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MINISTRY OF AGRICULTURE, LIVESTOCK, LANDS AND IRRIGATION

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Agriculture Sector Modernization Project

OPERATIONAL MANUAL

Pomegranate

AGRICULTURE SECTOR MODERNIZATION PROJECT

PARK
AGRICULTURE TECHNOLOGY DEMONSTRATION PARK

Prepared by -
Dr. Julian Velez - International Agronomist
FCG New Zealand (FCG ANZDEC Ltd.)

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PROJECT DIRECTOR'S MESSAGE

Sri Lanka takes great pride in its rich heritage, with a written history that spans thousands of years. Its fertile soil, diverse landscapes, and strategic location have long made it an ideal hub for farming.

While agriculture evolved globally, Sri Lanka faced challenges. The industry became less profitable and labour-intensive, compounded by the introduction of an open economy. The fragmentation of cultivable land into small, inefficient plots further compounded the challenges as farming was no longer seen as a reliable career.

Sri Lanka allocates a significant portion of its foreign exchange on importing agricultural commodities. Recognizing the potential of its nutrient-rich soil, the government saw an opportunity to cultivate crops that meet international demand while reducing imports and boosting foreign exchange through exports. To capitalize on this, the government prioritized advanced agricultural technologies. In 2017, the "Agriculture Sector Modernization Project" (ASMP) was launched with the World Bank funding.

The project focused on areas where Sri Lanka had the most potential, such as export-oriented tropical fruits and vegetables. It started pilot project in year 2018 with World bank funding with seven districts in five provinces (Jaffna, Mulaithevu, Batticaloa, Anuradhapura, Polonnaruwa, Mathale and Monaragala) and expanded with the grant of the European Union, in another five districts (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) The project secured a loan of USD 64 million from the World Bank, along with a grant of USD 25 million from the European Union. To date, the project has generated USD 65 million in foreign exchange earnings, with potential savings of up to USD 3 million domestically.

The project focused to high-demand tropical fruits and vegetables. Small farms were consolidated into larger groups of 300 to 400 entrepreneurs into Agriculture Technology Demonstration Parks (ATDPs) and modern technologies were introduced.

Tropical Fruit varieties are the main crops selected for Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) by the International Service Provider (ISP) identified as Tropical Queens (Banana, Mango, Guava, Papaya and Pomegranate) which are among the most popular fruits in the world. ISP engaged in producing those competitive and marketable commodities for both local and export markets

The socio-economic problems and the COVID pandemic of the Country during year 2020- 2022 affected the implementation of the ISP technology packages. Because of this, the ISP and the ASMP developed optional technology packages, designed to overcome the shortfalls of the crisis. Procurement of equipment and supplies already available in the Country was given priority to avoid import delays and constraints. Different irrigation systems were used when the preferred system was not available. Options are also being developed for inputs such as fertilizers and pesticides. Intercropping was implemented as the ideal weed control practice and staple food crops to provide much-needed food to the Country. More emphasis is given to IPM systems to control pests and diseases. Even existing crops were given pre- and post-harvest technology to start exports without waiting until newly planted crops are harvested. Therefore, most of ASMP crop clusters have both existing crops and new crops with complete ISP technology package. Therefore, the *Operational Manuals* of Dr Julian; the Agronomist of ISP are based on technology for both existing crops of farmers as well as new crops with entire technology package.

ASMP started with Pilots by introducing Department of Agriculture (DOA) technology. With the intervention of Dr. Julian, ASMP involved in Vertical upliftment of the existing DOA technology from land preparation to pre / post-harvest technology to end up with modern processing technology with reefer container protocol for export which have never been practised in Sri Lanka. High density double Row planting, Low pressure irrigation (mini sprinklers, Drip tapes), irrigation based on mini whether station data, soil test based fertigation, modern training and pruning of fruit trees (box and espalier), use of poly mulch, pre and post- harvest Technology (use of colour bagging , colour ribbons, fruit desk etc) are some of the promising technologies introduced by the ISP. ASMP has produced Operational Manuals for Banana (*Ambul, Kolikuttu, Cavendish*), Mango, Guava, Papaya, Soursop, Passion fruit, chilli, Vegetables, Jumbo peanut, potato, Red onion and Maize.

The project introduced innovative methods for increasing land productivity. Techniques like high-density double-row planting and the "espalier" method allowed agroprenuers to double or even triple their yields. Automated water-controlling systems based on weather station data ensured a effective use of water supply, enhancing productivity reducing use of fertilizer. Solar energy was harnessed to power these systems, reducing reliance on the main electricity supply.

Over the past seven years, the project had transformed the concept of "farming" in Sri Lanka. Once viewed as an unattractive profession, farming had become a thriving opportunity, attracting the new generation. This shift had marked a major change in societal attitudes and had empowered farmers as **agropreneurs**, driving innovation and growth in the agricultural sector.

A key initiative of the project was the transition from individual farming to the establishment of farmer companies. Farmers were organized into "Public Unlisted Companies (PUC)," raising the status of farming from a mere livelihood to an esteemed profession. This shift established a structured system, elevating agriculture to a professional level and instilling a sense of pride in the farming community.

Farmers of the Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) were organized into Farmer Producer groups and these groups were later registered as Farmer Companies under the Companies Act No 7 of 2007, in the Public Unlisted Company category. There are 59 Farmer Companies already functioning in the ASMP crop clusters.

The Farmer Company model facilitated direct business transactions between local farming organizations and international buyers, creating new global business opportunities

Specialized processing centres for each Farmer Company ensure that crops are processed, graded and packaged according to international standards. This system provides the buyers with access to high-quality products through a structured, well-organized, and accountable framework, ensuring benefits for both agropreneurs and buyers alike.

Dr. Rohan Wijekoon
Project Director
Agriculture Sector Modernization Project

Contents

1. INTRODUCTION

Pomegranate (*Punica granatum*) is a fruit-bearing deciduous shrub or small tree that is widely cultivated for its delicious and nutritious fruits. Renowned for its vibrant red arils and sweet-tart flavor, pomegranate has a rich history and is valued for both its culinary and medicinal properties.

The exact origin of the pomegranate is uncertain due to its ancient cultivation history spanning several millennia. However, it is believed to have originated in the region encompassing modern-day Iran and the northern parts of India. Pomegranates have been extensively cultivated and admired in the Mediterranean, Middle East, and parts of Asia for thousands of years. Today, pomegranates are grown in various regions across the globe, including the United States, Spain, Turkey, and India.

Pomegranate is a member of the family Lythraceae and is characterized by its dense, bushy growth habit. Here are the key botanical features of the pomegranate plant:

Size and Growth Habit:

Pomegranate plants typically range in height from 5 to 10 meters, although dwarf varieties are also available. They have multiple slender branches that form a rounded or slightly spreading crown.

Leaves:

The leaves of the pomegranate are glossy, narrow, and oblong, measuring approximately 3 to 7 centimeters in length. They are arranged in opposite pairs or clusters along the branches and are often deciduous in colder regions.

Flowers:

Pomegranate flowers are striking and vibrant, usually a deep red or orange in color. They are approximately 3 to 4 centimeters in diameter and have five to eight petals. The flowers are borne singly or in clusters at the branch tips and develop from early spring to summer.

Fruits:

The pomegranate fruit is a large, rounded berry, ranging from the size of a small apple to that of a grapefruit. It has a thick, leathery outer skin (pericarp) that ranges in color from yellowish green to deep red. The interior of the fruit contains numerous juicy arils, which are edible seed pods filled with sweet-tart juice. Each aril is enclosed in a translucent membrane.

With its distinctive flowers, attractive foliage, and delicious fruits, pomegranate continues to captivate people around the world, both as a culinary ingredient and for its potential health benefits.

1.1 Optimal Ecological Requirements

Climate and Temperature:

Pomegranate thrives in regions with a Mediterranean climate, characterized by hot, dry summers and cool, mild winters. The ideal temperature range for pomegranate cultivation is between 25°C to 35°C (77°F to 95°F) during the growing season. Pomegranate trees require a chilling period of approximately 150 to 300 hours at temperatures below 7°C (45°F) during dormancy for proper flowering and fruit set.

Sunlight:

Pomegranate trees require full sunlight exposure for optimal growth and fruit development. A minimum of six to eight hours of direct sunlight per day is recommended. Insufficient sunlight can lead to poor fruit quality and reduced yield.

Water and Irrigation:

Pomegranate trees are moderately drought-tolerant once established but require regular watering during the growing season, especially during flowering and fruit development stages. Adequate irrigation is essential for proper fruit size, quality, and yield. However, excessive water can cause root damage and increase the risk of fungal diseases. Drip irrigation systems are commonly used to provide controlled and efficient water supply.

Once established, mature pomegranate trees are considered drought-tolerant and can withstand dry conditions. In regions with a Mediterranean climate, where pomegranates thrive, an annual rainfall ranging from 400 to 800 millimeters is generally sufficient. However, it is important to note that pomegranate trees can benefit from supplemental irrigation during dry periods to ensure optimal fruit production and quality. Local climatic conditions and specific pomegranate cultivars should be taken into consideration when determining the precise water requirements for successful pomegranate cultivation.

Soil Requirements:

Pomegranate plants can adapt to a wide range of soil types, but they prefer well-drained loamy soils with a pH between 5.5 and 7.5. Good drainage is crucial to prevent waterlogging, which can lead to root rot. Prior to planting, soil preparation should include organic matter incorporation and adequate soil fertility based on soil analysis.

2. LAND PREPARATION

2.1 Primary Land Preparation

1. Deep ploughing using a 60 cm diameter disk plough.
2. Incorporation of organic matter/ Compost by broadcasting 12 MT per hectare or 5 MT per acre of compost
3. Deep plough again perpendicular to the first pass

Figure 1: Disk Plough

2.2 Secondary Land Preparation

1. Heavy Soil Textures
    a. Disk harrow using a disk harrow implement with disks having a diameter of 40 cm.
    b. Two passes perpendicular to each other are required.
2. Light Soil Textures
    a. Cultivate using a tine tiller implement.
    b. Two passes may be required in sandy clay loam soils.

2.3 Tractor

1. Tractor size 75 to 99 HP (75 to 85 POT), four-wheel drive[1]

2.4 Drainage

1. Light Texture Soils
   a. Sloping handmade ditches to evacuate water from rainfall quickly 30 cm wide x 15 cm deep
   b. These ditches will discharge into a larger sloping drainage trench 75 cm wide with a depth between 45 cm to 60 cm according to the conditions of the land
   c. This is a "U" type drainage design for small plots made up of two lateral drainage ditches at the extreme ends of the plot that drain into a primary drainage canal that evacuates the water away from the plot
   d. Before making the ditches, it is necessary to observe the slope of the plot and the East-West direction of the double row planting. Ideally, the double rows should drain into the lateral ditches without much effort.
2. Heavy Texture Soils
   a. Sloping drainage secondary canals 45 cm wide x 30 cm deep at 20 m intervals
   b. These canals will discharge into a larger primary type sloping drainage canal 1 m wide with a depth of 60 cm according to the conditions of the land.
3. Waterlogged Soils
   a. Drainage lines 45 cm wide and 45 cm to 60 cm deep at 5 m to 10 m intervals
   b. These lines will discharge into a larger primary type sloping drainage canal 1 m wide with a depth of 60 cm according to the conditions of the land.
4. Drainage Equipment
   a. Backhoe Excavator or similar with 30cm or 45cm wide bucket

3. VARIETIES

The Bhagawan (Bhagwa) Pomegranate variety originated from India and was brought to Sri Lanka by a private farmer in the form of tissue culture plantlets. It is one of the most preferred Pomegranates in India due to the following attributes:

1. Fruits have an attractive "saffron" to deep red skin color; at the same time, the peel is smooth and glossy, enhancing the market appearance of the fruits.
2. Cherry red colored and bold arils are abundant and suitable for fresh use and processing purposes.
3. Very suitable for long distance transport due to thick peel (less weight loss, less possibility of damage due to bruises).
4. Shelf life at room temperature is 12 to 15 days.
5. The fruits are tolerant to attacks of thrips and mites, a fact that reduces the use of pesticide and lowers production cost.

[1] It is unfortunate that Sri Lankan farmers do not have access to bigger tractors. It is recommended to procure modern machineries for Sri Lankan farmers, which can enable more efficient land preparation. ISP also recommends procuring moldboard plough to turn the soil over.

6. Fruits are moderately susceptible to black spots.
7. Arils are free from blackening even in the case of late harvesting (up to 7-5 months), preserving the market value of the fruits.
8. Cracking of fruits is very low, less than 10-15%.
9. There is no fruit drop observed in severe water shortage situations.
10. The yield is high and can reach 30-40 kg/tree with good management.

Pomegranate is one of the most popular fruits consumed in Sri Lanka, but there is very little local production, if any. The local market volumes are imported from India. This makes Pomegranate production in Sri Lanka a very significant import substitution proposition with high profitability expectations for the local farmers, especially in the Northern and Eastern regions of the Country.

Planting Material

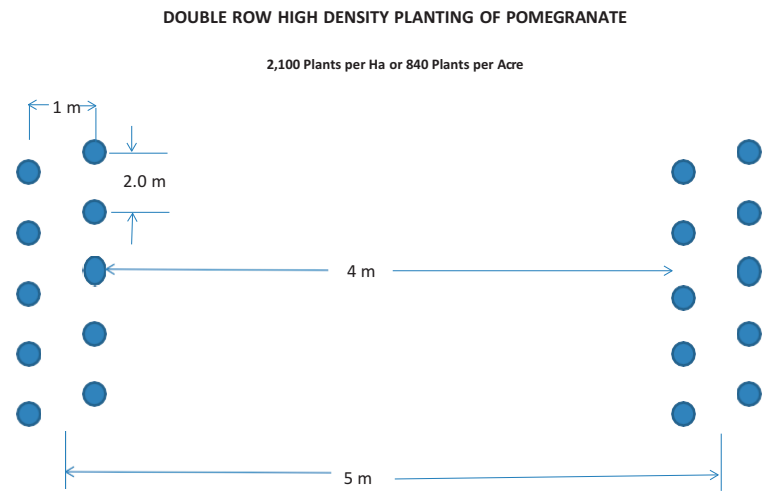
The preferred planting material in Sri Lanka are young plantlets produced by air layering. The height of the plantlets should be 20 cm to 23 cm, with pencil thick diameter and having at least 3 green leaves and hard enough for field planting (Annex 1). In most countries, Pomegranate is propagated or planted using rooted cuttings, considered the best planting material. This technique has not been very well developed in Sri Lanka; however, the ISP ASMP introduced technology in Batticaloa to produce rooted cuttings with success from cuttings left over from the Espalier Trellis pruning system.

All planting material must be free from pests and diseases.

4. HIGH DENSITY PLANTING

4.1 Procedure

For planting purposes, all distances are carefully measured and staked out in the field in order to achieve the population density as precisely as possible. An East-West orientation of the double rows is recommended to maximize the sunlight exposure of the fruit trees in the double rows throughout the day.



At the beginning, an origin or initial point is chosen at one end of the field making sure that there are no obstacles and no shading on either direction that can affect the development of the crop. A base line facing East or West is then laid out at one end of the plot from the origin. A second base line perpendicular to the first base line is drawn as well. The first double row is measured at 1 m on the East-West base line and layout by measuring 1m at 5 steps intervals down the row from the base line. The 4 m width of the first double row alley is then measured from the second row of the first double row. The alley is then laid out by measuring 4 m widths at 5 steps intervals down the row. The rest of the double rows and alleys are measured, and layout based on this initial double row and alley way using 1 m and 4 m widths.

The planting distances are measured on each double row laid out making sure a triangular or zig zag pattern is achieved within the double row. To achieve the zig zag pattern, the planting distances in the second double row begin being measured at half the planting distance from the origin of the base line.

Once the double rows and alleys are laid out and planting distances marked with wooden stakes, planting begins in the first double row established at the base line. All other double rows are planted as laid out from the first double row on the chosen base line.

Once the planting distances in the double rows are measured and delineated, planting holes are excavated of sufficient size and depth to accommodate the size of the bags containing the planting material coming from the nursery. The small plants are then placed in the planting holes without the plastic bags, but with the potting mix still attached to minimize transplant shock. The soil is then firmed around the new transplant to increase the anchorage of the new plant in its new environment. It is important to flatten out the soil around the newly planted meristem to avoid basins that may cause waterlogging around the new plant.

Water must be applied as soon as possible after the transplanting operation is completed. Water must continue to be applied throughout the growing period of the Pomegranate plant as required depending on rain fall.

4.2 Plant Spacings Within the Crop Rows

Pomegranate	2 m

4.3 Planting Aids

1. Construction twine (preferably white coloured)
2. A good number of wooden stakes to layout base lines and double rows
3. Right angle template made of a non-stretching rope with marks at 3 m, 4 m and 5 m.
4. Template of 1 m in length to confirm width of the double rows, made out of a non-stretching rope.
5. Template of 4 m in length to confirm width of the alleyways, made out of a non-stretching rope.
6. Planting stakes to mark planting holes (good quantity)
7. Spade type shovels to make planting hole size 30 cm x 30 cm x 30 cm or one cubic foot.

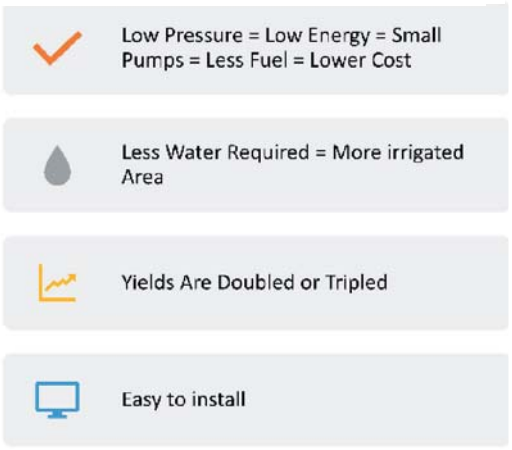
5. IRRIGATION AND FERTIGATION

5.1 Irrigation

Pomegranate requires 7 mm per day of water for optimum production. Low pressure irrigation is the best method of applying uniform and precise amounts of water directly to the root zone of the plants, as per their above requirement, through emitters at frequent intervals over a period, via a pipe network comprising of mains, submains, and laterals. In this system, water is applied drop by drop or by micro jet (micro sprinkler), on the soil surface or below it (sub-surface), at a rate lower than the infiltration of the soil.

Figure 2: Micro-Sprinkler System

Figure 3: Advantages of low-pressure irrigation



Micro sprinkler systems (micro jets) are preferred for fruit trees because the hydraulic head created by their height and discharge rates will push the waterfront downward in the soil profile to reach their deeper root systems of fruit trees.

5.2 New Irrigation Concepts

- Net Area Irrigation – Water for Cultivated Area Only
- Evapotranspiration for irrigation scheduling rather than soil moisture content.
- Consumptive Water Use by Crops: Different Crops Different Amounts of Water
- Water Amounts Are Adjusted to The Physiological Development of the Crops (Kc Constants per Crop)

5.3 Water Application

The Pomegranate consumptive water use of 7 mm of water per day is equivalent to 49 mm per week. This weekly amount can be applied in 3 cycles. Under this application regime, the chart below is the recommended irrigation time per cycle to irrigate Pomegranate using the ASMP micro sprinkler system:

Table 1: Irrigation Schedule

Irrigation Schedule	Year 1		Year 2		Year 3	
Irrigation Time (Hours/ Minutes)	1	22	1	45	1	45

5.4 Fertigation

Nutritional Requirements

Macronutrient Requirements:

Pomegranate plants require three primary macronutrients: nitrogen (N), phosphorus (P), and potassium (K). The ideal nutrient ratio for pomegranate is approximately 2:1:1. Nitrogen promotes vegetative growth and enhances fruit size and quality. Phosphorus is crucial for root development, flowering, and fruit formation. Potassium contributes to overall plant growth, disease resistance, and fruit coloration.

Micronutrient Requirements:

Apart from macronutrients, pomegranate plants also benefit from several essential micronutrients. These include iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B)[2], and molybdenum (Mo). These micronutrients play vital roles in enzyme activation, photosynthesis, and overall plant health. Foliar sprays or soil amendments can be used to address specific micronutrient deficiencies.

Organic Fertilizers:

Organic fertilizers, such as compost, manure, and biofertilizers, can be beneficial for pomegranate cultivation. These organic amendments improve soil structure, enhance nutrient retention, and promote microbial activity. They can be used alone or in combination with synthetic fertilizers to meet the nutrient requirements of pomegranate plants.

Meeting the fertilizer requirements of pomegranate is crucial for achieving healthy plant growth and maximizing fruit production. A balanced approach, considering both macronutrients and micronutrients, along with proper soil analysis and irrigation management, is essential. The nutrient status of the soil should be monitored frequently to adjust fertilizer applications accordingly to ensure the successful cultivation of pomegranate.

Fertilizer Application Through Fertigation:

Fertilizer application is based on soil test results (Annex 4). The Pomegranate Clusters soil analysis reports were interpreted using critical levels of nutrients for pomegranate in the soil and critical cation ratios to determine the cation balance of the soil. The results for the Batticaloa Pomegranate Clusters area soil tests indicated the following:

Organic matter and N are low. N very low
Ca, Mg and K are low
S and Mn are rather low
Cu and Zn are at deficient levels. Very low
Cation ratios show Mg unfavoured by ratios. Soil amendment with Mg will increase Mg in the soil exchange complex
Ca Saturation a bit low, but Ca ratios favor Ca

Therefore, the recommendations for the application of fertilizers for this soil test are as follows:

Organic matter like compost must be applied
Apply N as required by crop
$MgSO_4$ as a soil amendment and MOP need to be applied as well
Foliar applications of micronutrients, especially Cu and Zn are urgently needed
TSP is required only in Chenkalady - Thalawai as basal soil applications in granular form
The amounts of fertilizer to be applied will vary by crop
Specific recommendations will be made by crop

[2] The ISP recommends the application of micronutrients through foliar fertilizers that contain a mix of these nutrients including Boron.

Based on the above considerations, the amount of nutrients to be applied is in elemental and oxide form below[3]:

Recommendation	N	P	K	Mg
Kg/ Ha	200	20	330	100
Lb/ acre	200	20	330	100
Kg/ acre	90.9	9.1	150	45.5

Table 2: Nutrition Quantities

Recommendation	N	P_2O_5	K_20	$MgSO_4$
Kg/ Ha	200.0	45.8	397.7	139.9
Lb/ acre	200.0	45.8	397.7	139.9
Kg/ acre	90.9	20.8	180.8	63.6

For these amounts, the quantities of fertilizer materials per year (season) are:

Kg/ Acre	Urea	P Acid	MOP	$MgSO_4$
Fertilizer per year (Season)	198	35	301	455

Table 3: Quantities of fertilizer materials per year (season)

Considering the stage of development of the crop, the quantities of fertilizer materials required per season.

Ratio Based on Tree Age	Year 1	Year 2	Year 3+
Urea	158	198	237
P Acid	35	35	35
MOP	301	301	301
MgSO4	455	455	455

Table 4: Quantities of fertilizer as per stage of development

In a crop year in Sri Lanka, the number of irrigation weeks is 26 weeks. The rest of the year, rainfall is enough to satisfy the water requirements of the Pomegranate crop. Therefore, the amounts of fertilizer required per week are:

Kg/Acre	Year 1	Year 2	Year 3+
Urea	6.1	7.6	9.1
P Acid	2.7	2.7	2.7
MOP	11.6	11.6	11.6
$MgSO_4$	17.5	17.5	17.5

Table 5: Week-wise, fertilizer quantities

[3] Higher amount of Mg recommended as soil amendment to improve the chemistry of the soil cation exchange complex and make the soil more fertile and productive. Small supplemental quantities of Mg from 50 Kg/Ha to 100 Kg/Ha (0.21 meq to 0.42 meq of the Mg^{2+} ion) are recommended. Because the concentration of Mg in fertilizer grade MgSO4 is only 10%, a large application of the fertilizer is required to supply to the soil with a low amount of the Mg^{2+} ion.

These amounts are to be applied in 2 cycles per week. On a per application basis (irrigation cycle), the amounts of fertilizer materials required are:

Kg/Acre/Week	Year 1	Year 2	Year 3+
Urea	3.0	3.8	4.6
P Acid	2.7	2.7	2.7
MOP	5.8	5.8	5.8
$MgSO_4$	8.7	8.7	8.7

Table 6: Fertilizer quantities, as per application basis (irrigation cycle)

These amounts are further reduced based on the net area cultivated in Pomegranates. For a production plot with size of half an acre, the net area to be fertigated is only 0.11 acres. Following are the fertigation recommendations for this net area:

Kg/Acre/Application	Year 1	Year 2	Year 3+
Urea	0.34	0.42	0.51
MOP	0.64	0.64	0.64
$MgSO_4$	0.97	0.97	0.97
Applications per week	2		
P Acid Application every two weeks (ml)	175.7	175.7	175.7
Foliar Applications of Micronutrients every two weeks			

Table 7: Fertigation Recommendation per Application per Plot

6. WEED CONTROL

The best weed control practice is intercropping. Not only it will control undesired weeds, but it will also generate income for the farmers. In the absence of intercropping, only mechanical weed control practices are to be used. Herbicides are not allowed to be used. The most common mechanical weed control practices are:

1. Cultivation with a tractor using a rotavator implement.
2. Motorized weed cutters that use plastic cords to cut weeds (weed eaters)
3. Workers using bush knives or any other cutting or chopping tool.

7. PEST AND DISEASE CONTROL

IPM concepts and practices must be applied to manage Pomegranate pests and diseases. The Quantity/Intensity factor is a practical and easy to apply IMP concept in deciding whether to apply pesticides:

Quantity	Coverage		
Intensity	Severity		
Intensity	Low	Medium	High
Low	Observation	Observation	Localized
Medium	Spot Treatment	Localized	Full Treatment
High	Localized Treatment	Full Treatment	Full Treatment

The most common Pomegranate pests and diseases found in Sri Lanka by International Service Provider will be discussed below:

7.1 Anthracnose

Anthracnose, caused by the fungal pathogen *Colletotrichum* spp., is a significant disease affecting pomegranate production worldwide. The disease can lead to severe economic losses due to reduced fruit quality and yield. Effective control and management strategies are essential for mitigating the impact of anthracnose on pomegranate orchards.

Anthracnose disease poses a significant threat to pomegranate production, and effective management is crucial for maintaining orchard health and productivity. While chemical control measures can be effective, an integrated approach that includes cultural practices, resistant cultivars, and biological control agents should be employed to ensure sustainable disease management and minimize the development of resistance.

Symptoms: Anthracnose primarily affects pomegranate fruit, causing characteristic sunken lesions with dark, concentric rings. As the disease progresses, the lesions may expand, leading to fruit rot and premature fruit drop. In severe cases, the disease can also affect leaves and stems, causing defoliation and dieback.

Chemical Control

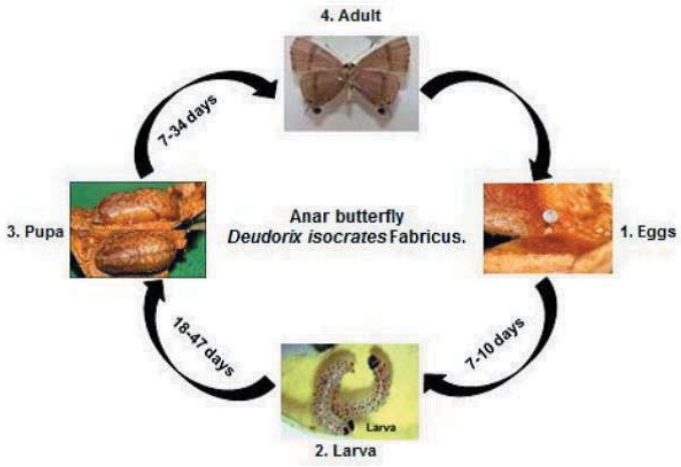
Chemical control measures are often employed to manage anthracnose in pomegranate orchards. Several fungicides have been found to be effective in controlling the disease, including those containing active ingredients such as azoxystrobin, tebuconazole, and mancozeb. It is important to note that the use of fungicides should be combined with other cultural and integrated pest management practices to reduce the risk of fungicide resistance and minimize environmental impact.

Recommended Application

The recommended application of fungicides for anthracnose control in pomegranate orchards should be carried out based on the specific product label instructions and local regulations. However, as a general guideline, a typical application might involve spraying a fungicide solution containing azoxystrobin at a concentration of 150-200 ppm or tebuconazole at a concentration of 250-300 ppm during the pre-bloom and post-bloom stages. Subsequent applications may be necessary based on disease pressure and weather conditions.

7.2 Pomegranate Fruit Borer

The pomegranate fruit borer (*Deudorix isocrates*) is a serious pest of pomegranate that causes significant losses in yield and quality. It is also known as the anar butterfly or the pomegranate butterfly. The adult is a bluish brown butterfly that lays eggs on the fruits, tender leaves, flower buds and stalks of the pomegranate plant. The eggs hatch into larvae that bore into the fruits and feed on the arils (seed coats). The infested fruits develop holes, rot, drop and emit an unpleasant odour. The larvae pupate either inside the fruits or on the stalks. The life cycle of the pest varies from 32 to 81 days depending on the temperature and humidity.



The pomegranate fruit borer is a major threat to pomegranate cultivation and requires timely and integrated management to prevent the losses and ensure the quality of the produce.

The pomegranate fruit borer can be controlled by various methods, such as:

1. Biological control: The parasitoid Trichogramma species, the predators lacewing, ladybird beetle, spider, red ant, dragonfly, robber fly, reduviid bug, praying mantis, wasp, big-eyed bug, earwig, ground beetle, pentatomid bug and bird species can reduce the population of the pest.
2. Cultural control: The calyx cup should be clipped off immediately after pollination, as the pest lays eggs on it. The infested fruits should be collected and destroyed. The plant should be pruned regularly to remove the excess branches and improve the air circulation.
3. Organic control: The application of neem oil (3%) or clean mud around the base of the fruit can deter the pest from attacking the fruit.
4. Chemical control: The spraying of insecticides such as azadirachtin, indoxacarb, cypermethrin, profenophos, lambda-cyhalothrin, emamectin benzoate or spinosad at regular intervals from flowering to fruit development can effectively control the pest

7.3 Other Pests and Diseases of Pomegranate

1. **Pomegranate Butterfly (Virachola isocrates):** The larvae of this butterfly species feed on pomegranate leaves and can cause extensive defoliation, leading to reduced photosynthesis and yield. Chemical control: The use of insecticides such as chlorpyrifos, malathion, or spinosad can effectively manage pomegranate butterfly infestations.
2. **Pomegranate Aphid (Aphis punicae):** Aphids can infest pomegranate trees, causing damage by sucking sap from the leaves and excreting honeydew, which promotes the growth of sooty

mold. Chemical control: Systemic insecticides such as imidacloprid or acetamiprid can be used to manage pomegranate aphid populations.

3. **Alternaria Fruit Rot (Alternaria spp.):** This disease affects pomegranate fruits, causing dark lesions and decay. Chemical control: Fungicides containing azoxystrobin, mancozeb, or difenoconazole can be used to control Alternaria fruit rot.
4. **Bacterial Blight (Xanthomonas axonopodis pv. punicae):** Bacterial blight can lead to leaf spots, defoliation, and twig dieback in pomegranate trees. Chemical control: Copper-based fungicides, such as copper oxychloride or copper hydroxide, are often used to manage bacterial blight.

7.4 Summary

Pests and diseases pose significant challenges to pomegranate cultivation, and effective management strategies are essential to ensure optimal yield and fruit quality. Chemical control measures, including the use of insecticides and fungicides, play a crucial role in mitigating the impact of pests and diseases on pomegranate orchards. However, it is important to use these chemicals judiciously and in accordance with recommended practices to minimize environmental impact and ensure food safety.

8. PRUNING

Pruning is an essential practice in pomegranate cultivation to promote healthy growth, improve fruit quality, and maintain an open and balanced canopy. Adhering to appropriate pruning techniques at different stages of pomegranate tree development ensures a well-structured canopy, optimal light exposure, and efficient fruit production. The specific growth habits and regional conditions must be taken into consideration when implementing pruning practices, aiming to strike a balance between vegetative growth and fruiting potential.

8.1 Pruning Young Pomegranate Trees

During the first year of growth, pomegranate trees require minimal pruning. The focus is primarily on establishing a well-structured framework and encouraging two strong leader trunks. Key points to consider include:

1. Removal of Suckers: Remove any suckers emerging from the tree base to prevent competition for resources.
2. Selective Pruning: Trim back any side branches that are crossing, competing, or growing too close to the central leader. This helps maintain a well-spaced and balanced framework.
3. Head Back Leader Trunks: If necessary, lightly head back the central leader to encourage lateral branching and promote overall tree vigour.

8.2 Pruning Young Bearing Pomegranate Trees

Once pomegranate trees enter the bearing stage (2-3 years old), pruning techniques aim to strike a balance between vegetative growth and optimal fruit production. Key considerations at this stage include:

1. Thinning Out Crowded Branches: Remove inward-growing, weak, or crossing branches to improve sunlight penetration and airflow within the canopy.
2. Removal of Dead or Diseased Wood: Prune out any dead, damaged, or diseased wood to maintain tree health and minimize the risk of pest and disease infestations.
3. Heading Back Long Shoots: Heading back excessively long shoots helps to encourage branching, increase fruiting wood, and prevent excessive shading within the canopy.

8.3 Pruning Mature Pomegranate Trees

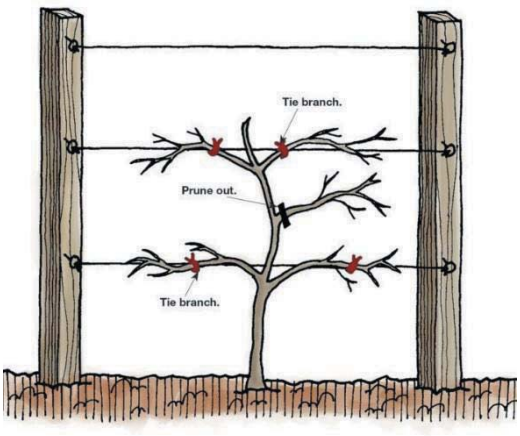
Mature pomegranate trees (4 years and older) require regular pruning to maintain productivity, control size, and rejuvenate the tree. Key considerations for pruning mature pomegranate trees include:

1. Renewal Pruning: Periodically remove older, unproductive branches to stimulate the growth of new, fruit-bearing wood.
2. Thinning and Canopy Management: Thin out dense areas of the canopy to improve light penetration and airflow, reducing the risk of fungal diseases.
3. Structural Pruning: Address any structural issues, such as weak crotches or crossing branches, to enhance the tree's stability and longevity.
4. Size Control: If necessary, selectively prune back the overall size of the tree to manage its height and spread, making harvest and maintenance easier.

Annex 3 Includes a graphical guide to traditional Pomegranate pruning according to the growth stage of the bush or tree.

8.4 Espalier Trellis System[4]

- ✓ The espalier trellis allows for the total control of the architecture and growth of the Pomegranate tree to make it easier to manage i.e., spraying, pruning, harvesting, and other practices are made much easier to manage.
- ✓ The espalier trellis production system for Pomegranate is made up of one dominant central trunk and lateral branches tied along a wire which is secured to wooden posts.



✓ Third tier and even fourth tier branches are allowed to grow from lateral branches along the wire to produce fruit.

✓ From tied lateral branches tertiary branches develop to produce fruit.

✓ The Espalier Trellis applies the new biological concept of “less biomass more flowers and more fruit”.

✓ First, 4”- 5” diameter wooden posts are placed 6 meters apart inside Pomegranate tree rows (middle of double row).

- ✓ Posts should be placed 3 m tall above ground and 0.5 m below ground.
- ✓ Wire lines, spaced at 0.5 m, are laid out and held by the posts to form the trellis.
- ✓ Wires must be tensed tightly to be able to support tree branches.
- ✓ Post placement can be mechanized.
- ✓ Wires are tightly fixed to posts.
- ✓ the wire gauge should be at least #14

[4] The ISP ASMP introduced the Espalier Trellis system for pomegranate because the use of this system is applicable to a large variety of flexible branching trees and shrubs with spurs, regardless of the species and including fruit trees, ornamental trees and climbing plants (Annex 5)

- ✓ Tools and other accessories to tie Pomegranate branches to trellis.
- ✓ Water suckers and very low branches are removed before trellising the tree.
- ✓ Small trees must be taller than the first wire on the trellis which is 0.5 m high from the ground level.
- ✓ When the tree height is at least 10 cm above the next wire, the top is cut or clipped.
- ✓ At least three leaf whorls must remain above the wire.
- ✓ The cut for clipping the tree top off must be in the middle of a leaf node.
- ✓ Is important to clip the tree at an internode.
- ✓ Avoid pruning immediately above a whorl of leaves. This weakens the tree.
- ✓ Avoid working with very new and young branches (flush) developed after clipping the tree off.
- ✓ Once the new lateral secondary branches are matured, they can be bent and tied along the wire.
- ✓ Do not tie too tightly to allow the lateral branches to grow in diameter.
- ✓ These secondary branches are trained along the wire to increase the width of the Pomegranate tree on the trellis.
- ✓ Prune the tied lateral branches to a length of 15 cm - 20 cm to produce tertiary branches.
- ✓ Tie the top of the tree to the next wire to train it to grow straight up.
- ✓ The treetop must be secured to the wire after it grows past the wire.
- ✓ One of the tertiary branches developed from pruning the tied secondary branches must be tied along the wire to extend the width of the tree over the wire.
- ✓ Prune other tertiary branches to about half their length.
- ✓ Continue pruning tertiary branches to induce terminal buds that will flower.
- ✓ Even fourth tier branches can be allowed to flower if they are well positioned.
- ✓ Do not over-prune the tertiary or fourth tier branches. This will delay flowering.
- ✓ A ladder is used to work on high trees.
- ✓ After harvesting the trellised Pomegranates, manual pruning of tertiary and fourth tier branches completes the preparation for the next harvest.

8.5 De-Blossoming

The process of removing flowers in Pomegranate trees makes possible the shifting of production from one period to another perhaps more favourable marketing period. It can also delay production by 6 to 8 weeks.

9. FLOWER INDUCTION

Fruit	Growth Regulators	Chemicals	Pruning	Other
Pomegranate	Cycocel, Ethrel	DAP	Pruning and Thinning	Irrigation Stress

Table 8: Flower Induction

There are mainly three ways to induce flowering, chemical, pruning and physiological stress:

- Applying Cycocel and Ethrel on the foliage of the tree at the pre flowering stage.
- Pinching the terminal buds or branches of matured Pomegranate trees. This method produces a flowering response.
- Induced physiological stress:
- ✓ Deprive the trees of nutrients and/or water.

Flower induction in pomegranate, a process to stimulate the formation of flower buds, can be achieved through the application of plant growth regulators such as cycocel and ethrel. Cycocel (chlormequat chloride) and ethrel (ethephon) are commonly used chemicals in horticulture to promote flowering in various crops. When applied appropriately to pomegranate plants, these growth regulators can effectively initiate the flowering process. Cycocel acts by inhibiting gibberellin synthesis, leading to reduced vegetative growth and increased flower bud formation. Ethrel, on the other hand, releases ethylene gas, which triggers flower initiation and development. By carefully applying cycocel and ethrel at the right concentrations and timing, it is possible to enhance flower induction in pomegranate plants, ultimately resulting in improved fruit set and yield.

The recommended application rates of Cycocel (chlormequat chloride) and Ethrel (ethephon) for inducing flowering in pomegranate trees can vary depending on several factors. Firstly, it is important to consider the specific pomegranate variety being cultivated. Different varieties may have different sensitivities and responses to growth regulators. Additionally, the growth stage of the pomegranate tree is crucial in determining the appropriate application rates. Generally, these growth regulators are applied during the pre-flowering or early flowering stages to promote flower formation.

For Cycocel, the recommended application rates for pomegranate flowering usually range from 500 to 1,500 parts per million (ppm). However, it is essential to note that higher concentrations of Cycocel can potentially inhibit growth and adversely affect the plant's health. Therefore, it is advisable to start with lower concentrations and observe the plant's response before increasing the dosage, if necessary.

As for Ethrel, the recommended application rates for pomegranate flowering typically range from 200 to 500 ppm. Ethrel is known to stimulate flowering and enhance fruit set. However, it is important to exercise caution with Ethrel application, as higher concentrations can lead to excessive fruit drop or fruit abnormalities.

Appropriate concentrations and application timings of Cycocel and Ethrel specifically for pomegranate flowering in your area are set considering factors such as climate, soil conditions, and growth patterns.

Furthermore, it is essential to carefully follow the instructions and guidelines provided by the manufacturers of the Cycocel and Ethrel products. Adhering to proper dosage, timing, and application techniques will help ensure effective results while minimizing any potential negative impacts on the pomegranate trees. Regular monitoring of the plants' response to the growth regulators is also recommended to make any necessary adjustments and optimize the flowering process.

10. BAGGING

Bagging is a common practice in horticulture that involves covering fruits with protective bags during their growth and development stages. This technique is widely utilized in pomegranate orchards to improve fruit quality, protect against pests and diseases, and enhance market value. This report aims to provide an overview of the bagging process for pomegranate fruits, including specifications for the bags used.

Bagging pomegranate fruits is a beneficial practice that provides numerous advantages in terms of fruit quality, pest management, and reduced chemical usage. When selecting bags for this purpose, it is important to consider specifications such as size, material, UV protection, ventilation, and closure mechanism. Implementing proper bagging techniques can contribute to the production of high-quality pomegranate fruits and ultimately enhance the profitability of the Pomegranate farm operation.

There are several benefits from bagging Pomegranate fruits:

1. Pest and Disease Protection: Bagging acts as a physical barrier, preventing pests such as insects, birds, and fruit flies from damaging the fruits. It also reduces the risk of diseases caused by pathogens.
2. Enhanced Fruit Appearance: Bagging helps maintain the integrity and appearance of pomegranate fruits by shielding them from external factors such as sunburn, wind damage, and mechanical injuries. It promotes uniform color development and reduces blemishes.
3. Reduced Chemical Usage: Bagging reduces the need for chemical interventions like pesticides and fungicides, as the bags provide a protective shield against pests and diseases. This promotes more environmentally friendly and sustainable farming practices.

When selecting bags for bagging pomegranate fruits, certain specifications should be considered. These include:

a. Size and Material: The bags should be large enough to accommodate the growing pomegranate fruit. Generally, bags with dimensions of approximately 15-20 cm (6-8 inches) in width and 20-25 cm (8-10 inches) in length are suitable. The bags should be made of breathable, lightweight, and durable materials such as paper, non-woven fabric, or biodegradable plastics.
b. UV Protection: To protect the fruits from sunburn, it is advisable to choose bags with ultraviolet (UV) resistant properties. UV-resistant bags prevent excessive heat buildup inside the bag while allowing sufficient light penetration for fruit development.
c. Ventilation: Adequate ventilation is essential to prevent excessive moisture buildup inside the bags, which can lead to fungal infections. Bags with perforations or mesh windows are ideal for maintaining airflow and humidity control.
d. Closure Mechanism: The bags should have a secure closure mechanism, such as drawstrings or adhesive flaps, to ensure proper sealing and prevent pests from entering.

The recommended stage of fruit development to put a fruit bag on a pomegranate may vary depending on the specific purpose of using the bag. Here are a few common scenarios and their corresponding recommended stages:

a. Pest Protection: If the purpose of using a fruit bag is to protect the pomegranate from pests such as insects or birds, it is generally recommended to bag the fruit when it is still small and green. This is typically done when the fruit is about the size of a golf ball or slightly larger. Bagging at this stage helps prevent pests from damaging or feeding on the fruit as it matures.
b. Sunburn Prevention: In hot and sunny climates, fruit bags can also be used to protect pomegranates from sunburn. Sunburn can occur when the fruit is exposed to excessive heat and direct sunlight for prolonged periods. To prevent sunburn, it is advisable to bag the pomegranates when they are slightly larger than golf ball size but before they start to develop any color. This is usually when the fruit is still green.
c. Thinning and Size Control: Fruit bags can also be used as part of a thinning and size control strategy. By bagging selected fruits, you can reduce the overall number of fruits on the tree, allowing the remaining ones to grow larger and develop better quality. In this case, it is recommended to bag the pomegranates when they are at a stage where you can assess their size and quality. This is typically when the fruits have reached about one-third to one-half of their mature size.

It's important to note that bagging pomegranates requires careful handling to avoid damaging the fruit or trapping moisture, which could lead to fungal diseases.

11. INTERCROPPING

The double row and high-density planting system is very well suited for intercrops with the Pomegranate trees in the 4 m alley between double rows.

Intercropping is always possible during the life of the plantation as long the coverage of the canopy of the Pomegranate tree does not affects the growth and development of the intercrop by shading.

Intercrops of annual crops, such as onions or chili, could be used for better utilization of land and as an additional source of income for the farmers and as a weed control strategy.

Intercropping with crops that share common pests and diseases must be avoided. The use of chemicals that can harm the Pomegranate tree and the fruit must be avoided as well in intercropping.

12. HARVESTING

Harvesting pomegranates is a relatively simple process. Here's a step-by-step guide to help harvest pomegranates:

1. Determine the right time: One way to check for ripeness is by looking at the color of the fruit. When a pomegranate is fully ripe, its skin should have developed a deep red color. Additionally, the fruit should feel heavy for its size, which indicates that the seeds inside are plump and juicy.
2. For harvesting, Pomegranates should have their characteristic color and sound when tapped.

3. Prepare for harvesting: A pair of gloves and a pair of pruning shears or a sharp knife are required to harvest Pomegranate. A crate or basket is needed as well to collect the harvested fruit.
4. Cut the fruit from the tree: The fruit is carefully cut from the tree using the pruning shears or knife, leaving a small section of stem attached to the fruit. This stem will help the fruit last longer after it's been harvested.
5. Handle with care: Pomegranates have a thick, tough skin, but the fruit inside can be easily damaged. Handle the harvested pomegranates with care to avoid bruising or cutting into the seeds.
6. Store the pomegranates: Once harvested, store the pomegranates in a cool, dry place. They can be kept at room temperature for a few days, but if you want to store them for longer, place them in the refrigerator. Pomegranates can last for several weeks when refrigerated.

Keep in mind that the exact timing for harvesting pomegranates can vary based on factors such as climate, variety, and local growing conditions. It's best to monitor your pomegranate trees closely and harvest the fruit when it has reached its peak ripeness.

Intense Red Colour

The intense red colour of pomegranate fruits is primarily due to the presence of pigmented compounds called anthocyanins. However, there are several reasons why some pomegranate fruits may lack this characteristic intense red color:

1. Varietal Differences: Different varieties of pomegranates can exhibit variations in color. Some varieties naturally produce fruits with a lighter or more yellowish color, as opposed to the deep red color that is commonly associated with pomegranates.
2. Maturity: The color of pomegranate fruit intensifies as it ripens. Fruits that are harvested prematurely may not have fully developed their characteristic red color. Therefore, some fruits picked too early might lack the intense red color.
3. Growing Conditions: Environmental factors such as temperature, sunlight, and soil composition can affect the development of fruit color. Pomegranate fruits grown under suboptimal conditions might not develop the full, intense red color.
4. Stress: Pomegranate trees subjected to stress, such as water stress or nutrient deficiencies, may produce fruits with less intense color. Stress can affect the production of pigments and other compounds responsible for color development.
5. Storage and Handling: Improper storage and handling of pomegranates can also lead to a loss of color. Exposure to excessive heat, light, or rough handling can cause pigments to degrade, leading to a loss of color intensity.

It's important to note that the absence of intense red color doesn't necessarily indicate poor quality or flavor. Pomegranates can still be perfectly edible and delicious even if they lack the deep red color typically associated with high-quality fruit.

13. POST-HARVEST HANDLING

Pomegranates are popular fruits known for their vibrant color, unique flavor, and high nutritional value. Proper post-harvest management is essential to preserve their attractive fruit characteristics as follows below:

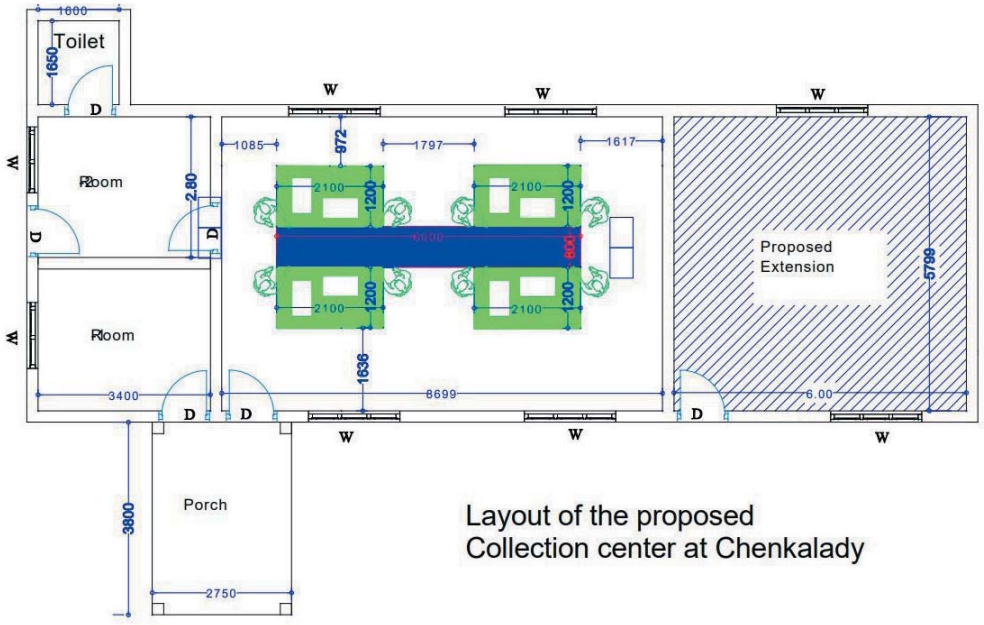
1. Sorting and Grading: After harvest, pomegranates should be sorted and graded based on their size, color, and overall quality. This process helps to separate damaged or defective fruits from those suitable for market distribution. Automated sorting systems will improve efficiency and accuracy in this sorting and grading process.
2. Cleaning and Sanitization: Proper cleaning and sanitization are essential to maintain the quality and safety of pomegranates. Using chlorine-based sanitizers or other approved sanitizing agents

to reduce microbial contamination is recommended. It is important to follow recommended concentration levels and contact times to ensure effective sanitization while avoiding any potential residue on the fruit.

3. Storage and Temperature Management: Pomegranates should be stored under controlled conditions to extend their shelf life and preserve quality. Pomegranates should be stored at temperatures between 32°F (0°C) and 41°F (5°C) with a relative humidity of around 90-95%. Cold storage helps to slow down the fruit's respiration rate, delay senescence, and reduce the risk of decay.
4. Packaging and Transportation: Proper packaging is crucial to protect pomegranates during transportation and minimize physical damage. Using sturdy containers with appropriate cushioning materials to prevent bruising and maintain fruit integrity is also strongly recommended. Adequate ventilation in packaging is also important to prevent moisture buildup and reduce the risk of fungal growth.
5. Ethylene Management: Pomegranates are sensitive to ethylene gas, which accelerates fruit softening and can lead to quality deterioration. Minimizing exposure to ethylene during post-harvest handling and storage will prevent ethylene damage. Separating pomegranates from ethylene-producing fruits or using ethylene absorbent materials can also help mitigate the negative effects of ethylene.

Pomegranate Collection Center

Pomegranate is an ASMP import substitution crop for the local market in Sri Lanka. This means the required post-harvest technology practices will mostly be implemented in a “Collection Center” rather than in a “Packing Center” for export. The Pomegranate Collection Center, therefore, will have minimum equipment and facilities. The main technical feature will be a 10-m long conveyor belt for sorting and grading to comply with local market specifications.



Layout of the proposed Collection center at Chenkalady

Pomegranate Shelf Life

The shelf life of fresh pomegranates can vary depending on various factors such as the maturity of the fruit at the time of purchase and the storage conditions. Generally, fresh pomegranates have a relatively long shelf life compared to some other fruits. When stored properly, in a cool and dry place, pomegranates can last for about 1 to 2 months. It is important to keep them away from direct sunlight and moisture, as excessive heat and humidity can accelerate spoilage. Additionally, inspecting the fruit regularly for any signs of decay or mold and removing any affected ones can help extend their shelf life. It's always recommended to consume pomegranates as soon as possible for the best taste and nutritional value.

14. Cost Benefit Analysis

Table 9: Farmer Level Cost Benefit Analysis

Item	Unit	Without project	With Project
Fresh Production /acre	MT	9.5	18
Production Waste	%	20%	15%
Sales Volume/acre	MT	7.6	15.3
Cost of Production/ acre	LKR	769,391	1,460,680
Cost/Kg	LKR	101.2	95.5
Selling Price/Kg	LKR	320	450
Gross Income/ acre	LKR	2,432,000	6,885,000
Gross Margin/ acre	LKR	1,662,609	5,424,320
Benefit/Cost Ratio		**3.2**	**4.7**

ANNEX 1: SPECIFICATION FOR POMEGRANATE PLANTING MATERIAL

Supplier

1. Supplier should own a DOA SCS registered nursery.
2. Supplier should transport the plants to the site directed by the ASMP.
3. Supplier should submit a certificate from a reputed laboratory to prove that plants are free from pests and diseases.
4. Preference should be given to suppliers within the district to minimize physical damages in transportation as well as to minimize transportation cost.

Plantlets

1. Plantlets must be grown in black color Polyethylene bags. The s size of bags should measure as diameter 12.5 cm and height 20 cm.
2. Bags must be filled with compost mixture as the potting media.
3. Plantlets should be placed in the center of the bag to allow for a well-developed root system.
4. Air layer plantlets should be obtained from reputable suppliers of imported Pomegranate plants.
5. Main stem height of the plantlet should be 20 cm to 23 cm, with pencil thick diameter and having at least 3 green leaves and hard enough for field planting.
6. The plantlets must reflect the characters of the Bhagawan variety.

ANNEX 2: FERTIGATION PROTOCOL

Management of the Irrigation System

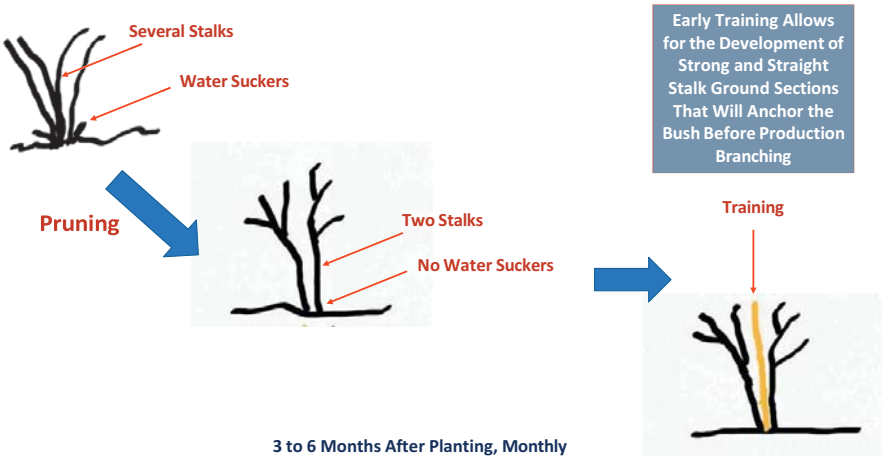
1. Turn irrigation pump on and allow the operating pressure of the system to become stable at the correct operating pressure (1 Bar to 2 Bar).
2. When pressure is stable, make sure venturi system is working correctly using only water in the fertigation tank or container.
3. Once venturi system is checked, proceed to fertigate with the fertilizer solution.
4. After fertigation, allow the system to continue to apply irrigation water to the plot for at least 10 minutes in order to flush out any fertilizer solution residue remaining in the system.
5. Make sure to apply Phosphoric acid every two weeks as recommended to make sure system remains unclogged by deposits of calcium salts.

Using Fertigation Solutions

1. Carefully follow "*Irrigation and Fertigation Recommendations*" issued by the ISP to make sure the right amounts and types of fertilizer materials are used for fertigation.
2. To prepare the fertigation solution, accurately weigh the correct amounts of fertilizer materials using a portable weighing scale.
3. Mix the weighed fertilizer material with water in an appropriate container such as a 20-litre plastic bucket using a clean wooden stick to stir the fertilizer material into the water to make sure all the fertilizer material is dissolved.
4. In case there is a fertilizer material that is not 100% soluble in water such as TSP, mix for at least 5 minutes to dissolve as much material as possible.
5. Filter the fertigation solution into the fertigation container to be used with the venturi system (fertigation tank or container) using a cloth filter such as an old t-shirt or similar.
6. After filtering, the fertilizer material left on the cloth filter when using a partially soluble fertilizer material such as TSP must be saved into a container to be used in the next fertigation with the same material.
7. Close the main valve of the irrigation system and open the valves of the venturi system to force the irrigation water to flow through the venturi system. This will create the necessary vacuum to suck the fertigation solution into the irrigation system to be distributed throughout the plot and applied to the crop.
8. After the fertigation solution is applied, add clean water to the fertigation container and allow this water to flow though the venturi system to clean it.
9. Open the main valve and close the venturi system valves to allow for normal irrigation to resume.

ANNEX 3: GRAPHICAL GUIDE TO POMEGRANATE TRADITIONAL PRUNING

POMEGRANATE FIRST YEAR PRUNING



Early Training Allows for the Development of Strong and Straight Stalk Ground Sections That Will Anchor the Bush Before Production Branching

3 to 6 Months After Planting, Monthly

POMEGRANATE FIRST YEAR PRUNING

Remove Overlapping and Interfering Branches and Branches Growing Straight Up

Begin to Shape the Canopy

3 to 6 Months After Planting, Monthly

POMEGRANATE SECOND YEAR PRUNING

Prune Branches Back 1/3

Remove Water Suckers

After One Year

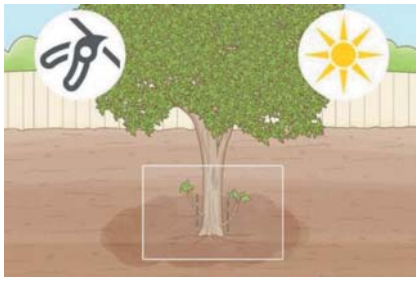
POMEGRANATE THIRD YEAR PRUNING

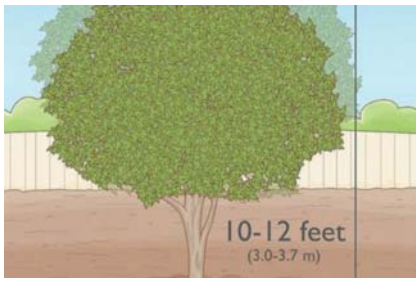
Cut Dead or Damaged Branches

Remove Crisscrossing and Erect Branches. Allow Light Penetration

POMEGRANATE MAINTENANCE PRUNING

Prune Away Water Suckers

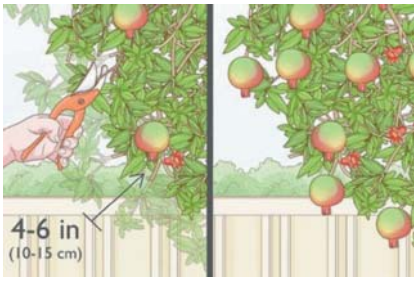




Control Tree Height, Shape and Width

POMEGRANATE MAINTENANCE PRUNING

Trim Tips of Branches to Encourage New Growth



Remove Branches that Yield Low Quality Fruit

ANNEX 4: SOIL ANALYSIS RESULTS AND FERTILIZER RECOMMENDATIONS

Analytical Report on Soil Batticaloa Sample tested on: 10/12/2021 - 13/12/2021

Description of sample(s): Moderate wet soil

Test(s) performed according to: Agro Services Internation (ASI) Methods and Walkely, and Black Method

			1:2.5, H20	%	µ5/cm	Exchangeable (meq/100g)			Total %	Available (ppm)						cmol/kg	Cation Ratios				
Crop	Sample Code	Lab No.	pH	OM	Ec	Ca	Mg	K	N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mag	Ca/K	Mg/K	Ca+Mg/K	Ca Saturation
Pomegranate	1. Kaluwanchikudy	B10 434	6.90	1.34	98.4	1.93	0.46	0.23	0.20	46	34	5.5	154.5	12.1	2.1	2.62	4.2	8.4	2.0	10.4	73.7
Pomegranate	1. Chenkalady - Thalawai	R1 435	5.87	1.34	68.4	1.80	0.77	0.08	0.14	10	18	4.4	105.7	4.4	1.5	3.05	2.3	22.5	9.6	32.1	59.0
Pomegranate	2. Chenkalady - Savukkaday	R2 435	5.92	1.61	95.4	3.07	0.31	0.16	0.14	35	21	5.7	159.9	3.1	1.0	3.94	9.9	19.2	1.9	21.1	77.9
Banana	1. Vellaveli - Malayarkaddu	R3 435	5.77	1.48	86.4	1.78	0.63	0.71	0.17	72	32	8.0	345.9	57.8	3.1	3.52	2.8	2.5	0.9	3.4	50.6
Banana	2. Vellaveli - Sinnawaththai	R4 435	5.70	1.21	89.1	1.83	0.71	0.86	0.17	90	29	9.0	272.2	47.3	2.8	3.80	2.6	2.1	0.8	3.0	48.2
Banana	3. Vellaveli - Thikkodai	R5 435	6.05	0.67	54.7	3.29	2.01	0.45	0.01	29	19	9.8	262.3	25.0	1.6	5.95	1.6	7.3	4.5	11.8	55.3
Banana	4. Vellaveli - Vilanthoddam	R6 435	5.98	1.08	46.2	1.77	0.69	0.38	0.11	51	27	6.1	215.5	44.7	3.3	3.24	2.6	4.7	1.8	6.5	54.6
Banana	5. Vellaveli - Palayadivaddai	R7 435	5.90	1.88	46.9	1.89	0.64	0.60	0.11	43	34	6.5	170.3	39.0	4.1	3.53	3.0	3.2	1.1	4.2	53.5
Banana	6. Vellaveli - Vammiyadiuththu	R8 435	5.97	1.34	37.5	1.97	0.72	0.66	0.11	35	27	5.3	153.7	29.5	1.7	3.75	2.7	3.0	1.1	4.1	52.5

Interpretation:

Organic matter and N are low. N very low
Ca, Mg and K are low
S and Mn are rather low
Cu and Zn are at deficient levels. Very low
Cation ratios show Mg unfavored by ratios
Ca Saturation a bit low, but Ca ratios favor Ca

Fertilizer Recommendations:

Organic matter like compost must be applied
Apply N as required by crop
MgSO4 and MOP need to be applied as well
Foliar applications of micronutrients, especially Cu and Zn are urgently needed
TSP is required only in Chenkalady - Thalawai as basal soil applications in granular form

Kg/ Plot/ Application	Year 1	Year 2	Year 3+
Urea	0.34	0.42	0.51
MOP	0.64	0.64	0.64
$MgSO_4$	0.97	0.97	0.97
Application per week	2		
Phosphoric Acid (ml) *Application every two week*	175.7	175.7	175.7
Foliar applications of micro-nutrients every two weeks are recommended, especially Cu and Zn			

Table 9: Fertigation recommendations per Application per Plot

Chenkalady Basal Application of Phosphorous

TSP	Sub-Plot A	
Kg/ Bed/ Month	1.036	Apply broadcast on the soil in the double row

Analytical report on Soil FM/AR4 - REPORT CIC/0037/21-22

Mullaitivu

Sample received on 03/07/2021 — sanple Ref: 37/CIC/0003/21-22

Description of Sample : Moderate wet soil (06) Samples were collected by client, — sample tested on: 18/08/2021- 21/08/2021

Tests performed accotrding to ASI Methods and Walkley Black Method

	Code		1:2.5, H_2O	%	µS/cm	Exchangeable (meq/100g)			Available (ppm)							cmol/hg					
Site	Sample	LAB NO	pH	OM	EC	Ca	Mg	K	NH_4-N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mg	Mg/K	Ca+Mg/K	Ca Sat.	Ca+Mg+K
Pom	MU-I	R2 432	6.02	1.61	73.6	2.13	0.66	0.23	18.7	22	61	5.3	215.6	21.7	2.7	3.42	3.23	2.87	12.13	62.28	3.02
Papaya	MU-II	R3 432	6.21	1.61	80.7	5.75	1.60	0.69	15.5	2	31	8.4	164.6	73.9	5.9	8.24	3.59	2.32	10.65	69.78	8.04
KK Bana	MU-III	R4 432	6.4	1.61	45.5	3.28	0.89	0.33	26.8	23	43	7.1	234.4	55.7	5.3	4.7	3.69	2.70	12.64	69.79	4.50
Chili	MU-IV	R5 432	6.84	2.15	200.0	7.22	1.81	1.16	31.4	54	28	8.8	212.6	91.6	7.5	10.19	3.99	1.56	7.78	70.85	10.19
Chili	MU-V	R6 432	7.25	2.02	116.4	8.25	5.1	0.24	22.9	36	50	11.4	149.9	83.9	9.5	13.59	1.62	21.25	55.63	60.71	13.59
TJC	JF-I	R7 432	6.15	0.67	20.6	1.74	0.36	0.33	13.7	23	36	6.5	181.9	26.3	1.1	2.63	4.83	1.09	6.36	66.16	2.43
Am Bana	JF-II	R8 432	6.96	3.09	243.0	11.61	1.14	0.5	31.8	101	38	9.5	56.4	77.3	8.9	13.25	10.18	2.28	25.50	87.62	13.25
Potato	JF-III	R9 432	7.07	1.88	305.0	11.97	1.55	1.3	13.0	133	77	9.6	50.4	44	11.4	14.82	7.72	1.19	10.40	80.77	14.82

Interpretation:

Low Organic Matter
Low Potassium
Low Magnesium in some sites
Very low Phosphorous in Papaya site
Micronutrients S, Cu and Zn are deficient
Ca/Mg very low
Achili site has a very high Mg/K

Recommendations:

Applied Nitrogen as required by the Crop
Apply MOP
Apply MgSO4
Foliar application of micronutrients is very important

Kg/ Plot/ Application	Year 1	Year 2	Year 3+
Urea	0.34	0.42	0.51
MOP	0.64	0.64	0.64
$MgSO_4$	0.97	0.97	0.97
Application per week	2		
Phosphoric Acid (ml) *Application every two week*	165.5	165.5	165.5
Foliar applications of micro-nutrients every two weeks are recommended, especially Cu and Zn			

Manual Applications

Grams/ Plant*		Urea	MOP	MgSO4
Fertilizer per Month per Plant	grams	19	29	44

*Apply monthly

ANNEX 5: ESPALIER TRELLIS PRODUCTION SYSTEM FOR POMEGRANTE

Espalier is a very practical technique that allows farmers and gardeners to grow fruit trees, shrubs and other branching and climbing plants in a **two-dimensional** manner, saving space while increasing productivity, facilitating caring for the plants, and maintaining aesthetics.

1. **What is Espalier?**
    - Espalier involves training fruit trees (or shrubs and climbing plants) to grow flat against supports, such as fences or walls, almost two-dimensionally rather than their natural growth pattern.
    - The word "espalier" originates from Italian *spalliera*, meaning "something to rest the shoulder against."
    - Initially developed by orchardists to maximize fruit production in limited spaces, espalier trees can also be found in historical gardens across Europe.

2. **Benefits of Espalier:**
    - **Space-Saving**: Espalier allows you to grow fruit trees along fences or walls, saving valuable garden space.
    - **Aesthetics**: Espalier trees have an artistic or architectural quality that adds sophistication to any garden.
    - **Abundance of Fruits**: Even in small gardens, you can achieve a bountiful harvest using this technique.
    - **Facilitate Caring for the Trellised Plants and Trees:** Practices such as pruning, harvesting, spraying, gagging can be applied very easily.

3. **Suitable Plants for Espalier:**
    - Choose flexible trees or shrubs with spurs for espalier trellising.
    - Apples, pears and other flexible branching fruit trees and shrubs are popular choices because they respond well to training and produce masses of fruits in a small space.
    - Pomegranate trees adapt very well to the Espalier Trellis system because they have flexible branches and produce spurs along those branches.

4. **How to Espalier Fruit Trees:**
    - Start when the trees are young saplings (usually about a year to two years old).
    - Bend supple new-growth branches to shape and secure them to a trellis or wires.
    - Prune off new shoots that won't conform to the desired pattern.
    - There are various patterns and forms for espalier, both formal and informal.

By mastering this art, farmers and gardeners can enjoy a fruitful harvest while adding visual appeal to the field or garden. One must remember that Espalier trellising is not only practical but also adds an elegant touch to the field or garden.

1. **References:**

    - Moulton, M. (2024). *How to Espalier Fruit Trees and Climbing Plants in 6 Easy Steps.* Epic Gardening
    - *How to Prune and Train Espalier Fruit Trees.* Nature Hills. (2019)
    - *An Easy Approach to Espalier.* Fine Gardening
    - *Espalier Fruit Trees: Big Harvests In Small Spaces.* Epic Gardening. (2023)
    - *How to Espalier Fruit Trees to Maximize Growing Space*. Morning Chores