Demonstration of Model Pomegranate Production Practices for Effective Management of Bacterial Blight Disease

PROJECT REPORT

January, 2014 to March, 2017

National Horticultural Board

(Funded by National Horticulture Board, Ministry of Agriculture, Govt. of India)

ICAR-National Research Centre on Pomegranate
(Indian Council of Agricultural Research)
Solapur-413255 (Maharashtra)

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Preface

Bacterial blight disease of pomegranate caused by *Xanthomonas axonopodis* pv. *punicae* which was once a major bottleneck in pomegranate industry is now manageable to get economic yield. Many farmers are now convinced that they can have profitable return from pomegranate cultivation by following model pomegranate production practices which was earlier known as Integrated Disease and Insect-Pest Management (IDIPM) schedule. Developing resistant variety to bacterial blight disease is a long term proposition. In absence of resistant variety, it is wise to follow integrated management practices aimed at reducing pathogenic inoculum load in the orchard and enhancing plant's innate defence mechanism through proper nutrient and water management practices.

Looking into the importance of pomegranate and at the same time huge losses caused by bacterial blight disease, a network project on "Mitigating the bacterial blight disease of pomegranate in Maharashtra, Karnataka and Andhra Pradesh" was sanctioned by the Ministry of Agriculture, Govt. of India, New Delhi in 2008 and the said project demonstrated an average of 73.97% reduction of bacterial blight disease with significant improvement in pomegranate productivity. In order to percolate the impact of IDIPM schedule to the farmers at grass-root level and to create mass awareness about the technologies for management of bacterial blight disease, a project on "Demonstration of model pomegranate production practices for effective management of bacterial blight disease" was sanctioned in 2013 by the National Horticulture Board, Ministry of Agriculture, Govt. of India, Gurgaon for implementing the project in village cluster so as to create convincing mass awareness of these model practices.

With the successful demonstration of model pomegranate production practices for management of bacterial blight disease, the villagers of Mohol Taluka, Solapur who once lost their confidence on pomegranate now are convinced that they can fetch a good return in-spite of existence of bacterial blight disease in the orchard through adoption of model pomegranate production practices. Most of the farmers are now well aware of the significance of disease free nurseries, shifting of season and management schedule to be followed throughout the year in mitigating bacterial blight disease of pomegranate. This was amply reflected by increase in area under cultivation, production and productivity of pomegranate over the period at national level.

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R.K. Pal

INTRODUCTION

Pomegranate (*Punica granatum* L.), an economically important fruit crop is drawing a great attention to the people world-over because of its immense nutraceutical value and multipurpose uses (leather, dye and pharmaceutical industry). This crop is adaptable to diverse climate, soil and water condition and more specifically it has high tolerance to drought. Therefore, this is an excellent choice under arid and semi-arid condition and is most suitable for replacing subsistence farming and bringing prosperity in arid and semi-arid regions. In addition, it provides nutritional security and has potentials to develop wastelands widely available in the arid and semi-arid regions of India and is an ideal crop for diversification. Moreover, it can make higher contribution to GDP with small area.

It is believed that the pomegranate originated in Iran/Turkey; trees were grown over the whole Mediterranean region of Asia, Africa and Europe; later the plant migrated to Far East along silk route where it has been cultivated since the pre-Christian era. Theophrastus, whom Linnaeus called Father of Botany, provided description of this fruit tree about 300 years before the birth of Christ. Having its centre of origin in Mediterranean region, this fruit was always associated with various culinary and medicinal uses in these regions. Afghanistan was a major producer and exporter of the fruit in better times. Khaled Hosseini's stories often associate the better times with pomegranate trees lining compounds of affluent Afghans. While the crop still is an important one in Afghanistan, countries like India, Iran and some in the Caucasian and Mediterranean regions have emerged as some of the major commercial producers and exporters of pomegranate in modern times. Pomegranate shrub flourished naturally in northern India, in the lower ranges of Himalayas and Kashmir valley but is relatively a new introduction in the horticulture sector for fruit cultivation, compared to other major fruits viz. Mango, Banana, Citrus etc. Indians considered it as one of the rarest fruits having high nutritive value from ancient times; its medicinal properties being described in Ayurveda. In our childhood, baskets of pomegranate fruits were offered as gift to near and dear ones suffering from critical illness or recovering from surgical operations to help them recuperate fast.

India is one of the leading countries in pomegranate acreage and production worldwide. The area under cultivation of pomegranate has grown up by 35.19 per cent during the last decade, as area increased from 96.9 thousand hectares (2003-04) to 180.64 thousand hectares (2014-15). At present, Maharashtra with an area of 90.0 thousand ha is the leading state in acreage and accounts for 68.7 per cent of the total area under pomegranate in the country. Maharashtra experienced a very rapid growth in pomegranate area during the last 23 years from 4.6 thousand ha. (1990-91) to 90.0 thousand ha. (2013-14). Other

major pomegranate growing states are Karnataka (16.62 thousand ha), Gujarat (9.38 thousand ha) and Andhra Pradesh (6.00 thousand ha) (Table 1). In recent years, pomegranate cultivation has also been started in Rajasthan, Orissa, Chhattisgarh, Uttarakhand and Madhya Pradesh at small scale. There has been steady increase in area and production of pomegranate in the country with a total production of 2198 thousand tonne obtained from total area of 193 thousand ha in 2015-16 (third advance estimate), although it was considered minor fruit till 1986. But in the recent-past, major pomegranate growing states viz. Maharashtra, Karnataka and Andhra Pradesh were facing great losses due to wide spread incidence of bacterial blight disease in pomegranate resulting from intensification of cultivation practices under changing climatic scenario. In order to mitigate this huge losses, an orchard health management schedule was formulated by the pomegranate research worker and all over India at a high-level meeting under the chairmanship of Deputy Director General (DDG), ICAR, New Delhi in February, 2007 and the schedule was validated in 2007-08 at farmer's field with the successful harvest of 16 tonne disease-free yield form 1 ha area. Subsequently, the same schedule was demonstrated in a network mode project in Maharashtra, Karnataka and Andhra Pradesh. The schedule was successfully demonstrated in 28 blight affected orchards with reduction of blight severity by 67.49 % in the first year and 73.97% in the second year and resulted production of 8.61 t fruit yield ha^{-1}. Hence in order to replicate these success stories in village cluster, a project on "Demonstration of model pomegranate production practices for effective management of bacterial blight disease" was sanctioned by the National Board of Horticulture, Ministry of Agriculture, Govt. of India vide their letter No. NHB/27 BMHBTD 000013/2012-13 dated 03.12.2013 with the following objectives.

Objectives

1. Dissemination of proven technologies to the growers through organizing training programs
2. To organize demonstration programme on model production practices in pomegranate at farmers' field
3. Impact Assessment of the training and demonstration on improving production, productivity and profitability due to intervention

Capacity building through organizing training programmes

With the intensification of pomegranate cultivation, dreaded disease viz. bacterial blight disease caused by *Xanthomonas axonopodis* pv. *punicae* spreaded rapidly in the major pomegranate growing areas under the changing climatic scenario. Because of lack of awareness on technologies for management of bacterial blight disease at grass-root level, many of the pomegranate farmers lost their confidence in managing this disease and started uprooting their orchards. Under such circumstances, training programme on "Model pomegranate production practices for effective management of bacterial blight disease" were organized in pomegranate growing states like Maharashtra, Andhra Pradesh and Gujarat to disseminate the success stories of network project on "Mitigating the bacterial blight disease of pomegranate in Maharashtra, Karnataka and Andhra Pradesh" at grass-root level.

Training programme organized in Maharashtra

1. Training programme organized at Yavatmal, Maharashtra

Pomegranate cultivation is getting popularized in a great way in Yavatmal and the area under pomegranate cultivation is also increasing at faster rate. The growers who are interested to have plantation of pomegranate are in dire need of technical aspects of pomegranate cultivation. Realizing their quest for technical know-how for pomegranate cultivation, a training programme was organized at Krishi Vigyan Kendra, Yavatmal in collaboration with KVK, Yavatmal on 7th March, 2014. The training programme was graced by honorable Vice-chancellor of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. About 186 farmers participated in the training programme. The farmers were imparted taining on 'plantation, training, pruning, nutrient management, water management, bahar regulation and plant protection measures with particular reference to bacterial blight. The participants were provided with technical folders on above mentioned aspects.This training programme was followed by interaction session where participants interacted directly with the resource persons on specific problems. Approximate area under cultivation of pomegranate in Yavatmal district is 240 ha.

Plate 1. Farmers' training programme organized at Yavatmal on 7th March, 2014

2. Training programme organized atBaramati, Maharashtra

Considerable area in Baramati of Pune district, Maharashtra is under pomegranate cultivation. And some new area is also coming under pomegranate cultivation. Realizing the quest of farmers for technical know-how on pomegranate cultivation, a farmers' training programme was organized at Krishi Vigyan Kendra, Baramati on 24th March, 2014. About 51 farmers participated in the training programme. They were imparted with technical knowledge on 'plantation, training, pruning, nutrient and water management, bahar regulation, plant protection measures and value addition to pomegranate' by number of resource person expertise on the respective field. They were also provided with technical literature on the above mentioned topics in the form of technical folder for easy and effective references. An interactive session was also arranged at the end of training programme where specific issues raised by the farmers were discussed. The farmers participated actively in making the training programme a successful event.

3. Training programme organized at ICAR-NRCP, Solapur for pomegranate farmers of Beed district, Maharashtra

The area under pomegranate cultivation is also growing at rapid pace in Beed district of Maharashtra. This area experiences very congenial climate for pomegranate cultivation and produces are exported to the international market. However, the majority pomegranate farmers of this district started cultivation following fellow pomegranate growers of other pomegranate growing districts of Maharashtra and they were unawared of latest technological management practices for mitigating important diseases like bacterial blight and wilt. Realizing their training need a three-days residential training programme on "Model pomegranate production practices" was organized at ICAR-National Research Centre on Pomegranate, Solapur from 16th – 18th February, 2015. About 25 pomegranate growers from Beed district of Maharashtra participated in the said training programme. They were imparted with technical knowledge on production of planting material, orchard establishment, training and prunning operation, nutrient management, disease and insect-pest management and value addition of pomegranate followed by visit to the well managed farmers' pomegranate fields. Interactive sessions were kept after every theoritical lecture wherein farmers actively interacted with the experts on specific problems faced by them in cultivation of pomegranate. They were also provided with training kits consisting of training manual and extension folders for various technologies for future references.

Plate 2. Farmers' training programme organized at Baramati on 24th March, 2014

Plate 3. Three-days residential training programme organized at ICAR-NRCP, Solapur from 16th -18th February, 2015 for the pomegranate growing farmers of Beed district of Maharashtra.

Training programme organized in Gujarat

1. Training programme organized at Bhuj, Kachh district of Gujarat

Pomegranate cultivation is also gaining momentum in Bhuj area of Kachh district. At present about 8000 ha in Kachh district is under pomegranate cultivation. Many more areas in Kachh district are coming with new plantation of pomegranate. Since it is new crop in this area, the growers are in dire need of technical knowledge on pomegranate cultivation. Therefore, a training programme was organized at Krishi Vigyan Kendra, Bhuj on 18th March, 2014. About 55 farmers actively participated in the training programme. The farmers were imparted technical knowledge on 'site selection, plantation, training, pruning, nutrient and water management, bahar regulation and plant protection measures' by the resource person expertise in the respective fields. Technical folders on the above mentioned topics were also distributed to farmers for easy references. The programme ended with interactive session where various specific issues raised by the growers were discussed in details and appropriate solutions were put forth. Approximate area under cultivation of pomegranate in Kachh district of Gujrat is 8000 ha.

2. Training programme organized at Bhimapura, Tharad Taluka and Centre of Excellence for pomegranate, Deesha, Gujarat

Owing to high return per investment in pomegranate, many areas of Gujarat have been brought under cultivation of pomegranate. However, because of lack of awareness among the pomegranate growers on good management practices, wilt and bacterial blight diseases are spreading in the state very fast. Realizing the training need of pomegranate farmers of Gujarat, one-day training programme on "Model pomegranate production practices" was organized at Bhimapura, Tharad Taluka, Gujarat on 7th March, 2015. About 230 pomegranate growers participated in the training programme. Training programme started with the identification of problems in the farmers' field through field visit followed by discussion on technical aspect for mitigating the identified problems. Besides, farmers were imparted with technical knowledge on various horticultural practices like training and pruning of plant and flower regulations, nutrient management practices, disease and insect-pest management, processing and value addition of pomegranate. Pomegranate farmers participated actively through interactive session wherein various specific issues raised by the farmers were discussed and practices recommended for resolving those issues.

Plate 1. Farmers' training programme organized at Bhimapura, Gujarat on 7th March, 2015

Training programme organized in Andhra Pradesh

1. Training programme organized at Rural Development Trust, Kanekal, Anantapur (AP)

Pomegranate cultivation is also getting momentum in Andhra Pradesh. Many new areas are coming with pomegranate plantation. Realizing the need of farmers for technical knowledge on model pomegranate production practices two training programme were organized, one at Rural Development Trust, Kanekal and other at Regional Horticultural Research Institute (RHTI), Anantapur in collaboration with Department of Horticulture and Horticultural Research Station, Anantapur on 25th and 26th March, 2014 respectively. About 107 farmers participated in training programme on 25th March, 2014 and about 105 farmers participated in training programme organized on 26th March, 2014. The farmers were imparted knowledge of method of pomegranate plantation, training, pruning, nutrient and water management, bahar regulation and plant protection measures by the resource person expertise in the respective field. They were also provided with technical folders on various aspects of production and protection practices of pomegranate for easy reference. At the end of training programme, an interactive session was organized where various specific issues raised by the farmers were enlightened to the farmers by the resource persons. Approximate area under cultivation of pomegranate in Anantapur district is 7000 ha.

Training programme organized for MGNREGS Functionaries of Bankura and Purulia Districts of West Bengal

1. Training programme organized at ICAR-NRCP, Solapur for MGNREGA functionaries of Bankura and Purulia districts of West Bengal

Pomegranate has been introduced in drier tract of West Bengal i.e. Bankura and Purulia districts of West Bengal for the first-time in convergance with the Mahatma Gandhi National Rural Employment Guarantee Scheme, Govt. of India, involving tribal women self-help groups of both the districts. The said scheme is being implemented with the State Govt. functionaries working at village level. A four-days residential training programme on "Model pomegranate production practices and value addition of produce" was organized at ICAR-National Research Centre on Pomegranate from 27th Feb. to 2nd Mar., 2017 for these village level State Govt. functionaries who are in direct contact with the women self-help groups. About 18 State Govt. functionaries actively participated in the said training programme. They were

imparted with technical knowledge on production of planting material, establishment of new orchards, Horticultural operations like training and prunning operation, nutrient management, disease and insect-pest management and value addition of pomegranate followed by visit to the well managed farmers' pomegranate fields and the farmer shared practical experience with pomegranate cultivation step-by-step. Interactive sessions were kept after every theoritical lecture wherein farmers actively interacted with the experts on specific problems faced by them at initial stage of pomegranate cultivation. They were also provided with training kits consisting of training mannual and extension folders for various technologies for future references.

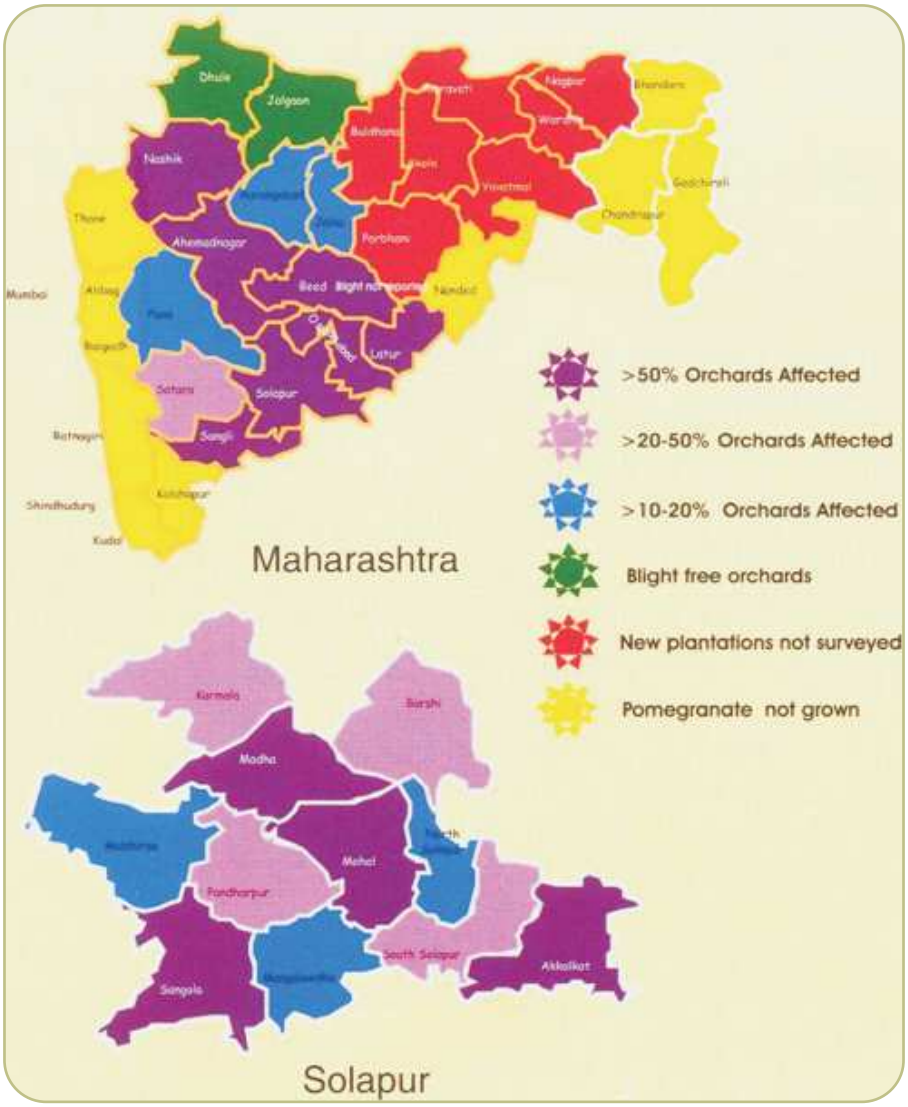
Plate 1. Training programme organized at Rural Development Trust, Kanekal, Anantapur, AP on 25th March, 2014

Plate 2. Training programme organized at Regional Horticultural Research Institute (RHTI), Anantapur, AP on 26th March, 2014

Plate 1. Four-days residential training programme organized at ICAR-NRCP, Solapur from 27th Feb. -2nd Mar., 2017 for the State Govt. functionaries of Bankura and Purulia districts of West Bengal involved in MGNREG scheme, Govt. of India.

Implementation of model pomegranate production practices at farmers' field

Changing climatic scenario and intensive cultivation practices followed by the farmers led to outbreak of bacterial blight disease caused by *Xanthomonas axonopodis* pv. *punicae* in pomegranate causing heavy losses to the pomegranate growers ranging from 30 to 80% depending on the pathogenic load in the orchard and aberrant climatic condition. Solapur is one of the badly affected districts, wherein more than 50% of the orchards are affected by bacterial blight disease in Maharashtra. Within Solapur, Mohol was found to be the hot spot for bacterial blight disease incidence in pomegranate.



The pomegranate farmers of Shej-Babhalgaon and Ankoli villages were badly affected by the incidence of bacterial blight disease as it caused huge losses by spoiling the fruits. These two villages viz. Shej-Babhalgaon and Ankoli of Mohol Taluka were selected with active participation of Maharashtra Pomegranate Growers' Association for implementation of Integrated disease and insect-pest management schedule developed, validated and refined by ICAR-National Research Centre on Pomegranate, Solapur.

The pomegranate orchards in these villages were selected for demonstration on the basis of bacterial blight disease incidence, severity and farmers' acceptance to take Hasta bahar crop in place of Mrig bahar. On these basis six pomegranate farmers' orchards namely: (1) Bapu Adgale, (2) Nirmala Chanbas Kapse, (3) Vitthal Sathe, (4) Ramchandra Narayan Power, (5) Sameer Mubarak Mulani, (6) Latika Vilas Patil, each giving 2.5 acre of orchard were selected for demonstration of IDIPM schedule. The selected orchards were in very bad condition (plate 2, 3, 4, 5, 6 &7). Bacterial blight disease incidence in leaves ranged from 32.62-50.26% with severity ranging from 30.06 to 45.23%. The owners of selected orchards harvested fruit yields ranging from 8-18 tonne/ha in the previous year while potential yield of the area recorded to be 30 tonne/ha. There existed a wide yield gap ranging from 15-22 tonne/ha owing to severe infection of bacterial blight disease. While contacted with the farmers of these two villages, they were of opinion to uproot these pomegranate orchards owing to huge losses inflicted upon them.

Table 1. Condition of orchards before adoption for implementing IDIPM schedule

Pomegranate orchard	Bacterial blight disease (%)		Fruit yield obtained in previous year (tonne/ha)	Potential fruit yield of the area (tonne/ha)	Yield gap (tonne/ha)
	Incidence	Severity			
Orchard 1	35.02	34.28	9.00	30.00	21.00
Orchard 2	48.65	40.67	8.00	30.00	22.00
Orchard 3	48.02	42.54	9.00	30.00	21.00
Orchard 4	32.62	30.06	18.00	30.00	12.00
Orchard 5	38.75	35.72	10.00	30.00	15.00
Orchard 6	50.26	45.23	8.50	30.00	21.50

Plate 2. Condition of Orchard1 before adoption for implementation of IDIPM schedule

Plate 3. Condition of Orchard 2 before adoption for implementation of IDIPM schedule

Plate 4. Condition of Orchard 3 before adoption for implementation of IDIPM schedule

Plate 5. Condition of Orchard 4 before adoption for implementation of IDIPM schedule

Plate 6. Condition of Orchard 5 before adoption for implementation of IDIPM schedule

Plate 7. Condition of Orchard 6 before adoption for implementation of IDIPM schedule

The integrated Disease and Insect-Pest Management (IDIPM) schedule for pomegranate was developed at a two-days joint meeting of pomegranate researchers from ICAR institutes and State Agricultural Universities of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu at ICAR-National Research Centre on Pomegranate, Solapur under the chairmanship of Dr. J.H. Kulkarni, former Vice-Chancellor, University of Agricultural Science, Dharwad and a panel of experts consisting of Dr. Srikant Kulkarni, former Professor and Head, Plant Pathology, UAS, Dharwad, Dr. V. Ponnuswami, Dean, Horticulture College & Research Institute, TNAU, Tamil Nadu, Dr. G.S. Karibasappa, Principal Scientist, ICAR-National Research Centre for Grapes, Pune and Dr. V.T. Jadhav, Director, ICAR-National Research Centre on Pomegranate, Solapur. Later on this schedule was validated in 35 pomegranate farmers' orchards spreaded over Maharashtra, Karnataka and Andhra Pradesh in network mode and refined based on results obtained in demonstration plots. This refined IDIPM schedule so called "Model pomegranate production practices" was implemented /demonstrated in six pomegranate orchards of Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur. This model pomegranate production practices included following operations.

1. **Selection of bahar**: Selection of appropriate bahar is one of the important aspects for reducing pathogenic inoculum load in the orchards. In Mrig bahar, flowering generally occurs in the month of June-July and fruit setting and subsequent development coincides with the humid climate of rainy season. This results in rapid spread of bacterial blight disease if inoculum of pathogen already exists in the orchard. While in hasta bahar, flowering generally takes place in September-October and subsequent fruit setting and development do not encounter with humid climate, hence bacterial blight causing pathogen does not spread rapidly unless there happens to be unseasonal rain. So, pomegranate growers are advised to take hasta bahar crop if bacterial blight infection exists in the orchards in the refined IDIPM schedule. For demonstration of model pomegranate production practices in Shej-Babhalgaon and Ankoli villages, hasta bahar crop was taken in order to reduce the bacterial blight disease causing pathogenic inoculum load.

2. **Sanitation measures**: Diseased twigs and infected fruits were removed with secateurs sterilized with sodium hypochlorite (2.5%) and brunt outside the orchard. Infected dried leaves, flowers, fruits and twigs lying on the orchard floor and irrigation channel were collected and brunt. Bleaching powder (a.i. 33% chlorine) was dusted at every 3 months @ 100-150 g per plant on the ground below the canopy in the tree basin in order to reduce the disease and pest inoculum on leftover plant debris if any in the orchard. The orchards were kept weed free from time to time to reduce the chances of latent

infection of bacterial blight disease during lean period.

3. **Nutrient management**: Leaf samples (preferably 7th and 8th pair) were collected from all sides of plant selected randomly in the orchards. These leaf samples were washed thoroughly in tap water followed by in detergent, dilute acid solution (0.1 N HCl) followed by thorough washing with plenty of water and finally washed with double distilled water. Leaf samples were dried at 60°C for 48 h in an oven and then ground and wet digested for nutrient analysis. Nutrients viz. N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu concentration in the digested samples were measured using different instruments like micro-kjaldhal, spectrophotometer, flame photometer and atomic absorption spectrophotometer. The nutritional status of selected orchards is given in Table 2. Nutritional imbalance indices of pomegranate orchards were computed and presented in table 4. The data indicated that nutritional imbalance indices had close relation with bacterial blight disease severity i.e. higher the values of nutritional imbalance indices, higher will be the bacterial blight disease severity. In order to narrow down these nutritional imbalances, recommendations of nutrient required for all the adopted orchards have been presented in table 5.

Table 2. Nutritional status of orchards before adoption for demonstration

Pomegranate Orchard	Primary nutrients (%)			Secondary nutrient (%)			Micronutrients (mg kg^{-1})			
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
Orchard 1	2.21	017	0.74	0.96	0.46	0.086	480.00	84.60	61.00	70.00
Orchard 2	2.25	0.14	0.97	1.44	0.34	0.071	558.00	58.40	69.00	60.00
Orchard 3	1.98	0.13	0.75	1.36	0.38	0.047	548.00	24.60	30.00	18.00
Orchard 4	2.15	0.15	0.74	1.52	0.43	0.098	510.00	105.80	61.00	88.00
Orchard 5	2.92	0.22	1.22	1.84	0.48	0.078	423.00	46.40	77.00	131.00
Orchard 6	2.31	0.13	0.94	1.12	0.24	0.052	543.00	34.40	35.00	47.00

Table 3. Optimum leaf nutrient concentration standards of pomegranate for making them moderately resistant to bacterial blight disease

Primary nutrients	Optimum concentration range (%)	Secondary nutrients	Optimum concentration range (%)	Micro-nutrients	Optimum concentration range (mg kg^{-1})
N	1.56-2.05	Ca	1.60-2.16	Fe	132.50-187.00
P	0.11-0.28	Mg	0.38-0.82	Mn	31.60-58.40
K	0.83-1.20	S	0.09-0.16	Zn	13.20-27.40
				Cu	26.00-47.80

Table 4. Relation between nutrient imbalances and bacterial blight disease severity

Pomegranate orchard	Nutrient imbalance indices	Bacterial blight disease severity (%)
Orchard 1	296.64	34.28
Orchard 2	321.76	40.67
Orchard 3	382.45	42.54
Orchard 4	224.38	30.06
Orchard 5	287.75	35.72
Orchard 6	382.89	45.23

Table 5. Recommendation of nutrient requirement for adopted orchards based on leaf nutrient analysis

Pomegranate orchard	FYM (kg $plant^{-1}$)	N	P_2O_5	K_2O	Micronutrients
		(g $plant^{-1}$)			
Orchard 1	40	470	250	625	-
Orchard 2	40	470	250	500	-
Orchard 3	40	625	250	625	Foliar application of $MnSO_4$ @ 0.6% and $CuSO_4$ @ 0.2%
Orchard 4	40	470	250	625	-
Orchard 5	40	470	250	500	-
Orchard 6	40	470	250	500	-

Use of bio-fertilizers: Bio-fertilizers like N_2 fixer, phosphate and potash solubilizers were mixed with ground well decomposed farmyard manure (FYM) in 1:25 ratio and incubated for 21 days with 3 turnings at 7 days interval and maintained at field capacity moisture content under shed. Then this bio-fertilizers and FYM mixture was applied @ 0.5 kg per plant 7-10 days prior to chemical fertilizer application.

Organic manure: Ten to fifteen kilogram of well decomposed farmyard manure was applied immediately after removal of infected twigs and fruits i.e. at the initiation of rest period, followed by light irrigation. Rest amount of FYM was applied at the time of releasing stress with first irrigation in bahar treatment.

Nitrogen: About 80% of the annual N use is from tree reserves, while only 20% is from the immediate nitrogen application. The later nitrogen is applied during the growing season, the less it is used in the year of application, the greater its contribution in the next year. Therefore, nitrogen applied late in the year is stored mainly in the root system for use in the following season. One-third of the recommended nitrogen dose in the form of neem-coated urea was applied at the initiation of rest period along with well decomposed FYM and the rest amount was applied in three splits in the ratio of 1:0.7:1 during 15-45 days after full bloom (DAFB), 50-70 DAFB and 100-120 DAFB respectively.

Phosphorus: Phosphorus availability in calcareous alkaline soil is usually restricted. Maximum availability to plants of both native and applied P is in the range of 6.0 to 7.5. Half dose of P_2O_5 was applied in band in the form of single super phosphate at the initiation of rest period and rest amount of P_2O_5 was applied through irrigation water in 5:0.2:1 ratio during 15-45 DAFB, 50-70 DAFB and 100-120 DAFB respectively in the form of water soluble fertilizer 0-52-34.

Potassium, calcium and magnesium: The status of available potassium, magnesium are usually found in an adequate supply in pomegranate growing soil owing to high level of native exchangeable K and Mg which are hardly leached in low rainfall region. High Ca levels in soils generally suppress uptake of K and Mg by plants in part presumably through competition. Half the recommended dose of K_2O was applied in the form of muriate of potash during initiation of rest period and rest half of K_2O was applied through irrigation water in 3.8:3.4:1 ratio during 15-45 DAFB, 50-70 DAFB and 100-120 DAFB in the form of water soluble fertilizer 0-52-34 and 0-0-50.

Calcium and magnesium were applied in two equal splits at the rate of 250 g and 125 g as calcium sulphate and magnesium sulphate per plant during 15-45 DAFB and 50-70 DAFB respectively to the soil.

Micronutrients: Zinc, manganese and boron were applied through foliar spray. Zinc sulphate @ 0.3%, Manganese sulphate @ 0.6% and boric acid @ 0.25% were applied three times one at flowering and other two at 30 and 60 days after flowering.

4. **Cultural practices and plant protection measures during rest period**: After previous crop, infected branches, twigs

were pruned and infected fruits were removed from the plant. Then plants were allowed a brief period of 4 months rest after application of basal dose of fertilizers and manures as mentioned in previous section for better plant health and vigour. As the rest period of hasta bahar crop coincided with the rainy season, Bordeaux paste (10%) was applied on the pruned end of stem to prevent further entry of pathogen through cut end. Besides, Bordeaux mixture (1%), streptocycline (@ 0.5 g/lit) along with copper oxychloride (@ 2.5 g/lit) and bronopol (@ 0.5 g/lit) along with captan (@ 3 g/lit) were sprayed alternately at 15 days interval. Water shoots were removed regularly. During this period only lifesaving irrigation was provided to keep plant alive. After three months of rest period, irrigation was totally withheld for a period of 30-45 days to impose stress in plant.

5. **Prunning and bahar regulation**: Towards the end of stress period, plants were pruned to remove old branches, cris-cross branches and infected branches (at 2 inches below the infected area) to open up the centre for proper light and air penetration. Bacterial blight cankers were scooped out and pasted with Bordeaux paste (10%). Half pencil thickness (i.e. 0.25-0.30 cm thick) and refill thickness branches were pruned at 5 to 8 cm from the top all around the plant to promote axillary bud formation for flowering. Bordeaux paste (10%) was applied on the cut ends after pruning and a foliar spray of bordeaux mixture (1%) was undertaken immediately after pruning. Once pruning was over, ethrel 39% SC was sprayed @ 2.0-2.5 ml/lit. along with DAP 5 g/lit. for defoliating pomegranate plant. Within a week all plants got defoliated to the extent of 70-80%. Fallen leaves were collected and brunt outside the orchard for maintaining good sanitation. Bleaching powder was dusted @ 100-150 g/plant on the ground below the canopy.

6. **Water management**: After defoliation, a light irrigation at the rate of 6-8 lit./day/plant was provided, thereafter gradually amount of irrigation water was increased following below mentioned irrigation schedule.

Table 6. Irrigation schedule for hasta bahar crop

Month	Meteorological week	Amount of irrigation water applied (lit./day/plant)
September	36	6
	37	9
	38	11
	39	13
October to third week of December	40	15
	41	18
	42	20

	43	24
	44	25
	45	28
	46	29
	47	30
	48	31
	49	32
	50	30
	51	30
Fourth week of December to second week of February	52	30
	01	29
	02	30
	03	31
	04	35
	05	37
	06	39
	07	41
Third week of February to March	08	44
	09	47
	10	49
	11	49
	12	52
	13	52
	14	52
	15	52

Plate 1. Flowering in demonstrated plots at Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur

7. **Plant protection measures**: The following spray schedule was adopted in demonstration plots for management of bacterial blight disease.

Spray schedule	Time of spray	Plant protection chemicals sprayed
1st	Immediately after prunning	Bordeaux mixture (1%)
2nd	Seven days after 1st spray	*Pseudomonas fluorescens* talc based formulation @ 2 g/lit. with continuous agitation
3rd	Eight days after 2nd spray (When new flush come out)	Sprayed Thiamethoxam 25 WG @ 0.3 g/lit. for management of sucking pest. Copper oxychloride 50WP (2.5 g/lit) + Bronopol (0.5 g/lit) along with spreader sticker.
4th	Fifteen days after 3rd spray (at flower bud initiation)	Streptocycline (0.5 g/lit.) + Carbendazim 50 WP (1.0 g/lit) + Acetamiprid 20SP (0.3 g/lit) along with spreader sticker.
5th	Fifteen days after 4th spray	Captan 50 WP (2.5 g/lit.) + Bronopol (0.5 g/lit.) + Imidacloprid 17.8 SL (0.3 ml/lit.) along with spreader sticker.
6th	Fifteen days after 5th spray (at initiation of fruit setting)	Streptocycline (0.5 g/lit.) + Thiophanate methyl 70 WP (1.0 g/lit.) + Cypermethrin 25% EC (1 ml/lit.) along with spreader sticker.
7th	Seven days after 6th spray	*Pseudomonas fluorescens* talc based formulation @ 2 g/lit. with continuous agitation

8th	Seven days after 7th spray	Bordeaux mixture (0.5%)
9th	Fifteen days after 8th spray (at 50% fruit setting)	Streptocycline (0.5 g/lit.) + carbendazim 50 WP (1.0 g/lit.) + Chloropyriphos 20% EC (2.0 ml/lit.) + neem seed kernel extract (50 g/lit.) along with spreader sticker.
10th	Fifteen days after 9th spray (at 100% fruit setting)	Bordeaux mixture (0.5%)
11th	Fifteen days after 10th spray	Captan 50 WP (2.5 g/lit.) + Bronopol (0.5 g/lit.) + Methomyl 40% SP (1.0 g/lit.) along with spreader sticker.
12th	Fifteen days after 11th spray	Streptocycline (0.5 g/lit.) + Thiophanate Methyl 70 WP (1.0 g/lit.) + Acetamiprid 20 SP (0.3 g/lit.) along with spreader sticker.
13th	Fifteen days after 12th spray	Bordeaux mixture (0.5%)
14th	Fifteen days after 13th spray	Streptocycline (0.5 g/lit.) + copper hydroxide 77 WP (2.0 g/lit.) + neem seed kernel extract (50 g/lit.) along with spreader sticker.
15th	Fifteen days after 14th spray	*Pseudomonas fluorescens* talc based formulation @ 2 g/lit. with continuous agitation.

Plate 2. Demonstrated orchard in fruiting stage (Orchard 4)

Plate 3. Demonstrated orchard in fruiting stage (Orchard 1)

Plate 4. Demonstrated orchard in fruiting stage (Orchard 5)

Plate 5. Demonstrated orchard in fruiting stage (Orchard 2)

Plate 6. Demonstrated orchard in fruiting stage (Orchard 3)

Organization of pomegranate field day

Pomegranate growers of Mohol Taluka, Solapur were about to lost their confidence to manage bacterial blight disease owing to lack of awareness on the technologies for management of bacterial blight disease and vagaries of weather. Some of the farmers started uprooting their orchards owing to loss of crop due to bacterial blight disease infection. At this juncture, demonstration of model pomegranate production practices were implemented in six pomegranate orchards in the Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur. When the crop in one of the best demonstration plot was ready for harvesting, "POMEGRANATE FIELD DAY" was organized to present the results of demonstration before pomegranate growers of Mohol Taluka. About sixty pomegranate growers participated in celebrating pomegranate field day. Participating farmers were taken to the demonstration plot and explained to them on various technologies being adopted in demonstration plots to manage effectively bacterial blight disease in pomegranate. Later on they were imparted with technical knowledge on 'production of planting materials', 'canopy management', 'nutrient and water management', 'plant protection measures' and 'value addition of pomegranate'. Pomegranate growers were made aware of various government schemes by the Taluka Agriculture Officer for boosting horticulture sector in Maharashtra. At the end of the day, pomegranate growers of Mohol Taluka got convinced after witnessing the result of demonstration and regained their confidence, once they lost, in managing bacterial blight disease of pomegranate to have a good harvest.

Plate 7. Best demonstrated plot where pomegranate field day was celebrated

Plate 8. Organization of pomegranate field day at demonstration plot.

Impact assessment of model pomegranate production practices for management of bacterial blight disease

The model pomegranate production practices for management of bacterial blight disease were demonstrated in six pomegranate orchards in Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur. However, one orchard was discontinued due to non-cooperation of selected beneficiary. The results showed that bacterial blight disease in demonstrated plots got drastically reduced to 2.49-8.93% compared to 30.02-46.85% as recorded in plots managed by the farmers (Table 1). There was 80.94-93.01% reduction of bacterial blight disease in demonstration plots as a consequence of adoption of model pomegranate production practices.

Table 1. Effect of model pomegranate production practices on bacterial blight disease incidence

Pomegranate orchards	Name of the beneficiaries and address	Area under demonstration	Demonstration plot	Farmer's own plot	Reduction of bacterial blight disease (%)
			Per cent of fruits affected with bacterial blight at harvest		
Orchard 1	Sh. Bapu Adgale A/P Sejbhabhalgaon, Tal Mohal, Dist- Solapur, Maharashtra.	2.5 acre	4.19	30.02	86.04
Orchard 2	Ms. Nirmala Chanbas Kapse A/P Sejbhabhalgaon, Tal Mohal, Dist- Solapur, Maharashtra	2.5 acre	8.93	46.85	80.94
Orchard 3	Sh. Vithal Sathe, A/P Sejbhabhalgaon, Tal Mohal, Dist- Solapur, Maharashtra	2.5 acre	5.98	42.42	85.90
Orchard 4	Sh. Ramchandra Narayan Powar A/P Ankoli, Tal Mohal, Dist.- Solapur Maharashtra	2.5 acre	4.15	30.54	86.41
Orchard 5	Sh. Sameer Mubarak Mulani A/P Ankoli, Mohal, Dist- Solapur, Maharashtra	2.5 acre	2.49	35.63	93.01

MPPP =Model Pomegranate Production Practices; FOP =Farmers Own Practices

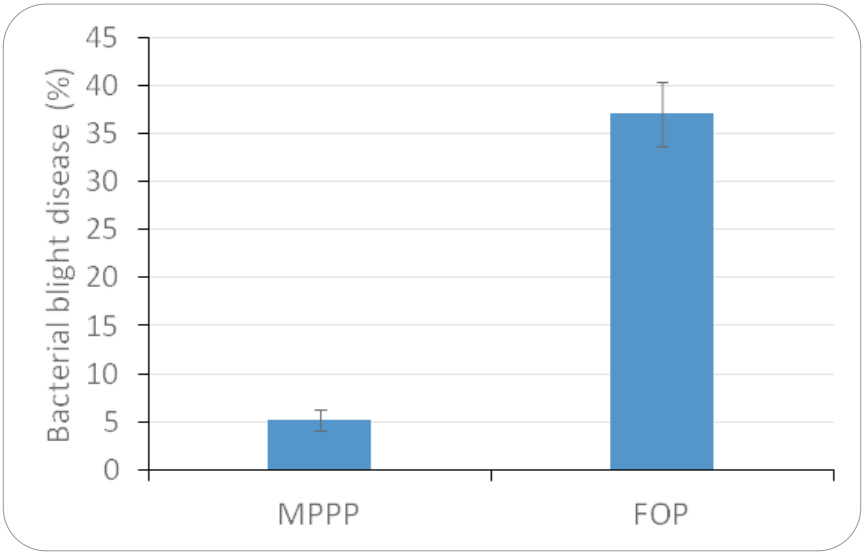


Figure1. Effect of model pomegranate production practices on bacterial blight disease infection.

Fruit yield in demonstrated plots ranged from 13.53 to 30.00 t ha^{-1}, while with farmers' own practice, it ranged from 8.40 to 22.99 t ha^{-1} (Table 2). A clear cut increase of fruit yield by 30.49-63.21% was recorded in the demonstrated plots as compared to farmers' owned managed plots.

Table 2. Effect of model pomegranate production practices on fruit yield

Pomegranate orchard	Fruit yield (t ha^{-1})		Yield gap with reference to farmer's own practices (t ha^{-1})	Yield gap with reference to potential yield* of the area (t ha^{-1})	Increase in fruit yield (%)
	Demonstration plot	Farmer's own plot			
Orchard 1	13.53	8.40	5.13	16.47	61.07
Orchard 2	15.20	10.31	4.89	14.80	47.43
Orchard 3	17.17	10.52	6.65	12.83	63.21
Orchard 4	30.00	22.99	7.01	0.00	30.49
Orchard 5	18.39	12.25	6.14	11.61	50.12

Potential yield of the area was taken as 30 t ha^{-1} in pomegranate

MPPP =Model Pomegranate Production Practices; FOP =Farmers Own Practices

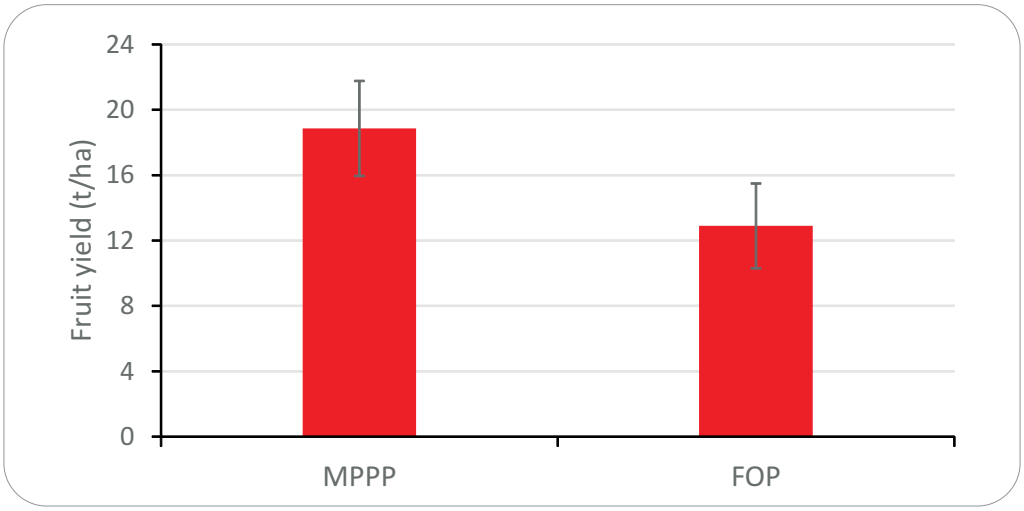


Figure 2. Effect of model pomegranate production practices on fruit yield of pomegranate.

Before adoption of pomegranate orchards for demonstration, the yield gap was quite high, ranging from 12.00 to 22.00 t ha^{-1}. With the adoption of model pomegranate production practices, these yield gaps got narrowed down, ranging from 0-16.47 t ha^{-1} (Figure 3). The cost of cultivation in demonstration plots ranged from Rs. 1,02,575/- to Rs. 1,15,000/-, while income obtained from selling of produce ranged from Rs. 6,00,950/- to Rs. 15,00,000/- (Table 3). The net profits in the demonstrated plots were appreciably high ranging from Rs. 4,98,375/- to Rs. 13,85,000/- with cost-benefit ratio ranging from 1:4.86 to 1:12.04.

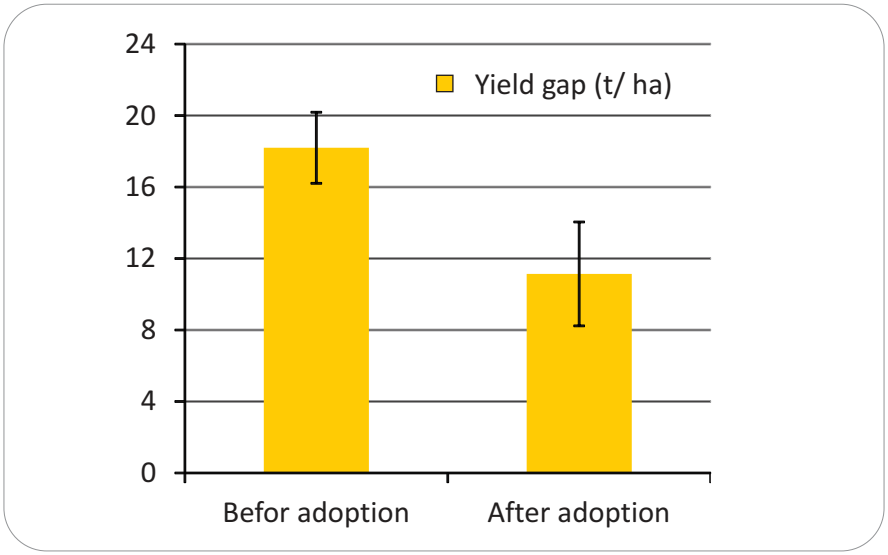


Figure 3. Effect of model pomegranate production practices on narrowing down the yield gap of pomegranate.

Table 3. Cost of cultivation and profit obtained in demonstration plots

S. No.	Demonstration plot	Cost of cultivation (Rs.)	Income from selling of produce (Rs.)	Net profit obtained (Rs.)	Cost benefit ratio
1	Orchard 1	104500.00	635910.00	531410.00	1: 5.08
2	Orchard 2	108750.00	714400.00	605650.00	1: 5.57
3	Orchard 3	102575.00	600950.00	498375.00	1:4.86
4	Orchard 4	115000.00	1500000.00	1385000.00	1:12.04
5	Orchard 5	110800.00	827550.00	716750.00	1:6.46

Plate 1. Harvesting sorting and packaging of pomegranate fruits in demonstrated plot

Plate 2. Harvesting sorting and packaging of pomegranate fruits in demonstrated plot

The results of demonstration of model pomegranate production practices clearly shows that if these practices are followed thoroughly, it is sure to bring down significantly the level of bacterial blight disease infection in pomegranate orchard and enhance productivity to appreciably high level. The training programmes conducted in the state of Maharashtra, Andhra Pradesh and Gujarat under this project was very fruitful in creating awareness on the management of bacterial blight disease with model production practices as envisaged in this report.

The impact of training programme could be visualized from the rising trend of area, production and productivity of pomegranate at national level (Figure 4)

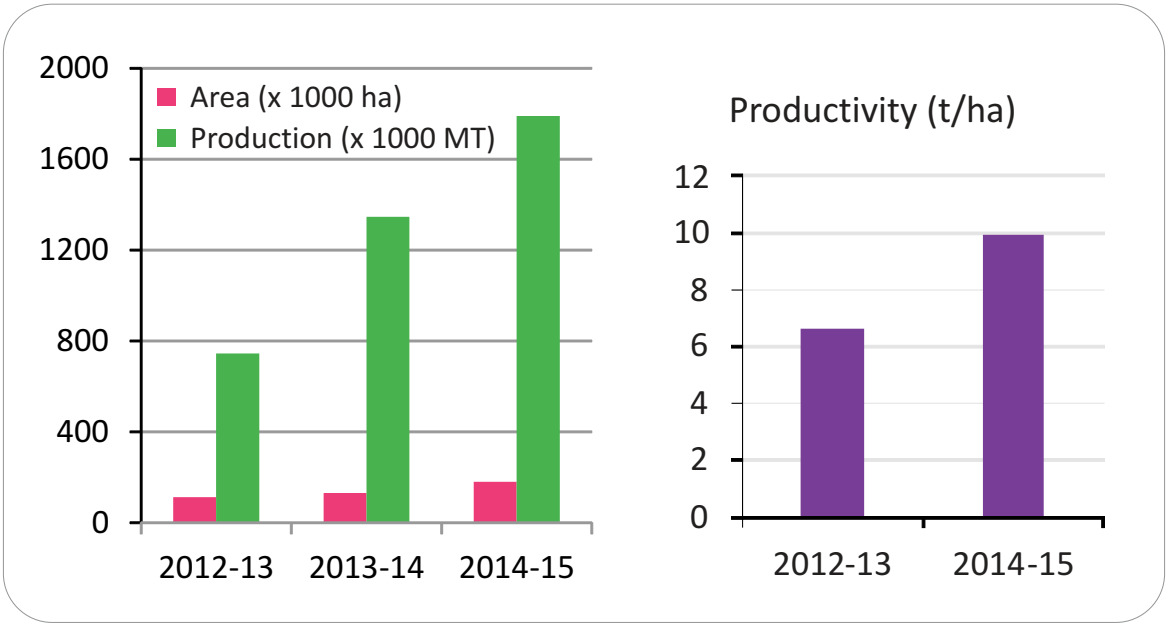


Figure 4. Trend of pomegranate area and production and productivity over the period.

During 2012-13 the area, production and productivity of pomegranate were 113.20 thousand ha, 745 thousand MT and 6.6 MT/ha respectively which rose to 180.64 thousand ha, 1789.31 thousand MT and 9.90 MT/ha respectively in 2014-15. Because of wide spread awareness made under this project, farmers who were once thinking to uproot pomegranate orchards now planning for establishing new orchard.

Conclusion

On the basis of demonstration at farmers' field in Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur, it was inferred that bacterial blight disease of pomegranate could be managed to have profitable return using model pomegranate production practices (IDIPM schedule). If any spot appear in leaves of new plantation, the first and foremost step would be to get it confirm

whether these spot are of bacterial blight disease or not from nearest research organization for under taking timely measures to prevent its further spread in the orchard. Besides following points need to be taken care off to prevent the entry and spread of bacterial blight disease in the orchard.

- Planting and establishing new orchard with disease free planting material from certified disease free nursery.
- Only one crop should be taken in a year with sufficient i.e. 3-4 months rest period.
- Plant should be provided with balanced nutrition and nutrient management .

should be started immediately after harvest of previous crop

- Proper sanitation measures should be adopted by the growers.
- Affected orchards should not be neglected.
- Due care should be taken to prevent spread of disease from this infected orchards.
- During rest period proper plant protection measures as mentioned in this report should be adopted.
- Effort should be made to avoid un-necessary sprays of chemicals / nutrients and keep number of sprays as possible as minimum.

Plate 3. Visit to demonstrated plot by the Deputy Director of NHB and interaction with the beneficiary.

Plate 4. Visit to demonstrated plot by the Deputy Director of NHB and interaction with the beneficiary.

Plate 5. Visit to demonstrated plot by the Deputy Director of NHB and interaction with the beneficiary.

Plate 6. Visit to demonstrated plot by the Deputy Director of NHB and interaction with the beneficiary.

Plate 7. Visit to demonstrated plot by the Deputy Director of NHB and interaction with the beneficiary.