

PRODUCTION TECHNOLOGY OF POMEGRANATE IN ARID REGION



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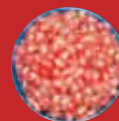
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PREFACE

Pomegranate (*Punica granatum L.*) is an important fruit crop of arid and semi-arid regions of India. It has ability to withstand harsh climate and tolerate heat, drought and moisture deficit situations. Pomegranate has high medicinal and nutritional value and one of the richest sources of antioxidants. It is grown commercially in the states of Maharashtra, Gujarat, Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh and Rajasthan. During 2016-17, pomegranate was cultivated over 2.16 lakh ha with an annual production of 24.42 lakh tonnes and productivity of 11.70 tonnes/ha in India. The area under pomegranate cultivation in hot arid region of India is increasing at faster rate owing to its high demand, hardy nature, better storage quality and nutritional values.

In Rajasthan, pomegranate is grown in Jaipur, Ajmer, Alwar, Tonk, Sriganganagar, Pali, Kota, Jalore, Banswara, Sawai Madhopur, Bhilwara, Jhunjhunu, Sirohi, Jodhpur, Jaisalmer, Bikaner and Barmer districts over 12,000 ha area. Complete technical knowledge for pomegranate cultivation in hot arid region is necessary to harvest maximum benefit under harsh climatic conditions with limited resources. This technical bulletin covers various aspects of pomegranate cultivation under hot arid region such as quality planting material production, planting and aftercare, canopy management, irrigation and nutrient management, flower regulation, insect, pest and disease management, harvesting and marketing etc. The compiled information, guidelines and pictures in the bulletin will be useful not only for pomegranate growers but also for nursery growers, researchers and students and will encourage a better pomegranate growing culture especially in hot arid regions of India.

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(Authors)

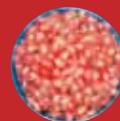


1. Introduction

Pomegranate (*Punica granatum L.*) is an important fruit crop of arid and semi-arid regions originated from Iran. Arid region is characterized by high temperature, low and erratic rainfalls with frequent drought; soils are poor in availability of nutrients and water holding capacity. The environmental conditions of arid region are very harsh for sustainability of plants, hence; selection of a fruit crop for such region is important for economic production. In India, pomegranate is grown commercially in the states of Maharashtra, Gujarat, Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh and Rajasthan. India is one of the major producer of pomegranate with largest acreage in the world. During 2016-17, pomegranate was cultivated over 2.16 lakh ha with an annual production of 24.42 lakh tonnes and productivity of 11.70 tonnes/ha in India. Maharashtra is the leading state with 65.51 per cent of the area and 64.61 per cent of total production under pomegranate (Anonymous, 2017). India is the only country in the world where pomegranate is available throughout the year (January – December). Iran is the greatest exporter of pomegranate (60,000 t) followed by India (35,176 t) (Chandra and Jadhav, 2009).

Iran, India, China, Turkey and the USA are major producing countries in the world with 76% of the total production. It is also grown in Afghanistan, Bangladesh, Myanmar, Vietnam, Thailand, Kazakhstan, Turkmenistan, Armenia, Georgia, Morocco, Tunisia, Egypt, Israel, Syria, Lebanon, Greece, Cyprus, Italy, France, Spain, Portugal, Mexico, Argentina and Chile for table and ornamental purpose. However, there is no exact data in world owing to continuous expansion in area. In Rajasthan, it is mainly grown in Jaipur, Ajmer, Alwar, Tonk, Sriganganagar, Pali, Kota, Jalore, Banswara, Sawai Madhopur, Bhilwara, Jhunjhunu, Bikaner and Sirohi districts in 12,000 ha area and acreage in Thar desert particularly Barmer, Jodhpur and Jaisalmer is increasing at faster rate.

Pomegranate has ability to withstand harsh climate and tolerate heat, drought and moisture deficit. The area under pomegranate cultivation in India is increasing day by day owing to its high demand, hardy nature, low maintenance cost, high yield, better storage quality and therapeutic values. It has enormous medicinal, nutritional value and one of the richest sources of antioxidants. A number of processed products such as juices, squash, jelly, anardana and mouth freshener are prepared by processing fruit. The juice is highly nutritious and is recommended for patients suffering from gastric troubles. It contains 67.95 kcal energy, 1.41 g protein, 1.60 g fiber, 2.50 mg calcium, 10.22 mg magnesium, 34.3 mg phosphorus, 0.39 mg iron, 0.26 mg zinc, 0.09 mg thymine, 0.22 mg niacin, 23.38 mg ascorbic acid and 26.00 mg total carotenoids per 100 g fresh weight of fruit. It has been used in treatment of sore throats, coughs, urinary infections, digestive disorders, skin disorders and it might help to prevent heart disease, heart attacks and strokes. The seed is used to treat syphilis while juice used to treat jaundice and diarrhoea. Juice of flower is used to treat nose bleeds. The fruit pulp and the seed are stomachic; dried, pulverized flower buds are employed as a remedy for bronchitis (Debjit *et al.*, 2013) and owing to numerous health and nutritional benefits it is known as “super food”. The high return per unit area has resulted in incessant increase in area and production of pomegranate in arid region in this decade. Complete technical knowledge for pomegranate cultivation in arid region is necessary to harvest maximum benefit under extremities of abiotic stresses with limited resources.



2. Soil and climate

Pomegranate can be grown on a wide range of soils from sandy soil to sandy loam soil. Light soil with pH range 6.5 to 7.0 is highly suitable for its cultivation; however it can tolerate pH up to 8.5 under proper management practices. Fruit quality and colour development is good in light soils but poor in heavy soils. It tolerates salinity up to 6.00 dSm⁻¹ and sodicity up to 6.78 ESP (Waskar, 2006). Pomegranate cultivation is successful in arid ecosystem as it can withstand dry climate and adverse soil conditions prevailing in arid ecosystem. It can grow well even in marginal lands with poor fertility and shallow depth. Arid soils are poor in organic matter and nutrients content, therefore proper management of soil health, nutrients supply is required to get high yield.

Pomegranate has wider adaptability as it grow well in tropical, subtropical, arid and temperate regions due to its hardy nature. However, its main cultivation is confined to the northern hemisphere. Interestingly, the best quality fruits are produced in arid regions (Chandra *et al.*, 2010). It grows as a deciduous shrub in the temperate region but evergreen or partially deciduous under tropical and subtropical conditions, which also depends upon the variety/ genotypes. It grows very well in the semi-arid climate where cold winter and hot summer prevails. The tree requires warm and dry climate during fruit development and ripening. The unique plasticity of pomegranate is evident from the threshold limit it exhibits for higher of 44°C and lower as -12°C temperature. Arid and semi-arid regions having annual rainfall 500 to 1000 mm with long, hot and dry summer and mild winter are suitable for pomegranate growing. It can easily tolerate temperatures up to 45-48°C along with dry hot winds.

3. Varieties

There are many commercial varieties which are cultivated in different parts of India (Table1). Jalore Seedless is popular in Rajasthan (Fig. 1) while Bhagwa is the predominant ruling variety of India owing to its dark red arils and attractive red colour rind (Fig. 2). Important varieties of pomegranate are Ganesh, Dholka, Bhagwa, Phule Arakta and seedless varieties such as Paper Shell, Spanish Ruby, Mascut Red and Velladu, which showed great potential. Earlier, Ganesh variety with big sized fruits was the preferred, but presently soft seeded, red peel and aril colored varieties with high per cent of juice are preferred such as Bhagwa and Mridula. In hot arid climatic condition, the varieties like Jalore Seedless, Bhagwa, G-137, Mridula, Phule Arakta and Ganesh are found promising.

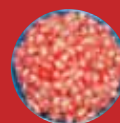


Fig. 1. Jalore Seedless - a popular variety of Rajasthan

Fig. 2. Bhagwa - a predominant ruling variety of India


Table 1. Promising varieties/ hybrids of pomegranate developed in India

Sr. No.	Variety	Parentage	Characteristics	Developed by (Year)
1.	Ganesh	Clonal selection from Alandi	Oldest variety, fruits medium sized, with yellow, smooth surface and red tinge, arils soft with pinkish color and sweet in nature.	MPKV, Rahuri (1936)
2.	CO-1	Clonal selection	It is a high yielding selection. Fruits are medium-sized with attractive rind, soft seeds, higher pulp content and sweet taste.	TNAU, Coimbatore (1983)
3.	G-137	Clonal selection from Ganesh	Fruits are large sized, surface smooth, yellow with red tinge, deep pink and bold aril, and soft seeds, sweet and prolific bearer.	MPKV, Rahuri (1984)
4.	Yercaud-1	Clonal selection from Acc No.455	Its fruits are medium sized, with easily peelable rind. The seeds are soft with attractive, deep purple aril.	TNAU, Coimbatore (1985)
5.	Jyoti	Open pollinated seedlings of Bassein Seedless and Dholka	The fruits are medium to large sized, having attractive, yellowish red, more fleshy and pink aril. Fruits are very sweet, soft seeded and taste good. It yields moderately.	UAS, Dharwad (1985)
6.	Jalore Seedless	Clonal selection from Ahore area of Jalore	Popular variety of Rajasthan, fruits round fruit, yellow with red tinge in colour, aril colour light pink to pink, juicy, taste sweet, TSS 15-16° Brix and plants semi vigours.	CAZRI, Jodhpur
7.	Mridula	Ganesh x Guleshah red	Fruits medium sized, rind smooth, dark red in colour, blood red sweet arils with very soft seeds, plants are dwarf.	MPKV, Rahuri (1994)
8.	Ruby	Multiple hybrid between Ganesh x Kabul x Yercaud and Gulesha Rose Pink	It has soft and red arils with good flavour. The plants are dwarf, prolific bearer, providing uniformly red fruits.	IIHR, Bengaluru (1997)
9.	Amlidana	Ganesh x Nana	Arils are highly acidic (4.8 %), fruit medium size, plant dwarf, suitable for anardana	IIHR, Bengaluru (1999)



Sr. No.	Variety	Parentage	Characteristics	Developed by (Year)
10.	Bhagwa	Clonal selection Ganesh x Guleshah red	Ruling variety of pomegranate in India, fruits big size, glossy red rind, thick rind, bold red arils, sweet and soft seeded, matures in 170 to 180 days after full bloom	MPKV, Rahuri (2003-04) under AICRP -AZF
11.	Phule Arakta	Ganesh x Guleshah red	Fruit medium sized dark red rind colour, arils are also dark red, soft seeded and sweet.	MPKV, Rahuri (2003)
12.	Goma Khatta	Ganesh x Daru	Suitable for anardana. Yield 6.59 kg/plant and anardana yield 1.18 kg/plant. Seeds medium hard, juice 46.7%, TSS 14.5° Brix and acidity 7.3%.	CIAH, Bikaner (2010)
13.	Phule Bhagwa Super	Selection from Bhagwa	Very attractive, dark saffron rind colour with glossiness on rind surface, good quality fruits, matures earlier than Bhagwa	MPKV, Rahuri (2013)

Exotic varieties

- Wonderful:** This variety developed in California, USA. Fruits are large in size with deep uniform red colour. Rind is medium thick and hard. Arils are deep crimson in colour, juicy, with medium hard seeds. This variety is highly suitable for juicing with acidity 1.5-1.75% and TSS 17° Brix. The fruit matures in late September and October in India.
- Granada:** Early maturing variety originated in California as a bud mutation of Wonderful, but displays a red crown while in the green stage, darker red in colour. Seeds are medium hard and less acidity than Wonderful. The fruit ripens one month earlier than Wonderful but smaller in size. Owing to early maturity it fetches premium price in the market.
- Early Wonderful:** It is high yielding variety. Fruits are large in size, thin-skinned, deep-red colour. Arils are delicious with medium hard seed. It ripens about 2 weeks earlier of Wonderful.

4. Nursery establishment

Quality planting material is the key for a successful pomegranate production. Pomegranate planting material especially multiplied through hard wood cuttings and air layering's carry infections of threatening diseases like nematode, bacterial blight and wilt. These diseases may express after 5-10 months of planting in the orchard, thus introducing disease in new orchards. Besides this several other pests may also be introduced. Hence, procurement of quality planting material from a certified nursery is highly important.



Points to be considered for establishment of nursery

- i. The mother plants should be maintained by Govt./Certified agency for maintaining their varietal identity and purity with molecular characterization data.
- ii. The progeny orchards should be established by nursery growers from mother plants free from nematodes, bacterial blight and wilt. This progeny orchard is used to collect planting material hard wood cuttings/ tissue culture explants for commercial production.
- iii. Propagating material has to be monitored regularly and tested through diagnostic tool recommended for the detection of diseases.
- iv. The nursery soil should be sterilized through solarization or formalin. Soil solarization can be done by covering moist soil with 25-75 μ m thick transparent polyethylene sheets for 5-6 weeks during hottest summer months (April to June). It kills most of the diseases, pests and destroys weed seeds. Formalin 2.5-5ml/l is also used for soil treatment and soil covered with polythene sheet for 1 week which kills all diseases, pests, weeds along with beneficial microorganism.
- v. Apply bordeaux paste (10%) to the cut ends of the mother, progeny plant and air layered cuttings.
- vi. Nursery raised plants need to be checked regularly for possible infection of diseases and pests like bacterial blight, wilt, fruit spots and rot, termite, mites, thrips and root knot nematode.

5. Propagation

Pomegranate is commercially propagated through stem cutting and air layering. Air-layering is commonly used for propagation of pomegranate in the South India and hardwood cutting in the rest of India. Pomegranate multiplied through stem cuttings and air layers carry dormant infections of challenging diseases like nematodes, bacterial blight and wilt, which introduce disease inoculums in new orchards. Hence, production of quality planting material is of supreme importance. Recently, tissue culture plant production becoming popular owing to uniform condition and free from insect, pest and diseases. Standardization of grafting technique and identification of suitable rootstock can play important role in mitigating abiotic stresses particularly drought, salinity and high temperature in arid region.

i. Hard wood cutting

Pomegranate can be propagated both by hardwood and semi-hardwood cuttings under mist system; though the better success was obtained with semi-hardwood cutting. Semi-hard wood cuttings of 6-12 month old, 20-25 cm length and pencil thickness perform best (Fig. 3). Pruned wood of winter season can be used, which gives high success rate. July is the best time for planting of cutting under mist system, however cutting can be planted during February. Flower and fruit producing lateral branches should not be used for making cuttings. Dip lower part of stem cuttings for 5 minutes in a solution of 2500 ppm IBA for inducing roots (Saroj *et al.*, 2008). This treatment induces fibrous root system, which is essential for better establishment of plants under field conditions. Cuttings are planted in a mixture of cocopeat and sand (4:1) or cocopeat alone for faster rooting in mist chamber. Before planting it is advantageous to sanitize the cuttings by giving 5



minute dip in 2-bromo-2-nitro-1,3-diol @ 500mg/l + carbendazim @ 1.0 g/l dissolved in lukewarm to reduce surface pests and disease infestation. Well rooted cuttings should be transferred after 45 -60 days to nursery bags containing sand: soil: FYM (1:1:1). Before transplanting in field, the plants are kept in shade for 7-10 days for hardening which gives higher survival of plants.

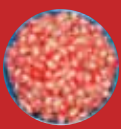


Fig. 3. Plant propagation through stem cuttings

(a). Preparation potting mixture of cocopeat and sand (4:1, v/v), **(b).** Filling of protrays with potting mixture, **(c).** Preparation of stem cutting, **(d).** Disinfection treatment, **(e).** Rooting hormone (IBA) treatment, **(f).** Planting of cutting in protrays, **(g).** Sprouted and rooted cuttings and **(h).** Transfer of rooted cuttings in polybags

ii. Tissue culture

Tissue culture propagation is highly successful in most of the high value crops and has vast scope in pomegranate. There is a growing demand of pomegranate quality planting material in arid region, for which mass multiplication of pomegranate through tissue culture is required. Plants produced through tissue culture are free from any kind of infection and true to type. Uniform plant growth and synchronized flowering and fruiting of tissue cultured plants make



them more suitable for mechanized cultivation with better quality and high yield. In pomegranate cultivation nematodes, wilt and blight major challenging diseases and tissue culture provides disease free planting material for extension of pomegranate to non-traditional areas of hot arid region. However, it is costly and high skill requiring technology. Intensive care is required for tissue cultured plants to harvest its full potential in term of yield and quality. Tissue culture technology requires high initial cost, intensive care and skilled man power. There are also needs for proper standardization of package of practices for commercial cultivation of tissue culture raised plants.

6. Establishment of new orchard

Square or rectangular planting systems are popular in pomegranate planting. Planting should be done in pits of 1 m x 1 m x 1 m size and pits are dug about a month prior to disinfect by intense solar radiation. Heat of April and May is most beneficial for soil solarization. Planting should be done during spring season (February-March) or rainy season (July-August) depending on availability of irrigation water. Planting distance depends upon soil and climatic condition, variety and ease of intercultural operation for weeding, hoeing, drip system installation and mechanization *etc.* In general, 4 m x 3 m (833 plants/ha), is optimum for cv. 'Bhagwa' (Fig. 4). However, spacing of 5 m x 2.5 m (800 plants/ha), 5 m x 4 m (500 plants/ha) and 5 m x 5 m (400 plants/ha) can be followed for more spreading varieties like Ganesh and Jalore Seedless (Fig. 5). Support should be provided to young plants to keep the plant straight and avoiding breakage of shoots by winds in arid region. Use 50-80 cm long plastic or bamboo sticks and tie the main branches with strings. Wooden sticks should be treated with chloropyriphos 2 ml/litre for termite protection.



Fig. 4. Layout preparation and planting in arid region



Fig. 5. Rectangular system of planting in pomegranate 'Jalore Seedless' in arid region



7. Canopy management

Training operation starts after 6-8 months to develop structural framework and last up to 2-3 years after planting. The lowest branch should be allowed to develop at 30-40 cm above the ground with single stem training or multi stem training. In arid region, multiple stem training (3-5 stems) system (Fig. 6) is preferred to avoid losses of stems/plants by termite attack which is severe problem in hot arid region in initial stage of orchard development. Pruning is done twice a year to remove dried twigs, branches and maintain balance between vegetative and reproductive growth. Major pruning is practiced just after harvest in winter and light pruning is done at flower regulation during May-June. In severe bacterial blight infected orchards, heavy pruning is done after harvest and remove as far as possible diseased portion. Apply 10 % bordeaux paste on the cut end of plant after training and pruning.

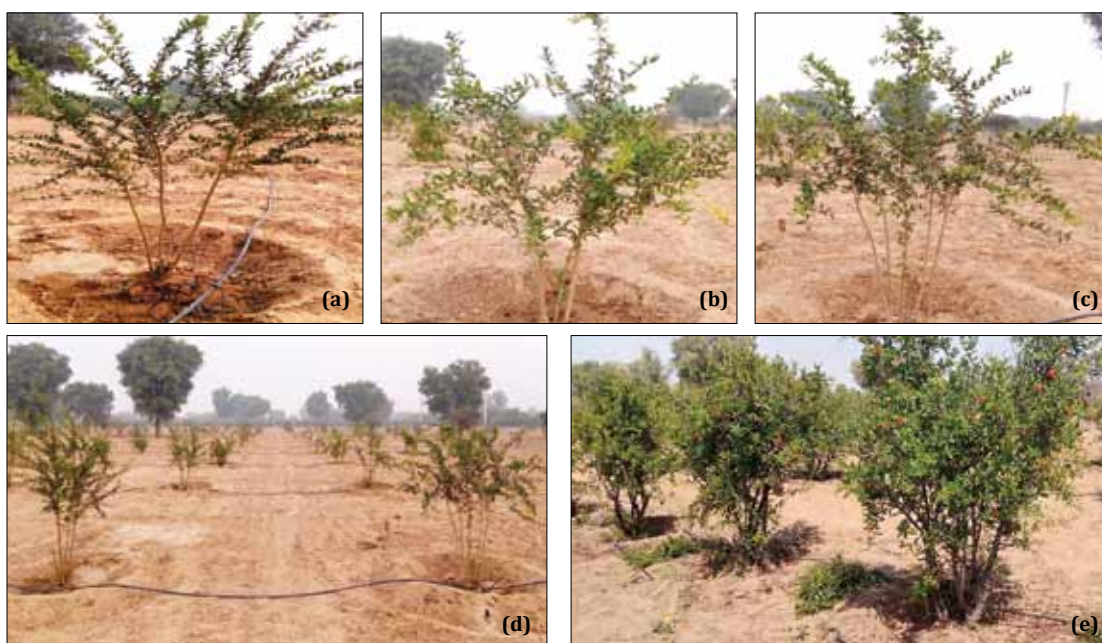


Fig. 6. Training and pruning in pomegranate in arid region

(a). Three stem training, (b). Four stem training, (c). Five stem training and (d). Well trained orchard and (e). Bahar pruning

8. Flower regulation

Pomegranate flowers continuously under arid and semi-arid climatic conditions and bear small crop irregularly at different period of the year, which may not be desirable commercially. To avoid this plants are given flower regulation/bahar treatment. In this treatment, irrigation is withheld one to two months prior to the bahar and ethrel (1-2 ml/litre) is applied which facilitates the shedding of leaves. The trees are light pruned 40-45 days after withholding irrigation. The



recommended doses of fertilizers are applied immediately after pruning and irrigation is resumed. This leads to profuse flowering (Fig. 7) and fruiting.



Fig. 7. Profuse flowering with higher number of bisexual flowers after flower regulation



Fig. 8. Bisexual, intermediate and male flowers in pomegranate

The fruits are ready for harvest 4-5 months after flowering. Pomegranate bears bisexual, intermediate and male flowers (Fig. 8) on both new and old growth in three flushes. In arid and semi-arid climate, there are three flowering seasons, viz., February-March (*ambe* bahar), July-August (*mrig* bahar) and September-October (*hasta* bahar). The choice of flowering/fruiting to be regulated depends upon the availability of irrigation water, market demand and pest/disease incidence in a given locality. The fruit of *ambe* bahar requires assured irrigation and become ready for harvest in the month of June to August. As the fruit development takes place during dry months, the size and colour are not good in this bahar and yield is also low. The incidences of pest like mites are higher. Therefore, *ambe* bahar is not taken hot arid region.

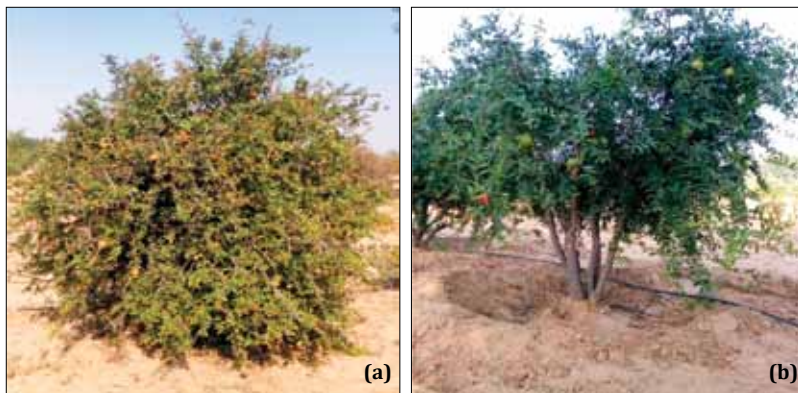
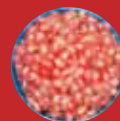


Fig. 9. Pomegranate plants (a) without canopy management and flower regulation (b) with proper canopy management and flower regulation treatment



The *mrig* bahar crop is harvested in the month of December to February. Usually this bahar is favoured as the flowering and fruiting period coincides with monsoon season, and the crop is taken without much irrigation. The fruits develop during the rainy season and mature during winter. This bahar is preferred in arid and semi-arid region due to limited water availability and climatic condition. The fruits from *hasta* bahar are harvested during the month of March to April. They have very attractive rind with dark coloured arils. Since the availability of the fruits during this season is limited, they fetch high value. Optimum water stress cannot be developed during this period as withholding of irrigation coincides with the rainy season. This leads to poor flowering and fruit set which affect yield. Therefore in pomegranate proper canopy management and flower regulation (Fig. 9) is required to get high yield with sustainable production.

In hot arid region, induction of flowering during August-September is beneficial as fruit develop and mature during milder climatic condition from November to February. For this irrigation is withheld for one month during May-June followed by light pruning (20 cm of new growth) and application of defoliant ethrel (1-2 ml/litre) mixed with 5 g DAP. It helps in improvement of fruit size and aril colour particularly in light coloured variety like Jalore Seedless (Fig. 10). Deblossoming of flower produced prior and after of main blooming period/bahar is also beneficial in improving yield and quality of fruits as it compete with developing fruits for nutrients and water. Around 80-120 fruit are kept after fruit set by removing weak, deformed and cluster fruits/flower.



Fig. 10. Improved fruit set, fruit size and colour through flower regulation

9. Intercultural operations

In hot arid region, termite are major problem in initial stage and newly planted saplings take 2 to 3 months for proper root development. Therefore, proper management of termite through neem cake 1-2 kg/plant or chloropyriphos 2 ml/litre is essential. Intercultural operations like irrigation, weeding, hoeing and desuckering should be carried out regularly. Suckers should be removed as early as possible after emergence as they are fast growing and non productive in nature. Maintenance of orchard sanitation is required to keep orchard free from weeds, which may be host of several diseases including bacterial blight, nematodes and other insect-pests. Remove dried and infected fruits and twigs regularly and burn them properly to reduce the disease and pest inoculum in the orchard. Pruning secateurs should be sterilized after handling each infected tree with sodium hypochlorite (2.5%).



10. Irrigation management

In arid and semi-arid regions pomegranate is grown with limited irrigation facilities. It requires regular irrigation to get optimal yield and fruit quality. In commercial production, irrigation should be scheduled as per the requirement of crop growth stage. The most sensitive phase of a plant growth cycle occurs during pollination, fruit set and development. Further water deficits, at fruit maturity and ripening stages results in fruit cracking and such fruits become unsuitable for the fresh market. The water requirement of plants depends on age, season, location and management practices. Drip irrigation has great potential due to high water use efficiency and increased yield. Besides water saving (60%), yield can be increased up to 30-35% by drip irrigation. Drip irrigation system with 2-4 adjustable drippers per plant should be installed depending upon age of the tree. For one to three year old plants, 2 drippers/plant may be enough to provide required irrigation to the plant whereas from fourth year onwards 4 drippers/plant found better. Even fertilizers and chemicals can be applied through drip irrigation. In general, for nonbearing trees, about 5-25 litres/plant/day and 20-65 litres/plant/day for bearing trees are needed (Chandra *et al.*, 2011).

Excess irrigation should be avoided which may increase wilt and nematode problems in the orchards. Therefore, judicious irrigation should be provided to the plants. Covering the soil with inorganic or organic mulches during dry months after the rainy season conserves soil moisture and saves irrigation water, creates favorable conditions for plant growth and development.

Types of drip irrigation system

In hot arid region, particularly on sandy soils surface drip irrigation system is recommended (Fig. 11). In this system drippers and the lateral are laid on the soil surface. Based on the types of laterals used, the drip irrigation system is classified in to two groups:

On line drip system

In this system, the drippers are fixed on extension tube, which fixed on the lateral pipes by punching suitable holes as per crop spacing and canopy spread. Two dripper 15 cm away from plant are used during initial three years on one lateral and from 4th year onward four drippers on one or two laterals are needed depending on plant height and spread.

In line drip system

In line drip irrigation system, drippers are already installed within or on the drip lateral at regular intervals by the manufacturer. This is suitable for close spaced crop and easy to handle.

Points to be considered for efficient drip irrigation

- Clean filters regularly based on the water quality and content
- Additional flushing should be conducted at the end of the irrigation season
- Flush the mainline, sub main and laterals ends to remove sediments
- Check the flow and pressure at head, valves, laterals and drippers randomly
- Check repair damage caused by rodents, insects, animals or farming tools regularly

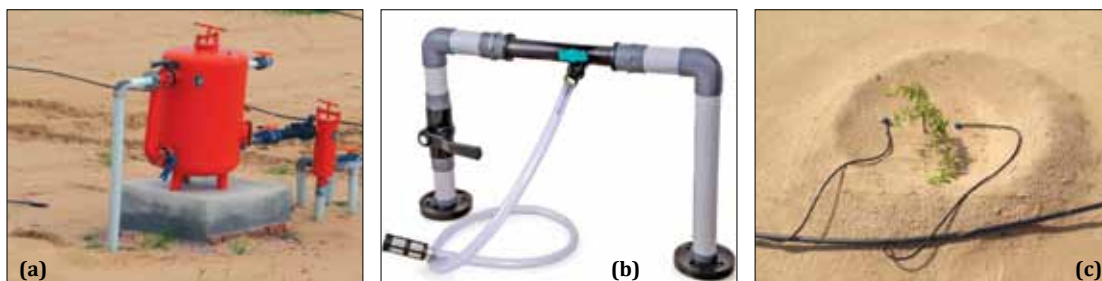


Fig. 11. Drip irrigation system (a) filter tank, (b) venturi and (c) adjustable drippers

11. Nutrient management

Good soil health is necessary for plant growth, fruit yield and quality sustainable production. Most of the root system is distributed in top 50-60 cm of soil and within 1 m of the stem. Manures and fertilizers should be applied in ring and covered with soil to avoid volatilization loss. Recommended dose of manure and fertilizer should be applied to non bearing trees (1-3 years) in three split doses coinciding with growth flushes during January, June and September. A full grown tree (5 year or above) requires 40 kg FYM, 625 g nitrogen, 250 g phosphorus and 250 g potash annually (Table 2). The plants are exhausted to a considerable extent after fruit harvesting. Therefore, it is required to promote vegetative growth by proper nutrition for better flowering, fruit set and development of the fruit in the next season. Thus, 1/3 recommended dose of manure and fertilizer should be applied just after pruning. Remaining 2/3 recommended dose of the manure and fertilizer should be applied in split doses after flower regulation (defoliation and pruning). First split dose consisting of full dose of FYM, 1/3 dose of N and K and full dose of P should be applied as basal dose just after first irrigation and remaining two split doses of N and K at 3-4 weeks intervals. Apply manure and fertilizer in shallow circular trenches/small pits (8-10 cm depth) at 45-60 cm away from main stems below tree canopy and cover with soil and provide irrigation.

Organic manures

In arid region soils are deficient in organic matter content. The use organic manures like FYM, poultry manure, vermicompost are highly important for increasing organic carbon in arid soil. Organic manures not only decrease bulk density but also improve soil porosity, water holding capacity, and pH of the soil. Organic amendments also result in higher microbial activities, which results in increased availability of all major and micronutrients. Vermicompost is rich in macro and micronutrients, growth promoting substances, nitrogen fixers and beneficial microorganism's population. One third nutrient requirement should be given through organic manures. In pomegranate organic manures should be applied least twice a year, first after harvest and second time at flower regulation.


Table 2. Manure and fertilizer requirements of pomegranate plant

Age of plant (years)	FYM (kg)	Nitrogen (g)	Phosphorus (g)	Potash (g)
1	10	250	125	125
2	20	250	125	125
3	30	500	125	125
4	40	500	125	250
5 and above	40	625	250	250

Note: Doses are total requirement per year and should be reduced depending on available nutrients in specific orchard soil.

Source: Sheikh (2006).

Micronutrients have ability to improve fruit size, colour, taste and earliness, thereby enhancing produce quality and market appeal. It also improves fertilizers and water use efficiency, impart disease resistance, prevent physiological disorders and increase marketable yield. Micronutrient can be managed by giving three foliar sprays during crop season. First spray each of ZnSO_4 @ 0.3%, MnSO_4 @ 0.6% and boric acid (17% B) @ 0.6% should be given before flower and bud initiation i.e. 15-20 days after defoliation when new growth emerged. The second and third spray of ZnSO_4 @ 0.3% and MnSO_4 0.6% should be given at 30 to 60 days after peak flowering. Timely identification of deficiency symptoms (Table 3) is very important for proper management.

Table 3. Micronutrient, their deficiency symptoms and management in pomegranate

Micronutrient	Deficiency symptoms	Management
Boron	<ul style="list-style-type: none"> Growth hampered at the growing point and poor development of roots Impaired pollen development and premature shedding of male flowers which leading to poor fruit setting Deformed fruit growth and cracking 	<ul style="list-style-type: none"> Spray boric acid (17% B) @ 0.05-0.1% during pre bloom period and followed by two post bloom application, one at 10 days after petal fall and other during fruit set stage Apply borax (11% B) @ 0.5-1.0 kg per ha. Application of boron during fruit maturity must be avoided as it results in abnormal fruit ripening
Copper	<ul style="list-style-type: none"> Stunted leaf/shoot growth and abnormal size with die back Poor flowering with low fruit set Production of small fruit with inferior quality 	<ul style="list-style-type: none"> Spray 0.2% copper sulphate either alone or neutralized with fresh hydrated lime before flowering and during post harvest period Apply copper based fungicides like copper oxychloride/sulphate for disease control



Iron	<ul style="list-style-type: none"> Suckers/water sprouts show leaf chlorosis Yellowing of leaves 	<ul style="list-style-type: none"> Foliar sprays of Fe- chelates (Fe-DTPA) @ 0.3-0.5% during late summer-early dormant period twice or thrice. Also apply Fe chelates (Fe- EDDHA) through drip system @ 3-5 mg /litre Use surfactants like 0.2% CaCl₂ to enhance effectiveness of foliar spray
Manganese	<ul style="list-style-type: none"> Inter veinal chlorotic areas develops and become pale green or dull yellowish Appearance of light green mottle between the main veins 	<ul style="list-style-type: none"> Spray manganese sulfate @ 0.40 to 0.60% depending on the severity of deficiency after 10 days of petal fall Spraying of fungicide- mancozeb also supplement readily available Mn to tree
Zinc	<ul style="list-style-type: none"> Reduction in leaf size and shoot growth Poor flowering and low fruit set Production of small size fruit 	<ul style="list-style-type: none"> Apply chelated zinc (EDTA-Zn) @ 2.5-7.5 g /plant through soil Foliar sprays of zinc sulphate @ 0.3 to 0.5% before bud opening and after fruit harvesting. Add surfactant to increase efficacy of foliar spray

12. Physiological disorders

In hot arid climate, major physiological disorders (Fig. 12) are fruit cracking, sun scald and aril browning. Proper management of these disorders is essential to get quality yield.

i. Fruit cracking

It is major problem in pomegranate under arid and semi-arid regions and about 25-60% fruit cracking has been reported during maturity in different bahar. It also varies with variety, season and climate. The cracked fruits are sweeter with low keeping quality; highly liable to fruit rot and are unfit for transport. In fruit cracking, xylem and phloem tissue loss their ability to divide and enlarge. In summer, after dry spell (April-June) water supply is increased and meristematic tissue quickly resume growth but due to uneven growth rate fruit splitting occurs, while during winter fluctuating moisture and temperature causes cracking. Dry hot wind at the time of fruit ripening are the main cause of cracking during *ambe* bahar, rapid aril growth, temperature higher than 38°C combined with less than 60% humidity favoured cracking. Nutrients like boron, calcium, copper, zinc, molybdenum, manganese and potash are involved in different physiological activities during fruit growth and development. Deficiencies of nutrients along with imbalanced use of nutrients also cause cracking. In young orchard, fruit cracking is due boron deficiency while in old orchard moisture imbalance and fluctuating temperature are major factor associated with fruit cracking. Fruits split generally when rains come or irrigation is given after a long dry spell. For cracking management apply adequate and regular irrigation during fruiting season. Spray of gibberellic acid @ 20 ppm, calcium chloride 2% and boron 0.2% at fruit enlargement and 1 month before harvest can help in reducing cracking. Cover fruits with bags in hot dry period and maintain sufficient calcium and potassium levels as per soil test report.



ii. Sun scald

In hot arid region, sun scald is also serious disorder particularly in *ambe* bahar crop and improper canopy managed orchard. Surface of fruits which is towards sun light turns brownish black due to intensive scorching heat during hot months particularly during May to July. Proper canopy management is required to avoid the direct exposure of fruits to sunlight. Kaolin 5% spray during May to July months is useful in reducing the sunscald. Shading with 35% shade net is helpful in reducing sunburn on pomegranate fruit. Bagging of fruits with cover bags is also useful in minimizing sun sunscald problem. White colour bags are more efficient in reflecting sunlight.

iii. Aril browning

It is due to delayed harvesting in which arils become brown and start rotting. The harvesting should not be delayed beyond maturity period. The pomegranate fruits should be harvested as soon as they mature viz. between 140-150 days after blooming in Jalore Seedless and 170-180 days in Bhagwa.



Fig. 12. Physiological disorders of pomegranate: fruit cracking, sun scald and aril browning

13. Insect-pest and disease management

Pomegranate is affected by numbers of diseases, insect and pests. Bacterial blight and wilt are severe threat to pomegranate in India, while in hot arid region of Rajasthan nematode, fruit spot, mite, thrips and termite are major problems. Major diseases of pomegranate are described below.

i. Bacterial blight (*Xanthomonas axonopodis* pv. *Punicae*)

Water soaked spots of irregular size appear on undersurface of leaves and after some time these spots turn blackish brown. These spots with cracks also appear on fruits (Fig. 13). The bacterial ooze comes out after rains, which gives sticky appearance and after drying gives white shiny encrustation on the surface of blight lesion. For management of disease, avoid *mrig* bahar crop and change to *ambe* or *hasta* bahar crop for at least initial few years. Collect and remove infected fallen leaves, twigs and burn them properly away from field and avoid dumping in field. Drench bleaching powder (33% Cl) every 3-4 months @ 25 g/litre on ground under the plant canopy. Proper sanitation of pruning tools and secateurs etc. with sodium hypochloride (2.5%) is essential and keep orchard free from weeds. In case of severe infections, heavy pruning should be followed immediately after



harvest and remove all stems with blight infection. Prune about 5-8 cm below the infected area. Apply bordeaux paste (10%) to the cut ends after pruning. Spraying of 500 ppm tetracycline or streptomycin sulphate can suppress this disease. The intensity of disease on fruits and leaves was lowest with 500 ppm streptomycin application (Rani and Verma, 2011). During crop season spray bordeaux mixture altered with streptomycin (0.5g/l)/bronopol @ 0.5g/l mixed with copper oxychloride (2-2.5g/l). Depending on fungal disease present, copper based formulations may be replaced with appropriate fungicides viz. carbendazim 50WP (1g/l), captan 50WP (2.5g/l), hexaconazole 5EC, and difenaconazole 25 EC@ 1ml/l (Sharma *et al.*, 2014).



Fig. 13. Bacterial blight infected fruit and leaves

ii. Wilt (*Ceratocystis fimbriata*)

In this disease foliage become yellowish and plants start drying (Fig. 14) due to non availability of nutrients and water. Fungus, *C. fimbriata* cause brownish black discolouration in entire root wood while only xylem is brownish black in *Fusarium* species infection. In pomegranate, shot hole borer and nematodes also causing wilting which can be easily identified by shot hole on stem and nodes in the roots, respectively. The planting material should be free from pathogenic fungi and proper soil solarization is essential in nursery as well as in field. Drench soil with chloropyriphos 20EC (2.5 to 4.0 ml/l) + carbendazim 50WP (2.0g/l) or propiconazole 25EC (2ml/l) using 5-8 litre solution/plant. Also drench at least 2-3 healthy row plants around the infected plants and repeat the drenching 3-4 times at 20 days interval. Drenching with metalaxyl or indofil M-45 (2g/l) will be beneficial for *Phytophthora* management.



Fig. 14. Yellowing of foliage and drying of wilt infected plant

iii. Fungal spots and rots

The fungal pathogens cause leaf and fruit spots and rots in plants. In *Cercospora* fruit spots dark black discrete spots of various sizes without cracks and no stickiness appear on fruits, while in fruit scab rough raised brown spots develop which give russet appearance to fruit skin. In anthracnose (*Colletotrichum gloeosporioides*), fruit spot are hard, minute, dark black to brownish



black, irregular shape or size, sometimes spots with light centre and dark brown black edges. *Colletotrichum* rot causes discolouration of fruits which start from calyx end. The discoloured area becomes dry and reddish brown to black after coalesce of spots (Fig. 15). The rot extends beyond rind into the arils which disintegrate and are dark grey/brown black colour but not watery. Spraying of mancozeb (0.2 %) + carbendazim (0.2 %) were found to be most effective treatment in reducing anthracnose disease.



Fig. 15. *Colletotrichum* spot on infected fruits of pomegranate

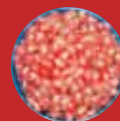
In orchards, where fungal spots or *Phytophthora* blight affects regularly, changing of flower regulation time (bahar) from rainy to winter season is found beneficial. Proper orchard sanitation is required by removing leaves, twigs and dry branches. During rest period application of bordeaux mixture (1%) alternated with copper oxychloride at 15 days interval helps to reduce the pathogen load for forthcoming season. Spray with carbendazim (0.2%), mancozeb (0.2%), bordeaux mixture (0.5-1%) and copper oxychloride (0.25%) can effectively manage the leaf and fruit spots/rots.

iv. Nematode (*Meloidogyne* sp.)

Root-knot nematodes are most damaging pest under hot arid climate. It can spread by water, soil and cell sap through farm equipments, secateurs, and scissors or through infested planting materials. In infested plants leaves turn pale green and yellowish with stunted plant growth and resulting in wilting and drying of the plant and roots show galls towards its tips (Fig. 16). For nematode management, field and nursery soil should be sterilized through soil solarization or fumigation. Use healthy seedlings free from nematode infestation at the time of orchard planting. Enriching soil with organic matter introduce microbes which can act against nematodes. Intercropping with marigold suppresses the nematodes owing to antagonistic effect. Neem cake @ 1-2 kg per plant should be applied which discourages nematodes from feeding. Apply phorate 10G @ 15-25 kg/ha.



Fig. 16. Nematode infected roots and wilting of affected plant



Insect-pests

In hot arid region of Rajasthan, mite and thrips are major pest causing severe damage while fruit borer, aphid and fruit sucking moth are minor pest.

i. Mites

Mites are red or brown in colour and remain most active during dry spell from April to October. Shiny white or brown patches can be seen on the undersurface of affected leaves which may further curl and fall. Adult and nymphs feed on the lower leaf surface by sucking sap. Leaf show reddish look on severe infestation (Fig. 17) and pressing of infested leaves with thumb give red colour. For mite management, spray of propargite 57% @ 1ml/l, spiromesifen 240 SC @ 0.5 ml/l or dicofol 18.5 EC @ 2.0 ml/l in rotation for effective management and provide irrigation regularly.



Fig. 17. Pomegranate mite, infected fruits and leaves

ii. Thrips (*Scirtothrips dorsalis*)

Thrips can be seen by tapping the tender shoots on white background. It always prefers feeding on new growth of plants. Nymphs and adults lacerate and suck the sap from buds, flowers, leaves and fruits. Affected leaves curl upwards and downwards (Fig. 18). The tip of the tender shoots becomes dried. Scrapping marks on buds and fruits can be noticed easily. Collect and destroy affected plant parts and dried tender shoots regularly. Do not grow intercrops which act as alternate hosts like chilli, onion, garlic, brinjal and tomato in pomegranate. Spray imidacloprid @ 0.4 ml/l or acephate 75 SP @ 1ml/l on observing the symptoms.



Fig. 18. Pomegranate thrips and curling on infested leaves



iii. Fruit borer (*Deudorix isocrates*)

The adult males are glossy bluish and brownish violet and females have conspicuous orange patch on the forewings. The adult female lays eggs on flower bud and young fruits. Infested fruits have holes with blackish brown excreta of larva on surface (Fig. 19). The fruit borer infected fruits attracts bacteria and fungi which cause rotting in the fruits producing foul smell and fruits drop down. For management of fruit borer, collect and destroy the infected fruits. Alternate host plant like guava, aonla and tamarind should not be planted in the pomegranate orchard. Cover fruits with bags to distract the butterflies as well as larva. During flowering spray neem seed extract 50g/l and spray deltamethrin 2.8 EC @ 1.5 ml/l or malathion 50EC @ 2ml/l or azadirachtin 1500 ppm @ 3.0 ml/l at 10-15 days intervals up to harvesting.



Fig. 19. Pomegranate butterfly and damaged fruit

iv. Aphids

It infests new flush of pomegranate. Whitish green aphids appear on foliage, buds, flowers and fruits (Fig. 20). Sticky honey like semi solid substance found on leaves which gives sooty mold and honeydew appearance. High humidity during rainy season favours the multiplication of aphids. Do not grow ornamental plant like rose which are host to aphids. Spray imidacloprid 0.3 ml/l, thiamethoxam @ 0.4ml/l or dimethoate 1.5 ml/l when new shoots emerge.



Fig. 20. Aphid infested new flush and buds



v. Fruit sucking moth (*Othreis sp.*)

Fruit sucking moths remain active from August to October and attack on fruits of pomegranate. Adult males and females of moth penetrate the fruits (Fig. 21) at night time. Damaged fruits become soft owing to secondary infections from different fungi and bacteria. Punctured holes on fruits with oozing fruit juice can be seen and infected fruits drop down. For management, destroy alternate hosts like *Lantana camara* and castor in and around the field. Keep poison baits (95% jaggery + 5% malathion) in the big flat earthen pots and install in field.



Fig. 21. Fruit sucking moth and damaged fruit

vi. Termite (*Odontotermes sp.*)

The worker termites feed on roots and trunks of the pomegranate plant and move upward making the tunnels. Soil tunnel on tree trunk on scrapping shows the damage caused due to feeding of tissues inside. Field should be kept clean and free from plant debris. All the dried and decaying wood should be regularly collected and removed. Scrap the soil tunnel on trunk and spray the trunk with malathion (1.5 ml/l). Application of neem cake (1-2 kg/plant) followed by irrigation, helps to drive away the termites. Drench the soil with chloropyriphos (2ml/l) around the base of the plant. Train the plant in multiple stem (3-5) to avoid yield losses by termite damage.



Fig. 22. Termite and damaged stem of pomegranate

vii. Bird damage

Birds particularly parrot and sparrow cause heavy losses to pomegranate fruits after 2-3 month of fruit set when aril start developing. The type of control method will depend on a number of factors like crop stage, damage patterns and species behavior *etc.* For small orchard



and isolated trees, netting with anti bird net is the most effective way to reduce bird damage (Fig. 23). In most cases, netting is spread directly over the plants through support by iron frame. It has a high initial cost, but effective in pomegranate due to high cost of produce. Bird scaring ribbon and noise makers also used to keep birds away from crops. Noise making devices such as cannons, exploders, sirens are also available. These devices work best when the sound is presented at irregular intervals and the sound source is moved frequently. Covering of fruit with bags is also found effective against bird damage.



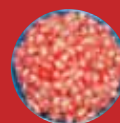
Fig. 23. Bird damaged fruits and pomegranate plants covered with anti bird net

14. Maturity indices

Early harvesting in order to avoid cracking is one of the causes of poor quality of pomegranate in India. The pomegranate fruits should be harvested only after attaining proper maturity as it is non-climacteric fruit. The fruits are ready for harvest in 135-170 days after full bloom depending upon the variety. In *ambe* bahar during summer, the fruit colour changes to dark yellow and dark red at maturity in *mrig* bahar during winter. The fruit gives a metallic sound on tapping. The crown and styler end get curved inside and become hardy and dry at maturity. Properly mature fruits can be easily scratched with nails. Some of the maturity indices for harvesting of pomegranate fruits at right maturity are described below (Table 4).

Table 4. Maturity indices for harvesting of pomegranate fruits

S. No.	Maturity indices	Attributes
1	Fruit Colour	When the skin attains its characteristic colour of variety (Reddish-Bhagwa, Ruby, Arakta, Mridula; Yellowish with red tinge- Ganesh and Jalore Seedless) with waxy shining surface.
2	Shape of crown and fruit	The bud at the anterior end of the fruit gets curved inside and become hard and dry at maturity. The fruit shape becomes compact.
3	Sound	The fruit gives a metallic sound when tapped.
4	Scratch	Properly mature fruits are easily scratched with finger nails.
5	Maturity period	The fruits become ready for harvest in 135-175 days after full bloom. Eg. Bhagwa (170-180 days), Ganesh (145-155 days), G-137 (145-150 days), Jalore Seedless (140-150 days), Phule Arakta (130-140 days) and Mridula (130-140 days)



S. No.	Maturity indices	Attributes
6	Aril colour	The arils attain deep intensity of colour (Dark red- Bhagwa, Pink-Ganesh, Light pink to pink-Jalore seedless) with high juice recovery
7	Juice colour	Red colour of juice in Bhagwa, Phule Arakta, Mridula, Ruby; Pink colour of juice in Ganesh and light pink in Jalore Seedless
8	TSS	12-16° Brix
9	Titrate acidity	Below 0.8%
10	TSS/acid ratio	It is one of the most reliable maturity indicator. Mature fruit have TSS/acid ratio between 25 to 40.

15. Harvesting, grading and packaging

The pomegranate start bearing after second years but flowering and fruiting should be taken from third year onwards for proper growth and development of plants. Fruits should be harvested at right maturity with secateurs or scissor. Early harvest leads to poor quality of fruits and late harvesting of fruits on the other hand results in a physiological disorder known as aril browning. The maturity period for commercial cultivars depends on variety and season. The fruit of cultivar Jalore Seedless is harvested after 140-150 after full bloom while after 170-180 days in cultivar Bhagwa. A TSS/acid ratio of 25 to 40 in general is good index of maturity of pomegranate cultivars under Indian conditions. Matured pomegranate fruits give a metallic sound on tapping. The fruit shows a characteristic rind colour upon maturity i.e. 75-80% red colour in case of red coloured varieties (Bhagwa and Mridula).

The flowering and harvesting period of pomegranate varies for different flower regulation periods. Usually the harvest commences in December-January and extends up to June-July depending on the bahar. The severity of different physiological disorders like fruit cracking, sunscald and aril browning are maximum in fruits of *ambe* bahar crop during April-May. After harvest, the fruits collected in plastic crates should be immediately precooled to remove the field heat. Then, the fruits are graded and packed in CFB boxes. Grading is done to obtain a reasonable price in market. Cracked, damaged, diseased and infested fruits should be removed. The fruits are graded (Table 5) on the basis of their size, external appearance and quality.

Table 5. Grading of pomegranate fruits for export market

Sr. No	Grade	Fruit weight	Skin colour and quality
1	Super	Above 750 g	Good attractive bright red colour and no spots on skin
2	King	500-750 g	Attractive red colour and spot free
3	Queen	400-500 g	Bright red and spot free
4	Prince	300-400 g	Fully ripe bright red and spot free
5	12 A	250-300 g	Fully ripe red colour and spot free
6	12 B	250-300 g	Fully ripe red colour with some spots



Considering the high keeping quality and availability throughout the year, India has great potential for export of pomegranate fruit. It is necessary that proper monitoring and surveillance should be in place to eliminate the possibility of the residues of pesticides/chemicals in pomegranates in excess of prescribed levels of the importing countries. In pomegranate monitoring of residue levels of agrochemicals permitted for use by the Central Insecticide Board and Registration Committee is a major concern particularly for export purpose. Agricultural and Processed Food Products Export Development Authority has standardized grading, maximum residue levels and their analysis procedure for export of pomegranates. Therefore, it is necessary to check agrochemicals used in the pomegranates growing for exports fulfilling the food safety standards of importing countries. It is also necessary to grade the pomegranates according to the AGMARK standards (Table 6) before issue of the phyto sanitary certificate. The pomegranate fruits are graded into various grades as per AGMARK standards for marketing.

Table 6. AGMARK standards for grading of pomegranate fruits

Grade designation	Grade requirements	Grade tolerances
Extra class	Superior quality fruits which must have the shape, development and colouring those are typical of the variety/cultivar. Free of defects; with the exception of very slight superficial defects, provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package.	5% by number or weight of pomegranate not satisfying the requirements for the grade, but meeting those of Class I grade or exceptionally coming within the tolerances of that grade
Class I	Good quality fruits those must be characteristics of the variety/cultivars. The slight defects provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package are slight defects in shape, colouring and skin defects (i.e. scratches, scars, scraps and blemishes) provided these do not exceed 5% of the total surface area.	10% by number or weight of pomegranate not satisfying the requirements of the grade, but meeting those of Class II or, exceptionally coming within the tolerances of that grade.
Class II	Fruits do not quality for inclusion in the higher grades but satisfy the minimum requirements. Pomegranates retain their essential characteristics as quality, the keeping quality and presentation. Defects may be allowed are defects in shape, colouring skin defects (scratches, scars, scrapes and blemishes) provided these do not exceed 10% of total surface area.	10% by number or weight of pomegranates not satisfying the requirements of the grade, but meeting the minimum requirements.

Source: Anonymous (2015)

Other requirements for export

Pomegranates must be carefully picked and have reached an appropriate degree of development and ripeness in accordance with criteria proper to the variety and/or commercial type and to the area in which they are grown. The development and condition of the pomegranate must be such as to enable them to withstand transport and handling, and to arrive in satisfactory condition at



the place of destination. Size is determined in accordance with the weight or maximum diameter (Table 7) of the equatorial section of the fruit.

Table 7. Provisions concerning sizing for export of pomegranate

Size code	Weight in grams (minimum)	Diameter in mm (minimum)
A	400	90
B	350	80
C	300	70
D	250	60
E	200	50

Size tolerance:

- (i) For all grades, 10% by number or weight of pomegranate corresponding to the size immediately above and/or below than indicated on the package.
- (ii) The maximum size range of 8 mm between fruit in each package is permitted (Anonymous, 2015).

16. Processing and value addition

There is increasing demand for food produce with high nutritional value and free of additives for a healthier diet. Pomegranate has great scope for the processing into different value added products. The fruit disorders such as sun scald, fruit cracking, improper rind and arils colour reduces market demand and fetch low prices. These fruits can be used in processing for development of products like minimally processed fresh arils, juice, squash, beverage, juice concentrates, frozen seeds, jam, jelly, marmalades, grenadine, wine, seeds in syrup, pomegranate powder, pomegranate rind powder, anardana, confectionery and pomegranate seed oil *etc.*

Anardana

Arils of wild sour type pomegranate (daru) are dried to prepare anardana. It is used in the ayurvedic medicine as digestive and stomachic. It is used as acidulent and condiment in Indian culinary or traditional system of medicine. Goma Khatta, Amlidana and Phule Anardana varieties are suitable for anardana purpose. In arid climate solar radiations can be used for drying of arils and peels.

17. Rest period

A rest period of three-four months is suggested for healthier plant growth, development and reduction of insect and pathogen inoculums load if any. Sprays of bordeaux mixture 1% alternated with COC (2.5g/l) are required at 15-20 days interval after winter pruning in December -January. Apply 1/3 dose FYM and minimum irrigation should be given during rest period. Remove the water shoots on a regular basis.



18. Marketing of produce

Pomegranate is marketed through cooperative marketing societies in Maharashtra where a group of pomegranate farmers join together on cooperative basis to sell their produce. The growers finalize the picking and packing activity only after acceptance from the cooperatives society. After receiving the produce from the growers, the cooperatives society sends to commission agent. Scheduling the dispatch of consignments in respective lots is the responsibility of the cooperatives society. Transport cost is in the range of Rs. 4-10 per box. Another way is group arrangement, in which about 5 to 10 growers having mutual understanding make joint arrangement for sale of their produce. Some farmers are having contract system in which farmers sell their produce on plant without harvesting the fruits to the contractor directly or through middle man. The farmers also send their produce to the distant markets through their own arrangements. Progressive farmers have their own means of transport to send their produce to the markets. In Rajasthan cooperative marketing and contract system are not yet developed; however with the expansion of area and increasing demand, some cooperative societies are emerging particularly for providing technical knowledge on growing techniques. Pomegranates grown in different parts of country are transported to the district places and big cities for marketing. The fruits produced in Rajasthan find market in Jaipur, Delhi and nearby city market. Large farmers are sending their produce to distance market in other states after proper grading and packaging. Lower grade fruits are transported and sold without loss of much time so as to retain the glossiness and freshness of the fruits for local market. Pomegranate is exported to the different countries from Mumbai and Kolkata ports. Maximum export is from Maharashtra and Karnataka which are exporting to Gulf and European countries. The major importers of Indian pomegranate are UAE, Bangladesh, Netherlands, UK, Saudi Arabia and Russia. In pomegranate export, Spain and Iran are major competitor of India which exports to European countries in maximum quantity. For export, pomegranate varieties such as Bhagwa, Mridula, Phule Arakta and Ganesh are highly preferred. Bright red coloured varieties, fruit size more than 500 g with soft seed, high juice content and easily separable arils are highly accepted in the international market. Unload the fruits in the pack house without keeping too many crates over each other so that bruising of fruits is avoided. The losses are very high (15-20%) during transit through conventional rail wagons used for commercial transportation.

Desirable characters of fresh pomegranate for export purpose

- Fruit colour dark rose pink and fruit weight around 500 grams.
- Round shape of the fruit and uniform size in a box.
- Soft, dark red arils with pleasant flavour and aroma.
- Higher TSS about 16-17° Brix.
- Free from scars, russetting, disease spots and insect injury etc.
- Smooth cutting at the stem end.
- Calyx without any damage and having freshness.



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