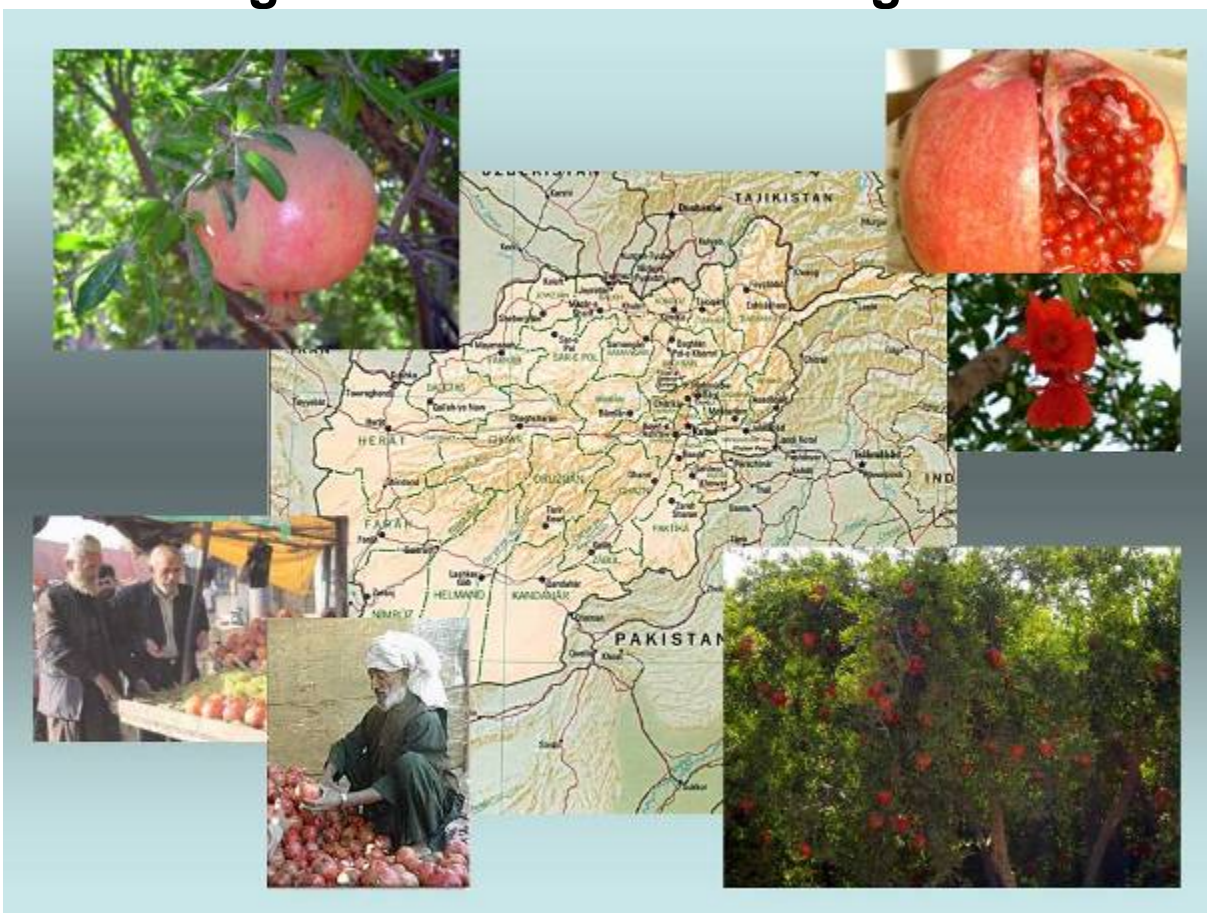




Pomegranate Production in Afghanistan



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1. Pomegranate: Origins and where it is grown

The pomegranate is native from Iran to the Himalayas in northern India and has been cultivated and naturalized over the Mediterranean region and the Caucasus region of Asia since ancient times. Pomegranate adapts to all kinds of soil and climate; it is tolerant of drought, salt, iron chlorosis and active calcium carbonate. It is widely cultivated throughout Iran, India, the drier parts of southeast Asia, Malaya, the East Indies, and dry, hot areas of the United States and Latin America. It typically grows below 1000 m in altitude, is mainly confined to the tropics and subtropics and grows well in arid and semi-arid climates.

Favorable growth takes place where winters are cool and summers are hot. It has the ability to withstand frosty conditions, but below -10°C will not survive long. A temperature of 38°C and a dry climate during fruit development produces the best quality fruits. Areas with high relative humidity or rain are totally unsuitable for its cultivation, as fruits produced under such conditions tend to taste less sweet and are prone to cracking.

Today, pomegranates are grown on all continents except Antarctica. Production worldwide is led by the United States (states of California and Arizona), followed by Turkey, Tunisia, Spain and Iran, although few current production statistics are available.

- California produces about 17,000 metric tons annually on about 6,639 hectares, for a value of \$4.9 million. Plantings are increasing as the health benefits of the fruit are high.
- In Tunisia, total acreage in 1999 was reported at about 15,000 ha amounting to 5 million pomegranate trees as regular plantations or scattered trees in mixed fruit orchards. The annual production was ~50,000 tons in 1997. The fruits normally are sold in the local markets and small quantities (1%) are exported.
- Turkey reported annual production of 56,000 tons in 1996.
- Iran reported total pomegranate production at 600,000 tons in 2005.
- Currently about 2% of the horticultural production in Afghanistan is from pomegranates. (Altai Consulting, Kabul, Afghanistan and FAO Survey 1997, 2003), growing in Balkh, Helmand, and Nimroz provinces and in Kandahar. The local varieties grown in the main production area of Kandahar Province (4,032 jeribs or 806 ha) are known for their high quality and productivity. Farmers reported average yields ranging from about 1,720 kg/jerib (344/ha) in Dand District to more than 3,800 kg/jeribs (760 kg/ha) in Arghandab District. Farah Province is also well known for pomegranate production and the high quality of its fruits (1,097 jeribs or 219 ha). Pomegranate ranks second as its main fruit crop.

Production is increasing due to higher demand for pomegranate products, especially juice, as the health benefits of pomegranate are realized.

2. What kind of fruit is a pomegranate; what are its growth characteristics?

The pomegranate (*Punica granatum*) is a shrub or a small tree up to 8 meters high (most are considerably smaller) that is evergreen in the tropics and deciduous in the subtropics and temperate zones. The pomegranate plant is more or less spiny, deciduous, with small, narrow, oblong leaves with short stems.

The trunk is covered by a red-brown bark which later becomes gray. Branches are stiff, angular and often spiny. There is a strong tendency to sucker from the base, which gives rise to the bush or shrub form of growth. In orchards, plants are normally trained to a single trunk, forming a large shrub or small tree. Trees may be trained to multiple trunks in colder areas, to reduce risk of total tree loss. While pomegranates may live as long as 200 years, vigor declines after about 15 years and the plant becomes non-productive. Most pomegranates begin fruiting in their second year (some in the first year), but substantial bearing does not begin until 3-5 years.



Flowers may be white, pink, red or orange. Flowers may be male (with a few atrophied ovules) or 'perfect', containing both male and female parts and producing the crop. Most pomegranates are self-fertile, although they will set a better crop if another cultivar is available for cross-pollination; fruit set has been increased 38% with cross pollination. A few pomegranates are not self-fertile and require compatible pollenizers. Pollination is by insects, usually honey bees. Normal flowering of pomegranate varieties occurs, in general, between March-April and July-August. It continues for up to 10-12 weeks or more depending on variety and geographical situation. The period of full bloom lasts about one month, and it was observed that flowering and fruit set occurs in about 3 or 4 distinct waves (periods). The percentage of male flowers is high (more than 60-70%) depending on varieties and season. There are cultivar differences in when the two types of flowers predominate in the bloom period (more male flowers or more perfect flowers), but generally, higher numbers of perfect flowers bloom in the first wave of flowering, gradually decreasing towards full bloom, then increasing again. Fruit retention (at harvest) from the earliest flowers to those opening near full bloom, increased from about 30% during early flowering to about 80% during full bloom and/or late flowering. Flowers produced 4 to 5 weeks after the onset of blooming give the highest fruit set (90%) with the lowest fruit cracking and the best fruit quality. Thus, thinning the early and late fruit can improve the crop overall in quality.

The fruit is 3.5 to 6.5 cm wide, weighs 30 to 120 grams and requires 3 to 6 months to develop and ripen. The pomegranate has a leathery smooth skin and is divided by thin inedible membranes into a number of cells, each packed full of angular seeds contained in a juicy pulp sac. Fruits may be white/green, pink or red on the exterior with a background yellow hue and the pulp color follows that of the exterior.

High temperatures are essential during the fruiting period to get the best flavor. Darkly color fruit tend to have the best flavor; fruit color is cultivar-specific.

3. Cultivars

The only other species of the genus *Punica* is *P. proto-punica* (also called *P. nana*), which is not commercially produced or edible.

Many cultivar names are unique to the country where grown and genetic origins of these cultivars is often undetermined, therefore, there may be more than one cultivar name for a given pomegranate. Hundreds of cultivars and types exist across many countries. Varieties are often classified as sweet, sweet-sour and sour, early, mid season and late, juicy and table fruit, soft-seeded and hard-seeded or major and minor. The names originate frequently either from the place of cultivation or from the color of the fruit. Although about 3,000 cultivars have been described, only one cultivar, 'Wonderful', is commonly grown worldwide, especially in California, Chile, and Israel.

Fruits with hard seeds possess poor eating quality and, therefore, cultivars producing soft seeded fruits are preferred. Hard seeded fruits with higher juice content and an intense red color are utilized for processing.

USA

'Wonderful'—originated as a cutting in Florida; propagated in California in 1896. The fruit is round but flattened at the poles, very large, dark purple-red, with medium-thick rind; deep-red, juicy, winey pulp; medium-hard seeds. Plant is vigorous and productive. Large purple-red fruit. Best quality in hot inland climate; long-lived any soil. Bears in the first year of planting. Self-fertile. Harvest is Aug 25-Oct 1. Requires 150 chill hours (hours at or below 6 °C).



Other cultivars are also available, but less commonly grown. These include:

'Ambrosia' -- up to three times the size of 'Wonderful'. Pale pink skin, purple sweet-tart juice, similar to 'Wonderful'. Needs 150 chill hours.



'Eversweet' -- Very sweet, virtually seedless fruit. (Even immature fruits are sweet.) Red skin, clear (non-staining) juice. Harvest late summer through fall. Coast or inland. Large, showy, orange-red flowers. Requires 150 chill hours. Self-fruitful.

'Grenada' -- Fruit is a deep red color, inside and out. Commercial plantings of this cultivar are increasing in California.



'Kashmir'

'Red Silk' -- A dwarf pomegranate which will grow up to 2 m. This UC Davis cultivar is a heavy bearer of large fruit with red juice and a delicious grenadine flavor. It has a pleasing balance of acid and sweetness.

'Sweet Pomegranate' -- Sweeter fruit than 'Wonderful', with better quality in cool-summer climates. Small, glossy-leaved, ornamental tree with showy orange-red blossoms in late spring. Very suitable to espalier and container growing. Harvest late summer. Unsplit ripe fruit stores in cool, dry place for two months or more. Very low chilling requirement, about 100 hours. Self-fruitful.



Turkey

One of the countries of origin of the pomegranate; many types and forms growing over diverse areas. Types are based on sweetness and seed type, primarily, and include: sour, sour-sweet and sweet varieties and those of varying seed toughness (soft-seed, intermediate and hard-seed).

'Fellahyemez', 'Eksilik', 'Ernar', 'Hicaznar', 'Katirbasi' and 'Asinar'

Tunisia

One of the countries of origin of the pomegranate and grown in various regions of the country; numerous types and forms, or 'cultivars'. Their names are strictly local originating from the place of cultivation or from the color of the fruit and many synonyms may be found. Interchange of plant material was very frequent between regions, as shown by genetic typing (types found in any given area may not be closely related, thus, not specific to region of current production). Fruits produced in traditional orchards are not appropriate for the new markets and many old plantations have been removed. A few local varieties are propagated in commercial nurseries and used in the new plantations. Some forms are called 'Mezzi', 'Ruanzi' or 'Garoussi'; there are at least 4 genetically-related groups.

Spain

In Spain, pomegranates are mainly grown in the Alicante and Murcia provinces (southeast of Spain), where summer air temperatures normally rise above 40 °C. The species characteristics are highly variable among cultivars; 'Mollar de Elche' is the main cultivar grown, 'Roja' and 'Valenciana' are additional cultivars. 'Valenciana' is redder on the outside than 'Mollar', but more pale inside and not as sweet. New cultivars are currently being introduced through breeding programs to improve commercial products.

Iran

Sweet cultivars (for fresh consumption): 'Alak-E-Shirin', 'Bihasteh', 'Syah', 'Agha Mohammad Ali Shirin' and 'Malase Shirin'. Others: 'Malase Torsh' and 'Pust Sefeede Shirin' Rootstock and ornamentals: 'Alak-E-Torsh', 'Tabestani' and 'Pust Sefeede Torsh'

Italy, especially Sicily

'Ragana', 'Racalmuto', 'Profeta', 'Selinunte', 'Neirana' and 'Dente di cavallo'

India

Preference is usually given those with fleshy, juicy pulp around the seeds. Types with relatively soft seeds are often classed as "seedless". 'Bedana', 'Kandhari', 'Alandi' ('Vadki'), 'Dholka', 'Kabul', 'Muscat Red', 'Paper Shell', 'Poona', 'Spanish Ruby', 'Velloodu', 'Muscat White'

While there is limited information available on the cultivars of pomegranate grown in many parts of the Middle East and Asia, the following cultivars are of commercial importance as listed:

Iraq: 'Ahmar', 'Aswad', 'Halwa'

Saudi Arabia: 'Mangulati'

Israel (Jewish sector): 'Wonderful' and 'Red Loufani' – less sweet and tangy than those of the Arab sector

Israel (Arab sector): 'Malissi' and 'Ras el Baghl'

4. Breeding of Pomegranates; selection of commercial cultivars

Main objectives related to the tree are:

- High productivity: high yielding is desirable.
- Dwarfing habit: this is a desirable pomegranate tree characteristic for mechanical and easy hand harvesting in particular growing conditions.
- Frost resistance: this is particularly important in zones with very severe winters. Frost-hardiness is dependent on many factors (age, state of the plant, time of minimum winter temperature occurring). Frost sensitivity varies with cultivars. Soft-seeded cultivars are, generally, less frost-hardy than hard-seeded ones.

Main objectives related to fruits are:

- Good fruit quality: includes fruit size and shape, rind and seed color, juiciness, sugar content and acidity, taste. There is large variability among cultivars for these traits that may be greatly influenced by agro-environment and harvesting date. There is no consistent relationship between fruit size or skin color development and internal fruit quality. Relatively high juice content may be more desirable than large size.

- Soft-seededness: softness or absence of seeds is a desirable economic trait that improves the consumptive qualities of fruits. Many cultivars and forms of pomegranate are quite heterogeneous for this characteristic. Hard seed formation can be induced by cross-pollination of soft-seeded cultivars with hard-seeded ones.
- Resistance to fruit cracking: this is strongly affected by climate and orchard management, particularly water regime and irrigation scheduling.
- Resistance to fruit borers: various larvae of moths and butterflies are well known pests of pomegranate and can cause considerable fruit losses when larvae (worms) damage fruit. Acid fruits are less damaged than sweet ones.
- Good post-harvest quality: storage and transport of pomegranate fruits are becoming common in many countries. Keeping post-harvest good quality and resistance to fruit handling are desirable traits.

5. What are pomegranates' growing requirements?

5.1 Temperature

The species is primarily mild-temperate to subtropical and naturally adapted to regions with cool winters and hot summers. It can be severely injured by temperatures below -11 °C. The plant leafs out first and then blooms and is susceptible to frost damage from first leafing through their extended flowering. The plant favors a semi-arid climate and is extremely drought -tolerant. Pomegranates produce best in full sun. Bark damage due to freezing or sunburn may be reduced by painting trunks white to minimize temperature fluctuation during cold nights and warm days when the trunk is exposed to direct sunlight.

5.2 Soil

The pomegranate grows in most soils, with the exception of saline or very calcareous, alkaline soils. While pomegranate tolerates mildly alkaline soils, up to pH 7.5, they prefer slightly acid soil (pH 5.5-6.5). Pomegranates produce best on deep, heavy loam, but medium to heavy soils are acceptable if good drainage is provided. Pomegranates will tolerate some flooding. However, as pomegranates are generally irrigated heavily in the fall to increase fruit size through harvest no irrigating is done in the winter as this will produce excessively vegetative spring growth. In heavy soils planting on berms (raised mounds of soil) will improve soil aeration and yields. Light to sandy soils are also used in pomegranate cultivation as long as orchards are well-irrigated.

6. Where do pomegranates grow in Afghanistan? What cultivars are grown?

Pomegranates from Kandahar province have historically been widely known as of high quality. Many pomegranate orchards are located along the Arghandab River. Annual

production in the Kandahar Province is approximately 20,000 metric tons; and the main cultivar is 'Kandahari'. In the Tagib Province, the main cultivar is 'Bedana' and approximately 4,000 metric tons are produced annually. Smaller volumes are produced elsewhere in Afghanistan. Elevation is the main restriction in production, with 'Bedana' produced in Nangarhar at or above 1000 m in elevation. 'Kandahari' is produced at elevations from 550 m to below 1000 m.

7. Planning the orchard

7.1 Choosing a cultivar

What cultivar should a grower plant and why?

Generally, the best cultivars can be recognized using the following characteristics:

- Pink or red-flowered types includes most of the common and all the desirable and commercial varieties of pomegranates.
 - Dark crimson fruited varieties tend to be more tart
 - Whitish or pinkish fruit tend to be more sweet
- Fruit maturing at the same time all over the tree; allows a single picking and tends to split less, therefore
- Large fruit, unless small-fruited varieties are very early-maturing, therefore demanding a premium market price
- Stores and ships well
- Fruit's seeds have high percentage of flesh to seed; seeds very small and soft are preferable
- Self-compatible (most cultivars are)

Self-Compatibility: Most cultivars are self-compatible, and set fruit without a pollinizer, but fruit setting can be improved with pollinizers. When in doubt, plant 2 or more cultivars and they will most likely be cross-compatible, and set a better crop than a single cultivar.

7.2 Propagation

The pomegranate may be propagated by means of hardwood or softwood cuttings, or by seed. Softwood cuttings made late in the growing season can be rooted in nursery beds or greenhouses, but this is not the standard method of propagation. Seeds germinate easily without going through a rest period, but trees are not grown commercially from seed germination because seedlings do not come true to variety. Such seedlings produce fruit of widely varying characteristics: large to small, juicy to woody, dark-red or purple to almost white, and from sweet to sour.

Trees are easily propagated by hardwood cuttings, 15-20 cm in length and pencil size or larger in diameter. Cuttings should be taken from the previous seasons sucker or vegetative

shoot growth (cut off portions with flower buds and any remaining leaves) in late dormant season before any bud expansion occurs (February or March) and placed vertically in sterile soil with the top node exposed in greenhouses, or directly planted in nursery beds. Pomegranate cuttings root with great ease, facilitating the spread of desirable clones. Cuttings may be left in nursery rows for 1 to 2 years; a single year in the nursery bed is most often adequate before planting in permanent orchard. When transplanting from the nursery bed the slightly brittle roots will grow better if trimmed. Grafting pomegranate is not generally successful.

7.3 Site selection and preparation

Production depends on tree size, vigor and ability to crop. The factors most limiting tree size in Nangahar fruit-growing areas include:

- climate, especially lack of abundant water by rain or irrigation, and frost, where winter temperatures may be -5 to -15 °C. If frost occurs in spring just before or during bloom, the crop can be destroyed
- soil—deep, fertile soils optimize growth; poor soils restrict growth; do not grow on saline or alkaline soils
- fertility—to be productive, trees do best with applied fertilizers

7.3.1 Site selection

Deep, well-drained sandy loams with good moisture and nutrient-holding capacity are the best soils for pomegranate growing. Do not plant in salty (saline) or alkaline soils. Pomegranates can tolerate moderate flooding. Full sunlight nearly all day long is essential. Trees that do not receive at least 6-8 hours of direct sunlight each day will produce long thin branches with few flowers and fruits. Areas of heavy summer rainfall are not appropriate for pomegranate cultivation as fruit will be soft and rot easily in storage.

Here's a simple test to determine your soil's internal drainage—to see if you have a good site for fruit trees. Dig a narrow hole 1 meter deep and fill it up with water. If the water is gone within 24 hours, you'll have no trouble growing fruit and nut trees. If the water is gone within 48 hours, the soil is acceptable but can give problems. If water is still in the hole after 48 hours, grow vegetables or flowers instead.

7.3.2 Frost protection

Planning the orchard to reduce the danger of frost at early leaf out, bloom and young fruit stage:

Trees planted in open areas and trees exposed to cold prevailing winds are most likely to suffer frost damage. Low areas will collect cold air; avoid planting in depressions or basins. Planting near structures or walls, especially those with a southwest exposure, will take advantage of heat absorbed by the structure.

- Do not plant in low areas where cold air is trapped by surrounding hills or vegetation
- Make sure the ground is firm, moist and exposed to sunlight by removing ground cover or keeping it low and not cultivating the soil during the cold months

- Plant on north-facing slopes to help trees bloom later

The best way to reduce cold damage is to maintain healthy trees. Use cultural practices that induce and maintain dormancy in winter. These methods include no late summer or fall fertilization or pruning. Vigorous trees may recover from cold injury. Weak trees that show disease, insect damage, or nutritional deficiencies are the most severely damaged and the slowest to recover.

Grass, weeds, and straw mulches prevent heat from entering the soil during the day, so less energy is stored for release at night. Keep the ground around the tree as clean and free from mulch, weeds and ground cover as possible. Avoid planting a cover crop in the orchard, or follow the guidelines under the section 'Cover crops'.

7.3.3 Soil preparation, amendment/fertilization

Prepare soil thoroughly by plowing, tilling or spading before planting. Remove all weeds. Incorporate lime and organic matter such as well rotted manure or compost into the top 20-25 cm of soil before planting. Apply lime if soil is below pH 7, at a rate of 4.5 kg lime per 9 square meters. Prepare the soil before the trees arrive from the nursery if possible.

Pomegranate does not usually develop many nutrient deficiencies. The level of N fertility has more influence on the growth, yield, and quality of pomegranates than any other single plant nutrient. Adequate supplies of N are necessary to optimize growth and development of newly planted trees.

7.3.4 Pre-plant fertilization

Compost, animal manure and green manure can be worked into the soil to a depth of 1 m, however, this should not be added directly to the tree planting hole at the time of planting, but in advance of planting so that rotting can occur and be completed prior to planting, otherwise root rot is likely. Organic sources of N, such as urea should be applied during winter and/or spring, to allow for timely decomposition and release of nutrients. If nitrogen is to be applied, it should be applied at the rate of 20-55 kg per hectare of actual nitrogen.

7.3.5 Eliminating weeds

Many weeds compete strongly with new pomegranate trees and should be eliminated before tree planting.

7.3.6 Planting design

Pomegranates are planted in solid blocks if self-fruitful, at spacings of up to 5-7 and 3-5 meters between rows and trees in the row, depending on form chosen (tree or bush form), potential vigor of orchard (dependent on soil quality, adequate water, cultivar and nutrition). If cross-pollination is required, pollenizers can be in equal numbers as the cultivars they pollinate, if the pollenizer produces desirable fruit. If the pollenizer fruit is of poor quality, plant 1 pollenizer to every 9 main crop trees, spacing the pollenizers evenly in the orchard. The most effective design with pollenizers is on a 3 x 3 tree square, with 9 trees and the center tree is a pollenizer; the pattern is every third row and every third tree..

Closer spacing may result in smaller trees, or if trees become too big they will shade each other out and fruit production will be reduced. Pomegranate trees that are well-watered and well-fertilized can grow up to 9 meters tall, but if allowed to grow vigorously to this size, few fruit will be produced. Pomegranate trees will develop at least a 5-meter diameter limb spread at maturity. Plant them far enough apart to avoid excessive competition. Orienting the tree rows north to south will improve light exposure to the fruit.

7.3.7 Shaping your young trees

Pomegranate is naturally multi-trunked, or bush form, however, pomegranates are usually grown as trees, trained as 'vase-shaped' or 'open center' trees to get enough light into all parts of the canopy so that flower buds will form and best quality fruit will be produced. If grown as 'bush form', generally no more than 3-5 trunks will be allowed to grow. Growing pomegranates as a hedge reduces fruit production as trees benefit from light on all sides. In a crowded orchard, production is lowered, fruits are set only at the top of the trees, fruit color is poor and proper application of spray materials is not adequate. Ideal planting distance is 6×4 m or 6×5 m for full-size cultivars. In semi-dwarf cultivars planting distances can be closer (5×3 m). New vigorous branches appearing on exposed trunks should be hand-removed when they appear during the growing season as they will not be very productive and light penetration will be reduced. However, if the tree needs renewal because it is aging and production is reduced, new branches may be left as one per trunk, to renew the old wood. These will replace a trunk with fruit production within 2-3 years. Tree height should be maintained at 3.0-3.5 m. for a pedestrian orchard, or no more than 5 m. for ladder work, as harvest becomes more difficult as fruit will mostly be produced at the top of the tree. If the orchard is not vigorous, do not allow growth above 3-3.5 m because the orchard space will not be filled and land will be wasted with reduced yields. **Trees have limited resources for growth and reproduction; if all resources are used for vegetative growth to get big trees, no resources will be available to produce fruit. Big trees do not produce more fruit.**



8 Orchard establishment

8.1 Nursery trees and planting

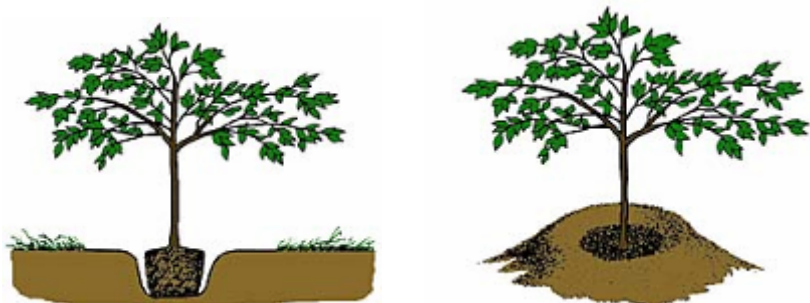
If bare root trees arrive from the nursery wrapped, open the bundles immediately to inspect for damage and check general condition of the trees. Make sure the roots do not dry out; most fruit trees will be 'bare root', that is without soil around the roots when they come from the nursery. "Heel in" the trees if you are not ready to plant them. "Heeling in" means to dig a shallow trench in which tree roots or a bundle of trees can be covered with moist soil to protect them until planting. Potted trees may be held until the ground is ready for planting, but monitor the potting soil to make sure it does not dry out completely. Trim the roots before planting to root breakage. Plant when the ground is not frozen, but before trees start to 'leaf out' in the winter, to allow for root development before spring growth.

During the first two or three years, the objective is to develop a sturdy tree of good size. Little or no training is given pomegranate trees, other than topping them at planting to assure development of low heads. It is advisable to allow the tree to grow its branches at a minimum height of 2/3-1 m to prevent fruit from touching the soil when on low limbs.

8.2 When to plant, How to plant (potted or bare root trees)

If planting a potted tree, hand dig a planting hole approximately twice as big as the pot and slightly deeper than the root ball of the potted tree. Do not add fertilizer to the hole or immediately next to the new tree at the time of planting; the roots need time to grow into the orchard soil before they can absorb fertilizer.

Build a mound of soil in the center of the hole and rest the trimmed root ball on the mound, measuring for the final height of the tree's original soil line at the top of the root ball to be level with, or slightly higher than, the soil level of the orchard. Add soil to the mound, tamping it slightly, until it is high enough to bring the tree's soil line up to the proper level. Do not add any other soil amendments to the hole, such as fertilizer or compost. Remove the plant from the pot, gently loosen the root ball and place in the planting hole. If container-grown trees have a tap root curled in the bottom of a container, cut this root off at the point where it begins to curl. Separate and trim the roots of container trees that may be root-bound. If the root ball is very compacted, score the sides in several places with a knife and slightly loosen the soil around the roots. The pomegranate should be planted at or slightly above the same level at which it grew in its pot. Fill the planting hole with soil around the root ball while holding the tree upright. Gently but firmly tamp in the soil, adding enough to fill the hole and keep the top of the root ball level with, or slightly higher than, the orchard soil line. Water thoroughly to settle the roots and eliminate air pockets. If the tree sinks too much, re-dig and add more soil to bring the tree up.



If planting bareroot, dig a hole only as large as necessary to accommodate the root system. Do not add any other soil amendments to the hole, such as fertilizer or compost. Trees should be planted with their top major roots even with the soil line. Prune any damaged roots back beyond the damaged area. Save the soil from the hole to use as backfill, removing any rocks, grass or debris from the dug-up soil; break up clods. If the hole is deeper than the root system (with the root line even with the soil line), prior to placing the tree in the hole, backfill with enough soil to hold the tree slightly higher than the soil line. Firmly press the soil before setting the tree on it. Be sure the root ball or container soil rests on solid ground to prevent settling.

8.2.1 Water

After the tree is planted, water well. Check the original soil line one last time. If the tree does settle, now is the time to move it back to the correct position with the soil level against trunk at the same level that it was in the container. Construct a basin for watering the newly planted tree, making sure that water drains away from the trunk. The basin should be slightly wider than the planting hole so that water can be applied to the entire root area and just beyond. Most of the root volume occupies a rather limited area, particularly through the first growing season, so frequent watering may be needed until the roots become established. Fill the basin once or twice a week in hot weather, less often when it is cool or rainy. Water must soak into the root ball of container-grown or bare-root trees since they cannot obtain water from the surrounding soil until their roots grow into it. Level the basin in winter so that the tree does not stand in accumulated rainwater. The ground within about 1 m of the tree trunk should be kept free of grass, weeds, or other vegetation that can compete with the tree for water and nutrients. A layer of mulch 7.5 to 15 cm thick, such as wood chips or grass cuttings helps control weeds, keeps roots cool and conserve moisture. Mulch should be kept several cm away from the trunk to minimize the occurrence of crown rot and eliminate hiding places for insect pests.

8.2.2 Stake if needed

Unless the tree bends over, it will not need support from staking. If stakes are needed, place them on opposite sides of the tree, perpendicular to the direction of the prevailing wind. Stakes should be positioned outside the root ball area, but no further than the tree ties can reach. Drive stakes into soil so that the top of the stakes should be a couple of inches below the lowest main branch.

Place tree ties about 15 cm above the spot where the tree bends which will be about 2/3 to 1/2 of the way up the tree. In order to prevent ties from rubbing the tree's bark use rubber loops cut from automotive tires between the ties and the tree. Loop ties around the tree and attach one to each stake. Ties should be loose, so that the tree can sway, and the trunk can grow stronger.

8.2.3 Sunburn protection at planting

The bark of newly-planted trees is very easily damaged by too much sun; when injured, the bark is easily infested by borer insects. Protect the bark of the tree from sunburn immediately after planting by painting with white interior latex paint diluted to half strength with water. Apply the paint mixture from the soil surface up the entire trunk, including the dormant buds.

8.3 Training and Pruning newly-planted trees

After planting, cut trees back to 60-75 cm and develop three to five symmetrically spaced scaffold limbs by pinching back new shoots, the lowest at least 20-25 cm from the ground. Shorten branches to 3/5 of their length ('heading' or 'stub' cut) during the winter following planting, leaving 2-3 buds per headed lateral branch. Remove interfering branches and sprouts leaving two or three shoots per scaffold branch. If bush form is desired, do the same for the 3-5 trunks selected as the strongest; remove other trunks. Shorter upright branches are preferred as these will not bend as easily and expose fruit to the harsh sunlight and sunburn late in the season. Too much sun exposure also causes the arils to lose their desirable red color.

The pomegranate trunk spirals as it grows, and due to its bush like habit suckers easily. The combination of these two traits sometimes forms a bulge low on the trunk, often below the soil line. Care should be taken to not let water accumulate in the depression between this bulge and the trunk as it generates *Phytophthora*. Generally, care should be taken to keep the trunks dry.

8.3.1 Why prune pomegranate?

- Training develops a strong tree structure that can support heavy crops without breakage.
- Training helps to bring a young tree into production at an early age.

An important goal of is to train the tree to use its resources for fruit production, not just vegetative growth. Training also maintains trees that are easier to prune, thin excessive crop to get big fruit, manage pests and harvest. Young trees are pruned to establish a strong scaffold (main branch) system of wide-angled, well-spaced branches capable of supporting large crops with a minimum of branch breakage. If a bush form is desired for pomegranate, 3 to 5 trunks can be left, evenly-spaced. With older bearing trees pruning is done to:

1. Eliminate or reduce those parts/portions of the tree that tend to bear fruit of poor quality ; particularly in season tipping to encourage early bloom or to remove the latest bloom which produces poor quality fruit because it does not have time to fully ripen.
2. Maintain suitable branch spacing to allow penetration of light and spray materials
3. Maintain desired shape, height and breadth of the tree.

See Figure 1 below for tree structure and definitions.

8.3.2 General rules for pruning pomegranate trees

- Prune trees at planting time to balance the tops with the roots.
- Prune young trees very lightly.
- Prune mature trees more heavily, especially if they've shown little growth so that they are re-invigorated. Tree canopy should be kept open with considerable thinning-out in order to induce annual formation of fruit-bearing wood. The fruit will form mostly on the outer part of the canopy where light penetration is best.

- Prune when all danger from fall or early winter freeze has passed, but before full bloom in spring. This reduces the risk of disease and injury, however, pomegranates bloom very early; consequently, all or most of the flowers or young fruits are frequently killed by frost. Delaying pruning until after bloom may be advisable with pomegranates grown in an area that gets late frost frequently.
- Prune less heavily if there is a light or no crop at all.
- Prune the top portion of the tree more heavily than the lower portion as the top is where most vegetative growth occurs.
- Thin out more shoots toward the end of a well-pruned branch in a mature tree. This will increase fruit size and quality on the remaining shoots.
- Prune to maintain height that makes management and harvesting easy and keeps tree productive (taller trees do not bear more fruit!)

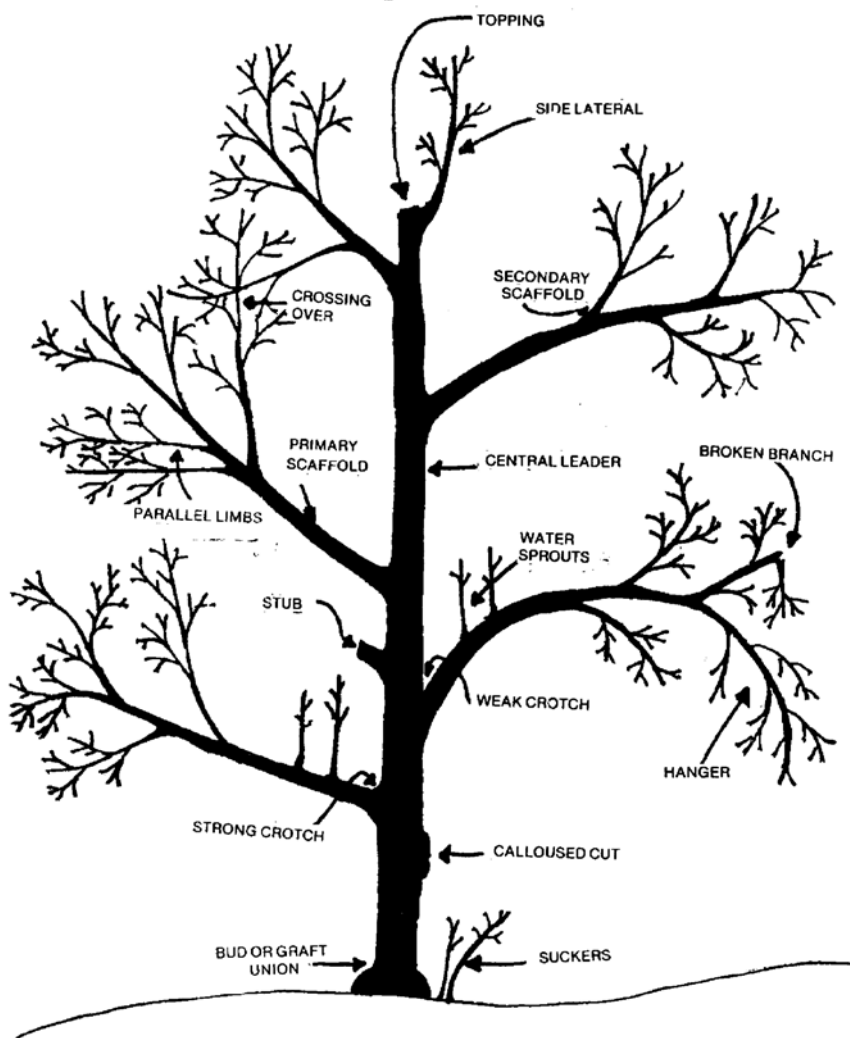


Figure 1. General fruit tree structure

8.3.3 Training systems

Pomegranate can be grown either as a tree form (most often with open center or 'vase' structure) or as a multi-trunk bush form (3-5 trunks), which is the pomegranate's natural tendency (tend to be bushy). In the first 2 years of growth, prune to develop and maintain 3-5 scaffolds, either as trunks for a bush form or as scaffold limbs arising evenly spaced from a single trunk (tree form). Pomegranate tends to sucker as part of its 'bushy habit'. Suckers should be removed frequently as they will divert growth from fruiting into non-productive vegetative growth

Year 1: In the first year, the new trees are topped (headed back) at planting and suckered in summer. (see pruning after planting)

Year 2: Regular pruning and suckering begins in late dormancy of the second year with additional suckering in summer. Prune branches by 1/3 during the first winter after planting. Remove crossing branches and shoots, leaving 3-5 shoots/branch.

Year 3 and thereafter: Light annual pruning of established trees encourages fruit production; pomegranates tend not to require heavy pruning if maintained regularly. Remove dead and damaged wood during late winter and remove sprouts and suckers as they appear. Heavy pruning will reduce the crop.

Types of pruning cuts: The 2 main types of pruning cuts are 'heading' or 'heading back' and 'thinning' or 'thinning out'. Trees respond differently to these cuts.

- 1) Heading cuts: Heading back is cutting the plant back to a stub, lateral bud, or small lateral branch (Figure 2). Depending on the severity of pruning, heading back results in a flush of vigorous, upright, and dense new growth from just below the cut.

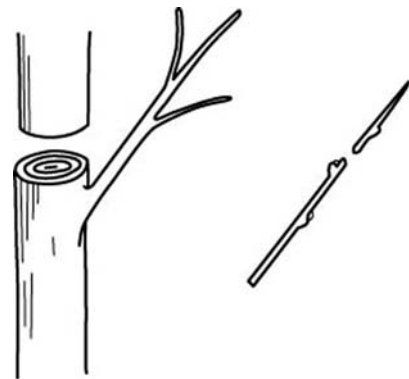


Figure 2. Heading cuts on main trunk and on side limb.

- 2) Thinning cuts: Thinning is removing a lateral branch at the bottom where it attaches or shortening a branch's length by cutting to a lateral large enough to take over the 'job' of the terminal limb (Figure 3). A woody plant responds to thinning by becoming more open but retaining its natural growth habit and does not usually produce a flush of new vigorous growth from the cut. Foliage grows more deeply into the tree because more light can

penetrate the canopy. Except when trees are newly-planted, pruning cuts should be mostly thinning cuts.

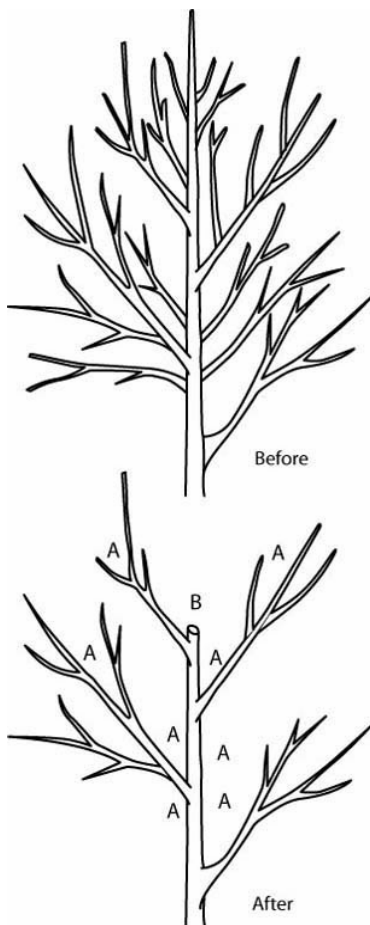


Figure 3. Thinning removes branches completely (a thinning cut made at every 'A' location), while a heading cut removes the end of a shoot (as at 'B').

8.4 Irrigating pomegranate trees after planting and in the first year

Water requirements for pomegranate are about the same as for citrus--125-150 cm per year. If rainfall during the growing season isn't frequent, pomegranate orchards should be watered every 7-10 days, with more frequent irrigations for light to medium soils, less frequent for heavy soils. Pomegranate orchards are most often irrigated by drip or microsprinkler in California, Israel and European areas of production. When planting new trees, microsprinklers or drip irrigation emitters should be placed close to each tree, with 2 emitters (or sprinklers) for each tree to evenly wet the root zone. As trees grow to fill the space, these may be moved to a single emitter or microsprinkler between trees, as long as the entire root zone is wetted with each irrigation. Where flood irrigation is used, it is often controlled due to lack of water so that liberal use is not typical. As is typical for most fruit trees, newly planted bare root trees should usually not be flooded after planting if soil is heavy loam or clay and the trees have been planted during the wet dormant season. There is usually sufficient moisture in the soil for emerging roots, and flooding in a basin eliminates air spaces in heavy

soils, creating anaerobic conditions that can kill trees. The tree should be basin irrigated if the soil is sandy to loam, if the clay soil is dry, or when a potted tree is planted during the growing season.

For proper growth and fruiting it is essential that trees receive water in 'on time'. To ensure adequate moisture the soil should be thoroughly wet before wilting occurs. To avoid over-watering, excess water must drain away. Alternate wetting and drying allows oxygen necessary for root growth to enter the soil. Where pomegranate is grown in heavy soils, planting in berms may improve soil aeration and reduce water-logging of the root zone.

Watering young trees is more important than fertilizing. Young trees have a limited root system, and water should be applied frequently. As a general rule, if two weeks pass without at least 2.5 cm of rainfall on recent transplants, trees should be irrigated. Even though watering may be needed for several years, watering is most critical during the first year of grove life. Irrigate during the dry season to maintain optimum moisture in the upper soil layer where most of the roots are, especially during the crucial period of leaf expansion, bloom, fruit set and fruit enlargement.

Symptoms of too much water: yellowing leaves that drop; root rot.

Symptoms of too little water: yellowing leaves that drop, drop of small fruit

9 Orchard management: Taking care of a mature orchard

9.1 Pruning pomegranate trees – maintenance

In order to achieve the desired shape of trees they are pruned in the winter. In the winter pruning the height of the trees is brought back to the desired height. Broken, bent, and interfering branches are removed. In order to keep the interior of the tree open during growing season, summer pruning is carried out according to needs.

Remove all suckers: shoots arising from the rootstock or low on the scion (trunk suckers or water sprouts) or from the ground (root suckers) once a year. Remove branches that cross from one side of the tree to the other during dormant season pruning. Pomegranate tends to sucker heavily from the roots.

9.2 Weeds

Weed by hand frequently or with a hoe, working shallowly to prevent damage to roots.

9.3 Fertilizing young and mature orchards of pomegranate—overfertilization can cause fruit drop!

9.3.1 Typical fertilization in California:

Nitrogen is the major nutrient required for proper tree growth and optimum yields. Nitrogen fertilizer (ammonium nitrate is most common) is applied by hand during the first two years and the amount applied increases each year up to the fourth year. Beginning in the third year, the fertilizer is applied with the grower's tractor and a broadcast spreader. Annual rates of actual N applied (kg per hectare) and the equivalent in kg/ha of ammonium nitrate (33% nitrogen) for 331 trees per hectare:

Year	kg N/ha	kg ammonium nitrate/ha
1	19	57.6
2	30.5	92.4
3	50.5	153
4 and thereafter	114	345.5

Rates are for 331 trees.

This may be applied in one application in fall or winter. On light soils a split application may be desirable, one-half of the fertilizer being applied in late winter and the remainder in spring. Excessive or late applications of nitrogen may delay fruit maturity and color. Some evidence indicates that excessive nitrogen applications cause increased vegetative growth and reduce fruit production. Nitrogen can be applied in different forms: ammonium nitrate (33-0-0) or ammonium sulfate (21-0-0) are common. Urea (46-0-0) is a good source of nitrogen.

If soil pH is above 6.5, use ammonium sulfate (21-0-0) as the nitrogen source as it helps acidify the soil. If soil pH is 6.5 or below, use another source of nitrogen. If soil pH is above 7.5, do not apply phosphorus fertilizer. Generally a soil this alkaline is not suited to pomegranate. Scatter fertilizer under the spread of branches and just beyond the dripline of the outermost branches. To prevent fertilizer burn, do not apply fertilizer closer to the trunk than 20 cm.

Water thoroughly to carry the nitrogen down into the root zone. Remove competition for nutrients and water by keeping the ground bare under the tree using shallow cultivation, herbicides, or organic mulches. Don't apply excessive amounts of fertilizer. Too much nitrogen causes excessive branch growth, inhibits fruit set, causes poor fruit color and flavor, delays ripening and may subject the tree to more severe winter injury. Also, late application of nitrogen, after mid-July, can prevent the proper "hardening off" of the tree for winter dormancy.

There is not evidence to show that phosphorous (P) or potassium (K) will improve growth or fruit quality when used to fertilize pomegranate orchards. Occasionally, zinc deficiency is evident in trees. This is corrected by applying zinc sprays during the dormant season or to the foliage in spring and early summer.

Nitrogen (N) and zinc (Zn) are typically the only fertilization pomegranate requires. Nitrogen is a 'macronutrient' and zinc is a 'micronutrient', only needed in small quantities if deficiency symptoms develop.

9.3.2 Fertilization practices in other countries

Israel: About 200-300 kg/hectare nitrogen is applied annually in Israel, with the same amount of potassium as K_2O . Manure is not typically used. These practices have been based on other fruit tree cultivation and not established for pomegranate specifically.

Spain: fertilization is not recommended unless leaf deficiency symptoms appear. Fertilization practices are dictated by restrictions to reduce pollution from fertilizers. In these cases, the maximum tolerated fertilizer rates are as follows:

The following limits should not be exceeded: 110 units nitrogen, 84 phosphorus, 234 potash and 25 magnesium, applied with orchards that are flood-irrigated. In drip irrigated orchards, maximum tolerance is 85 units nitrogen, 67 phosphorus, 187 potash and 20 magnesium. Of total nitrogen requirements, any amounts supplied by organic matter should be deducted from these tolerated maximums. When flood irrigation is used, split applications of nitrogen should be applied monthly in the following percentages beginning with bud break: March, 5%; April, 25; May, 25; June, 20; July, 15 and August, 10%.

9.4 Recognizing nutrient deficiencies

Visual deficiency symptoms of N or Zn can usually be recognized by distinctive symptoms that most often occur in the leaves, but can sometimes be seen in the fruit, branches, or general growth of the tree. These are, typically, the only deficiencies that pomegranate may show.

If nitrogen is deficient, older lower leaves of fruit trees may become yellow, terminal shoot growth is reduced, and fruit yields decline since the tree may not set or carry much fruit. If nitrogen is excessive, vegetative growth may be lush, but fruit set may be reduced and fruit maturity delayed by 7 to 10 days. Therefore, either an excess or deficiency of nitrogen should be avoided. Yellow leaves of new growth usually indicate iron or zinc deficiency, and in severe cases the entire tree may be yellow.

Zinc deficiency symptoms are most obvious in spring; trees may have delayed opening of flower and leaf buds. Leaves are smaller, often have chlorotic (yellow) areas between the veins, and have a "wavy" leaf margin. Sometimes internodes are shortened. Later in the season, subsequent growth hides these symptoms. Zinc deficiency is most common in rapidly growing young trees or in areas with alkaline soils, but may also appear in mid summer in mature trees. Soil applications are expensive and inefficient. Zinc is not well-absorbed through the roots and is fairly immobile in the plant. Zinc deficiency is best overcome by foliar sprays of basic zinc sulfate (neutral zinc, 52%) or by 14% chelated zinc. Application can be made at any time in the growing season, but may result in some leaf 'burn'. Application after harvest and before the dormant season is best, generally, as a single foliar spray of a solution containing 1-2.2 kg of elemental Zn per hectare.

The examples below are not pomegranates but the specific deficiency symptoms in pomegranate are similar.



Nitrogen-deficient peach leaves



Zinc-deficient kiwifruit leaf

9.5 Irrigation

Regular irrigation is needed to grow tree fruit. Uniform soil moisture is important in maintaining tree vigor, productivity, and fruit size. It is especially important to provide the tree with adequate water during the first year after planting to help develop a good root system. Irrigate from the onset of growth in the spring through the growing season after harvest. Avoid frequent shallow irrigation. Frequent, light watering encourages a shallow root system and can cause the development of wood rot which attacks the trunks and roots, killing the tree. Less frequent and deeper watering is preferable. Irrigate your trees with a deep soaking every 7 to 15 days, depending on the season and weather.

In a mature orchards, the amount of irrigation depends on the climate and soil. A general guide is to start with 15 m³/hectare/day in the spring (although irrigation may be weekly, this should be the daily average), and raise the daily amount to 50 m³/hectare/day in the summer days close to harvesting. The total amount of water per season should total around 6000 m³/hectare, in addition to 4500 m³/hectare of rain. If rainfall is lacking, irrigation must be increased to make up the difference. Less water will result in poor fruit size, higher fruit drop, stressed trees and may reduce return bloom. After harvest very little irrigation is carried out. Winter irrigation is avoided as the heavy irrigation during harvest, to improve fruit size, often is not depleted during the winter. Any further winter irrigation will only spur long, vegetative, non-fruiting spring growth.

Surface irrigation by furrows and flooding (Gravity flow): Furrows should be filled with water and then drained, to ensure that the entire root system receives a sufficient amount of water. Border berms can be used to contain the water for a 1 to 2 day period for adequate absorption. Berms should then be removed until the next watering.



Young orchard under flood irrigation



Flood irrigation contained by border berms

Soil-based Scheduling Methods (How to know when to water): Irrigation should be done when about 50% of the water has been depleted from the soil. To check the water content in the soil, take a trowel, shovel, or soil tube and dig down 20 to 40 cm. A soil that has about 50% available water will feel as follows:

Soil texture

- coarse - appears almost dry, will form a ball that does not hold shape;
- loamy - forms a ball, somewhat moldable, will form a weak ribbon when squeezed between fingers, dark color;
- clayey - forms a good ball, makes a ribbon an inch or so long, dark color, slightly sticky.

Mulches are beneficial to young fruit trees. Mulches of any plant material, such as shredded bark, grass clippings, straw, or sawdust conserve soil moisture, moderate extreme soil temperatures, and help reduce competition from weeds and turf. Apply a mulch 10 to 15 cm deep, but keep the mulch several inches away from the trunk.

In early fall, remove the mulch. This lets the roots know that temperatures are getting cooler and winter is on its way. The tree will begin to harden off or get physiologically ready for winter. Removing the mulch also prevents mice and other rodents from hiding in the mulch and chewing off the bark during the winter.

9.6 Fruit thinning

When all factors are favorable trees can set too many fruit. Pomegranates have an extended bloom that produces fruit maturing at different times. An overabundance of fruit on a tree may weaken it and result in fewer buds, leading to a smaller crop for the next season. A

heavy crop also can result in small-sized fruit of poor quality. To avoid these problems, thin trees two to three weeks after bloom. Remove all but the largest fruit in each cluster. Remove small, insect- or disease-injured fruit first and follow recommended average spacing distances. Fruit should be spaced by 7 to 10 cm apart on each branch, with small branches having only 1 or 2 fruit. Thinning should be done to allow a closer spacing near the base of the branch and a wider spacing near the tip of the branch. This is done to avoid the branch bending or breaking off from too much weight at the tip. It is also done to keep the fruit from bending the branch and being exposed to harsh sunlight late in the season. Remove any fruit setting after June as this fruit will generally not fully mature.

Severe fruit drop during the plant's juvenile period (3-5 years) is not uncommon. Fruit drop is aggravated by practices favoring vegetative growth such as over-fertilization and excess irrigation. Avoid putting young trees under conditions of stress. Mature trees tend to hold more fruit that are set than will younger trees. Thinning also tends to reduce fruit drop because the tree (or bush) is better able to produce enough nutrients to maintain a 'thinned' crop load than an excessive crop load.

10 Major disorders, diseases and insects and their control

Pomegranates have few disorders, pests or diseases. Nevertheless, on occasion, depending on country of production the following pests and diseases may develop on pomegranate.

10.1 Disorders of pomegranate and their control

- Fruit cracking; maintain regular irrigation. Alternating very wet soil with very dry soil increases cracking
- Fruit splitting after rain and subsequent sun exposure.
- Fruit sunburning; keep good leaf cover by adequate fertilization, primarily with nitrogen and strong pruning.
- Stem or root rot; maintain good drainage
- Scratching of fruit by branches; eliminate interfering branches by pruning and keep fruit well-spaced
- Rind-blackening; most often develops on immature fruit in storage. Harvest only mature fruit and maintain cleanliness

10.1.1 Insect pests

The controls for these pests is the same as with other fruit trees; in California mites and worms are the only common pest:

Leaf Footed Plant Bugs

Leaf footed plant bugs, *leptoglossus* sp. can cluster alarmingly on pomegranates, particularly split pomegranates. Until the acid level drops they will pierce the yellow albedo (a shallow, exploratory piercing), but not pierce the arils (seeds). However, the secondary fungal pathogens *Alternaria* and *Botrytis* often colonize these punctures. *Bacillus thuringiensis* is not effective against leaf footed plant bug. Interestingly these insects are often territorial and will not stray far from an orchard; thus not infesting a neighboring orchard.



Management: Leaf-footed bugs normally do not appear in orchards until late in the season (August and September). However, if they overwinter in or near pomegranates, they may be found earlier. In most years leaf-footed bug populations are controlled by natural mortality from temperature extremes and an egg parasitoid (*Gryon pennsylvanicum*). However, these natural controls can not be relied upon if there is a large overwintering population. This is especially true during the critical spring period as the egg parasitoid will only impact the adult's offspring, and it is the overwintered adult that will cause most damage. There are no cultural controls known to affect the density of the leaf-footed bug or the damage it causes to pomegranates. However, cultural controls such as cleaning debris from near the orchard may help reduce overwintering populations.

Aphids

Small numbers of aphids are not a concern. However, large populations cause curling, yellowing, and distortion of leaves and stunting of shoots; they can also produce large quantities of a sticky exudate known as honeydew, which often turns black with the growth of a sooty mold fungus that can damage fruit.

Management: Catch infestations early. Once aphid numbers are high, it is often hard to



control them because the curled leaves shelter aphids from insecticides or natural enemies. Where aphid populations are localized on a few curled leaves or new shoots, the best control may be to prune these areas out and dispose of them. In large trees, some aphids thrive in the dense inner canopy; pruning these areas out can make the habitat less suitable. Keep the area free from weeds that can harbor aphids. High levels of nitrogen fertilizer favor aphid reproduction. Never use more nitrogen than necessary. Insecticidal soap, neem oil, and narrow-range oil (e.g., supreme or superior parafin-type oil) provide temporary control if applied to thoroughly cover infested foliage. To get thorough coverage, spray these materials with a high volume of water and target the underside of leaves as well as the top. Soaps, neem oil, and narrow range oil only kill aphids present on the day they are sprayed, so applications may need to be repeated.

Mites: Mites can be recognized by their flattened bodies and long front legs.

Adults can be various colors, with or without spots. Mites overwinter as **eggs** on twigs and branches. Eggs hatch in spring and the young move out to leaves where they feed. Some produce webs. Mites feed by sucking the contents out of leaf cells. Such leaf damage reduces tree vitality and can adversely affect fruit size. Leaf injury caused by mites begins as a **mottling** and browning of leaves. Trees can tolerate low to moderate populations of mites, but heavy populations can remove almost all the chlorophyll from leaves and entire trees will take on a pale yellow appearance. Some insecticides used for other pests cause mite populations to increase dramatically.



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Management: Mites are sometimes controlled by natural predators (other mites). Generally, hot weather and predators cause brown mite populations to decline in summer. Dormant oil applications in winter can help control mites, but will also kill predatory mites (the biological control). Use dormant sprays with oils at the high rate to help control the overwintering eggs if more than 20% of fruit wood examined have mite eggs. An insecticide can be added to control other pests. Miticides may be necessary in some orchards in spring or summer but only when mite populations begin damaging foliage. Dusting Sulfur (or wettable) applied twice, once in May (late spring) and once in June (early summer)

Worms: various larval worms, including omnivorous leafroller—Leaves will develop a ragged appearance from the larval worm feeding on them. Fruit on trees are also attacked by the larvae, and young fruit may fall because of deep feeding grooves made just after the fruit has formed. Less severely damaged fruit remain on the tree and develop characteristically deep, bronze-colored scars with roughened netlike surfaces that are mostly cosmetic, although the fruit may be deformed.

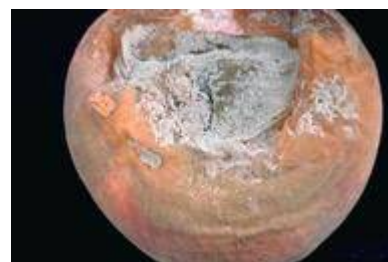
Management: *Bacillus thuringiensis* (sold as a variety of products) is effective against the larval stages of the leafroller. Bt, as it is commonly known, is a bacterial preparation that causes a disease in many kinds of caterpillars but does not harm beneficial insects, birds, man, or other organisms. Leafrollers stop feeding within hours after feeding on a sprayed leaf and die several days later. Thorough spray coverage of the tree is required for control. (Bt will also control other caterpillars present at the time of application.) Bt is only effective on leafroller larvae when they are small (less than 1 cm long) and usually requires more than one application. Caterpillars must ingest the pesticide to be killed. Other pesticides may be used, but will kill beneficial insects such as honeybees and lacewings (these will parasitize leafroller larvae).



10.1.2 Diseases

The common diseases of Pomegranate, their symptoms and controls include:

- Alternaria, Botrytis, fruit rots-- Surface mold can occur on both green and ripe fruit. The lesions usually occur in areas of fruit contact (helped by reducing fruit clusters by thinning). Fruit rot is primarily a problem on ripe fruit, especially when rains occur during harvest. The first symptoms of fruit rot are water-soaked areas, usually developing on the surface where two fruit touch. These lesions soon are covered with dark spores. Infections are favored by cool, rainy spring and summer weather usually around 15C. Fruit may show gray, fuzzy areas, especially if seeds are exposed by fruit cracking. These pathogens often develop as secondary pathogens after exploratory piercing of the albedo by the leaf footed plant bug.
- Manage by harvesting fruit as soon as ripe, reducing dust in the orchard as the spores are spread in airborne dust, and maintaining clean conditions in fruit containers and storage



11 Harvest and postharvest handling

11.1 Maturity

Harvestable fruit are usually produced by the second or third leaf (year after planting). Pomegranates for fresh consumption are color picked when skin of the fruit is highly colored (dark red). Due to the extended bloom fruit can mature at different stages. Any corkiness of the husk indicates overripeness. Full yields will not typically be realized until the 6th leaf (6th year after planting). Yields in a very productive orchard can reach 6 tonnes per hectare.

11.2 Harvest method

Pomegranates for fresh consumption or processing are picked by hand and carefully handled. Despite pomegranate's leathery skin, a bruise or scratch may cause a dark blemish on the shiny rind, but not actually damage the inside of the fruit. External appearance, hence commercial value is decreased by blemishes. Shears should not be used to cut the fruit off as the pomegranates' deep stem structure is often marred by cutting shears; pulling off the fruit is preferable. The fruit should be protected from sharp twigs and placed it carefully in harvesting bags or boxes to avoid bruising. Likewise, the crown (calyx) should be kept intact for a better appearance.

11.3 Fruit for processing

Pomegranates may be crushed for juice or making jelly. If peel is left on during crushing, polyphenolics will be higher. Juice can be concentrated and sugar added for syrup production. Pomegranate wine may also be produced. In some parts of Asia the fruit is dried, ground and used as a spice.

11.4 Storage

When supply is bigger than the demand, and for prolonging the season, fruits can be stored in cold storage. Fruits are kept at 7°C and 90% relative humidity. Only clean fruits with no insect damage should be stored. Fruits damaged by insects may rot in storage. Fruits can be easily stored for a period of 3 months. If the stored fruit is not mature, external browning of the rind occur. Even when stored until the peel dries and turns brown the seeds will keep fresh for some time.

Chilling injury can occur in storage. Storage at 5°C or lower results in chilling injury to the fruits, and the severity of the symptoms increase with time and temperature-decrease below 5°C. Chilling-injury symptoms, which become more visible after transfer to 20°C, included brown discoloration of the skin, surface pitting, and increased susceptibility to decay organisms. Internal symptoms are manifested as pale color of the seeds and brown discoloration of the white segments separating the seeds.

11.5 Contribution to diet

Dietary value, per 100 ml juice or 100 g of edible portion

	Pomegranate
Water (%)	79
Calories	70
Protein (%)	1.1
Fat (%)	0.9
Carbohydrates (%)	18
Crude Fiber (%)	0.3
% of Recommended Daily Requirement Contributed by Pomegranates	
Vitamin A	---
Thiamin, B1	0.2
Riboflavin, B2	1.2
Niacin	1.4
Vitamin C	8.9
Content Contributed by Pomegranates (mg)	
Calcium	1.0
Phosphorus	2.8
Iron	8.0
Sodium	--
Potassium	5.5

Pomegranate juice is a good source of antioxidant polyphenols.

The most abundant polyphenols in pomegranate juice are the hydrolyzable tannins called punicalagins that are mainly extracted from the peel in crushing.

In preliminary laboratory research and human pilot studies, juice of the pomegranate has been found effective in reducing heart disease risk factors, atherosclerosis and cardiovascular disease. Tannins such as those found in pomegranate have been identified as responsible for the reduction of oxidative stress. Pomegranate has been shown to reduce systolic blood.

Research suggests that pomegranate juice may be effective against prostate cancer and osteoarthritis. The juice may also have antiviral and antibacterial effects against dental plaque.

Pomegranates are high in fiber and vitamins and are especially good sources of vitamin A and vitamin C. Three small fresh pomegranates contain more than 50% of the recommended daily intake (RDA) of beta-carotene, a potent antioxidant. Beta-carotene prevents the build-up of plaque deposits in the arteries, protects the eyes from sun damage and deactivates free radicals that, if left unchecked, accelerate the ageing process and increase the risk of cancer. In addition, the body converts beta-carotene into vitamin A, which is vital for good vision and for keeping the eyes lubricated. Those at risk of dry eyes should include plenty of pomegranates in their diet. Pomegranates contain significant levels of iron, essential for hemoglobin, the oxygen-carrying pigment in red blood cells.

12 Cover Crops

12.1 Should the grower plant a second crop for income?

Cover crops are sometimes planted in fruit tree orchards; in some cases other agronomic row (vegetable, fruit), forage or grain crops may be interplanted in orchards. However, other plants will compete with fruit trees for water and nutrients, reducing yields, fruit size and tree size. Use of a cover crop, such as clover or other legumes, however, can be of benefit if the cover crop is disked under (incorporated into the soil) at the end of the rainy season before water becomes a limited resource. This practice increases soil fertility and soil structure. Cover crops, like weeds, can increase the possibility of frost damage.

12.2 Why plant a cover crop?

- Cover crops can provide a source of income during the establishment period of an orchard before fruit is produced.
- improved soil tilth
- increased water infiltration (winter-growing annuals will not use water the trees need and may increase the amount of soil moisture)
- better soil fertility (barley, oats, triticale, legumes)
- weed control
- reduced soil erosion.
- Some cover crops, when used in rotation (different cover crop planted each year) can help control soil nematodes. Good cover crops to use for nematode control include: rotations of cover crops such as sudangrass, mustard, vetch, and cowpeas.
- Sandy soil will support a cover crop such as barley or rye better than oats

12.3 Disadvantages of cover crops should also be considered

- Cover crops can increase the danger of frost damage to newly emerging leaves and blossoms of trees when the crop is tall and dense.
 - To reduce the risk of frost damage, plant a low-growing cover crop, but not grasses which can harbor frost-causing bacteria that can move into the trees.
- A dense spring cover crop may a lush spring cover crop may lead to extra brown rot, shot hole, rust, mildew, and other fungal diseases, especially when the crop is tall (such as tall grains and legumes—for example, faba bean).
- Summer cover crops can increase nematode numbers. Perennial crops like clovers can use too much water in the summer. Plant a winter annual crop.

12.4 Recommendations

- Winter cover crop can be tilled into the soil to improve soil tilth, nutrition and water penetration
- For improved soil nitrogen, plant legumes, such as vetch, peas, bell beans, clovers, medics, and cowpeas
- In order to benefit the soil, the cover crop must be mowed or disced into the soil. Harvest the part of the plant that can be sold and turn the rest of the plant into the soil to fertilize and improve the soil

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