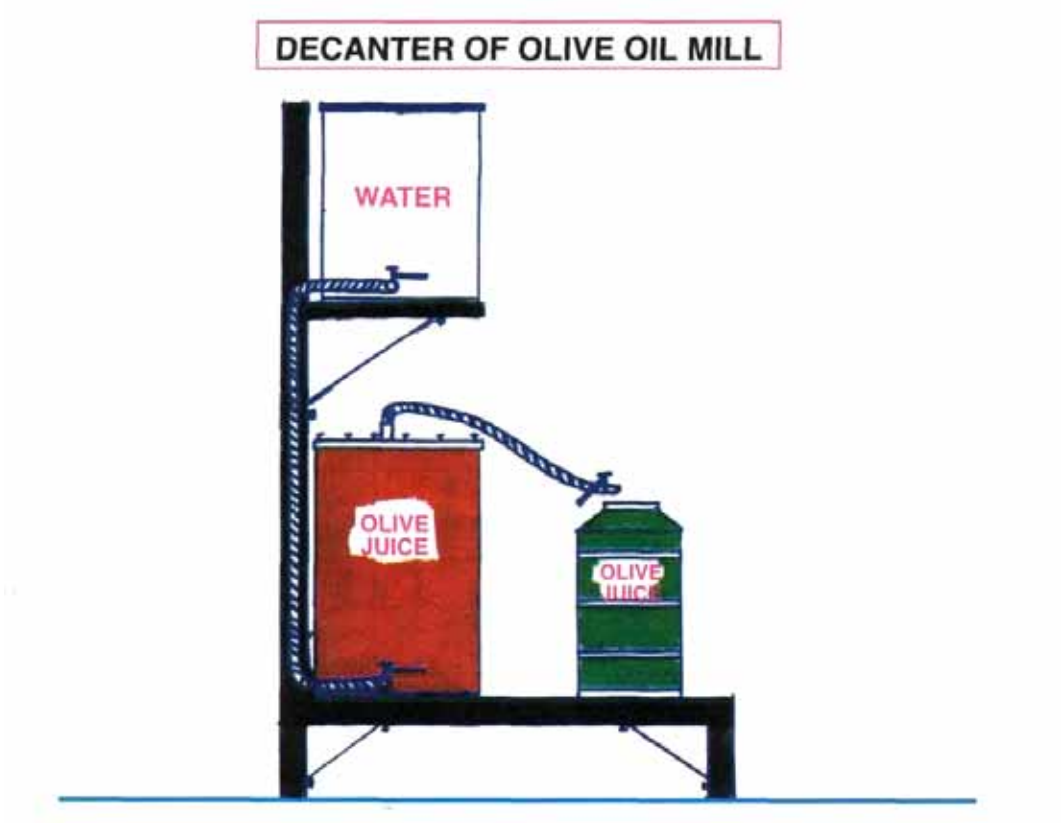

Fig. 15. Decanter of olive oil mill.

It is important to notice that all kinds of vessels should be made in stainless steel or atossic plastic specially utilized for holding fats and glass containers because the olive-oil absorbs any kind of contaminating agents quickly.

Some oil-mills do not have press because they work with other technologies. Mini oil-mills (50 to 100 kg/hour) are available today; these work in a similar system and the advantages are that they are completely automatic machinery, stony-seed can be saved by the machine and utilized for propagation purposes, and they require less power supply. They are also compact, save processing time and obtain good olive-oil quality.

Stuffed olives:

The world production of table olives is 1.000.000 tons every year and 80 % of the total is produced in the Mediterranean countries. The main producing countries are: Spain (220.000 tons), Turkey (110.000 tons), Italy (85.000 tons), Greece (80.000 tons), Morocco (80.000 tons), Syria (70.000 tons), and Portugal (18.000 tons).

There are three main kinds of table olive : green table olive, black olive (Californian style), black olive (Greece style) having natural color and fermentation.

Main cultivar characteristics of the table or stuffed olives are given in the table below (for Italian cultivars).

Table 7. Characteristics of Italian table olive cultivars.

Cultivar	live weight (g)	Stone weight (g)	Pulp weight (g)	Pulp rent (%)	Pulp: stone
ASCOLANA TENERA	**6.9**	**0.6**	**6.3**	**91.6**	**10.9**
BELLA D. CERIGNOLA	**9.7**	**1.1**	**8.6**	**89.0**	**8.1**
CONSERVOLIA	**7.6**	**0.8**	**6.8**	**89.4**	**8.5**
GIARRAFFA	**11.3**	**1.2**	**10.1**	**89.4**	**8.4**
NOCELLARA D. BELICE	**5.5**	**0.7**	**4.8**	**87.1**	**6.7**
NOCELLARA ETNEA	**5.5**	**0.6**	**4.9**	**89.0**	**8.1**
S. AGOSTINO	**8.5**	**1.0**	**7.5**	**88.7**	**7.8**
S. CATERINA	**8.9**	**1.0**	**7.9**	**88.5**	**7.7**
S. FRANCESCO	**8.6**	**1.0**	**7.6**	**88.5**	**8.0**
TONDAIBLEA	**6.5**	**0.7**	**5.8**	**88.8**	7.9

The main difference between olive for oil making and table olive is the size of the drup. Olives weighing more than 5 g are considerd big olives. The olive contains a bitter substance (oleuropein) which distract the fruit from eating at ripe stage and therefore processing is needed to eliminate this substance. However, some cultivars are more 'sweet' than others at ripe stage such as, Termite di Bitetto, Pasola, Mele, Thurbolea etc. Olives for table consumption must be harvested by hand, they should be free from insect pests and diseases, spherical form of the drup is better accepted in the market.

Green olives (Sevigliana style and Picholine style):

Olives are harvested when the colour is not yet changed in the epidermis. Fruits (sevigliana style) are submerged in a solution of NaOH which vary from 2 to 30 %. The concentration of NaOH depends on ripening stage of the fruits, cultivar, water characteristics, etc. The solution should cover all fruits placed in the container and olives during this process must be in the dark. The process is over when the solution penetrated 2/3 part of the pulp. It can be tested by taking some fruit samples, cut the pulp, then keep the olive fruit exposed to open air for few minutes and observe the brownish colour of the pulp penetrated by the NaOH solution. This check can be done with proper reagents also. The duration of

treatment is from 6 to 12 hours. Soon after NaOH treatment, olives are washed 30 times to take away the residual parts of NaOH solution. Washed olives are then placed in wooden barrels or other containers which contain a 6 to 8 % salt water solution. Fermentation process of olives starts in this solution and is completed within 25 to 40 days. Olives are ready when fruit colour changes to green-yellow, pulp is tender but of good consistency, the test is pleasant, aromatic and little bit of acidic flavour.

The process for green olives (Picholine style) is almost the same with the exception that there is one more fermentation in salt solution and adding citric acid (pH 4.5) in the solution. Olives become more greenish in colour.

Black olives (natural processing style):

Fruits are harvested at ripening time when full colour development is maximum but fruits are yet turgid and not damaged. Fruits are submerged in a water with salt concentration which vary from 8 to 10 %. Wooden barrels are good. Glass containers are also used. Avoid contacting olive fruits with air during fermentation process so the containers must be closed tightly. Salt solution during processing operation should be changed. Olives are ready for heating when they are kept in a solution of 8 % of salt. Sometime vinegar is added to the solution, about 25 % by volume.

Black olives (with dry salt):

This is a greek method of preparation and quite commonly used at home. Olives are washed from impurity and placed in glass containers or baskets or earth jars with 15 % of dry salt per kg of olives. At choice garlic cloves, chilli and aromatic herbs may be added in the container.

The Californian or American style of processing is related to obtain olives with complete and homogeneous black colour of the epidermis. For this process, it needs a treatment with 'gluconato ferroso' and the process is mainly related to the table olive industry.

There are several other methods of preparation for table olives by adopting some modifications of the above processes.

XIV. OLIVE OIL QUALITY

Olive oil quality depends on several factors of production and processing operations performed in olive fruits. The quality of olive oil depends on the following production factors and they contribute quality by 5 to 30 percent.

Table 8. Percentage of quality as affected by factors responsible for production.

Varietal character	20%
Ripening stage	30 %
Harvesting methods	5%
Transport facilities	5%
Storage and their methods	10%

But, the quality of olive oil from processing points depends on extraction methods (heat and cold methods) as much as by 30%. Compared to cold method the heat method produces low quality oils.

Varietal character:

In Europe there are also several agreements and regulations to promote olive oil quality as well as to protect special quality for specific geographic areas. The varietal characters in a determinate zone are given from the results obtained for a selected cultivar or cultivar groups following the indications of the Union International pour la Protection des Obtention Vegetables (U.P.O.V.), Geneva and its modifications made by Barranco et al. 1984 and Cimato et al., 1993.

Ripening stage and Harvesting time:

The best period for harvesting olives is at the stage when maximum quantity of oil together with best organoleptic characteristics can be obtained. The ripening process is initiated in the olive as the temperature starts decreasing and hormones like ethylene increasing. The typical change in the colour of epicarp and then the mesocarp is the ripening index. With the ripening process the oil content rise day by day inside the drup until all process have been completed; later on, the percentage of oil remains contstant but it looses
water.

In Himachal Pradesh (India), Pietro Bartolucci and Gaetano Tassone conducted a trial in 1992 to ascertain the percentage and quality of olive oil in different climatic environments. In main olive growing areas they observed that there was increase in oil in the pulp from 8.1 % to 19.6 % from 20th of October (first processing operation) up to 16th December. After December, any supplementary increase in oil content inside the pulp was only apparent as it is due to water loss through the epicarp. The oil was expressed in kg.

Table 9. Composition of olive oil in medium -ripe olive fruits per 100g.

Palmitic acid (%)	13.2
Palmitoleic acid	0.7
Stearic acid	2.2
Oleic acid	74.5
Linoleic acid	trace
Arachid acid	0.1
Unsaponif.	1.2
Hydrocarbon (mg)	500.0
Squalen(mg)	500.0
Sterols(mg)	100.0
Carotinoids (mg)	100.0
Tochopherol (ppm)	62.0

Table 10. Chemical composition of different parts of fruits *(%).*

Contents	Fruit	Pulp	Stone	Seed
Water	45-55	50-60	10.0	30
Oil	13-28	15-30	0.7	27
N compounds	1.5-2.0	2-4	3.3	10
C compounds	18-24	3-7	-	-
Fibre	5-8	3-6	-	-
Ash	1-2	1-2	4.0	1.5
Undeterminated	-	-	3.0	2.5

Composition of panels in terms of percentage is water 30%; oil 8%; solides (mainly carbohydrates) 62%.

High value extra virgin olive oil should have the following requisites:
Colour : green to yellow; Odor : intense, fruity; Test: fruity, little sour and pungency Fatty acid: total of oleic acid not more than 65 g. /100 g. of oil; Panel test : > = 7; Perossidi No. : > =12; K232 < = 2.0; k270 < - 0.20; Oleic acid < - 82%; and Poliphenols total: > = 150 ppm.

Olive ripening stages:

The ripening of olive fruits are categorized into 5 different phases which are listed below:

Phase 1 - 100% green olives.
Phase 2 - 50 % colour change.
Phase 3 - 100% colour change at skin level.
Phase 4 - 50% colour change in the pulp.
Phase 5-100% colour change in the pulp.

Olives should not be harvested at Phase 5. It is better to harvest fruits before natural drop (within a drop of 5-10% fruits) occurs. Good olive oil quality is obtained from processing olives that are harvested when they reach to Phase 2 and 3.

Storage of olive oil:

Olives should be processed within two days from the date of harvesting.
If they have to be stored for longer time then it needs to follow the recommendations given below:

a) Keep in cool store where temperature is 10-15° C.
b) At low Relative Humidity of 50 -60 %.
c) Keep olives on several layers of 10 to 12 cm thick to permit the air flow through the fruits, and plastic boxes can be utilized for this purpose.

XV. OLIVE-OIL INTERNATIONAL AGREEMENT

There is a production of 10 million tons of olive; out of which 9 million tons go to make oil and 1 for making table-olive. All the production is almost consumed in the same producing countries/areas.

All basic agricultural products are included in fundamental principles recommended by Social and Economical Council of the United Nations. The International Conference on Olive oil and Table olive aims to regulate the world olive market, better production efficiency particularly quality products, to promote the consumption of olive oil. This International Conference was held in 1956 to formulate policies and regulations, which were reactivated and implemented in 1986 when the Fourth International Conference was held. The International Olive -Oil Council (IOOC) is a Multi government Structure for the administration of International Conferences and for the regulation of the International Trade, amelioration of olive cultivation, to preserve and promote the olive sector.

IOOC has estimated a need of 200 million olive planting materials in the next few years. It is possible therefore there is a very bright market for olives in future.

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