International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Review Article

Pomegranate the Cash Crop of India: A Comprehensive Review on Agricultural Practices and Diseases

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ABSTRACT

Pomegranate (*Punica granatum*) is one of the most adapted subtropical minor fruit crop, which was introduced in India during 15th century from the Mediterranean region. India is largest grower, producer and exporter of pomegranate from last decade. Among eight major pomegranate growing states, Maharashtra is the largest producer, occupies 70.2% of total area in the country with average productivity of 13.24 MT. In recent years, there is decline in production in Maharashtra due to a disease like anthracnose caused by *Colletotrichum* sp. *Colletotrichum* causes the infection on all plant parts as sub circular or angular black lesions results in stem deformation, defoliation during shoot development, death of inflorescences, necrotic lesions on leaves. The productivity has decreased though the land coverage has increased in last decade. Under unfavorable climatic conditions this disease has caused yield loss of up to 100%. This review gives an account of the production, agricultural practices, crop biology and diseases of pomegranate causing crop losses. It highlights the epidemiology, symptoms and management strategies for common diseases in pomegranate. It has been observed that, due to monoculture practices and change in environment, the disease like anthracnose causes tremendous losses. Therefore, it warrants urgent consideration for developing new agricultural practices and effective methods to control the spread of disease.

Keywords: Pomegranate, Anthracnose, *Colletotrichum* sp., Disease management

1. INTRODUCTION

Fruits are an important source of nutrition as well as sustainable income for farmers. Presently in India, 7.2 million hectare area is under fruit crops cultivation with a production of 88.9 million tons and productivity of 12.3 MT which contributes more than 30% share in total production of horticulture (Horticultural Statistics at a Glance, 2015). India comes at second position, after China in the list of major fruit producing countries in the world with 13.6% share in world's total fruit production (Indian horticulture database, 2014).

Over the last decade, the area under horticulture grew with the rate of 2.7% per annum and annual production increased by 7.0%. Out of the six categories, that are, fruits, vegetables, flowers, aromatics, spices and plantation crops, the highest annual growth (9.5%) is seen in fruit production during 2013-14. The leading fruit growing states are Maharashtra which accounts for 15.0% of total fruit production by whole country, followed by Andhra Pradesh (12.0%), Gujarat (9.0%), Tamil Nadu (8.0%), Karnataka (8.0%), Uttar Pradesh (8.0%), Madhya Pradesh (6.0%), Telangana (5.0%), Bihar (5.0%), and West Bengal (21.0%) (Horticultural Statistics at a Glance, 2015). Banana is the major fruit accounting for 33.4% of total production followed by mango (20.7%), citrus (12.5%), papaya (6.3%), guava (4.1%), grape (2.9%), apple (2.8%), sapota (2.0%), pineapple (2.0%), pomegranate (1.5%), litchi(0.7%) and others (11.1%) in the country (Indian horticulture database, 2014).

Among all, Pomegranate is one of the most adaptable, subtropical, minor fruit crop and its cultivation is increasing very rapidly. According to Levin, (2006a) "Pomegranate was introduced from the Mediterranean region to the rest Asia, North Africa, Europe and into the Indian peninsula where it was first reported to be grown in Indonesia during the 15^{th} century."

At present Morocco, Tunisia, Egypt, Israel, Syria, Lebanon, Turkey, Greece, Cyprus, Italy, France, Spain, Portugal, Iran, Iraq, India, China, Afghanistan, Bangladesh, Myanmar, Vietnam, Thailand, Turkmenistan, Tajikistan, Georgia, the USA, Mexico, and Chile are some Pomegranate growing countries in the world for table use and as an ornamental tree (Mars, 1996; Tous and Ferguson, 1996). Among these India, Iran, China, the USA and Turkey are five major producers of Pomegranate contributing 76% of total production from all over the world. However, Spain, Egypt and Israel are leaders in export and research by developing several new varieties of pomegranate (Quiroz, 2009).

Table 1: Total Pomegranate production in India during last ten years.

Year	Area (in 000' ha)	Area over 2005-06 (in %)	Production (in 000' MT)	Production over 2005-06 (in %)	Productivity	Productivity Over 2005-06 (in %)
2005-06	116	-	849	-	7.3	-
2006-07	117	0.86	840	- 1.06	7.2	- 1.36
2007-08	122	5.17	884	4.12	7.2	- 1.36
2008-09	109	- 6.03	807	- 4.94	7.4	1.36
2009-10	125	7.75	820	- 3.41	6.6	- 9.58
2010-11	107	- 7.75	743	- 12.48	6.9	- 5.47
2011-12	112	- 3.44	772	- 9.06	6.9	- 5.47
2012-13	113	- 2.58	745	- 12.24	6.6	- 9.58
2013-14	131	12.93	1346	58.53	10.3	41.09
2014-15	143	23.27	1774	108.95	12.4	69.68

Source: www. nhb.gov.in

Table 2: Total Pomegranate production in Maharashtra during last ten years.

Year	Area (in 000' ha)	Area over 2005-06 (in %)	Production (in 000'MT)	Production over 2005-06 (in %)	Productivity	Productivity over 2005-06 (in %)
2005-06	91.0	--	593.6	--	6.5	--
2006-07	92.5	1.64	601.5	1.33	6.4	- 1.53
2007-08	90.5	- 0.54	596.2	0.43	6.2	- 4.61
2008-09	82.0	- 9.89	550.0	- 7.34	6.7	3.07
2009-10	98.9	8.68	555.5	- 6.41	5.6	- 13.84
2010-11	82.0	- 0.108	492.0	- 17.11	6.0	- 7.69
2011-12	82.0	- 9.89	478.0	- 19.47	5.8	- 10.76
2012-13	78.0	- 14.28	408.0	- 31.26	5.2	- 20.0
2013-14	90.0	- 1.09	945.0	59.19	10.5	61.53
2014-15	99.14	8.94	1313.4	121.25	13.24	103.69

Source: www.nhb.gov.in

India stands first in the list of Pomegranate producer countries with respect to cultivation area. The leading pomegranate growing states of India are Maharashtra (70.2%), Karnataka (10%), Gujarat (7.4%), Andhra Pradesh (6.7%), Telangana (1.9%), Madhya Pradesh (1.9%), Tamil Nadu (1.0%) and Rajasthan (0.4%) (Horticultural Statistics at a Glance, 2015). Maharashtra is the largest producer of pomegranate, occupying $2/3^{rd}$ of total pomegranate farming area. The scenario of pomegranate production in India and in Maharashtra state during past few years is portrayed in table 1 and table 2 respectively. India has become the largest exporter of pomegranate in the world from the last decade as its fruits are of edible quality and available almost throughout the year. Table 3 represents the data about export of pomegranate from India in past few years. According to the horticulture database of India, it has become the major exporter of pomegranate to entire world and UAE, Netherlands, Saudi Arabia and Bangladesh are major importing countries of pomegranate from India. Due to its increasing demand and export value around the world, it is considered as one of the "Vital Cash Crop" of India. This review covers the important aspects of Pomegranate crop including its production scenario, crop biology, agricultural practices, common diseases and strategies available for their management.

Table 3: Statistics of export of Pomegranate from India.

Year	Quantity (in Tons)	Value (in Lakh)
2005-06	19652.1	5670.15
2006-07	21670.4	7957.30
2007-08	35175.1	9119.49
2008-09	34811.2	11461.61
2009-10	33415.0	11942.84
2010-11	18211.7	7095.19
2011-12	30162.2	14727.82
2012-13	36027.4	23449.61
2013-14	31328.2	29851.62
2014-15	20937.0	32361.45
2015-16	310723.6	41599.77

Source: DGCIS, Annual export: https://www.agriexchange.apeda.gov.in/product search/pomegranate (Last visited on 28/3/17)

2. Biology of Pomegranate

Pomegranate (*Punica)* is a small genus of fruit bearing shrubs or trees. Although, earlier placed in monogeneric family *Punicaceae*, now it has been shifted to family *Lythraceae* by the Angiosperm Phylogeny Group (APG IV, 2016) on the basis of recent phylogenetic studies (Graham *et al.,* 2005). Including *Punica* there are 32 genera and about 620 species of flowering plants in this family. *Punica* is a minor genus with only two species named as *Punica protopunica* and *Punica granatum*. Among these two, the better known species is *P. granatum* and has been classified into two sub species i.e. Chlorocarpa and Porphyrocarpa on the basis of color of ovary. In pomegranate, it is a stable feature that is retained even when they are reproduced by seeds. The chromosome number varies among different cultivars of pomegranate form 2n=16 or 18 (Levin, 2006a).

The pomegranate tree is an attractive, perennial shrub or small tree of 6-10 m (20 to 30 ft) in height, although some are dwarf (1-2m) and has bushy appearance. It has smooth and often quadrangular stem with dark grey bark at maturity (Teixeira da Silva *et al.,* 2013). Leaves are1-10 cm long, evergreen or deciduous, opposite or sub opposite, petiolate, simple, entire, exstipulate, oblong or obovate, glossy, glabrous, glandular, exist in whorls of 5 or 6 and usually remain crowded on short lateral shoots (Lawrence, 1951; IBPGR,1986; Morton, 1987). Flowers are actinomorphic, bisexual, terminal or axillary solitary or sometimes five in a cluster. They are three centimeter wide, funnel shaped, red to brilliant orange in color and characterized by thick, tubular, fleshy calyx having five to eight lobes. They contain five to seven lanceolate, wrinkled, red or white variegated petals which enclose numerous stamens, dorsifixed anthers, colporate pollen grains and inferior ovary (Morton, 1987; El Kassas *et al.,* 1998; Teixeira da Silva *et al.,* 2013). Two flowering seasons have been observed in pomegranate cultivars which are gown in North India while those of Central and Western India has three blooming seasons viz. Ambe bahar (January-February), Mrig bahar (June-July) and Hasta bahar (September-October) as reported by Nalwadi *et al.* (1973). The fruit is nearly round, 5-12 cm in diameter with a prominent thick calyx. Fruit pericarp (skin or rind) is smooth, leathery, coriaceous and woody, varies in surface color among cultivars from yellow with a crimson cheek to solid brownish-red and also bright red. Mesocarp (albedo, the spongy tissue) is divided into several chambers by a horizontal diaphragm and vertical septal membranes which are made up of papery tissue. Each chamber is packed with transparent sacs, filled with several arils (number varies among cultivars but may be as high as 1300 per fruit) which represent about 52% weight of the whole fruit (Lawrence, 1951; Purseglove, 1968; Dahlgren and Thorne, 1984; Morton, 1987; Levin, 2006b). Arils, the edible part of the fruit are flavorful, fleshy, juicy, red or pink in color and not attached to the septal membrane (Morton, 1987; Watson and Dallwitz, 1992). Fruits of wild type pomegranate are acidic, but cultivated cultivars possess fruits with sweet to sour flavor. They ripe after 6-7 months of flowering developed a distinctive color and make a metallic sound upon tapping.

Pomegranate is self-pollinated as well as cross pollinated crop in which the size and fertility of pollens vary as per the season and cultivar (Pross, 1938; Nalwadi *et al.,* 1973; Jalikop and Kumar, 1990). Hundreds of cultivars have been identified throughout the world on the basis of flower type, rind and aril color, fruit size, sugar and acid content in fruit, resistance to biotic and abiotic factors, yield, shelf life of fruit, seed hardness etc. (Harlan, 1992; Hancock, 2004; Levin, 2006a; Holland *et al.,* 2009). Interestingly, huge genetic diversification has been observed among 500, globally distributed varieties of pomegranate, out of which around 50 are commercially cultivated (IPGRI, 2001). Some significant, Indian varieties of pomegranate having commercial value are Ganesh, Jalore, Khandhari, Kabul, Mridula, Bhagwa, G-137, Arka Ruby, Jyoti, Amildana, Alandi, Dholka etc (Hiwale, 2009).

3. Agronomic Practices

3.1 Climatic conditions

Mediterranean environment with cool winters and hot summers is most favorable for Pomegranate but it can be grown in tropical or subtropical humid environment. It can easily withstand temperature up to 45^{o}C-48^{o}C in combination with dry hot winds but optimum temperature is 38^{o}C. Mature plant can tolerate frost when it is in dormant phase but, young tree up to three years of age is injured by early or late winter frost due to temperature less than -11^{o}C (Badizadegan, 1975; Morton, 1987; Patil and Shewale, 2003). The pomegranate crop has long growing season of about 4-7 months and requires hot and dry climate during fruit development and ripening. It is a drought tolerant, winter hardy crop which thrives well under desert conditions. It can't produce sweet fruits unless get high temperature for a sufficiently longer period (Halilova and Yildiz, 2009). Deccan Plateau of India has perfect climatic conditions for pomegranate cultivation hence; quality fruits are available throughout the year. While in other pomegranate producing countries around the world, availability is confined to a shorter and specific period in a year. In Spain, fruits are available during August to March, in the USA from August to November and in Peru from April to July (Jalikop *et al.,* 2006; Kulkarni and Dethe, 2006; Kotikal *et al.,*2009). It requires annual rainfall of 500-800mm.

3.2 Soil type

The pomegranate is able to grow on diverse types of soil but prefers deep loamy or alluvial soil which is fertile, rich in humus, have medium density with good drainage. It grows best in neutral soil (pH 5.5-7.0) but can tolerate soil alkalinity up to pH 7.5 and active lime concentration between 12-15%. Although, it is a salt tolerant plant but excess accumulation of salts in soil (more than 0.5%) is harmful (Wang, 2003). According to Indian Horticulture database (2013) pomegranate plant can withstand salinity up to 9.00 EC/mm (electrical conductivity per millimeter) and sodicity 6.78 ESP (exchangeable sodium percent). It produces quality fruits in medium or light black soils of at least 60 cm deep. In major pomegranate growing areas of Maharashtra the crop is grown in black, red, gravel and rocky lands of sub marginal and dry areas (Chandra *et al.,* 2006; NRCP, 2007a; 2008; 2009). Adequate moisture in soil is recommended throughout the growing season which contributes to growth, production and reduction in splitting (LaRue, 1980; Sharma *et al.,* 2006).

3.3 Irrigation

Regular irrigation (weekly in summer and biweekly in winter) is recommended to obtain higher fruit yield whereas irregularity results into formation of cracked fruits (Badizadegan, 1975; Kulenkanp *et al.,* 1985; Levin, 2006b).

Implementation of different irrigation schedules during spring and autumn seasons was also suggested by Intrigliolo *et al.*, (2011) as they observed a considerable difference in leaf photosynthesis and stomatal conductance of pomegranate trees which were grown under different irrigation regimes. Drip irrigation and bed or basin irrigation strategies are usually implemented by farmers for pomegranate crop. Drip irrigation has proven to be more effective for proper growth of trees compared to basin irrigation because of slow and even distribution of water through plastic micro tubes. Additionally, it saves water, cost of labor, reduces soil erosion and provide space for intercropping (Chopade *et al.*, 2001;NRCP, 2007b; 2008; 2009; Patil and Bachhav, 2009). Over irrigation causes adverse effects on the crop yield by favoring the growth of field pathogens due to increased humidity and moisture. Continuous flowering is observed in pomegranate plant when watered regularly and quite frequently. Fruits are available from these plants throughout the year which is economically undesirable. To regulate this "Bahar treatment" is given in which irrigation is with hold for two months prior to normal flowering period. This treatment is helpful to get better quality fruits during a particular period in a year.

3.4 Nutritional requirement

Application of farmyard manure (10-20 Kg/tree) alongwith chemical fertilizers, salts of micronutrients (Zn, Mn, B, Fe, Cu each in 15-25 g/Plant), vermi-compost (3-5 Kg/ plant) and Neem Cake (1-3 Kg/plant) is commonly practised by farmers to provide various required macro and micronutrients to pomegranate crop. The type and dose of chemical fertilizers which need to be applied, varyies among cultivars and geographic location of farm like zinc is the only required nutrient in California whereas, in Isarail, nitrogen and potassium fertilizers has to be added in equal amount for pomegranate crop (LaRue, 1980; Blumenfeld *et al.,* 2000). Split application of fertilizers in February, May and September is suggested to improve plant vigour hence, yield. Annual supply of nitrogen fertilizer alone is suffecient for many pomegranate crops and if added in excess it affects the fruit maturity and color. In contarst to this, Bose *et al.,* (1988) reported that increasing levels of nitrogen improve juice and rind percentage of fruit but decrease TSS and TSS/TA ratio. The dose of fertilizers/plant/year (FYM and N:P:K) for important Indian cultivars of pomegranate is recommended by the National Hoticulture Board and summerized in table 4.

Table 4: Recommended dose of fertilizers for Indian pomegranate cultivars.

Age of plant (in years)	Dose of Fertilizer/Plant/Year			
	FYM(kg)	N(g)	P(g)	K(g)
2	5	250	125	125
3	10	500	125	250
4	20	500	125	250
5	20	500	125	250
Above 5	30-40	625	250	250

FYM: Farm Yard Manure; N: nitrogen; P: phosphorus; K: potassium

Foliar application of micronutrients not only helps to maintain nutrient balance in soil but also convenient for field use and induces very rapid plant response (Obreza *et al.,* 2010; Fernandez *et al.,* 2013). Foliar spray of Urea and Calcium chloride resulted into increase in aril size, fruit lenght and diameter, average fruit weight and ascorbic acid content. Similarly,enhanced growth, yield and fruit quality was obtained through treatment of proline and tryptophan (Ramezanian *et al.*, 2009; El Sayed, 2014).

Intercropping is practised by Indian farmers since long time ago to acquire technical as well as economic benefits from either both the component crops or atleast one in comparsion to monocrop system. Wasaki *et al.,* (2003) reported that intercropping improves mobilization of nutrients in the rhizosphere thus, resulted into better growth and yield from component crops. Low growing vegetables, pulses or green manure crops are suggested to be grown as intercrop in spaces between old trees, till 4-5 years of crop age. Sharma *et al.,* (2015) reported that Pomegranate-Urd-Pea intercrop sequencing improve the availability of macro and micronutrients as well as microbial population in soil as compared to pomegranate monoculture. Increased microbial activity resulted into higher concentration of carbon and nitrogen which lead to better growth of plants (Chirinda *et al.*, 2008). Maity *et al.*, (2014)observed improvement in uptake of potassium and phosphorus (47.47% and 63.44% respectively) by plants growing in soil inoculated with *Penicillium pinophilum*.

4. Diseases and Pests of Pomegranate

Table 5: Important pests and diseases of Pomegranate.

Diseases caused by insect pests				
Name of disease	Causal organism	Symptoms	Affected plant part	References
Pomegranate fruit borer (Pomegranate butterfly)	*Virachola Isocrates*	Cater-pillars bore inside the developing fruit and feed on pulp and seeds.	Fruit	NHB database, 2012
Bark eating cater pillar	*Indarbela tetraonis*	Pest bore into the bark of tree and feed inside the bark.	Stem	NHB database, 2012
Stem borer	*Aleurodes* sp.	Caterpillar makes a hole and bores through the main trunk or branches and feeds on the bark.	Stem	NHB database, 2012
Pomegranate whitefly	*Siphoninus phillyreae*	Yellowing of leaves, stunted growth, shedding of leaves in severe cases	Leaf	NHB database, 2012
Aphids	*Aphis punicae*	Chlorotic patches on leaves.	Leaves	NHB database, 2012
Mealy Bugs	*Drosicha mangiferae*	A heavy black sooty mould may develop on the honeydew like droplets secreted by mealy bugs. The infestation may lead to fruit drop.	Fruit	NHB database, 2012
Scale insects	*Saissetia nigra*	Adults and pupae suck the cell sap from the fruit and tender shoots causing drying of branches. In case of severe infestation, the whole tree dries up.	Fruit	NHB database, 2012
Flat mite	*Brevipalpus lewisi*	Causes rusting and checking on fruit	Fruit	Stover and Mercure, 2007
Leaf roller	*Platynola stultana*	Causes rusting and checking on fruit	Fruit	Stover and Mercure, 2007
Diseases caused by fungal and bacterial pests				
Alternaria fruit spot	*A. alternata*	Small reddish brown circular spots on fruits and surface of leaves.	Fruits and leaves	Ezra *et al.*, 2010
Alternaria internal black rot	*A. alternata, A. tenuissima* and *A. arborescens*		Fruits	Tziros *et al.*, 2008
Heart rot	*Aspergillus niger*	Decay of fruit rind; brown aril decay and black sporulation inside fruit; pale skin colour	Fruits	Yehia, 2013
Fruit rot	*Alternaria* Sp., *Fusarium* Sp., *and Aspergillus niger*	Heart rot, fruit spot, fruit rot and stylar end rot symptoms	Fruits	Ammar and El-Naggar, 2014
Grey mould rot	*Botrytis cinerea, Botrytis spp.*	Decay of fruit rind and arils; greyish mycelium	Fruits	Mirzaei *et al.*, 2008; Bardas *et al.*, 2009
Wilt	*Ceratocystis fimbriata, Fusarium oxysporum, Rhizoctonia*	Yellowing and wilting of leaves leading death within several weeks	Leaves	Somasekhara, 1999; Jadhav and Sharma 2011
Anthracnose	*Colletotrichum gloeosporioides*	Circular to irregular, dark brown spots with sunken centres resulting in fruit decay	Complete plant	Sataraddi *et al.*, 2011
Fruit rot	*Cytospora punicae*	Apoplexy collar rot	Fruits	Palavouzis *et al.*, 2015
Blue mould fruit rot	*Penicillium implicatum*	Water-soaked areas on fruit surface, later a green to blue green powdery mould develops. Infected areas are tan or grey when cut.	Fruits	Khokhar *et al.*, 2013
Fruit rot	*Penicillium* sp., *Botrytis cinerea, Coniella granati,*	Fruit decay	Fruits	Palou *et al.*, 2013
Die back and fruit rot, dry rot	*Coniella granati*	Death of aerial parts of plant, fruit decay and formation of pycnidia around the fruit	Fruits	Sharma and Tegta, 2011; Mirabolfathy *et al.*, 2012
Shoot blight (stem canker)	*Neofusicoccum parvum*	Blighted shoots having cankers on stem, leads to death of entire tree	Stem	Kc and Vallad, 2016
Leaf spot or blight	*Xanthomonas axanopodis pv punicae*	Dark brownish, regular to irregular water soaked lesions on leaves and fruits resulting in premature defoliation under severe cases.	Complete plant	Petersen *et al.*, 2010; Jadhav and Sharma, 2011

Plant pathogens and diseases caused by them is a major reason for crop losses which are occurring worldwide. Successful cultivation of pomegranate has met with a huge economic loss because of diseases and pest attack in recent years. A summary of various diseases caused by fungi, bacteria and other pests on pomegranate is outlined in table 5.Some common diseases which affect pomegranate crop severely and have major contribution in yield loss are described comprehensively in following paragraphs.

4.1 Anthracnose disease

Anthracnose is a fungal disease which characterized by variety of symptoms like leaf spots, defoliation, blighted shoots, blotches or distortion, twig canker and dieback. It is caused by various species of *Colletotrichum*, a fungus which has a wide host range including many deciduous and evergreen trees, shrubs, fruits, vegetables, various legumes, and turf grass. Farmers face huge economic loss due to incidences of anthracnose disease as 10-80% reduction in marketable yield of total crop production has been reported (Ashwini and Srividhya, 2012).Whole plant is affected by this disease and finally die due to severe infection. Up to 80-100% loss in overall yield has been recorded for lemons, sweet oranges, (Goes and Kupper, 2002), olives, sorghum (Ali *et al.,* 1987; Thomas *et al.,* 1996) and strawberries (Denoyes and Baudry, 1991). Remarkable decrease in photosynthetic activity is reported in affected plants which led to diminution in yield (Makambila, 1978; Theberge, 1985; Obilo and Ikotum, 2009). Information about the etiology and severity of anthracnose on different plants of economic significance is compiled and represented in table 6 which shows; fungus *Colletotrichum* sp. has a very broad host range. Pomegranate cultivation used to bear a major loss in fruit quality and yield, mainly due to anthracnose disease. Surveys were conducted in various districts of Karnataka (Nargund *et al.,* 2012) and Maharashtra states of India (Chavan and Dhutraj, 2017) in the year 2009-2010 and 2013-2014 respectively to analyze the extent of damage due to anthracnose. Disease symptoms were observed on all parts of plant but the maximum PDI was reported on fruits (28.80%), followed by leaves (23-24%). Similarly, incidences of anthracnose had been reported in all major pomegranate cultivating countries around the world. Thus, anthracnose presents a threat to pomegranate plantation and demands a higher level of concern. Therefore, this review emphasizes on important aspects of anthracnose disease. Anthracnose of pomegranate is caused by *Colletotrichum gloeosporioides* Penz. and Sacc. which belongs to phylum Ascomycete and Coeleomycetes class of Fungi imperfectii (Dean *et al.,* 2012). Colony of *C. gloeosporioides* on PDA medium is initially white to grey in color which becomes pink to orange due to formation of conidia. It is circular in shape with regular margin and shows radial pattern of growth. The conidia are cylindrical with both apices rounded, pink to orange in color and vary in size from 7.57-15.50 × 3.38-7.52 µm (Chowdappa *et al.,* 2012).

4.1.1 Physical factors for disease development

Incidences of anthracnose had been detected from all pomegranate growing countries around the world but their percentage is higher in countries having tropical or subtropical environment like India. The fungus remains latent during hot summer and cool winter seasons in or outside seeds, in soil or in garden debris. It starts infecting developing shoots and young leaves during spring and flourishes very well in rainy season (Moral *et al.,* 2009). Moisture is required for infection on the plant and for germination of conidia. Direct influence of environmental factors had been observed on disease occurrence and expansion. Interestingly, change in weather condition could change the behavior of pathogen and host, as well as the interaction between them (Davis *et al.,* 1987; Coakley *et al.*, 1999). Several authors reported that temperature between 20°C-30°C and relative humidity from 80-95% for 12 hrs are essential for infection and development of disease (Prakash, 1996; Roberts *et al.*, 2001; Pandey *et al.*, 2012). Furthermore, dispersal of conidia occurs primarily through water by rain splash, wind, insects and garden tools (Fitzell *et al.*, 1984; Guyot *et al.*, 2005).

Table 6: Etiology and severity of Anthracnose on different plants.

S. No.	Name of plant	Name of *Colletotrichum* species	% Damage	Reference
1	Mango (*Mangifera indica*)	*C. gloeosporioides*	60	Kumari *et al.*, 2017
2	Chilli (*Capsicum annum)*	*C. novaezelandiae, C. siamense*	12-50	Damm *et al.*, 2012; Sharma and Shenoy, 2014
3	Banana (*Musa* sp.)	*C. musae*	30-40	Ranasinghe *et al.*, 2003
4	Coffee (*Coffea arabica*)	*C. kahawae*	60-80	Mouen Bedimo *et al.*,2012
5	Avocado (*Persea americana*)	*C. gloeosporioides, C.boninense, C. godetiae*	Up to 70	Hernandez- Lauzardo *et al.*, 2015
6	Tomato (*Solanum lycopersicum*)	*C. agaves, C. dracaenophilum*	-	Farr *et al.*, 2006
7	Alfalfa (*Medicago sativa*)	*C. americaeborealis*	-	Damm *et al.*, 2014
8	Rubber (*Hevea brasiliensis)*	*C. annellatum*	-	Damm *et al.*, 2014
9	Sugar cane (*Saccharum officinarum)*	*C. falcatum*	-	Alexander and Viswanathan 1996
10	Strawberry (*Fragaria* sp.)	*C. fragariae*	-	Howard *et al.*, 1992
11	Watermelon (*Citrullus lanatus*)	*C. lagenarium*	-	Dean and Kuc, 1987
12	Muskmelon (*Cucumis melo*)	*C. lagenarium*	-	Dean and Kuc, 1987
13	Papaya (*Carica papaya*)	*C. gloeosporioides*	75	Saini *et al.*, 2016; Paulla *et al.*, 1997
14	Pomegranate (*Punica granatum)*	*C. gloeosporioides*	40-90	Mandhare *et al.*,1996
15	Guava (*Psidium guajava*)	*C. simmondsii*	-	Singh *et al.*, 2007

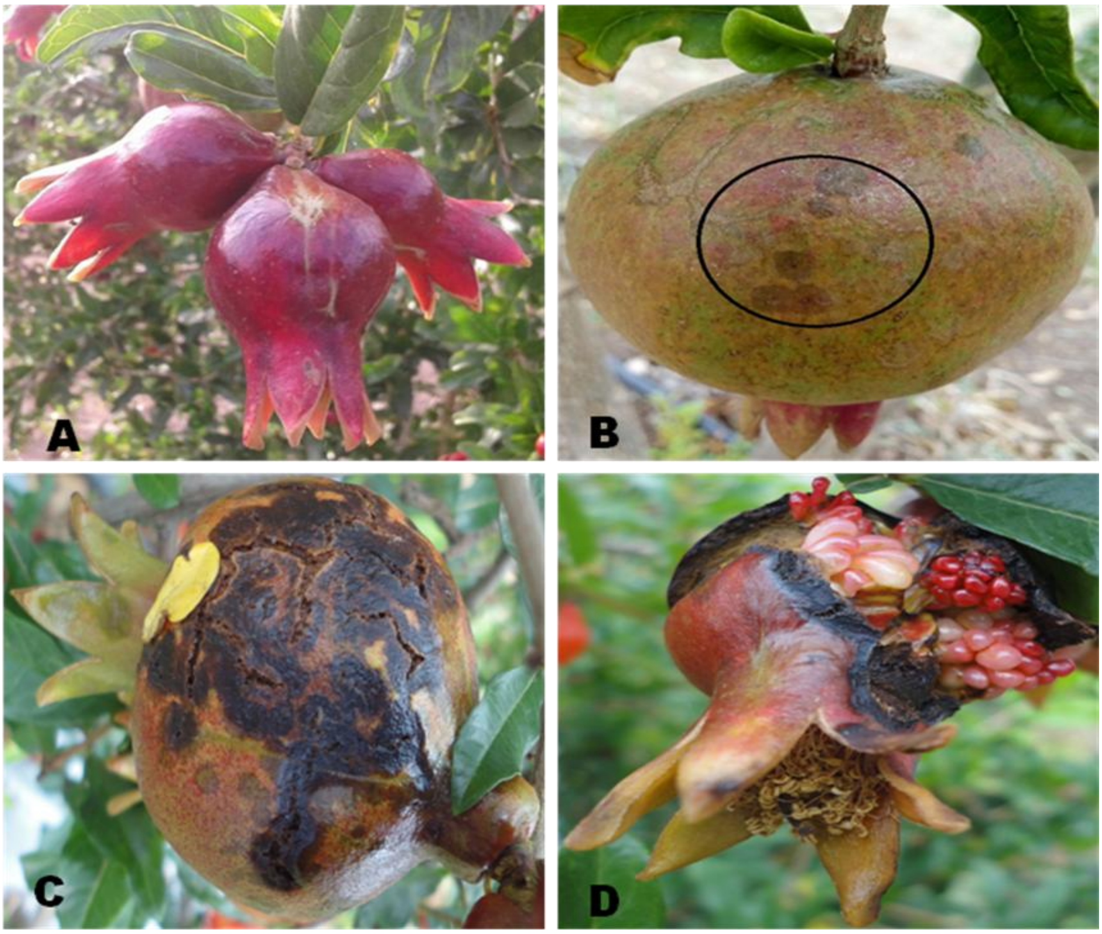

Figure 1: Symptoms of anthracnose on Pomegranate fruit: (A) Attachment of fungal spores on the surface of fruit through infected fruits, water splash, wind, insect etc., (B) Initial stage: Characterized by small, depressed, water soaked lesions, which are sub circular or angular with translucent light brown margins. (C) Intermediate stage: Characterized by the presence of black colored spots in concentric rings which become hard at maturity. Lesions can coalesce and become necrotic, as fruit grows cracking of peel occur, (D) Final stage: Infected fruits eventually dry up and mummify and can become a source of inoculum for the following season.

4.1.2 Disease symptoms

The pathogen infects all parts of the plant and produces broad symptoms which vary from one cultivar to another. Characteristic symptoms are stem rot, blighted shoots, leaf spot, defoliation, blotches, seedling blight and dieback (Pasin *et al.,* 2009). On fruit, observed symptoms are small, depressed, water soaked lesions, which are sub circular or angular with translucent light brown margins and at advanced stage of infection lesions appear as expanded necrosis (Robert *et al.,* 2001; Pujari *et al.,* 2013). Figure 1 depicts the characteristic, observable symptoms which appeared on pomegranate fruit due to infection of *Colletotrichum gloeosporioides*. The course of penetration, invasion and destruction is so rapid that by the time symptoms are recognized, the crop is in serious danger (Nutman and Roberts, 1960). It affects the fruit quality, marketability and a successful cultivation of pomegranate is converted into a waste within a short span of time (Mendgen and Hahn, 2002; Rodriguez-Lopez *et al.,* 2009; Prusky *et al.,* 2013).

4.1.3Disease cycle

In general, disease cycle is defined as a cascade of events which occur in a sequential manner and repeated continuously in the same fashion. In case of *Colletotrichum*, disease cycle begins with the attachment of fungal conidia on the surface of aerial parts of the plant. It consists of multiple, consecutive steps like germination of conidium, production of adhesive appressoria (crucial for cuticle penetration), penetration into the host cell, mycelial growth and colonization of host tissue by the fungus, formation of acervuli containing fungal spores for further spread (Prusky *et al.,* 2000; Wharton and Dieguez-Uribeondo, 2004; Arroyo *et al.,* 2005; Gomes *et al.,* 2007; Mota- Capitao *et al.,* 2008).The processes of infection and interaction with their hosts have been studied for several species of *Colletotrichum*. They are categorized either as an intracellular hemibiotrophic strategy, a subcuticular intramural strategy, or as a combination of both strategies (Bailey *et al.,* 1992; Saxena *et al.,* 2016). No report is available which describes the mechanism adopted by *C. gloeosporioides* to infect host plant (pomegranate). Therefore, the disease cycle which described here is of *C. destructivum* which causes anthracnose disease in tobacco. Similar infection mechanism can be predicted for *C. gloeosporioides* on the basis of its taxonomic relationship with *C. destructivum* (Shew and Lucas; 1991). The fungi reported to adopt an intracellular, hemibiotrophic strategy in which an initial biotrophic phase is followed by a destructive necrotrophic phase at later period of infection (Latunde-Dada *et al.,* 1996). The infection process of *C. destructivum* on tobacco leaves was studied and reported by Shen *et al.* (2001). Following events were observed to occur in a sequential manner (i) Attachment and germination of conidia on the host cell surface, (ii) Penetration of epidermal cell by appressorium or penetration peg. (iii) Formation of multi-lobed infection vesicle. The growth of this infection vesicle is limited up to initially infected host cells, (iv) Emergence of secondary hyphae from primary infection vesicle which colonizes new cells and tissues, (v) Formation of acervuli containing conidia on the plant surface, (vi) Spread of infection. In above mentioned process steps (i) to (iii) characterized as biotrophic phase of infection and step (iv) was designated as the beginning of necrotrophic phase.

Anthracnose is mainly transmitted through conidia (asexual spores) like other fungal diseases. Although appressoria, hyphal fragments and appressorium like thick walled cells may also transmit the disease (Nair *et al.,* 1983).Conidia are produced in a slimy matrix and easily dispersed through water, air current, insects or any other form of contact with infected plant part (Yang *et al.,* 1990; Agostini *et al.,* 1993; Ntahimpera *et al.,,* 1999; Mouen Bedimo *et al.,* 2012; Ali *et al.,* 2016). Disease transmission is also possible through mother plant by using infected cuttings as planting material. Over wintered shoots, infected leaves, mummified fruits on the tree or on the soil surface are main source of inoculum for the primary infection. As a result of digging, washing and transplanting exercises, conidia may wash down from the infected upper parts of the plant and facilitates root infection (Peres *et al.,* 2005). It is reported that the conidia of *Colletotrichum gloeosporioides* on infected stems pieces or on the soil surface survive for two dry seasons (Boland *et al.,* 1995).

4.2 Leaf spot or blight

Analogous to anthracnose, significant yield loss in pomegranate is reported due to leaf spot or blight disease (Petersen *et al.,* 2010). It is a bacterial infection caused by *Xanthomonas axonopodis*pv. *Punicae* which is a gram negative, flagellate, non-sporulating, aerobic, polar bacterium. It forms shiny and mucoid colonies on nutrient agar medium which are yellow in color (Jadhav and Sharma 2011; Kalyan *et al.,* 2012). The disease is characterized by appearance of small, irregular, dark brown and water-soaked spots on leaves and fruits. Under severe conditions disease leads to premature leaf defoliation (Jadhav and Sharma, 2011).

4.3 Alternaria fruit spot

This disease is caused by *Alternaria alternata* and identified by small, reddish brown, circular spots on fruits. At the advanced stage, these spots merged to form larger patches and rotting started in fruits. The affected arils change color from red to pale yellow and become unfit for consumption. Affected fruits should be collected and destroyed to prevent the spreading of disease. The spray of mancozeb solution at 0.25 % concentration is suggested to control the disease (Indian Horticulture Database, 2012).

4.4 Wilt

The wilt in pomegranate is produced by different fungal genera like *Ceratocystis fimbriata*, *Fusarium oxysporum* and *Rhizoctonia*. It is associated with yellowing of plants, drying of branches followed by flower and fruit drop. In severe cases the entire orchard is wilted. Since the infection is soil borne, it is essential to maintain soil fertility through judicious irrigation and application of farmyard manure and neem cake. Treatment with copper oxychloride and *Trichoderma* powder (10-15kg/ha) was found to be effective against wilt.

4.5 Fruit borer (Pomegranate butter fly)

This disease is caused by an insect named as *Virochola isocrates.* Infestation starts from flower and spread up to fruits. Cater-pillars bore inside the developing fruits and feed on pulp and seeds. Damaged fruits are subsequently infected by bacteria and fungi which cause fruit rotting. Collection and proper disposal of affected fruits is suggested to prevent the blowout of disease. Application of carbaryl (4g $l^{-1}$of water) or phosphamidon (0.3ml $1^{-1}$of water) at 10-15 days intervals is recommended to control the disease.

4.6 Bark eating cater pillar

The causative agent of bark eating cater pillar is *Indarbela tetraonis,*an insect pest, which bore into the bark of pomegranate tree and feed inside it. Due to insect attack trees become weak and fail to bear fruits. The disease is successfully controlled through sanitation, removal of unwanted twigs and cleaning of the affected portions. Plugging of holes with cotton soaked in carbon disulphide or Kerosene or petrol, reduces the disease incidences by preventing insect entry into the bark.

4.7 Whitefly

Whitefly is a serious matter of concern as it is reported in all pomegranate growing areas around the world including India and causes significant crop loss. The disease is caused by an insect i.e. *Siphoninus phillyreae*. Infection begins from leaf as female fly lays eggs on the lower surface of apical leaves in form of circle or in small groups. Honeydew, a liquid secreted by whitefly, causes a serious damage to crop. It runs down to the fruits and to the upper surface of leaves, supports bacterial and fungal growth which results into development of secondary infections. Thus, the entire plant is damaged severely and production is affected. Whitefly disease is characterized by yellowing of leaves and stunted growth, in severe cases leading to shedding of leaves. Mechanical and chemical methods are commonly practiced to get rid of from whiteflies. They can be trapped by hanging bright yellow sticky traps. Water spray with high volume sprayer by focusing the nozzle towards the under surface of leaves helps in washing out honeydew, eggs, larvae, pupae and adult whitefly. This should be followed by spray of triazophos 40 EC (1.5 ml l^{-1} of water) or a mixture of Monocrotophos 36SL (1.5 ml l^{-1} of water) and Dichlorvos 76 EC (1.0 ml l^{-1} of water) at an interval of 8-10 days.

4.8 Aphids (*Aphis punicae*)

Aphids are yellowish green insects which suck the cell sap from the lower surface of leaves and devitalize the plant. They secrete sweet sticky substance, which attracts fungal growth. The affected leaves show chlorotic patches. High humidity favors the multiplication of aphids. Spray of dimethoate (0.03%) or monocrotophos (0.05%) or malathion (0.1%) at 15 days interval effectively controls the aphid population.

4.9 Mealy Bugs

Leaves show characteristic curling symptoms in mealy bug disease which are similar to that of a viral infection but this is caused by an insect known as *Drosicha mangiferae*. Adult female bugs are oval in shape with waxy filaments all over the body. Nymphs and adults of mealy bugs suck sap from the leaves and tender shoots. A heavy black sooty mould may develop on the honeydew like droplets secreted by mealy bugs. The infestation may lead to fruit drop. These bugs lay eggs into the soil which remain dormant till the next bahar. Nymphs hatch from the eggs during the next bahar and attack the plants. The plants in the vicinity of the orchard should be destroyed as they serve as alternate hosts for mealy bugs. Pasting a grease band of 5cm width on the main stem prevents the crawlers from reaching the top. Unlike the adults, the crawlers are free from waxy coating and therefore the crawler stage is the most effective for spraying pesticides. Spray of insecticides like dichlorvos (0.02%) or malathion (0. 2%) with fish oil resin soap was found to control the insect population. Application of phorate (20 g/plant) is effective to control the pest population in the soil.

5. Disease Management

Pomegranate plant is very much susceptible towards various kinds of latent infections. Therefore, to avail maximum economic benefit from a pomegranate crop, it is desirable to protect it from the attack of various pathogens by practicing disease management. It is defined as a collection of preventive measures which are implemented for complete or partial eradication of pathogen, from a crop (Palou *et al.,* 2007). Control of disease always becomes very difficult once it spreads into the whole field. Therefore, it is recommended to follow an effective disease management program in every season to reduce the chances of both pre-harvest and post-harvest diseases. In pomegranate, it is observed that most of the infections are post-harvest but they begin in the field itself so control measures must also begin when crop is in the field (Munhuweyi *et al.,* 2016). Every disease requires for a specific management strategy depending upon its nature (pre-harvest or post-harvest), etiology (bacterial, fungal, viral or any other pests), severity (localized or systematic) and time of occurrence etc. This section of review paper describes various strategies which are proposed and evaluated for disease management in pomegranate by different research groups.

5.1 Chemical control

This is the most common, easy to implement strategy which offers the application of synthetic chemicals (fungicides, antibiotics, insecticides or pesticides) to minimize the risk of variety of infections of pomegranate crop. Fungicides such as thiophanate methyl and tebuconazole were found to be effective against shoot blight and fruit rot (Thomidis 2015). Performance of five fungicides viz., mancozeb (0.25%),companion (0.25%), carbendazim (0.05%), copper oxychloride (0.3%) and captan (0.3%) against fruit spot and rot diseases of pomegranate was compared through field trials in India. Significant reduction in diseases was observed by the use of captan, companion and copper oxychloride but copper oxychloride was however, observed to leave scars of dried spray materials on the fruit which reduced the market acceptability (Khosla *et al.,* 2008). During a survey it was found that the spray of streptocyclin (500 ppm) and copper oxychloride (2000 ppm) in a mixture was able to reduce the mean disease incidence of bacterial blight by 25.5% (Jadhav and sharma 2011). Although effective against a range of pathogenic infections, chemical methods are associated with hazardous effects on environment and human health. Continuous use of a particular chemical against a specific pest, leads to development of resistant strains (Palou *et al.,* 2007). Fungicides are usually applied as dips, sprays, fumigants, as treated wraps and liners or can be incorporated with fruit wax to control post-harvest pathogens and diseases hence, extend shelf life of pomegranate during storage (Ghatge *et al.*, 2005). After harvesting, dipping of fruit in the solution of fungicides like fenhexamid and fludioxinil resulted into decreased incidences of gray mould, caused by *B. cinerea* (Holland *et al.,* 2009).

5.2 Physical control

Implementation of physical agents like high temperature, humidity, radiation etc. comes under the category of physical control of diseases. They are more applicable for post-harvest infections and diseases in pomegranate. Temperature has proven to be effective in form of curing, treatment with hot water, dry heating and intermittent warming. Treatment with hot water (at 45 °C for 4 minutes) was not only found to be effective to reduce chilling injury, electrolyte and potassium leakage but also improved the nutritional value of fruits. Post-harvest heat treatment lead to increase in the levels of free putrescene, spimidine and polyamines (Mirdehghan *et al.,*2007). Preconditioning or curing of pomegranate (at 30°C -40°C and high relative humidity 90-95% for 1-4 days) improved the antioxidant activities of arils due to higher levels of total phenolics, ascorbic acid and anthocyanin. Sugar content (glucose and fructose) as well as organic acids (oxalic, citric, malic acids) also increased as compared to control (Pareek *et al.,* 2015). Among all heat conditioning (48 hrs at 35°C), intermittent warming (24 hrs at 20°Cevery 9 days) and hot water treatment (3 min, at 52°C); hot water treatment was found to be most effective to reduce chilling injury and electrolyte leakage as well as to maintain the fruit quality (Ben Abda *et al.,* 2010). Although, it is reported that heat treatment improves the physico-chemical and nutritional qualities of fruit but temperature needs to be managed very carefully. A sudden exposure of pomegranate juice to high temperature (70°C- 90°C for 90 minutes) resulted into loss in antioxidant activity, ascorbic acid and total phenolic content (Paul and Ghosh 2012) while curing and intermittent warming makes fruits susceptible to water loss. Treatment with hot water is not sufficient to control fungal growth hence it has to be supplement either with chemical treatment or biological process for better results. Exposure of Gamma irradiation at doses higher than 2 Kilogray (kGy) caused the complete inhibition of microbial growth in pomegranate juice during storage but along with significant reduction in anthocyanin content (Wisniewski *et al.,* 2001, Alighourchi *et al.*, 2008).

5.3 Mechanical control

Proper sorting and removal of infected, diseased and damaged plants, plant parts and fruits from healthy ones comes under the category of mechanical control, which is applicable at both pre-harvest as well as post-harvest levels. Preparation of field before starting new plantation by removing old branches and twigs, leaves and fruits is suggested to prevent the spreading of disease to next generation. Special care must be taken after pruning as most of the plant pathogens enter into host through wounds or natural cuts. Application of protective pastes to cut ends of pruned branches has proven a strong strategy to restrict the infection. Although, economically not feasible but covering the fruits in bags when they are on trees is helpful to protect them from damages; caused by insects and birds (Jadhav and sharma 2011).

5.4 Biological control

Several microorganisms, plants and animals have been discovered and well known for their antagonistic effect against other living organisms. Such organisms paved the way of another stream of plant disease management i.e. biological control. It is highly recommended and considered as most sustainable approach of disease management as it has no harmful effects on environment. *Bacillus subtilis* subsp. Spizizenii (Avogreen) and *Cryptococcus albidus* (Saito) were found to be effective in controlling fungal decay of pomegranate fruit (Janisiewicz and Korsten, 2002). The biocontrol potential of several actinomycete strains had been proved against *Xanthomonas axonopodis*pv. punicae, which causes leaf spot disease in pomegranate (Chavan *et al.*,2016). The potential of various bioagents including fungi, bacteria and plant extracts was assessed for the management of pomegranate anthracnose. Among the various microorganisms which were evaluated, the maximum decrease in PDI was obtained through *Trichoderma viride* in both *in-vitro* (79.1%) as well as *in-vivo* (18.9%) conditions. Along with that *Eucalyptus* extract showed maximum inhibition of mycelial growth of *C. gloeosporioides* (Sataraddi *et al.*, 2011). Extracts of several medicinal and ornamental plants have been analyzed by Moawad and Al-Barty (2011) for their growth retarding activity on pomegranate aphid, *Aphis punicae.* The disease control mechanisms of these biopesticides include production of antibiotics or phytoalexins, competition for nutrients and space with pathogenic fungi, mycoparasitism, as well as stimulation of host resistance (Yenjerappa *et al.*, 2013; Mutawila *et al.*, 2015).

5.5 Use of resistant cultivars

Development and subsequent cultivation of disease and pests resistant crop varieties is a strong approach for disease management. Screening and selection of existing, wild genotypes of economically important crops are prerequisites for expanding the range of resistant cultivars (Verma *et al.*, 2014; Thomidis, 2015). Limited reports are available on screening of wild genotypes of pomegranate with the aim of identification and selection of disease resistant natural cultivars. Wild genotypes of pomegranate were subjected to screening to determine their susceptibility for anthracnose disease (Jayalakshmi *et al.*, 2013),dry fruit rot and leaf spot *Coniella granati* (Kumari and Ram 2015) and against an insect i.e. *Ectomyelois ceratoniae* (Sobhani *et al.*, 2015). A screening of total 209 pomegranate genotypes including 105 exotic types form USDA, 66 wild types and 38 cultivated types from India against bacterial blight caused by *Xanthomonas axonopodis* pv. *Punicae* was performed by Tanuja Priya *et al.*, (2016). Five genotypes showing resistance for bacterial blight (108B and 99 A from USDA and 318734, Daru-18 and IIHR.30 from India) were identified through this survey from natural pomegranate population. Increased level of defense related metabolites like total phenol, flavonoid and antioxidants was detected in resistant cultivars. Replacement of morphological markers with potent molecular markers facilitated the selection of resistant genotype from natural population. Insertion of particular gene conferring specific resistance into elite genotype became feasible through application of molecular markers and gene transfer technologies (Chauhan and Kanwar 2012). Thorough screening of pomegranate germplasm through advanced biotechnological tools is highly needed and will certainly assist the development of resistant cultivars.

5.6 Storage management

Post harvest storage is a critical part of disease management program. Fruits usually change their organoleptic properties (color, taste, texture, smell) and become susceptible towards variety of infections if not stored properly under recommended environmental conditions. Pomegranate fruit is very much suceptible to dehydration thus temperatre and humidity should be maintained carefully after harvesting. Although the required conditions varies according to cultivars, production areas and post harvest treatments but fruits stored at 5^{o}C- 10^{o}C at 80-95% RHremain healthy without any shrinkage or spoilage up to seven months(Caleb *et al.,* 2012; Pareek *et al.,* 2015). Spermidine and calcium chloride (Ramezanian *et al.*, 2010), polyamide plastic (Sadeghi and Akbarpour 2009), wrapping in individual film with fludioxonil (D' Aquino *et al.,* 2010) are usually adopted treatments for improving the shelf life of pomegranate by reducing the risk of weiht loss, shrinkage, decay development, appearance of physiological disorders like scald and chiling damage (Elyatem and Kader 1984; Opara *et al.,* 2015). Advance and currently practiced technology for long term storage of fruits is “Modified Atmosphere Packaging”.In this technique, fruits are packed in special, perforated bags having 5% CO_2 and 12-14% O_2 and these bags are stored at a particular temperature. Pomegranates when subjected to modified atmosphere packaging at 6^{o}C up to 16 weeks resulted into 7-35% reduced weight loss as compared to control (Porat *et al.,* 2006; Sachs *et al.*,2006).

5.7 Good agricultural practices

The probability of disease incidences and pest attacks can be minimized by adopting Good Agricultural Practices. These include cleaning of field prior to next cultivation, crop rotation, intermittent cropping, management of irrigation schedule etc. Sanitation of field by removal and proper disposal of infected or dead plant parts from field, decreased the PDI of anthracnose in pomegranate (Ali *et al.,* 2016; Penet *et al.,* 2016). Roberts *et al.,* (2001) suggested that crop rotation after every 2-3 years with non-host plant protects the host crop from variety of diseases while, Ripoche *et al.,* (2008) supported mixed cropping. Proper planning and implementation of irrigation program is found to be effective in protecting crop from wide range of infections including *Colletotrichum.* Overwatering and overhead irrigation produced adverse effects on pomegranate crop hence, advised to avoid even under drought conditions. Relatively high humidity and moisture built up under canopy favor growth of all sort of pathogens therefore, fields should have a proper drainage system (Than *et al.,* 2008).

6. CONCLUSIONS AND FUTURE PROSPECTS

Pomegranate is a most adaptable fruit crop of subtropical countries in the world. India has become the largest producer and exporter of pomegranate during the last decade. Deccan Plateau which consists of Maharashtra, Karnataka and Andhra Pradesh states of India produces pomegranate throughout the year due to its unique geographical features and environmental conditions. Bhagwa, Ganesh, Arakta are commonly cultivated varieties of pomegranate which give huge hike to the horticulture economy. To prolong the shelf life of pomegranate and to obtain a continuous fruit supply throughout the year, the physiological disorders and diseases of pomegranate must be understood. Pomegranates are very susceptible to various insect pests and diseases. Presently, anthracnose has become major threat to pomegranate in India causing enormous loss and has created panic among the growers. Though, the epidemic nature of the disease has being studied since ages, many aspects are still unexplored in terms of host-pathogen interaction, its spread and effective management strategies. It demands serious research efforts to develop high quality cultivars with soft seeds and fruits which have resistance to insect pests and diseases. Additionally, modifications in existing agricultural practices will be helpful in management of the disease in better way and improves the quality and yield of the crop, thereby contributing efficiently to the economy of the country.

ACKNOWLEDGEMENTS

Authors are highly thankful to Dr. Pallavi Vyas Scientific writer and editor of "TEXTiFRAME" Sweden, for providing substantial contribution to edit the manuscript.

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How to cite this article: Jain K, Desai N. Pomegranate the cash crop of India: a comprehensive review on agricultural practices and diseases. Int J Health Sci Res. 2018; 8(5):315-336.

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