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Pomegranate Culture in Deccan Plateau of India

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ABSTRACT

The Deccan Plateau is a large plateau in India, making up the majority of the southern part of the country, ranging in elevation from 100 m in the north to 1000 m in the south. The main pomegranate producing areas are distributed between 300 and 950 m above mean sea level in hot arid and semi-arid regions having tropical and subtropical climate. Interestingly, the major production of pomegranate in India is from Deccan Plateau, especially from Maharashtra followed by Karnataka. The agro-climatic condition of Deccan Plateau is congenial for staggering of pomegranate production throughout the year. Maharashtra contributes about 84% in area and 75% in production of pomegranate in Deccan Plateau. Mainly three flowering seasons viz. winter (January-February flowering), rainy season (June-July flowering) and autumn season (September-October flowering) are promoted for fruit production in this plateau. In the present paper, information pertaining to Deccan Plateau and its climatic and soil conditions and existing cultivation practices of pomegranate has been envisaged.

Keywords: climatic conditions of Deccan Plateau, pomegranate culture

CONTENTS

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the remunerative fruit crops for arid and semi-arid regions of India (Jadhav and Sharma 2007). It has showed potential in marginal and sub-marginal lands of tropical and subtropical regions, especially in Deccan Plateau. It is becoming an export oriented crop for the last one decade and its area and production is increasing with a faster pace in India (Chandra *et al.* 2006). Now, India occupies first position in pomegranate area and production globally (Jadhav and Sharma 2007). Maharashtra is a leading state for production of pomegranate and is contributing more than 65% of its total production in India. It had been embedded in human history and utilization was associated to several ancient cultures as fruit, pharmaceutical and nutraceutical values (Levin 2006; Holland *et al.* 2009). Interestingly, every part of pomegranate viz., root and trunk bark, wood, sprouts, leaves, flowers, fruit, rind and seeds has economic value. Since time immemorial, it had been a universal therapeutic agent owing to presence of biologically active ingredients in its different parts. But recent modern research findings strengthen the status of pomegranate as an important medicinal fruit crop (Seeram *et al.* 2006; Holland and Bar-Ya'akov 2008). Consequently, its production and consumption are increasing with a faster pace in the world. The fruit, which is a high-value food product, is used in the fresh form or for juice extraction. The juice is mainly used to prepare grenadine, extracts, liquors, wines, jelly, etc. The arils are used to prepare jam or its dried form as condiments (Seeram *et al.*

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2006; Ram Asrey *et al.* 2008). Besides, it also has a certain reclamation value due to its capability to thrive on saline soils, loose sands and mountain/hills.

Interestingly, export of pomegranate from India has increased about five-fold in 2007-08 over 2002-03, indicating its bright future in years to come. At present, the major pomegranate importing countries from India are UAE, the Netherlands, Saudi Arabia and Bangladesh. It has been proved that Deccan Plateau of India can produce good quality pomegranates throughout the year. Owing to highly innovative and hardworking nature of the growers, the growth of pomegranate industry in Deccan Plateau is quite fast. Unfortunately, bacterial blight and wilt diseases have threatened the industry in pomegranate producing bowl.

GEOGRAPHY OF DECCAN PLATEAU

The Deccan Plateau, also known as the Peninsular Plateau or the Great Peninsular Plateau, is a large plateau in India (**Fig. 1**), making up the majority of the southern part of the country, ranging in elevation from 100 m in the north to 1000 m in the south. It is located among three mountain ranges and extends over 8 Indian states (Maharashtra, Andhra Pradesh, Karnataka, Chattisgarh, Orissa, Bihar, Madhya Pradesh and Tamil Nadu). Thus, it is the largest eco-region in India. It encompasses a wide range of habitats, covering most of central and southern India. The Western Ghats and Eastern Ghats form its western and eastern boundary. Each rises from their respective nearby coastal plains and nearly meets at the southern tip of India. These two ranges form the southward-pointing vertex of a triangle which encompasses the plateau with the roughly west-south-west to east-north-east running Satpura Range and Vindhya Range forming the third northern boundary of the region. Larger areas of the states of Maharashtra, Karnataka and some parts of Andhra Pradesh comprise the Deccan Plateau. The Western Ghat's mountain range is tall and blocks the moisture from the southwest monsoon from reaching the Deccan Plateau, so the region receives very little rainfall. The eastern Deccan Plateau is at a lower elevation spanning the southeastern coast of India. Its forests are also relatively dry, but serve to retain the rain to form streams that feed into rivers that flow into basins and then into the Bay of Bengal. The Deccan forests are of Southern Tropical Dry deciduous type and account for 9.9% of the total geographical area of the country. The Godavari River and its tributaries, including the Indravati River, drain most of the northern portion of the plateau, rising in the Western Ghats and flowing east towards the Bay of Bengal. The Tungabhadra River, Krishna River and its tributaries, including the Bhima River, which also run from west to east, drain the central portion of the plateau. The southernmost portion of the plateau is drained by the Kaveri River which rises in the Western Ghats of Karnataka and bends in Tamil Nadu. The climate of the region varies from subtropical in the extreme north to tropical in most of the region with distinct wet and dry seasons. June to October is the main rainy season, but March to June months remain very dry and hot with temperatures exceeding 40°C.

The genesis of Deccan Plateau is very unique in the world. The vast volcanic basalt beds of the plateau were laid down in the massive Deccan Traps eruption, which occurred towards the end of the Cretaceous period, between 67 and 65 million years ago. Layer after layer was formed by the volcanic activity that lasted many thousands of years, and when the volcanoes became extinct, they left a region of highlands with typically vast stretches of flat areas on top like a table. Hence, the plateau is also known as Table Top. The volcanic hotspot that produced the Deccan traps is hypothesized to lie under the present day island of Reunion in the Indian Ocean. Typically the Deccan Plateau is made up of basalt extending up to Bhor Ghat near Karjat. This is an extrusive igneous rock. The Deccan is rich in minerals. However, primary mineral ores found in this region are mica and iron ore in the Chhota Nagpur region, and diamonds, gold and other metals in the *Golconda* region (Sheth 2006).

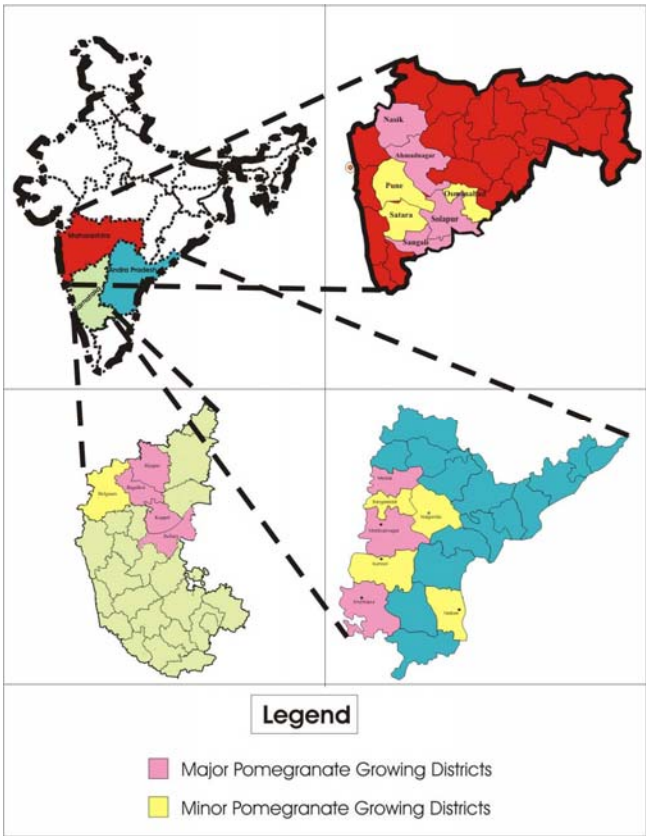

Fig. 1 Pomegranate-growing areas in India.

The major part of Deccan Plateau is consisted of Maharashtra state and has 0.308 million km^2. It extends between 15° 45′ to 22° N latitude and 72° 45′ to 80° 45′ E longitude. The state consists of the high Deccan Plateau, which is separated from the straight Konkan coastline by 'Ghats'. It has tropical monsoon type of climate with three distinct seasons (summer, monsoon (rainy) and winter). It is divided into three regions viz. Sahyadri Range, Konkan and Satpura hills. One of the three major regions of the state is the Sahyadri range with an elevation of 1000 m. The unique feature of this region is a series of crowning plateau lying between the Arabian Sea and the Sahyadri Range. Konkan is narrow coastal lowland, just 50 km wide and with an elevation below 200 m and third important region is the Satpura hills along the northern border and Bhamragad-Chiroli-Gaikhuri ranges on the eastern border form physical barriers preventing easy movement. These ranges also serve as natural limits to the state (Challa *et al.* 1995).

The second largest part of Deccan Plateau is Karnataka situated on the western edge of the plateau and lies between 11° to 19°N latitudes and 74° to 78° 30′ E longitudes and has 0.192 million km^2 geographical areas. Its northern and eastern districts like Bijapur, Bellary and Chitradurga receive low rainfall (< 65 cm annually). The climate is equable in the southern districts and warm in the northern districts. The state is divided into four regions viz. Northern, Coastal, Central and Southern Karnataka. Its northern part has the barren plateau with an elevation ranging between 300 and 600 m. Coastal part covers the Western Ghats, edges of the Karnataka Plateau, Uttara Kannad districts and Dakshina Kannad; Central Region encompasses Chitradurga, Raichur, Chikmagalur, Dharwad, Shimoga and Bellary districts with an elevation ranging between 450 and 700 m and Southern Region includes Bangalore, Hassan, Kodagu, Mandya, Mysore and Kolar. The general elevation of southern Karnataka varies between 600 and 900 m. The main soils of Karnataka are red clay, laterite soil, red soil mixed with clay and sand and black soil. Lateritic soil is

Table 1 Summarized meteorological data of some important pomegranate growing districts of Maharashtra.

Parameters	Maharashtra			
	A	**B**	**C**	**D**
Mean max. temp. (°C)	31.72	34.06	32.26	32.22
Range	27.9-37.7	30.5-40.3	28.5-38.2	29.5-36.9
SD	3.23	3.49	3.33	2.39
CV (%)	10.20	10.26	10.33	7.40
Mean min. temp. (°C)	17.60	17.49	17.28	17.82
Range	10.4-22.8	10.8-22.9	10.5-22.5	13.7-22.1
SD	4.62	4.62	4.68	3.09
CV (%)	26.22	26.43	27.07	17.37
Mean max. humidity (%)	71.93	74.38	76.55	76.88
Range	47.7-88.6	54.8-86.6	58.7-87.4	66.0-88.1
SD	13.62	10.65	9.46	7.68
CV (%)	18.93	14.32	12.36	9.99
Mean min. humidity (%)	45.92	39.60	40.14	51.10
Range	20.1-78.4	21.5-62.0	22.3-62.2	29.3-75.7
SD	21.34	14.87	14.79	16.10
CV (%)	46.48	37.56	36.85	31.51
Mean Evaporation (mm)	5.29	6.72	5.29	6.13
Range	4.1-6.9	4.1-12.0	3.2-9.5	4.5-9.9
SD	1.00	2.59	2.06	2.01
CV (%)	18.94	38.49	38.99	32.80
Mean Sunshine duration (hr)	7.19	7.79	7.81	7.68
Range	3.0-9.5	3.8-10.5	3.8-10.4	3.7-10
SD	2.41	2.31	2.31	2.22
CV (%)	33.50	29.71	29.63	28.93
Mean Monthly Rainfall (cm)	5.23	5.90	4.76	4.59
Range	0.01-19.4	0.3-14.8	0.2-13.1	0.0 – 13.7
SD	6.47	6.01	4.63	5.19
CV (%)	123.56	101.75	97.42	113.02

A: Nasik; **B:** Solapur; **C**: Ahmednagar; **D**: Sangli
Source: Indian Meteorological Department, Pune, Govt. of India (unpublished data).

basically a vesicular rock composed of a mixture of the hydrated oxides of aluminum and iron with small amounts of manganese oxides, titania, etc. Interestingly, red soil composes the majority of Karnataka which was formed by the weathering of the crystalline and metamorphic rocks and its red colour is owing to the diffusion of iron oxide in high proportion (Chadha 2005; Ramamurthy *et al.* 2009).

Andhra Pradesh is the third important state of Deccan Plateau covering geographical area of 0.277 million km^2 that lies between 12°41' to 22°N latitude and 77° to 84°40'E longitude. The state can be broadly divided into three regions, namely Coastal Andhra, Telangana and Rayalaseema. The state falls under the semi-arid region of peninsular India and has a typical tropical climate with hot summers but relatively pleasant winters, especially in the plains of the interior. South-west and north-east Monsoons are the two important periodic winds which are the important sources of rain. The south-west monsoon is spread over the period commencing from June and ending with September, while north-east monsoon spreads from October to December. Summer and winter temperature ranges from 20-41°C and 13-32°C, respectively. The category of soil in the state ranges from poor coastal sands to highly fertile deltaic alluvium. Mainly black, alluvial loamy clay and laterite soils are found in the state (National Horticulture Mission (NHM) 2005).

CLIMATE, AREA, PRODUCITON AND PRODUCTIVITY OF POMEGRANATE IN DECCAN PLATEAU

Maharashtra

Pomegranate cultivation is confined mainly in Nasik, Solapur, Ahmednagar, Sangli, Pune, Satara, Dhule, Latur, Jalana and Osmanabad districts of Maharashtra. Major parts of these districts fall under arid to semi-arid zone and have black soil with shallow to deep strata. But, Nasik, Solapur, Sangli, Usmanabad and Ahmednagar are comparatively dry having major area under marginal to sub-marginal type with gravely to rocky lands. Their altitude varies between 500 and 650 m above mean sea level. Mean maximum temperature ranges from 27.9-37.7, 30.5-40.3, 28.5-38.2 and 29.5-36.9°C in Nasik, Solapur, Ahmednagar and Sangli, respectively (**Table 1**). And their Mean minimum temperature remains between 10.4 and 22.9°C. Mean maximum and minimum humidity percentage generally ranges from 47.7-88.6 and 20.1-78.4. Mean evaporation, however, varies from 3.2-9.9 mm in these districts. Generally, March-May and November-February months experience more bright sunshine duration which ranges from 8.0-10.7 hr/day. During rainy season (June-October), mean sunshine duration ranges from 3-7 hr/day. Mean annual rainfall noted to vary from 55.0-62.8 cm in Nasik, Ahmednagar and Sangli. However, in Solapur district rain fall is more (70.83 cm) but some of its areas, where pomegranate is grown on commercial scale, are dry. In fact, Nasik, Solapur, Ahmednagar and Sangli are the main pomegranate growing districts of Maharashtra. Clay, loamy, deep and very deep soil, shallow and slightly deep soil are found in pomegranate growing areas. Pomegranate production was 0.596 million tonnes from 0.096 million ha during 2007-08 in Maharashtra. Interestingly, Nasik and Solapur were the major pomegranate growing districts of Maharashtra and accounted for about 70% of its area and production (**Table 3**). Productivity wise Ahmednagar and Sangli were the highest (6.88 t/ha) followed by Nasik (6.38 t/ha).

Karnataka

Bagalkot, Bijapur, Bellary, Koppal, Gadag, Damangiri and Chitradurg are pomegranate growing districts of Karnataka. These districts are hot and dry suitable for the quality fruit production. But the major production was confined in Bijapur, Bagalkot, Bellary and Koppal. These districts have red, gray and black soils with medium to deep strata and their altitude ranged from 445-533 masl (**Table 3**). Mean maximum and minimum temperature ranges from 28.3-41.6°C

Table 2 Summarized meteorological data of some important pomegranate growing districts of Karnataka and Andhra Pradesh.

Parameters	Karnataka				Andhra Pradesh		
	E	**F**	**G**	**H**	**I**	**J**	**K**
Mean max. temp. (°C)	34.55	33.70	34.00	33.21	34.13	33.42	33.32
Range	30.9-41.6	30.8-39.8	28.3-39.8	29.5-39.8	29.1-40.0	30.5-38.8	26.2-42.1
SD	3.30	2.99	3.54	3.61	3.19	3.02	4.76
CV (%)	9.55	8.88	10.42	10.87	9.33	9.05	14.30
Mean min. temp. (°C)	21.63	22.33	22.37	20.95	22.28	21.61	20.31
Range	15.6-26.8	16.5-27.5	15.8-26.8	15.7-25.6	16.1-26.2	16.3-26.4	13.0-25.0
SD	3.58	3.67	4.22	3.20	3.81	3.36	4.16
CV (%)	16.53	16.42	18.85	15.27	17.09	15.55	20.47
Mean max. humidity (%)	79.75	74.50	69.42	69.50	68.80	62.60	72.20
Range	65.0-90.0	65.0-88.0	55.0-83.0	48.0-85.0	58.0-81.0	42.0-76.0	50.0-84.0
SD	8.18	7.76	8.39	12.44	7.80	13.10	10.70
CV (%)	10.26	10.42	12.09	17.90	11.30	21.00	14.90
Mean min. humidity (%)	52.92	47.08	42.92	47.92	43.00	47.75	55.42
Range	36.0-71.0	28.0-62.0	25.0-58.0	28.0-65.0	26.0-59.0	24.0-66.0	33.0-74.0
SD	12.06	11.37	10.64	14.63	10.47	16.56	14.84
CV (%)	22.80	24.16	24.79	30.54	24.35	34.69	26.78
Mean evaporation (mm)	5.25	5.73	7.03	5.38	6.83	5.11	5.97
Range	3.2-9.8	3.9-8.3	4.3-11.2	3.2-9.9	3.9-12.5	3.6-8.5	4.1-9.8
SD	2.19	1.41	2.44	2.09	2.76	1.74	1.75
CV (%)	41.66	24.68	34.68	38.78	40.49	34.03	29.38
Mean sunshine duration (hr)	7.65	7.75	7.84	7.23	7.11	7.49	7.32
Range	3.2-11.8	3.2-11.5	3.5-11.5	3.1-10.5	3.2-9.8	3.1-10.2	3.8-9.8
SD	2.90	2.63	2.68	2.65	2.14	2.17	2.01
CV (%)	37.93	33.91	34.16	36.63	30.15	29.02	27.53
Mean Mon. rainfall (cm)	4.82	4.69	5.30	4.77	4.30	5.07	5.34
Range	0.0-20.4	0.0-18.5	1.5-19.8	0.0-15.5	2.6-5.9	0.0-20.8	0.0-24.5
SD	66.03	64.07	63.67	60.24	10.47	67.35	76.66
CV (%)	136.98	136.76	120.03	126.32	24.35	132.93	143.45

E: Bijapur; **F**: Bagalkot; **G**: Bellary; **H**: Koppal; **I**: Anantpur; **J**: Mahbubnagar; **K**: Medak
Source: Indian Meteorological Department, Pune, Govt. of India (unpublished data).

Table 3 Area, production and productivity of pomegranate during 2007-08 in Deccan Plateau.

State	Districts	Altitude (m above mean sea level)	Area (X 1000 ha)	Production (X 1000 tonnes)	Productivity (tonnes/ha)
Maharashtra	Nasik	500	35.40	225.94	6.38
	Solapur	480	31.04	189.34	6.10
	Ahemdnagar	560	6.39	43.98	6.88
	Sangli	550	6.31	41.49	6.58
	Others	500-650	17.36	95.45	5.50
	Total	-	96.50	596.20	6.18
Karnataka	Bijapur	480	2.68	28.78	10.73
	Bagalkot	533	2.49	32.95	13.23
	Bellary	445	1.95	21.69	11.12
	Koppal	530	1.98	24.38	12.31
	Others	500-780	4.00	42.10	10.52
	Total	-	13.10	149.90	11.44
Andhra Pradesh	Anant Pur	325	4.14	34.83	8.41
	Mahabubnagar	914	0.90	8.65	9.61
	Medak	442	0.04	0.35	8.75
	Others	270-570	0.02	0.17	8.50
	Total	-	5.10	44.00	8.63

Source: National Horticulture Board (www.nhb.gov.in)

and 15.6-27.5°C (**Table 2**) in Bijapur, Bagalkot, Bellary and Koppal. However, in these districts, mean maximum and minimum humidity percentage ranges from 48.85-90.0 and 25.0-71.0, evaporation from 3.2-11.2mm, sunshine duration from 3.1-11.8 hr/day. However, mean annual rainfall in these districts found to vary from 56.20-63.70 cm. Generally, June-September months receive moderate rainfall and rest of the months remain dry. Total area and production of pomegranate in Karnataka during 2007-08 was 0.013 million ha and 0.150 million tonnes, respectively (**Table 3**). Interestingly, the maximum productivity was 13.23 tonnes/ha in Bagalkot followed by Koppal (12.31 tonnes/ha).

Andhra Pradesh

Pomegranate cultivation is mainly observed in some parts of Anantpur, Mahbubnagar, Medak and Rangareddy districts of Andhra Pradesh. However, about 80% pomegranate area was available in Anantpur alone. In fact, Anantpur, Mahbubnagar and Medak districts have potential for area expansion of this crop. The mean maximum and minimum temperatures in these districts range from 26.2-42.1°C and 13.0-26.4°C, maximum and minimum humidity from 42-84% and 24-74%, evaporation from 3.6-12.5 mm and sunshine duration from 3.1-10.2 hr/day (**Table 2**). However, annual rainfall in these districts varies from 51.6-64.1 cm. In general, June-October months receive moderate rainfall and the remaining months remain dry. As compared to Maharashtra and Karnataka, the total area (0.005 million ha) and production (0.044 million tonnes) of pomegranate in Andhra Pradesh was very low (**Table 3**). However, the maximum productivity (9.61 tonnes/ha) was recorded in Mahabubnagar.

CULTIVATION PRACTICES

Pomegranate land holding

The pomegranate farm holdings are found to vary between 0.2 and 80 ha in Solapur district of Maharashtra. Majority of the growers maintain 0.2-4 ha of the orchards. In Nasik and Ahmednagar districts, the land holding ranges from 0.4-50 ha. But most of the pomegranate growers have 0.4-4 ha orchard size. In general, the cultivation is in medium to shallow black soil. However, in other pomegranate growing districts land holding is 0.5-2 ha. In Karnataka and Andhra Pradesh, the land holding of the growers ranges from 0.33-24.4 ha but majority of them have more than 2 ha (NRCP 2007a; Chandra *et al.* 2006).

Cultivars

'Bhagawa', 'Ganesh' and 'Arakta' are popular cultivars among the growers in Deccan Plateau (NRCP 2007b). However, 'Bhagawa' (**Fig. 2**) occupies the premier position (75-80%) followed by 'Ganesh' and 'Arakta' (Jadhav and Sharma 2007). Due to high demand of 'Bhagawa' for export, its more plantations are coming up in traditional and nontraditional areas. 'Ganesh' and 'Mridula' are medium maturing cultivars while 'Bhagawa' is late type but has prolific and early bearing tendency. Prior to release of 'Bhagawa', 'Ganesh' was popular in Maharashtra. Now, area under 'Ganesh' is being replaced by 'Bhagawa' due to its high demand in national and international markets.

Propagation

In general, air-layered planting material is used for establishment of the orchards in Maharashtra, Karnataka and Andhra Pradesh (NRCP 2007b). Although several reports are available that hard and semi-hard wood stem cuttings give high rooting success (>70%) (Panda and Das 1990; Panwar *et al.* 2001), but still the nurserymen/growers multiply the planting material through air- layering or *gootee.* It has been observed that for multiplication by air layering, 60-75 days is required while stem cuttings take about 100-120 days. Probably high rooting success and fast multiplication process of air-layering method might be the cause of its popularity in Deccan Plateau.

Spacing and planting system

In Solapur district, the plantation is done on mild sloppy lands (3-8% slope) having shallow soil depth (<50 cm). Generally, 60 × 60 × 60 cm or 75 × 75 × 75 cm sized pits are dug 1-2 months prior to planting and filled with surface soil mixed with well rotten FYM (10-20 kg/pit). Some growers also apply neem cake/cotton seed cake in the pits (NRCP 2006; NRCP2007b). Majority of the growers raise the soil to make 1-1.5 m wide beds of 20-25 cm height in the plant rows within one year of planting. Mainly growers follow 4-4.5 m × 3-3.5 m spacing but 4.5 m × 3.0 m spacing is most common. However, in Nasik district, wider spacing (3.5-5.5 m × 3.5-5 m) was more prevalent. Similar plant spacing is followed in Andhra Pradesh and Karnataka. However, flat bed planting system is prevalent in these states (Chandra *et al.* 2008).

Irrigation

The crop is considered to be tolerant to drought and it responds very well to irrigation. Drip irrigation system with two drippers per plant is followed in most of the orchards of Maharashtra, Karnataka and Andhra Pradesh. However, some of the growers make irrigation channel besides drip irrigation system in the same orchard. As far as frequency of irrigation is concerned, some growers irrigate the orchard daily but majority of the growers give irrigation twice or thrice in a week particularly during the cropping season. In general, water requirement of pomegranate is 15-65 l/tree/day depending on the age, season and type of soil. In dry areas, salt accumulation is a common phenomenon near the drippers but phytotoxicity was rarely noticed (NRCP 2007a). However, in long run strategy has to be developed to overcome the salt accumulation problem for its sustainable production. Some progressive farmers practice fertigation using liquid fertilizers.

Fig. 2 Profuse bearing in pomegranate cv. 'Bhagawa'.

Flower regulation

Interestingly, in Deccan Plateau, pomegranate flowers throughout the year. However, to get prolific harvest and quality fruits, the plants are given rest by with holding irrigation. Generally, 45-60 days stress period found to be sufficient to induce the flowering. Mainly three flowering seasons viz. winter (January-February), rainy (June-July) and autumn (September-October) are allowed for fruiting in Maharashtra. In dry areas of Solapur district, all the three flowering seasons are preferred. However, the rainy and autumn season flowerings are taken for export owing to its better fruit quality during this period. The fruits ripening during July-February have better colour development owing to mild day and night temperature. And such fruits fetch premium price in national and international markets (NRCP 2009a). However, winter season flowering is more common in Nasik and Ahmednagar districts (Marathe *et al.* 2006). Rainy and autumn season flowering is preferred in major pomegranate growing areas of Karnataka and Andhra Pradesh. Generally, ethrel or curacron or thiourea are sprayed on the plants during last phase of the stress period for defoliation and subsequent flowering. Leaf fall is completed within 10-15 days after spraying with chemical defoliants. In general, after 75% leaf fall, light pruning is done and manures and fertilizers are applied following light irrigation. And then regular irrigation is started at 2-3 days interval. New leaves start emerging within 5-7 days after first irrigation. Subsequently, flower buds are initiated. It has been observed that initially emerged flowers are male and they drop within a short period. Later on hermaphrodite flowers emerge. Major fruit setting takes place between 30-60 days after first irrigation (Chandra *et al.* 2008; NRCP 2009b).

Training and pruning

In most of the orchards, multi-stem training system with 2-5 main branches or stems from ground level are followed by the growers in Deccan Plateau. Two to three stem training system is common in Maharashtra but 3-5 stem training system is followed in Karnataka and Andhra Pradesh (Chandra *et al.* 2006, 2008; NRCP 2008). The suckers arising from the stem at ground level are removed regularly (2-3 times/year). Pruning is very common practice followed by the growers to encourage better flowering and fruiting and also to minimize the infection of diseases and infestation of insect pests.

Manure and fertilizer application

Although the crop is very hardy and grows successfully in low fertile soils, its productivity could be increased by application of balanced dose of manures and fertilizers. About 20-30 kg FYM along with 250-650 g N, 100-260 g P_2O_5 and 150-225g K_2O is applied in a bearing plant by majority of the growers. However, some of the growers apply *neem* cake with FYM and fertilizers at the time of flower regulation treatment. Half of the N doze and full doze of P and K are applied at the time of first irrigation after stress period and remaining dose of N subsequently after 3 weeks. Liquid fertilizer is also applied through drip irrigation systems by some of the innovative farmers. Some micro nutrients like Fe, Zn, Mn and Cu are also incorporated in the soil or applied through foliar feeding (Chadha 2005; NRCP 2007; Chandra *et al.* 2008; NRCP 2008).

Cropping system

Intercropping is a beneficial proposition in pomegranate culture, particularly in those areas where adequate irrigation facility is available. Due to water scarcity in Solapur district, some growers take inter crops like gram, water melon, onion, tomato and brinjal in one to three year old orchards. However, pomegranate + mango (*Mangifera indica*), pomegranate + papaya (*Carica papaya*), pomegranate + aonla (*Emblica officinalis*), pomegranate + ber (*Ziziphus mauritiana*) (**Fig. 3**) and pomegranate + sapota (*Manilkara achras*) cropping systems are also noticed in some areas (Chandra *et al.* 2006). However, intercropping with onion and garlic in pomegranate orchard is prevalent in Nasik and Ahmednagar districts. Interestingly, most of the growers take sole crop of pomegranate in Maharashtra and Andhra Pradesh. The annual crops like wheat, maize, beans, groundnut and fruits crops mainly sapota, sweet orange, papaya and mango are grown in Bagalkot, Koppal and Chitradurg districts of Karnataka (Chandra *et al.* 2008).

Diseases and insect pests

Among the diseases, bacterial blight and wilt found to be the most devastating and causing severe loss to growers. Based on symptomatology, microscopic examination of diseased samples and isolation of pathogen on media and pathogenicity tests, causal organism of bacterial blight is *Xanthomonas axonopodis* pv. *punicae* (Nallathambi *et al.* 2009). The disease is prevalent in Maharashtra, Karnataka and Andhra Pradesh and causing huge loss to the growers. However, Solapur in Maharashtra, Anantpur in Andhra Pradesh and Bijapur in Karnataka are worst affected districts with bacterial blight. Bijapur revealed the maximum disease prevalence of 78% followed by Koppal (64.0%). Koppal and Bagalkot districts were most affected, as blight was observed in moderate form (11.0-40.0% intensity) in these two districts. In general, bacterial blight prevalence in Karnataka was 57.13% (Sharma *et al.* 2006; Chandra *et al.* 2008). However, wilt is another important disease of pomegranate and is caused by *Ceratocystis fimbriata.* Survey of Karnataka revealed wilt prevalence in 59.0% orchards from traces to severe form. Wilt was prevalent in Bagalkot, Koppal and Bijapur districts of Karnataka. Initially disease symptoms observed as yellowing of foliage of one or a few branches of a tree followed by yellowing and dropping of foliage of the entire tree. Occasionally in some plants wilt symptoms were observed as dropping of entire tree's foliage all of a sudden. Though, wilt is also causing significant loss in Maharashtra and Andhra Pradesh (Chandra *et al.* 2006; Sharma *et al.* 2006; Chandra *et al.* 2008). Some other diseases like leaf and fruit rots are also observed in pomegranate, but they do not cause much economic loss and are easily manageable with suitable fungicides. Insect pests are also associated with pomegranate crop. Mainly fruit borer, stem borer, shot hole borer, thrips, aphids, whitefly and mealy bug infests different parts of the plant (Sharma *et al.* 2006). Even in some of the orchards, roots are found to be infested with nematode. The infestations of insect pests vary according to agro-climatic conditions and cultural practices followed. Pomegranate growers are quite concerned in Deccan Plateau and manage them effectively.

Fig. 3 Pomegranate + Ber cropping system.

Physiological disorders

Some physiological disorders like Sun scald, fruit cracking and internal break down or aril browning are noticed in pomegranate growing areas. Sun scald is prevalent in Maharashtra and Karnataka, especially in severely pruned orchards. The fruit damage is more severe where fruits are exposed to direct sun light. However, incidence of sun scald on fruits is noticed up to 10%. Growers were observed protecting fruits from sunburn using paper covers and saries (Chandra *et al.* 2008). However, proper canopy management can tackle this problem. Fruit cracking is not a very common phenomenon in Deccan Plateau due to less variation in day and night temperatures, while fruit cracking is more severe in northern India, especially in Rajasthan (Prasad *et al.* 2003) and Western Himalayas. Both small and big sized fruits are cracked when irregular irrigation is given during fruit development and ripening period. However, some times small fruits are also cracked due to infection of bacterial blight. Another important physiological disorder in pomegranate is internal breakdown. It is observed once the fruits are cut open as the colour of the arils change to blackish brown, the fruits often reveal rot. These arils are unfit for consumption. 'Ganesh' is more susceptible to this menace in Solapur and Nasik as compared to 'Bhagawa' (Sharma *et al.* 2006). It is suspected that delay in harvesting cause internal breakdown of arils. However, exact cause of the internal breakdown is to be ascertained for its effective management.

Harvesting, yield and post harvest management

Fruits of cultivars 'Ganesh', 'Mridula' and 'Arakta' are ready for harvesting in 125-160 days (Hiwale 2009) and 'Bhagawa' in 180-210 days after anthesis depending upon the agro climatic conditions. The harvesting is done by handpicking when fruits ripen. In general, fruiting starts from the 2nd year after planting but commercial crops are taken from 3rd year. The fruit yield varies with variety, frequency of irrigation, nutrition, plant protection measures and age of the plants. On an average 25-120 fruits/tree is harvested from 2-6 year old plants. However, some farmers even take >150 fruits/tree from 4-6 year old orchards. In general, fruit yield ranges from 7.4-61.10 t/ha depending upon age of the trees (NRCP 2007). Based on survey it was observed that the growers in Karnataka and Maharashtra take fruit yield of 10-25 t/ha and 5-15 t/ha, respectively. In general, the orchards are productive up to 10-12 years. The fruits are graded and packed at farm manually (Ram Asrey

et al. 2008).These packed fruits are transported to district markets for internal supply and export. The major production is marketed for fresh consumption in India or abroad. However, cracked and damaged fruits are used for preparation of fruit juice. Pre-cooling and cold storage facilities have been developed to some extent in Maharashtra and Karnataka.

Economics

Based on survey it was observed that the establishment cost of the orchard comes around 0.025-0.13 million/ha. On an average annual maintenance cost in bearing orchards vary from Rs. 0.015-0.075 million/ha. The productivity of 'Bhagawa' and 'Ganesh' is high in Deccan Plateau. Thus the growers get net profit of Rs. 0.035-0.15 million/ha (Jadhav and Sharma 2007).

PERSPECTIVES

Pomegranate is becoming export oriented crop for the last one decade and its area and production is increasing with a faster pace in Deccan Plateau. Its demand for internal consumption and export is a driving force for promotion of its cultivation in the country. Consequently, Maharashtra is leading state for production of pomegranate (NRCP 2007b) and its area is also increasing in Karnataka and Andhra Pradesh. At present major produce is consumed as fresh fruit in India and a little quantity is processed (2%) and exported (3%). It is also observed that the major production of the fruit is coming from the marginal and sub marginal lands. Growth of pomegranate industry in Deccan Plateau will check the land degradation and bring environmental protection. Besides, employment generation is expected and socio-economic condition of rural masses will also improve in years to come. Since, bacterial blight and wilt diseases have threatened the pomegranate industry in Deccan Plateau, a systematic research strategy has to be developed for their control and sustainable production. However, Indian Council of Agricultural Research and Government of Maharashtra, Karnataka and Agricultural Research Universities and other developmental agencies have launched different research and development programmes for promotion of pomegranate industry in India.

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