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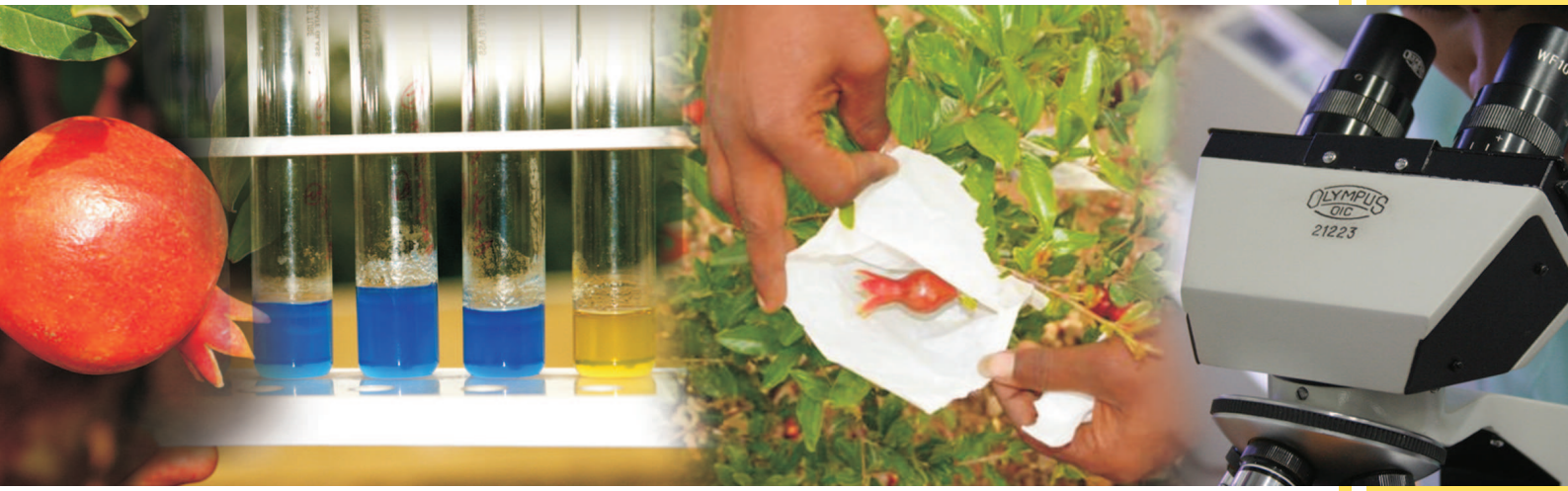
ICAR

Annual Report

2008-2009



National Research Centre on Pomegranate

(Indian Council of Agricultural Research)

Annual Report

2008-2009

National Research Centre on Pomegranate
Solapur-413 255 Maharashtra

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Preface

National Research Centre on Pomegranate (NRCP) from its inception at Solapur in 2005 has been moving forward both in the field of research as well as development in a commendable way. In a short span of four years, major constraints to pomegranate productivity in the semi-arid regions of India have been identified and addressed through undertaking various research programme under the discipline of crop improvement, crop production, natural resource management and crop protection to cope up with the existing problems and make quality pomegranate production sustainable in these eco-regions.

The NRCP has been coordinating with public sector agency like Agricultural and Processed Food Export Development Authority (APEDA) in developing software system "Anarnet" through providing necessary information on pest risk analysis, use of pesticides in pomegranate and their residue levels for domestic and export market. The 'Anarnet' software system will be helpful to all stakeholders involved in the supply chain management of pomegranate from growers to ultimate consumers. The NRCP is also co-ordinating with State Agricultural University (SAUs) through network project on "Mitigation of bacterial blight of pomegranate" in the state of Maharastra, Karnataka and Andhra Pradesh. The centre has joined hands with the State Department of Agriculture in activities like extension of area under new pomegranate plantation and impact assessment of orchards adopted by the State Department for mitigating bacterial blight. The centre played instrumental role in extending the financial assistance to the pomegranate growers for the third consecutive year through implementation of good management practices (GMP) package approved by the Union Ministry of Agriculture.

Many sophisticated instruments and equipments have been procured to carry out research in the frontier areas of tissue culture, post-harvest management and plant pathology. The office-cum-laboratory building is coming up at Kegaon farm at rapid pace and is likely to be completed within one year. The Kegaon farm has taken the shape of research farm from its barren look with two-three years old pomegranate plantation, where various experiments on different aspects of crop improvement, production and protection are underway. The expeditious development of the centre as well as research farm has aroused huge appreciation from the Research Advisory Committee (RAC) during its meeting in 2008.

The third annual report of the centre for the year 2008-09 comprehensively highlights the research achievements of eight ongoing research projects and also other developmental activities undertaken during the period. I implore my feeling of profound gratitude to my all staff members for their all out efforts towards the progress of the centre. I express my sincere gratitude to Dr. Mangala Rai, Secretary DARE and DG, Dr. H.P. Singh, DDG (Horticulture), Dr. S. Rajan, ADG (Horticulture) and Dr. S.N. Pandey, Retd. ADG (Horticulture), ICAR, New Delhi for their full cooperation and guidance in the development of this centre.

Date: September 2009
Place: Solapur

(V.T. Jadhav)
DIRECTOR

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Executive Summary

Crop Improvement

Germplasm collection and variability

Ninety six germplasm accessions of pomegranate collected from different sources, multiplied during 2007-08 were planted in field gene bank in July 2008.

Seedling population from IIHR Bangalore and six ecotypes of Bhagwa and Ganesh and Phule Arakta from Maharashtra revealed variation in growth parameters and fruiting. Maximum variability was observed in terms of fruit per plant (31.48%) followed by N-S plant spread (15.26%). Studies on variability through gamma irradiation revealed that flowering and fruiting was better in Bhagwa than cv. Ganesh irrespective of treatments.

Physiological response of mutants

Photosynthetic and transpiration rate and water use efficiency (WUE) were higher in March indicating better physiological activity during this period and subsequently with increase in temperature during April these parameter showed declining trend. There was a positive correlation between photosynthetic rate and stomatal conductance and photosynthetic rate and transpiration rate in February, March and April.

Sixty one varieties/ecotypes/landraces of pomegranate revealed variability with respect to leaf area (25.83%), followed by plants spread (E-W, N-S) and thorn length. Bedana Sedana ,Spendanader and IC-1203 recorded plant height more than 275 cm where as Nana was dwarf with plant height of 63.67cm. Flowering was recorded in more than 85% germplasm.

25 variants (seedlings and grafted plants) of cv. Bhagwa collected from Maharashtra, Karanataka and Andhra Pradesh revealed variation in skin and aril colour. Varietals evaluation of 4 improved cultivars viz. Bhagwa, Mridula, Phule Arakta and Ganesh revealed significant difference in plant height.

Flower Biology:

Studies on flower biology of pomegranate revealed three kind of flowers viz. hermaphrodiate (bisexual), staminate (male) and intermediate. The time taken for flower bud development was found maximum (20.40 days) in cv Ganesh as compared to cv Bhagwa (19.29 days) during the month of June.

The peak period of anthesis in cvs Ganesh and Bhagwa was between 10 am. to 12 noon. Total number of flowers per plant from two years old orchard were 124 and 133 in cvs Ganesh and Bhagwa respectively. Pollen viability was slightly more in cv Ganesh (93.2%) as compared to cv Bhagwa (91.0%). Studies on pollination revealed that in case of selfing fruit set was found to be slightly higher in cv Ganesh (16.6%) as compared to cv Bhagwa (16.0%), while in cross pollination fruit set was more in cv Ganesh (47.77%) as compared to Bhagwa (35.00%).

Screening of hybrids from IIHR Bangalore against bacterial blight revealed resistance in 6 hybrids out of 100 upto 2 months after inoculation.

Crop Production

Survey

Surveys of pomegranate orchards revealed pomegranate +Tomato cropping system in

some orchards. Tying of branches with coir string was a common practice in some orchards. Pruning of newly emerged shoots about 40-50 days prior to harvesting of fruits improved colour development and increased size of fruits. Air-layering was the main method of propagation.

Standardization of media for seedlings

Pomegranate seedlings raised in potting mixture containing soil and organic manures had higher contents of nitrogen, phosphorous and potassium in leaf, stem and roots but no increase was found in the calcium, magnesium, iron, manganese, copper and zinc contents of mentioned plant parts. However soil fertility status showed complete supremacy in Soil +FYM potting mixture as the treatment revealed highest content of macro and micronutrients.

Evaluation of Training system

Evaluation of training systems revealed more plant height in double and triple training systems.

Growth performance of grafted genotypes

The growth performance of cultivars Ganesh, Yercaud-1, Kandhari, 17/2 and Bhagwa on Phule Arakta root stock indicated vigorous growth in cv Yercaud-1. Maximum graft success of 84% after 30 days of grafting was recorded in Mridula (root stock) and Ganesh (scion) graft combination.

Grafting method and Time

Studies on wedge and Tongue grafting methods during different time periods revealed maximum graft success (85 %) at 90 days after wedge grafting done in January 30. The plant height and scion length after 6 months of grafting was higher with wedge grafting done between December 30 and January 30.

Effect of Bioagents on growth and physiological parameters

Application of different bioagents viz. *Azospirillium, Azospirillium* + *Pseudomonas striata, P.fluorescens, Trichoderma viridae* resulted in higher dry matter (total biomass), longer roots and more number of roots per plants. Use of *Azospirillium* + *P. Striata* improved photosynthetic and transpiration rate as compared to control.\

Bioagents: Different *penicillium* isolates showing potassium solubilization potential were evaluated *in vitro* and highest solubilization index was recorded after two days in isolate R2, though all the isolates had good potash solubilization potential.

Application of bioagent P*seudomonas flurorosens* and PPFM for control of bacterial blight significantly increased TSS in treated fruits as compared to untreated fruits. Pink Pigmented Facultative Methylotroph (PPFM) isolated from pomegranate significantly improved plant growth in potted plants as well as increased plant dry matter by 45.7%. The Bioagent also significantly increased nutrient uptake by plant and available K and Mn in the potting mixture.

Solarization did not significantly affect sprouting of air layers, hard wood cuttings or seed germination, however weeds were almost eradicated in solarized treatments. Solarized treatment of Sand+Soil +FYM in equal proportions significantly improved in this solarized treatment.

Soil, Water and Nutrient Management

Chemical properties and fertility of soil

Analysis of soil prior to planting revealed that soil pH and EC varied from 7.32 to 8.33 and 0.12 to 0.18 ds/m respectively, which was in normal range of pomegranate cultivation. Black soils were marked by higher pH and higher organic carbon contents as compared to light soils. Mixing of sand increased the $CaCO_3$ content which might affect the pomegranate cultivation. Black soils had higher content of Nitrogen and Potassium and micronutrient copper, while phosphorus, iron and manganese were higher in the light soils.

Leaf nutrient content in different soils

Analysis of leaf samples of one year old plantation did not reveal much variation in leaf content of N, Fe and Mn with respect to different soil treatments. However, higher N and Fe content was observed in loamy soils where as Fe was highest in black soil. Phosphorus content was higher in light soils as compared to black soils.

Black soils with varied depths (30 to 120 cm) found to supply sufficient quantity of different nutrients for growth of pomegranate plants. High leaf nutrient contents of K, Ca, Mg, and Fe were recorded under these treatments. Treatment comprising of murum only also supplied adequate quantity of nutrients at least during the initial stage (one year) of the plant growth.

In two year old plantation of cv Bhagwa highest plant height and spread was recorded under pits filled with black soils up to 120 cm depth, while it was lower in gravelly soils or mixture of Black Soil 50% + Sand 50%.

Performance of pomegranate under different planting systems

Studies on performance of pomegranate under different planting systems showed that height of the plant was maximum in treatment of pits of size 0.6 x 0.6 x 0.6 m followed by continuous trenches (1 m x 1m).

Nutrient deficiency Symptoms

Nutrient deficiency symptoms in pomegranate were studied with respect to macro and micro elements. **Nitrogen:** Deficiency symptoms first appeared on lower and mature leaves in the form of yellowing of whole leaf, which became stiffer in strength and broke into pieces on folding. N deficient plants flowered early and produced more number of hermaphrodite flowers (27 flowers/plant). **Phosphorous:** Deficiency symptoms first appeared on younger leaves and plants revealed stunted growth, yellowing of the leaves along with veins started from the tip and such leaves became slender, smaller in size and leaf margins turned upwards giving tunnel like shape. **Potassium**: Deficiency symptoms first appeared on older leaves which revealed many brown spots on the dorsal side along the margin starting from tip. Subsequently, leaf margin became yellow followed by scorching . **Calcium**: Symptoms first appeared on the younger leaves in the form of interveinal yellowing which started from the leaf tip and advanced from the margin towards midrib. In advanced stages, pinkish tinge appeared on the yellow portion of the leaf and leaf dried up from tip portion.

Magnesium: Gray patches appeared on the margins of the leaves which proceeded in inverted. 'v' shape manner and subsequently covered whole leaf and affected leaves showed drying up symptoms. **Sulphur**: Symptoms first appeared on middle leaf with leaf veins becoming light green in colour. Yellowing started around the midrib and interveinal areas turned yellow in colour and later on whole leaf became yellow.

Water quality analysis of the surveyed orchards revealed that though most of the water samples from Solapur were within safe range for irrigation, water sample from Sangola area had hard water with high EC, chlorides and sodium content.

Plant Protection:

Disease Surveillance: Surveys of pomegranate orchards conducted in Maharashtra to assess the severity of various diseases revealed prevalence of bacterial blight, wilt and fungal leaf and fruit spots in varying proportions. **Bacterial blight** was prevalent in 55% orchards of the State, of which 10% were severely affected, 20% moderately and remaining 25% were mildly affected by blight. Blight, however, was not observed in Dhule and Satara districts of the State during the year. **Pomegranate wilt** was prevalent in 45 percent orchards of which 5% revealed wilt in moderate form and rest 40% in mild form. **Leaf and Fruit spots** were, though, prevalent throughout the year, their severity was higher during the rainy season from July to September months. Isolation revealed association of different fruit spot pathogens namely *Cercospora punicae, Colletotrichum gloesporioides, Alternaria alternata and Sphaceloma punicae*. Scab caused by *Sphaceloma punicae* was recorded in severe proportion in many orchards of the State.

Bacterial blight:

Disease Epidemiology: Influence of weather factors on blight development at NRCP Kegaon farm during 2008-09 revealed that disease severity was significantly and positively correlated with humidity and rainfall where as disease had negative and non significant correlation with temperatures under Solapur conditions. Regression equation with all 7 meteorological variables (max temp. ^{0}C, min. temp. ^{0}C, Avg. temp. ^{0}C, max. RH, min. RH, Av. RH and rainfall) was found better for disease prediction.

Primary source of inoculum and Disease spread. At the research farm, disease initiated from one infector plant in April and spread further in the direction of the wind with rapid rate mainly in the rainy season. Maximum disease severity (50.0%) was recorded in October month and there after disease revealed declining trend.

Survivability: Bacterial blight pathogen (*Xanthomonas axonopodis* pv. *punicae)* was able to survive for 20 months in infected leaves collected from the blight affected orchard in year 2007 and incubated under laboratory condition (25.0°C 40.0 °C). The diseased leaves were able to produce bacterial ooze. However, the inoculum from such infected leaves failed to produce disease symptoms in inoculated plants, thereby, indicating reduced virulence in pathogen's ability to cause infection during the incubation period of two years.

Transmission of BBD was observed through apparently healthy hard wood cuttings from an infected plant. Apparently healthy stems of the plant developed blight symptoms at the nodes after about 7 months in 40% cuttings. This was followed by development of symptoms on the nearest leaf.

Screening of Germplasm for Bacterial blight resistance under Field conditions:

Screening of germplasm against bacterial blight under field conditions during August to December 2008 revealed that out of 63 accessions 6 were partially resistant (Patna 5, Nana, IC-1182, IC-1198, IC-1197 and IC-1205), 33 were susceptible and other 24 accessions were highly susceptible.

Screening of Germplasm under net house conditions About 240 plants of germplasm material including Indigenous collections (25 plants), crosses (25 plants of each of the 4 crosses) from IIHR, Bangalore, and varieties from MPKV (39) were screened for bacterial blight resistance under net house conditions, of these 20 plants were found totally free from bacterial blight, 50 days after disease appeared on leaves.

Bacterial blight Management :

***In vitro* studies** revealed that amongst different brands of 2-bromo, 2 nitropropane, 1,3-diol, Bactronol 100 was most effective followed by bactricell and bactrinashak, but all were superior to steptocycline as depicted through inhibition zone technique.

The recovery of bacterial blight pathogen from infected leaf samples treated with bactronol 100 was reduced after 3 hours where as in streptocyline recovery was reduced after 19 hours.

Under field conditions One antibiotic chloramphenicol (500ppm), 3 chemicals namely copper hydroxide carbonate (0.25%), copper sulphate pentahydrate (0.25%) and ammonium chloride (0.25%), one bioagent, P*seudomonas fluoroscens* and one commercial formulation bactrimax (0.3%) significantly reduced bacterial blight incidence over untreated control and were at par with Streptocycline.

Leaf and fruit spots:

Pomegranate Scab : Amongst various leaf and fruit spot diseases, pomegranate scab was recorded in severe proportion in several orchards of Baramati, Pune, Wadagi and Tuljapur. *Sphaceloma punicae* was isolated in pure culture to study its biology and pathogenicity.

Seedling blight of pomegranate: Seedling blight was observed in a severe form in 4-5 months old potted nursery seedlings of cv Bhagwa at the farm in the month of October 2008. Through microscopic and cultural and pathogenicity studies the blight pathogen was identified as *Phytophthora nicotianae*.

Fruit rot: Isolates comprising species of *Phomopsis, Colletotrichum, Aspergillus* and *Phytophthora* sp resulted in fruit rot on artificial inoculations.

Pomegranate wilt:

Etiology: The samples (Soil and plant parts) collected from the wilt affected orchards at Solapur, Ahmednagar and Dhule district of Maharashtra revealed presence of *Ceratosystis fimbrita*. Studies revealed that

C.fimbriata was the main cause of vascular wilt of pomegranate in the region. However, isolations from wilt infected orchards also revealed association of *Fusarium* spp., and root knot nematodes (*Meloidogyne incognita*). Pathogenicy of *Fusarium* spp., in causing wilt is yet to be established, though, preliminary pathogenicity tests did produce wilt symptoms in inoculated plants. In a few orchards shot hole borer (*Xyleborus fornicatus*) infestation resulted in weakening and ultimate drying of plants.

Epidemiology: **Survivability:** Wilt pathogen (*C.fimbriata*) was able to survive in soil in absence of host at least for 4 months.

Screening of germplasm for wilt resistance: In all 14 germplasm accessional were screened against wilt disease in a *C.fimbriata* infested sick plot prepared by artificially applying the pathogen in the rhizosphere of the plant . All the 14 accessions resulted in wilt infections due to *C.fimbriata* and none of the accession was able to show resistance against the wilt pathogen.

Management of wilt due to *C.fimbriata*: *In vitro* efficacy of bioagents and chemicals against *C.fimbriata* revealed that formulation biohit comprising of bioagent *Trichoderma viride* (0.1% and 0.2%), cycloheximide (100 and 200 ppm), Boric acid (0.1 and 0.2%) were significantly superior over control in inhibiting pathogen's growth, where as *Pseudomonas fluorescens* formulation (biomonarch) was effective only at 0.2% concentration.

Pesticide Residue analysis

Pesticide residue analysis of harvested pomegranate fruits from orchards adopted by the NRCP for mitigation of bacterial blight in particular and other diseases and insect-pests in general did not reveal any residue of majority of the pesticides applied during the period prior to one to two months of harvest. The residues of two chemicals namely carbendazim and thiophanate methyl which were detected in analysis were well below the MRL standards of EU and India.

Introduction

Pomegranate (*Punica granatum* L), a native of Iran was domesticated in 200 BC and adapted to the Mediterranean region of central Asia, Africa and Europe. Currently pomegranate is grown in most parts of tropical and subtropical countries. It is a high value crop and its entire tree is of great economic importance. Realizing the health benefits, demand in the international market has widened the scope for production and trade. Thus, pomegranate cultivation has become boon for Indian farmers in arid region, although it was considered as a minor fruit till 1986. India ranks first in area (0.13 million ha) and production (1.14 million tonnes) of pomegranate. Today Maharashtra state is considered as pomegranate basket in India contributing more than 70% of the total area under pomegranate followed by Karnataka and Andhra Pradesh. However, the productivity is only 9.12 t ha^{-1} which is significantly low as compared to other pomegranate growing countries like Spain (18.5 t ha^{-1}), U.S.A. (18.3 t ha^{-1}) and Iran (12.0 t ha^{-1}). Pomegranate being hardy in nature can adapt to wide range of agro-climatic conditions and is grown in poor soil, yet responds well to technological intervention in the field of water and nutrients management, plant protection and crop improvement. Keeping in view the vast potential of this fruit, Indian Council of Agricultural Research (ICAR), New Delhi established National Research Centre on Pomegranate (NRCP) at Solapur in Maharashtra in 2005 to explore and exploit its potential in the country through conducting basic and strategic research.

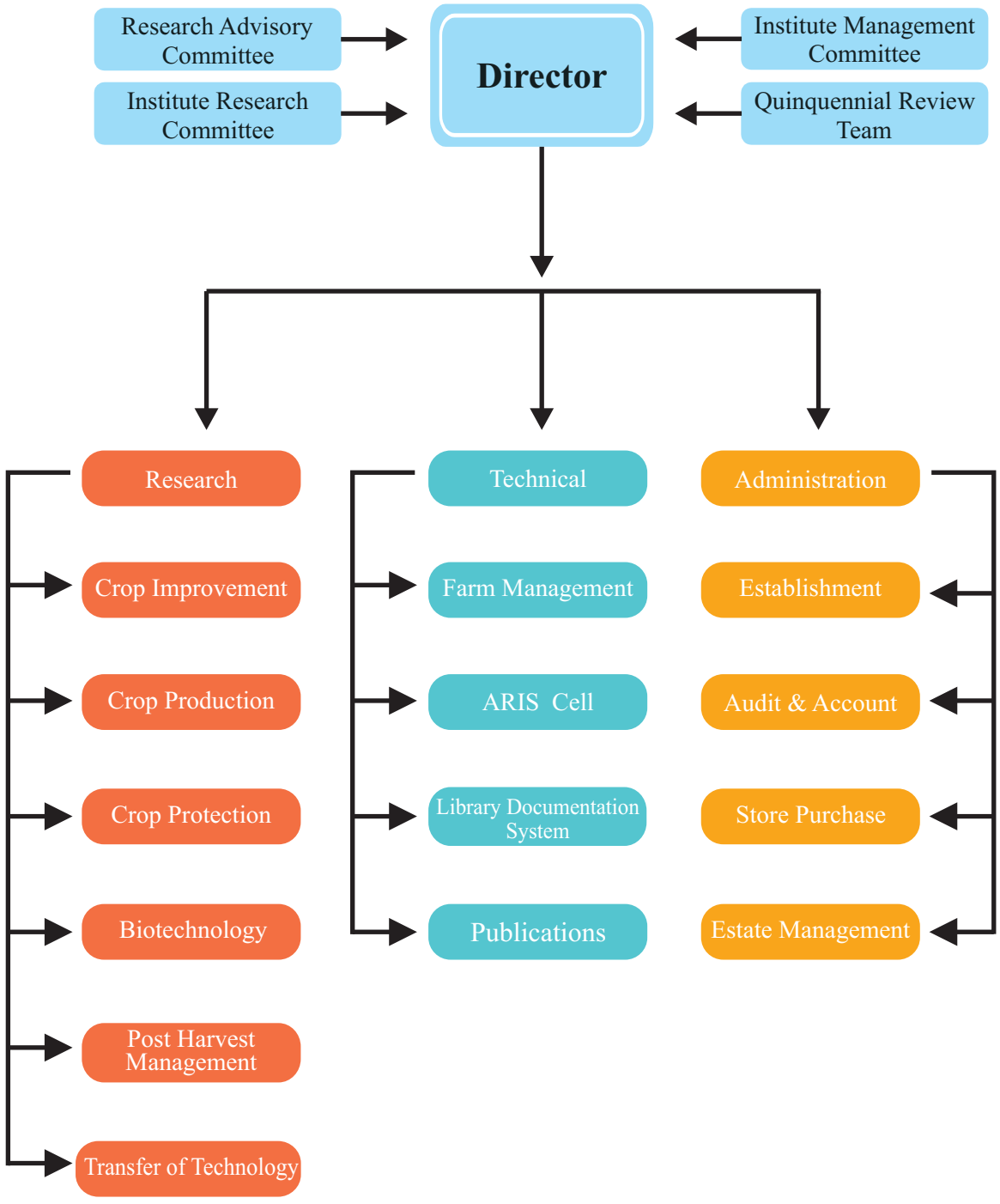
Location and Climate

National Research Centre on Pomegranate Solapur is located at 17°68' N latitude and 75°91' E longitudes and is at an altitude of 457m from m.s.l. The average annual rainfall of the area is 700.3 mm with temperature ranging between 8.4°C to 43.5°C.

Mandate

- To develop suitable varieties with high yield potential and quality fruits having resistance to biotic and abiotic stresses.
- To undertake, basic, strategic and applied research for developing production and post harvest technologies.
- To act as National Repository of pomegranate.
- To provide consultancy on pomegranate.
- To transfer technology to pomegranate growers.

Organizational Setup



Research Achievements

Programme 1: Improvement and Production in Pomegranate.

Project 1.1: Survey, Collection, Evaluation, Propagation and Improvement of Pomegranate.

1.1.1: Crop Improvement

Germplasm collection and multiplication

Ninety six accessions of pomegranate collected from different sources were multiplied during 2007-08, and planted in Field Gene Bank (Fig. 1) in July, 2008.

Fig. 1 Field gene bank of pomegranate at Kegaon, Solapur

Variability in seedling population of pomegranate

The seeds of seven hybrids from IIHR Bangalore and six ecotypes of 'Bhagawa', 'Ganesh' and 'Phule Arakta' were collected from Maharashtra and Karnataka. The seedlings were raised in polythene bags and planted after nine months in field for evaluation. The data recorded after one year of planting revealed variation in growth parameters and fruiting (Table 1a & 1b). The maximum variability (CV %) was observed in respect of number of fruits per plant (31.48%) followed by N-S plant spread (15.26%). Seedling population of NRCP-2 and NRCP-10 were dwarf in respect of plant height (115.2 -122.0 cm), while NRCP-8 had maximum plant height (175.3 cm).

Flowering and fruiting behaviour of gamma irradiated population of 'Ganesh' and 'Bhagawa'

Flowering and fruiting behaviour of seedling population of cvs Ganesh and Bhagawa obtained from gamma irradiation at 0-30 kR was recorded after one year of planting. Flowering ranged from 50-84 % and 0-50% in 'Bhagawa' and 'Ganesh' population, respectively. Similarly, fruiting in 'Bhagawa' and 'Ganesh' ranged from 6-35.6% and 0-25%. In general, flowering and fruiting was better in 'Bhagawa' than 'Ganesh' irrespective of treatments (Table 2).

Table: 1a. Plant height and spread in seedling population of pomegranate

Accession No.	No. of plants	Plant height (cm)		Plant spread (cm)			
				E-W		N-S	
		Range	Mean	Range	Mean	Range	Mean
NRCP-1	6	121-192	160.0	139-162	150.2	126-172	145.3
NRCP-2	6	88-132	115.2	73-128	112.5	76-132	110.0
NRCP-3	6	140-202	168.8	111-160	137.0	108-178	133.5
NRCP-4	6	105-152	129.3	95-170	130.3	93-152	114.8
NRCP-5	6	107-185	150.7	100-151	128.0	95-144	124.5
NRCP-6	6	110-186	131.0	96-154	113.0	89-139	106.7
NRCP-7	6	147-180	164.7	110-133	120.8	114-156	135.5
NRCP-8	6	150-198	175.3	130-150	140.7	134-156	145.0
NRCP-9	6	135-188	161.0	115-167	146.2	117-164	141.8
NRCP-10	3	76-154	122.0	134-154	147.0	122-152	138.3
NRCP-11	3	135-155	146.7	95-103	99.3	79-102	89.3
NRCP-12	6	125-168	146.7	138-170	152.3	145-178	156.0
NRCP-13	6	123-157	139.5	121-178	150.5	125-178	152.3
Mean				146.99	132.91		130.23
SD				18.78	17.22		19.88
CV %				12.77	12.95		15.27

Table: 1b. Stem girth and fruiting in seedling population of pomegranate

Accession No.	No. of plants	Girth (cm)		No. of fruits/Plant	
		Range	Mean	Range	Mean
NRCP-1	6	13.5-17.1	15.6	2-75	41.83
NRCP-2	6	10.2-14.5	12.3	28-51	42.0
NRCP-3	6	13.1-15.1	14.1	36-103	62.16
NRCP-4	6	13.0-18.2	14.8	7-63	24.16
NRCP-5	6	11.2-17.0	14.8	5-54	33.16
NRCP-6	6	12.7-18.5	14.4	41-130	65.33
NRCP-7	6	14.8-17.0	15.7	33-57	43.33
NRCP-8	6	13.0-17.7	16.1	28-47	36.66
NRCP-9	6	12.0-17.0	14.7	29-71	41.16
NRCP-10	3	13.2-14.9	14.1	51-93	68.66
NRCP-11	3	10.0-13.5	12.3	49-57	52.33
NRCP-12	6	13.0-15.4	14.7	52-81	65.33
NRCP-13	6	12.6-17.0	14.9	13-53	30.5
Mean			14.50		46.66
SD			1.14		14.69
CV %			7.87		31.48

Table 2: Performance of gamma irradiated population of Bhagawa and Ganesh

Irradiation Dose	Bhagawa		Ganesh	
	Flowering (%)	Fruiting (%)	Flowering (%)	Fruiting (%)
0 kR	59.3	27.6	50.0	24.6
3 kR	50.0	25.4	37.6	14.4
6 kR	61.8	33.00	30.20	12.70
9 kR	68.2	35.6	41.50	21.30
12 kR	56.6	32.5	23.0	12.8
15 kR	63.6	30.3	24.1	06.8
18 kR	52.9	12.5	25.0	08.3
21 kR	52.0	14.4	34.1	17.0
24 kR	52.4	6.0	50.0	22.7
27 kR	59.0	9.0	00.0	00.0
30 kR	84.0	22.6	50.0	25.0

Table 3a: Photosynthetic rate and Stomatal conductance of different mutants of pomegranate cv Ganesh

Mutants	Photosynthetic rate (µ mol m^{-2} s^{-1})			Stomatal conductance (µ mol H_2o m^{-2} s^{-1})		
	D_1	D_2	D_3	D_1	D_2	D_3
M-8	5.69	11.17	4.63	0.024	0.056	0.014
M-38	7.65	9.05	4.78	0.036	0.054	0.015
M-40	4.85	8.92	3.84	0.025	0.033	0.008
M-53	7.29	10.57	4.51	0.026	0.030	0.018
M-63	6.94	10.53	5.54	0.046	0.042	0.025
M-82	7.88	10.49	5.98	0.048	0.038	0.023
M-91	5.71	10.66	4.59	0.032	0.049	0.010
M-94	8.31	9.90	2.24	0.035	0.028	0.006
M-103	9.92	9.47	4.22	0.051	0.027	0.007
M-165	7.90	8.91	4.44	0.041	0.022	0.010
M-176	8.62	9.32	4.52	0.032	0.023	0.012
M-179	6.33	10.79	5.89	0.043	0.047	0.023
M-261	7.17	10.12	3.27	0.050	0.036	0.006
M-300	8.30	13.08	5.33	0.058	0.064	0.019
M-314	7.65	10.19	4.81	0.055	0.033	0.014
M-424	9.06	8.25	6.58	0.036	0.016	0.027
M-470	6.87	10.60	5.82	0.040	0.047	0.019
M-514	5.28	7.02	3.09	0.023	0.010	0.011
Range	4.85-9.92	7.02-13.08	2.24-6.58	0.023-0.058	0.01-0.064	0.06-0.027
Mean	7.30	9.95	4.67	0.039	0.036	0.0148
SD	1.35	1.31	1.11	0.011	0.015	0.007
CV (%)	18.49	13.16	23.76	28.205	41.66	47.29

D_1- February; D_2- March; D_3-April

Physiological response of different selected mutants

The physiological parameters of eighteen mutants based on leaf characters were recorded with LICOR photosynthesis system in February, March and April to test their physiological behavior (Table 3a and 3b). Photosynthetic and transpiration rate and WUE were higher in March indicating better physiological activity during this period and subsequently with increase in temperature during April, these parameters showed declining trend. The genotype M-300 showed maximum photosynthetic rate (13.08 μ mol m^{-2} s^{-1}), stomatal conductance (0.64 μ mol H_2o m^{-2} s^{-1}) and transpiration rate (4.17 μ mol H_2o m^{-2} s^{-1}) during March. Positive correlation between photosynthetic rate and stomatal conductance and photosynthetic rate and transpiration rate was recorded in February, March and April.

Table 3b: Transpiration rate and Water use efficiency of different selected mutants of pomegranate cv Ganesh

Mutants	Transpiration rate (μ mol H_2o m^{-2} s^{-1})			Water use efficiency		
	D_1	D_2	D_3	D_1	D_2	D_3
M-8	1.19	3.07	1.23	0.477	0.365	0.377
M-38	1.75	3.00	1.22	0.442	0.302	0.400
M-40	1.27	2.07	0.76	0.388	0.432	0.537
M-53	1.38	1.95	1.60	0.539	0.548	0.295
M-63	2.21	2.65	1.97	0.315	0.402	0.301
M-82	2.36	2.46	2.00	0.336	0.437	0.334
M-91	1.69	3.23	0.92	0.357	0.333	0.534
M-94	1.80	1.99	0.58	0.471	0.498	0.391
M-103	2.54	1.89	0.72	0.397	0.513	0.661
M-165	2.09	1.65	1.01	0.397	0.542	0.447
M-176	1.80	1.79	1.18	0.560	0.529	0.389
M-179	2.34	3.41	2.15	0.285	0.322	0.283
M-261	2.77	2.76	0.59	0.262	0.369	0.373
M-300	3.14	4.17	1.88	0.266	0.381	0.296
M-314	2.90	2.48	1.38	0.273	0.482	0.406
M-424	2.08	1.33	2.47	0.441	0.739	0.278
M-470	2.39	3.51	1.82	0.290	0.303	0.328
M-514	1.45	0.90	1.22	0.370	0.877	0.265
Range	1.19-3.14	0.90-4.17	0.58-2.47	0.262-0.560	0.302-0.877	0.265-4.424
Mean	2.06	2.46	1.37	0.381	0.465	0.383
SD	0.56	0.84	0.57	0.092	0.151	0.106
CV (%)	27.18	34.14	41.60	23.68	32.60	28.94

D_1- February; D_2- March; D_3-April

Evaluation of germplasm

Observations on growth parameters of sixty one varieties/ecotypes/landraces planted in 2007 were recorded after two year of planting. The maximum variability was recorded with respect to leaf area (25.83%) followed by plant spread (E-W and N-S) and Thorn length (Table 4). Bedana Sedana, Spendanader and IC-1203 recorded plant height more than 275 cm. Among different germplasm, Nana was dwarf which attained plant height of 63.67 cm. Flowering was recorded in more than 85% germplasm.

Table 4: Variability in pomegranate germplasm

Parameters	Range	Mean	SD	CV (%)
Plant height (cm)	63.67-292.33	238.21	33.41	14.02
Plant spread E-W (cm)	75.0-269.67	213.65	38.61	18.07
Plant spread N-S (cm)	67.0-268.67	211.55	41.95	19.82
Stem diameter (cm)	2.80-8.38	6.36	0.95	14.93
Stem girth (cm)	14.87-27.23	20.09	2.61	12.97
Thorn length (cm)	1.92-7.66	6.17	1.05	17.06
Leaf area (cm^2)	1.39-10.01	6.43	1.66	25.83

Collection of variability from Bhagawa population

More than 25 variants were collected from 'Bhagawa' population during survey to Maharashtra, Karnataka and Andhra Pradesh. These seedling and grafted plants were multiplied and planted in field for evaluation. Variation was mainly noted in skin and aril colour (Fig. 2). Some of the variants were medium maturing types.

Varietal Evaluation

Four improved cultivars viz. 'Bhagawa', 'Mridula', 'Phule Arkta' and 'Ganesh' were evaluated for growth performance after one year of planting in field. Except plant height, Plant spread in E-W and N-S directions and stem girth were non significant. 'Bhagawa' recorded short stature as compared to other varieties tested (Table 5).

Table 5: Growth performance of improved cultivars of pomegranate

Variety	Plant height (cm)	Plant spread (cm)		Stem girth (cm)
		E-W	N-S	
Bhagawa	155.3	114.80	112.40	10.73
Mridula	168.50	128.90	126.20	10.35
Phule Arakta	172.00	123.00	123.70	10.89
Ganesh	168.60	117.70	122.50	10.97
CD (0.05)	12.66	NS	NS	NS

Fig. 2 Variability in 'Bhagawa' population

1.1.2: Crop Production

Survey of pomegranate orchards

During survey of pomegranate orchards in Maharashtra (**Baramati, Indapur, Narayangaon, Sangamner, Ner, Satara, Solapur, Madha, Alandi, Theur, Ganeshkhind)** seventeen variants from cv Bhagawa were collected. In some parts of Mohol district of Maharashtra pomegranate + tomato cropping system was observed (Fig.3). Pruning of newly emerged shoots 40-50 days prior to harvesting helped in better colour development of fruits and also increased fruit size (Fig. 4).Moderate temperatures in rainy season favoured colour development in pomegranate (Fig.5). Large scale cultivation was quite common in Maharashtra and growers maintained the orchard on scientific line (Fig. 6). Even, waste and degraded rocky lands were utilized for pomegranate cultivation (Fig. 10). Generally, 2-3 stem system of training was common among them but some growers (5%) even maintained single stem training system (Fig. 7). Interestingly, tying of branches with coir string was noted in some orchards (Fig. 9). In some parts of Maharashtra and Andhra Pradesh, severe infection of bacterial blight was recorded and growers headed back infected branches (Fig. 8) to minimize inoculum load. Airlayering was the main method of propagation in Maharashtra (Fig. 11)

Fig. 3 Pomegranate + Tomato

Fig. 4 Young emerging shoots pruned 40 50 days before fruit harvesting

Fig.5 Good colour development in cv 'Ganesh' (a) and 'Bhagawa'(b) during rainy season

Fig. 6 Field view of a model pomegranate orchard

Fig. 7 Profuse bearing in single stem trained pomegranate tree

Fig. 8 Heavy pruning in bacterial blight affected orchard

Fig. 9 Tying of fruiting branches - a farmer's practice in Dhule district of Maharashtra

Fig. 10 Highly productive orchard on degraded land in Maharashtra

Fig. 11 Multiplication of pomegranate planting material through air layering

Water quality analysis of the surveyed orchards

Surveys of pomegranate orchards were conducted in different areas of Maharashtra and Karnataka states. Water samples were collected from some places and analysed for water quality (Table 7). The results revealed that, most of the samples from Solapur areas were within safer range for irrigation to pomegranate orchards. Water quality from Sangola area which is comparatively dry area had hard water with higher EC, Chlorides and Sodium content. One sample collected from Kanamadi, Vijapur district of Karnataka was totally unsafe for irrigation.

Influence of potting mixtures on macro and micro nutrient contents of leaf, stem and root of pomegranate cv Ganesh

In general, the pomegranate seedlings raised in potting mixtures, containing soil and organic manures, had higher contents of nitrogen, phosphorus and potassium in leaf, stem and roots (Table 6a). Interestingly, nitrogen content was higher in leaf and stem while phosphorus and potassium contents were more in leaf and root irrespective of treatments. Soil + FYM mixture improved nitrogen content in leaf, phosphorus in stem and roots and potassium in leaf, stem and roots. Calcium and Iron contents were more in leaf and root, but magnesium content was higher in leaf irrespective of treatments (Table 6b and 6c). Manganese and Copper was maximum in root (Table 6c), while leaf and stem contained higher concentration of zinc (Table 6d). In general, potting mixture containing organic manures did not increase the calcium, magnesium, iron, manganese, copper and zinc contents in leaf, stem and root.

Table 7 : Irrigation water quality of surveyed orchards

Farmer name and area	pH	EC dS/m	Ca+Mg (meq/100 g)	Carbo Nates (meq/100g)	Bicar Bonates (meq/100 g)	Chlorides (meq/100 g)	Sodium (meq/100g)	SAR
S. Solapur								
NRCP field, Kegaon	7.73	0.29	5.50	Tra	5.8	2.0	1.9	1.15
NRCP field, Kegaon	7.74	**0.93**	5.80	0.70	4.4	10.4	2.5	1.47
NRCP field, Hiraj (well)	7.34	0.34	3.90	Tra	7.2	5.2	1.8	1.28
NRCP field, Hiraj (pond)	8.05	0.24	3.20	0.45	6.8	2.0	3.2	2.53
Dongare, Hiraj	7.96	0.32	4.7	0.45	4.2	2.2	3.1	1.57
Mrs. Rukmini Patil, Wadgi	7.39	0.53	8.0	0.60	**8.3**	4.0	3.0	1.5
Shinde, Dahitane	8.36	0.22	3.4	Tra	4.5	2.2	2.8	2.15
Kumbhar, Dahitane	8.37	0.27	2.4	Tra	4.7	2.4	2.8	2.56
P. Shejale, Kandalgaon	8.66	0.36	3.8	Tra	**9.3**	2.8	4.6	3.35
R. Sayyad,Kandalgaon	8.18	0.31	3.3	Tra	6.4	3.2	3.5	2.73
S. Kole, Kandalgaon	8.82	0.64	9.9	Tra	5.0	**17.0**	3.0	1.35
S. Patil, Nimbargi	8.12	0.23	2.60	Tra	**8.40**	2.40	2.60	2.96
A. Bansode, Mohol	8.08	0.21	0.80	Tra	3.20	3.20	4.50	7.14
J.Deshmuke,Pandharpur	7.33	0.12	4.40	Tra	2.20	1.80	2.30	1.55
A. Gaikwad, Phule Chincholi, Pandharpur	7.54	0.33	5.20	Tra	5.10	3.40	2.50	1.73
Jadhav, Tuljapur	7.73	0.43	7.30	Tra	4.60	4.40	2.70	1.41
Hiremath, Akkalkot	8.22	0.31	2.20	Tra	5.90	2.00	4.70	4.51
Mangalwedha								
KT Padole, Junoni	7.65	0.40	4.80	0.40	4.70	2.80	3.80	2.46
C. Chavan,Mandrup	8.18	0.17	2.20	Tra	**8.40**	2.00	2.70	2.70
Sangole								
N. Sutar, Bamani	7.81	**1.25**	17.60	0.45	7.00	12.80	8.70	2.93
H. Lade	7.75	**0.89**	12.60	Tra	4.40	7.20	11.10	4.44
Kanamadi, Vijapur, Karnataka	8.31	0.83	11.20	2.00	3.40	**21.00**	**66.00**	**27.96**

EC: <0.25-Excellant, 0.25-0.75 Good, 0.76-2.0-Doubtful; Bicarbonates <1.5 permissible, 1.5-7.5 mod. Safe, >7.5 unsafe; SAR 18-25- mod. Unsafe)

Table 6a: Effect of different potting mixtures on N, P & K content in leaf, stem and root of pomegranate

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	L	S	R	L	S	R	L	S	R
Soil	1.15	0.58	0.48	0.132	0.074	0.101	1.25	0.71	1.19
Sand	0.76	0.54	0.48	0.099	0.089	0.074	0.87	0.082	1.25
Soil + Sand (1:1)	1.08	0.62	0.42	0.110	0.094	0.116	1.20	0.84	1.39
Soil + VC* (1:0.5)	1.24	0.59	0.59	0.115	0.117	0.117	1.26	1.01	1.47
Soil +FYM (1:1)	1.48	0.58	0.58	0.158	0.118	0.145	1.67	1.07	1.76
Soil + Sand +FYM (1:1:1)	1.13	0.64	0.51	0.161	0.101	0.138	1.57	0.95	1.72
Soil +Sand +VC (1:1:0.5)	1.25	0.76	0.61	0.124	0.094	0.117	1.20	0.93	1.58
Mean	1.16	0.62	0.52	0.13	0.10	0.12	1.29	0.80	1.48

L: Leaf, S: Stem, R: Root, VC* : vermicompost

Table 6b: Effect of different potting mixtures on Ca & Mg content in leaf, stem and root of pomegranate

Treatment	Calcium (%)			Magnesium (%)		
	L	S	R	L	S	R
Soil	1.71	1.67	1.60	0.59	0.51	0.53
Sand	1.74	1.50	1.80	0.50	0.46	0.63
Soil + Sand (1:1)	1.66	1.43	1.74	0.55	0.55	0.47
Soil + VC (1:0.5)	1.72	1.58	1.76	0.56	0.53	0.55
Soil +FYM (1:1)	1.87	1.59	1.70	0.63	0.54	0.55
Soil + Sand +FYM (1:1:1)	1.65	1.62	1.55	0.56	0.49	0.50
Soil +Sand +VC (1:1:0.5)	1.72	1.76	1.86	0.55	0.57	0.43
Mean	1.72	1.59	1.72	0.56	0.52	0.52

Stool layering

Stool layering trial in pomegranate cv Bhagawa was initiated taking six spacing treatments(0.5x0.5,0.m,0.75x0.50m,0.75x0.75m,1.0x0.50m,1.0x0.75m,1.0x1.0m). Shoot production/ plot was higher with 0.5x0.5m spacing followed by 0.75x0.50m spacing and these treatments were at par to each other (Table 7). However, shoot production/plant was significantly lower in T_1 and T_5 as compared to other treatments.

Table 6c: Effect of different potting mixtures on Fe & Mn content in leaf, stem and root of pomegranate

Treatment	Iron (ppm)			Manganese (ppm)		
	L	S	R	L	S	R
Soil	228.9	174.4	208.2	43.8	47.4	50.6
Sand	180.9	179.4	181.0	51.3	48.2	54.6
Soil + Sand (1:1)	221.2	178.8	162.6	49.4	47.0	53.3
Soil + VC (1:0.5)	208.8	173.3	215.7	48.8	46.6	58.1
Soil +FYM (1:1)	229.9	162.0	258.6	47.3	46.8	60.2
Soil + Sand +FYM (1:1:1)	199.3	195.0	201.3	48.2	48.7	55.9
Soil +Sand +VC (1:1:0.5)	194.1	171.5	211.6	47.9	46.5	55.9
Mean	209.01	176.34	205.57	48.10	47.31	55.51

Table 6d: Effect of different potting mixtures on Cu & Zn content in leaf, stem and root of pomegranate

Treatment	Copper (ppm)			Zinc (ppm)		
	L	S	R	L	S	R
Soil	12.7	12.6	20.3	36.7	41.4	29.8
Sand	11.2	10.1	13.0	35.7	37.8	24.2
Soil + Sand (1:1)	11.0	12.3	16.6	36.3	41.4	27.5
Soil + VC (1:0.5)	9.4	13.1	17.5	36.0	42.8	29.8
Soil +FYM (1:1)	12.5	12.6	20.3	43.0	45.0	35.0
Soil + Sand +FYM (1:1:1)	9.7	12.6	16.2	38.0	42.2	30.4
Soil +Sand +VC (1:1:0.5)	9.6	12.9	18.1	35.4	44.9	30.8
Mean	10.87	12.31	17.43	37.30	42.21	29.64

Table 7: Effect of spacing on shoot production in stool layering of pomegranate cv. Bhagawa

Treatment	Shoot production/plot (3X2m)	Shoot production/plant	Shoot production/m^2
T_1(0.50X0.50m)	303.25	12.88	50.54
T_2 (0.75X0.50m)	234.75	15.16	39.13
T_3 (0.75X0.75m)	128.50	16.06	21.42
T_4 (1.0X0.50m)	172.25	14.70	28.71
T_5 (1.0X0.75m)	94.50	12.27	15.75
T_6 (1.0X1.0m)	91.00	15.16	15.17
CD (0.05)	34.66	2.97	-

Evaluation of training system

An attempt was made to evaluate three training systems viz. single, double and triple stem. Plant height and spread (E-W and N-S) were recorded after one year of planting and these parameters were significantly influenced by training systems. Plant height was more in double and triple training system. But plant spread was better in triple stem (Table 8).

Table 8: Growth performance of pomegranate under different training system

Treatment	Plant height (cm)	Plant spread (cm)		
		E-W	N-S	Av.
Single stem	131.8	106.0	106.3	106.1
Double stem	140.6	125.1	122.4	123.8
Triple stem	144.7	134.9	133.7	134.3
CD (0.05)	7.84	8.59	10.34	7.83

Growth performance of grafted genotypes

The growth performance of 'Ganesh', 'Yercaud-1', 'Kandhari', 17/2 and 'Bhagawa' after one year of grafting on 'Phule Arakta' root stock, was tested. Among these genotypes, 'Yercaud-1' was vigorous in growth performance (Table 9).Stem girth at graft union was lowest in cv. 'Bhagawa'. Plant spread was uniform in all the genotypes.

Table 9: Growth performance of different genotypes of pomegranate grafted on Phule Arakta rootstock

Treatment	Plant height (cm)	Plant spread (cm)			Girth at graft union (cm)
		E-W	N-S	Av.	
Ganesh	156.0	163.0	159.3	161.1	12.5
Yercarud-1	212.5	164.3	168.5	166.4	13.1
Kandhari	163.8	148.0	150.5	149.3	13.6
17/2	152.8	159.3	143.0	151.1	14.0
Bhagawa	162.52	159.0	140.3	149.6	9.9
CD (0.05)	32.58	NS	NS	NS	1.64

Graft success as influenced by rootstocks

The scions of Bhagawa and Ganesh were grafted on 'Bhagawa', 'Mridula', 'Phule Arakta' and 'Ganesh' rootstocks. Sprouting took 10 - 20 days in different treatments. Maximum graft success of 84%, at 30 days after grafting, was recorded with 'Mridula' (root stock) and 'Ganesh' (scion) graft combination (Table 10).

Table 10: Effect of different rootstocks of pomegranate on graft success of Bhagawa and Ganesh

Root stocks	Scion	Days taken to sprouting	Graft Success at 30 days (%)
Bhagawa	Bhagawa	10	64
Mridula	Bhagawa	10	72
Arakta	Bhagawa	10	72
Ganesh	Bhagawa	10	80
Ganesh	Ganesh	11	72
Arakta	Ganesh	14	64
Bhagawa	Ganesh	20	48
Mridula	Ganesh	17	84
Mean	-	12.75	69.5

Influence of grafting method and time

Wedge and tongue grafting methods and time were evaluated. One year old seedlings of cv. 'Phule Arakta' were used as rootstock for the present study. In general, scion sprouting started between 9 and 12 days after grafting (DAG). Significantly highest scion sprouting was recorded with wedge grafting done in the last week of January at 15 (90.00%) and 21 (96.67%) DAG. Consequently, maximum graft success (85.00%) was recorded at 90 DAG with wedge grafting done on January 30. The plant height and scion length after 6 months of grafting was higher when wedge grafting was done between December 30 and January 30. The grafted plants during this period had perfect union as indicated by normal diameter recorded at graft union. This reflected high scion and rootstock compatibility. However, performance of wedge grafted plants has to be evaluated under field condition (Table 11).

Table 11: Effect of grafting method and time on growth performance of grafted plants cv Bhagawa

Treatments	Days taken to sprouting	Graft success at 90 DAG	Plant height (cm)	Scion growth (cm)	Scion diameter at union (cm) at 180 DAG		
		(%)	180 DAG	180 DAG	Lower	Middle	Upper
Wedge grafting on December 15	12	63.33	69.40	52.53	0.88	1.23	0.81
Wedge grafting on December 30	12	26.67	82.47	58.53	0.88	1.26	0.88
Wedge grafting on January 15	12	35.00	76.07	55.87	0.91	1.23	0.79
Wedge grafting on January 30	11	85.00	72.27	49.33	0.84	0.96	0.66
Wedge grafting on February 15	10	56.67	56.33	50.13	0.80	0.90	0.70
Tongue grafting on December 15	11	30.00	72.73	53.33	0.88	1.12	0.79
Tongue grafting on December 30	9	18.33	72.29	55.28	0.84	1.13	0.79
Tongue grafting on January 15	9	18.33	53.43	42.63	0.80	1.15	0.75
Tongue grafting on January 30	12	60.00	58.33	47.27	0.81	1.03	0.63
Tongue grafting on February 15	9	36.67	54.27	49.40	0.74	0.83	0.78
Mean	-	43.00	66.75	51.43	0.83	1.08	0.76
CD (0.05)		14.38	12.36	8.82	0.08	0.17	0.09

Project 1.2: Improvement of Pomegranate

1.2.1: Flower Biology of Pomegranate

Flowering and kinds of flowers

Pomegranate (*Punica granatum* L.) flowers throughout the year (Fig.1) under the conditions of Solapur and Maharashtra. However, to obtain maximum productivity, its flowering is regulated into three main seasons viz., *ambe bahar* (January- February), *mrig bahar* (June- July flowering) and *hasth bahar* (September- October flowering).

There were 3 kinds of flowers viz., staminate (male) (Fig.2), hermaphrodite (bisexual) (Fig.3) and intermediate. They were distinguished by their distinct shapes, viz., vase shape for hermaphrodite, bell shape for staminate and tubular for the intermediate ones. Again they differed in their size as: larger the hermaphrodite, smaller the staminate and moderate the intermediate flowers. The base of the ovary was broad in hermaphrodite, narrow in staminate and moderately broad in intermediate flower.

Fig.1: A branch with blossoms

Fig.2: Staminate flower

Fig.3:Hermaphrodite flower

Fig 4a:Flower initiation at collar region

Fig 4b:Flowers arising from collar region

Bhagwa cultivar of pomegranate tree produced one or two flowers in the collar region where the shoot and root unites (Fig 4a,4b)

As the flower bud developed from pin-head size to ready-to-crack condition, (Table 1), the weight of flower buds (g) increased gradually from stage 1 to stage 12.

Table 1. Flower bud weight (g) during its development

Stage of flower bud	Weight of flower bud (g)		Stage of flower bud	Weight of flower bud (g)	
	Bhagwa	Ganesh		Bhagwa	Ganesh
1	0.011	0.011	7	1.031	0.694
2	0.028	0.027	8	1.267	1.201
3	0.060	0.054	9	1.526	1.739
4	0.164	0.124	10	2.562	2.398
5	0.282	0.243	11	3.364	3.658
6	0.685	0.414	12	3.680	4.178

Fig 5:Flower bud development in Bhagwa

Fig.6:Flower bud development in Ganesh

The time taken for flower bud development was found to be maximum (20.40 days) in Ganesh (Fig.5) compared to Bhagwa (19.29 days) (Fig.6) during the month of June.

Anthesis

The appearance of cracks at the apex of the bud (where the calyx lobes unite together) was the first sign of unfolding of the floral bud. Then, the sepals gradually separated, exposing the crumpled scarlet petals which started bulging out. The sepals grew continuously by the pressure of the bulging petals inside, from the incurved form to straight, and fromed straight to slightly out-curved. After the full bloom, the corolla took about 3 to 4 hours to open and stretched completely from the inflated and crumpled stage.

In Ganesh, the anthesis commenced at 7 a.m. whereas in Bhagwa, it was at 9.00 a.m. and ceased at 6 pm (Table 2). It was observed that that maximum opening of flowers occurred between 10 a.m. - 12 noon during the month of June, thereby, indicating that the peak period of anthesis for pomegranate varieties Ganesh and Bhagwa was between 10 am and 12 noon.

Table 2. Anthesis of flowers of pomegranate

Anthesis (%)	Percentage of flowers opened							Total no. of flowers opened
	4-6am	6-8am	8-10am	10am-12noon	12 noon-2 pm	2-4pm	4-6pm	
Bhagwa	0.0	3.4	18.0	34.2	17.4	16.0	11.0	42.0
Ganesh	0.0	0.0	16.1	32.0	21.8	18.2	11.9	45

Flower biometry

The individual flower weight ranged from 1.71 to 4.82g. Hermaphrodite was found to be the heaviest (4.82g), staminate (1.71g) being the lightest and the intermediate weighing in between (2.62g) the hermaphrodite and staminate. The no. of flowers borne in a cluster arising from the leaf axil ranged usually from 1-7, however, it varied with varieties. The total no. of flowers per plant from 2 year old orchard was 124 and 133 in cvs Ganesh and Bhagwa, respectively.

Pollen viability

Pollen viability is a vital phenomenon deciding the fruit set. Pomegranate produced profuse pollen grains in their flowers. With acetocarmine 1.0%, the viable pollen grains adhered to stain and got deeply stained whereas the non-viable pollen grains remained unstained. Pollen viability was slightly more in Ganesh (93.2%) (Fig.8) compared to Bhagwa (91.0%) (Fig.7a,7b)).

Table 3. Pollen viability of pomegranate cultivars with acetocarmine 1% stain

Variety	Pollen viability (%)	
	Range	Mean
Bhagwa	85.0-94.0	91.0
Ganesh	84.0-95.0	93.2

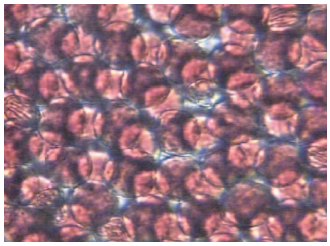


Fig.7a:Pollen grains of Bhagwa 400x

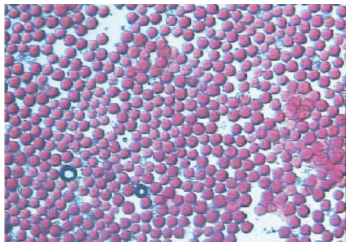


Fig.7b:Pollen grains of Ganesh 100x

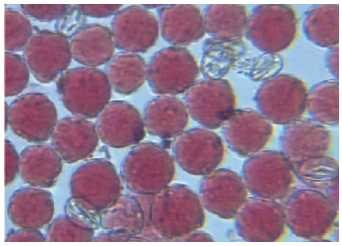


Fig.8:Pollen grains of Ganesh 400x

Heterostyly

Heterostyly refers to the presence of different kinds of flowers with respect to pistil length. The pistil in staminate flower was rudimentary. The flowers were categorized into pin type (the length of pistil is greater than or equal to or that of stamens eg. hermaphrodite, intermediate flower) and thrum type (the length of pistil is less than that of stamens eg. staminate flower). In Ganesh, the length of pistil was higher compared to Bhagwa (Table 4).

Table 4. Pistil length of pomegranate flowers in different cultivars.

Flower	Pistil length (cm)	
	Bhagwa	Ganesh
Hermaphrodite	1.96	2.00
Intermediate	1.45	1.55
Staminate	0.25	0.65

Selfing

Selfing was done by covering the fully developed, ready-to crack flower buds expected to open in the next day with butter paper cover one day prior to opening (Table 5). The fruit set was found to be slightly higher in Ganesh (16.6%) (Fig.10) compared to Bhagwa (16.0%) (Fig.9).

Table. 5. Extent of fruit set and fruit retention due to selfing

Selfing	Total no. of flowers	Flower drop (%)	Fruit set (%)
Bhagwa	75	84.0	16.0
Ganesh	114	83.3	16.6

Fig.9: Selfing in Bhagwa

Fig.10: Selfing in Ganesh

Crossing

Crossing was done by dusting the stigma of seed parent with the pollen grains garnered from the donor parent (Table 6). The fruit set was more in Ganesh (47.77%) (Fig.12) compared to Bhagwa (35.00%) (Fig.11).

Table. 6. Extent of fruit set and fruit retention due to crossing.

Cross	No. of flowers crossed	Flower drop (%)	Fruit set (%)
Bhagwa X Ganesh	135	65.00	35.00
Ganesh X Bhagwa	90	52.23	47.77

Fig.11: Crossing in Bhagwa

Fig.12: Crossing in Ganesh

1.2.2: HYBRIDIZATION IN POMEGRANTE

Two crosses viz.,* B x ([Gxn]xD) and G x ([Gxn]xD) were initiated in the farmers' field and the fruit set was found to be 31.25% and 28.57% respectively. The seeds of the hybrid B x ([Gxn]xD) were analyzed in the laboratory and sown in pots to work out the germination (%) and survival of hybrid seedlings and the results are as follows (Table 7).

(*: B- Bhagwa, G- Ganesh, n- *P. granatum var. nana*, D- Daru)

Table 7; Germination and survivability in hybrid B x ([Gxn]xD).

Parameters	Range	Mean
100 Seed Weight	(1.16-1.43g)	1.34 g
Seed length	(0.55-0.75cm)	0.67 cm
Seed width	(0.25-0.35cm)	0.29 cm
Time taken for germination	(7-23 days)	23 days
Germination	-	38.0 % (57/150)
Survival of Hybrids	-	78.94% (45/57)

III. SCREENING AGAINST BACTERIAL BLIGHT:

The hybrids developed at IIHR, Bangalore and raised in polybags were collected, transplanted in pots and screened against resistance for bacterial blight. In all 6 hybrids were found showing resistance to blight out of 100 tested hybrids after two months of inoculation (Table 8).

Table 8; Screening of hybrids against bacterial blight.

Name of Hybrid	No. of IIHR hybrids eveloped	No. of IIHR hybrids screened	No. of resistant plants (upto 2 MAI)
[(GxD)xG]xR	80	25	0
KxR	100	25	4
NxR	100	25	1
[(Gxn)x(GxD)]xR	70	25	1
Total	350	100	6

*: B- Bhagwa, G- Ganesh, n- P. granatum var. nana, D- Daru, R- Ruby, K- Kalpitiya, N-Nayana

1.2.3: EVALUATION

Nutritional analysis of pomegranate varieties : *Ambe & mrig bahar* fruits of Ganesh & Bhagwa varieties were analyzed for the nutritional composition at National Institute of Nutrition (NIN), ICMR, Hyderabad and results are presented in Table 9.

Table 9: Fruit quality of varities Bhagawa and Ganesh from *Ambe and Mrig bahar*

Sr No	Parameters	Ambe bahar		Mrig bahar	
		Bhagawa	Ganesh	Bhagawa	Ganesh
1	Moisture (%)	80.44	81.01	80.78	80.65
2	Total Ash (%)	0.78	0.73	0.50	0.44
3	Protein (%)	1.57	1.17	1.48	1.44
4	Fat (%)	1.14	1.22	0.72	1.09
5	Crude fiber (%)	-	-	1.10	1.29
6	Carbohydrates (%)	14.95	14.91	15.42	15.09
7	Calorific Value (K cals/100g)	76	75	74.00	76.00
8	**Minerals (mg/100g)**				
i)	Iron	0.41	0.40	0.48	0.46
ii)	Zinc	0.36	0.22	0.23	0.25
iii)	Calcium	7.16	5.30	6.12	6.96
iv)	Magnesium	17.89	14.96	12.57	11.75
v)	Copper	0.32	0.15	0.18	0.19
vi)	Manganese	0.17	0.13	0.15	0.13
vii)	Phosphorus	31.51	28.47	31.33	29.08
9	**Vitamins (mg/100g)**				
i)	Thiamine	0.085	0.06	0.08	0.07
ii)	Niacin	0.71	0.34	0.17	0.13
iii)	Ascorbic acid	12.93	12.12	13.23	7.44
10	Total Carotenoids (µg/100g)	-	-	13.00	14.00

Project 1.3: Exploitation of Bioagents in Pomegranate Production.

1.3.1:. Effect of Pink Pigmented Facultative Methylotroph (PPFM) on Growth and Nutrient Status of Pomegranate

Pink Pigmented Facultative Methylotroph (PPFM) isolated from pomegranate, when applied to potted air layers as soil application, significantly improved plant growth (33.16% increase) in 6 month old plants of variety Bhagwa as well as total plant dry matter by 45.7% (Plate 1). Major nutrient uptake of N increased by 34.18%, P by 44.22% and K by 37.34% where as secondary nutrient Ca increased by 45.56% and Mg by 48.95% (Fig.1). Increase in micronutrients Fe by 51.47%, Cu by 50%, Mo by 45% and Zn by 36.36% was also recorded (Fig 2). Soil fertility improved significantly as available K increased by 7.1%, Zn by 8.0% and Mn. by 34.4% (Table1).

Plate 1: Effect of PPFM on growth in Pomegranate

Table 1. Effect of PPFM on Soil Fertility

Soil Fertility	Control	PPFM	Per cent Increase or decrease
Organic carbon (%)	0.63	0.65	+3.1
Major Nutrients			
Available N (kg/ha)	183.5	173.7	-5.3
Available P (kg/ha)	29.5	25.0	-15.2
Available K (kg/ha)	709.8	760.5	+7.1
Micronutrients			
Available Fe (ppm)	5.26	5.51	+4.7
Available Cu (ppm)	0.93	0.98	+5.3
Available Mn (ppm)	4.36	5.86	+34.4
Available Zn (ppm)	0.62	0.67	+8.0

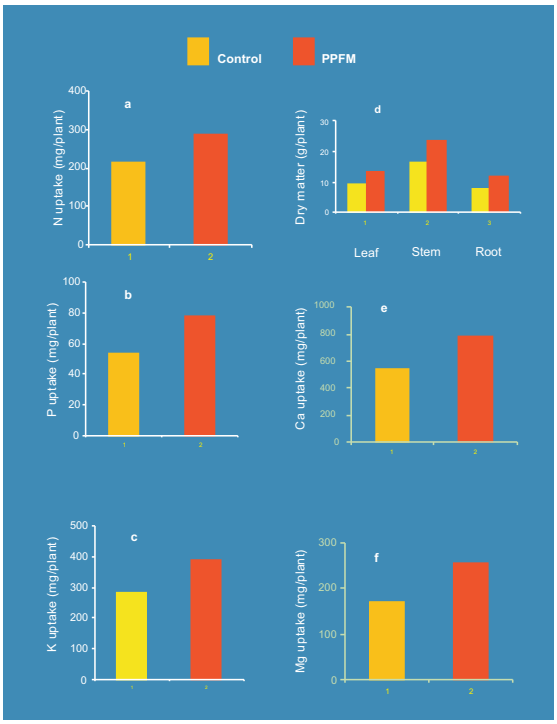


Fig. 1. Effect of PPFM on (a-c) Major Nutrient Uptake, (e-f) secondary nutrient uptake and plant dry matter in Pomegranate

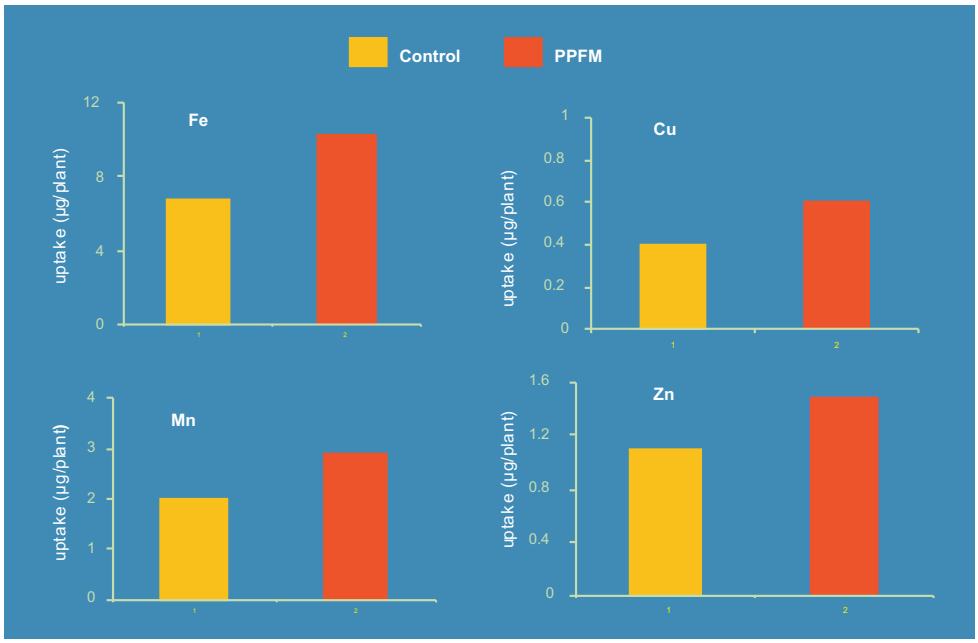


Fig. 2. Effect of PPFM on Micronutrients Uptake by Pomegranate

Effect of Bio-agents on Growth and Physiological Parameters of Pomegranate

Among 7 bioagents applied as soil application to air layers of variety Bhagwa in pot culture *Trichderma viride* significantly improved root length, total biomass, photosynthetic rate and water use efficiency over untreated control, recorded in 6 month old plants. Plant height was improved by

all bioagents except *T. viride,* while all the bioagents failed to improve plant spread, number of branches/plant significantly increased in treatments with *Acetobacter* and *Azospirillum* alone or in combination with *Pseudomonas striata* and with PPFM cotton isolate. All except *Acetobacter* and both PPFM isolates improved number of roots/plant significantly. Total biomass increased in all except *Acetoacter, P. striata* and both PPFM isolates (Table 2, Plate 2).

Table 2: Effect of bio-agents on growth parameters in pomegranate cv Bhagwa

Treatments	Plant height (cm)	Plant Spread (cm)	No. of Branches/ Plant	No. of roots/ plant	Total biomass (g/plant)
Acetobacter	85.85*	49.69	17.17*	9.83	39.11
Pseudomonas striata	91.00*	49.92	13.17	11.17*	41.07
Trichoderma viride	84.77	45.83	13.50	10.50*	48.14*
Pseudomonas fluorescence	87.17*	42.42	11.67	11.50*	52.35*
Azospirillum + P. striata	102.17*	46.25	17.00*	12.17*	52.92*
Acetobacter + P. striata	95.42*	41.58	21.17*	11.83*	42.42*
Azospirillum	96.04*	49.33	20.00*	10.33*	46.60*
PPFM (Pomegranate)	98.08*	46.58	14.67	10.33*	42.92*
PPFM (Cotton)	88.92*	48.83	17.00*	8.17	39.42
Control	75.12	49.92	11.50	8.00	31.70
CD. (P = 0.05)	10.67	NS	5.35	2.27	9.4

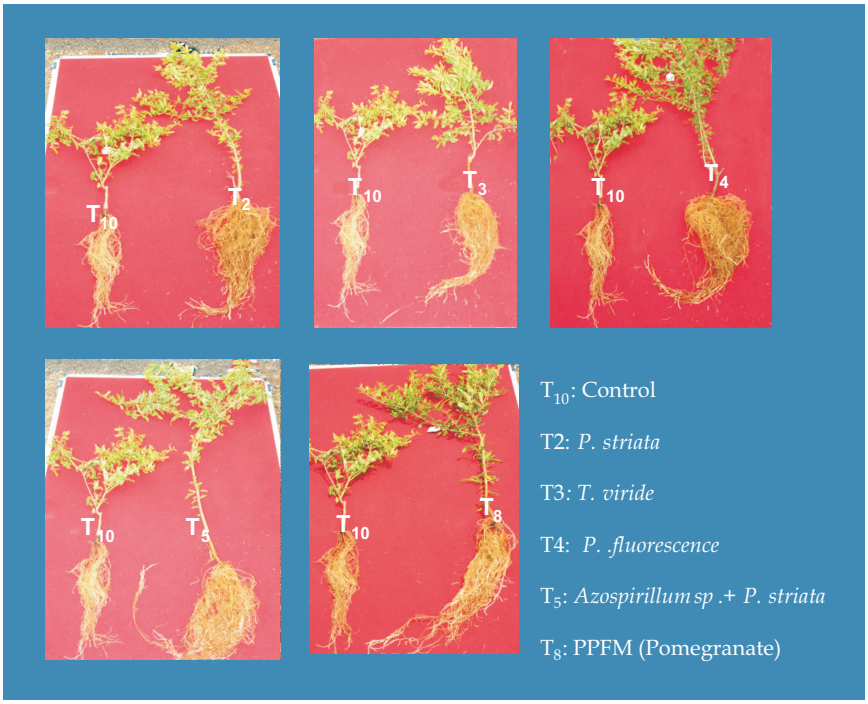


Plate 2. Effect of Bio-agents on Root and Shoot Growth of Pomegranate

Among the physiological parameters all bioagents except PPFM isolates improved photosynthesis whereas water use efficiency was also not improved by *Azospirillum*. Stomatal conductance increased only in *P. fluorescence* and *Azosprillum* and transpiration rate was significantly affected by *P. fluorescence, Azosprillum* and *P. striata* in combination with *Azospirillum* and *Acetobacter* (Table 3).

Azospirillum and *Acetobacter* were found associated with roots and *Pseudomonas* spp. and PPFM recovered from rhizosphere soils of plants in the respective treatments at the termination of the experiment (Table 4).
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Table 3: Effect of bio-agents on physiological parameters in pomegranate cv Bhagwa

Teatments	Photosynthetic rate (μ mol m^{-2} s^{-1})	Water use Efficiency	Stomatal Conductance (μ mol H_2o m^{-2} s^{-1}) r	Transpiration rate (μ mol H_2o $m^{-2}s^{-1}$)
Acetobacter	6.63*	0.26*	0.07	3.82
Pseudomonas striata	6.75*	0.19*	0.08	3.98
Trichoderma viride	6.61*	0.23*	0.07	3.74
P. fluorescence	7.43*	0.17*	0.11*	4.63*
Azospirillum + P. striata	6.73*	0.17*	0.08	4.11*
Acetobacter + P. striata	7.49*	0.22*	0.07	4.18*
Azospirillum	6.07*	0.10	0.09*	4.52*
PPFM (Pomegranate)	6.31*	0.12	0.06	3.56
PPFM (Cotton)	4.59	0.11	0.08	3.32
Control	4.29	0.12	0.07	3.26
CD. (P = 0.05)	1.04	0.05	0.02	0.75

In the soil treatment with bioagents which recorded improved root and shoot growth, the specific organisms - *Azospirillum* and *Acetobacter* were found associated with roots and *Pseudomonas* spp. and PPFM recovered from rhizosphere soils of plants in the treatments at termination of experiment.

Table 4:Microbial population observed at harvest

Treatments	Microbial population
Acetobacter sp.	Root colonization observed
Pseudomonas striata	1 x 10^{-4} g-1 soil
Trichoderma viride	Not detected
Pseudomonas fluorescence	2 x 10^{-5} g-1 soil
Azospirillum sp. + P. striata	Root colonization of *Azospirillum* observed
Acetobacter sp. + P. striata	Root colonization of *Acetobacter* observed
Azospirillum sp.	Root colonization of *Azospirillum* observed
PPFM (Pomegranate)	1.65 x 10^{-3} g-1 soil
PPFM (Cotton)	6.65 x 10^{-3} g-1 soil

III. Isolation of new bioagents:

Acetobacter:

Isolation of *Acetobacter* from roots of pomegranate plant showing luxuriant growth was done in semisolid LGI medium. Pellicle formation 2-3 mm below the surface (Plate 3) indicated growth of *Acetobacter* which was isolated, purified, confirmed by acetic acid production (Plate 4) on medium containing calcium carbonate and maintained in pure culture for further studies.

Azospirillum:

Isolation of *Azospirillum* from roots of pomegranate plant showing luxuriant growth was done in semisolid Malic Acid Nitrogren Free Bromothymol Blue (MANFB) medium. Pellicle formation 2-3 mm below the surface (Plate 5) indicated growth of *Azospirillum* which was isolated, purified, confirmed by colony characters on Congo Red Agar (CRA) Medium (Plate 6) and maintained in pure culture for further studies. Two isolates with two colony types were isolated, one with scarlet wrinkled and other scarlet smooth colonies on CRA medium.

Potassium Solubilizing Fungi:

Potential strains of Potasium solubilising fungi - *Penicillium* spp. have been isolated from local rhizosphere soil of pomegranate plants, on Aleksandrov medium (Plate 7). These have been maintained in pure culture for further studies. Six different *Penicillium* isolates showing potassium solubilization potential were evaluated *in vitro* on **Aleksandrov** Agar Medium. Highest solubilization index was recorded after 2 days in isolate F2, though all the isolates had good potash solubilizing potential.

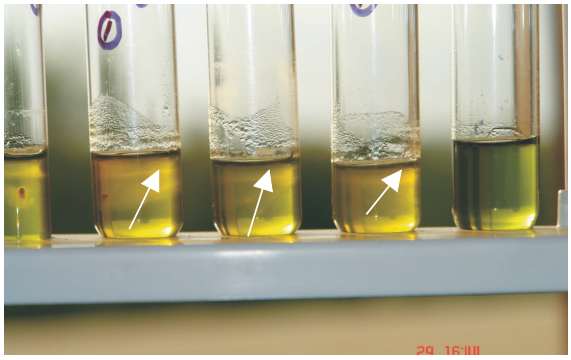

Plate 3: Pellicle formation (indicated by arrow head) by *Acetobacter*

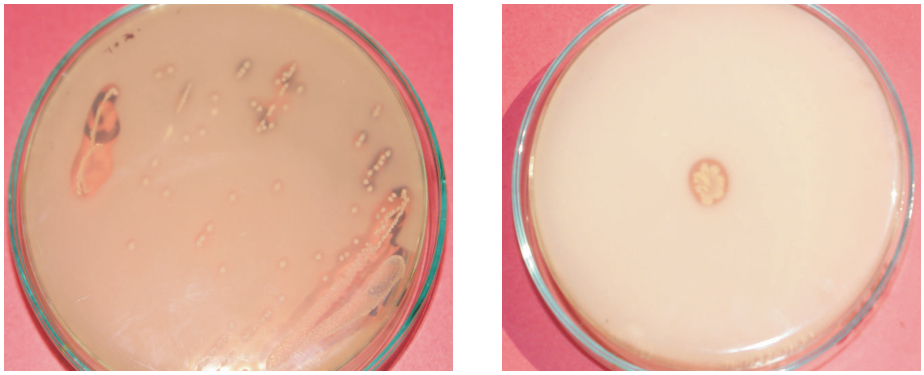

Plate 4: Acetic Acid Production by *Acetobacter* in Medium containing $CaCO_3$

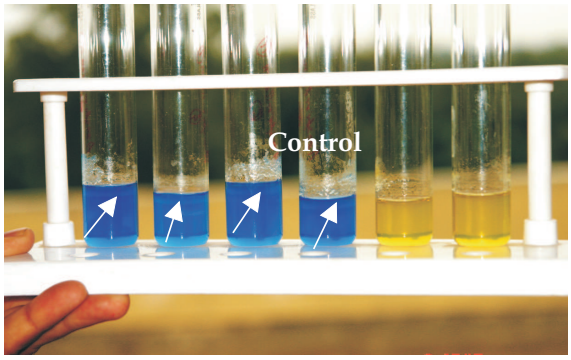

Plate 5: Pelicle formation (indicated by arrow head) and colour change to blue by *Azospirillum* growth in MANFB medium.

Plate 6: Colony characters of *Azospirillum* on Congo Agar Medium

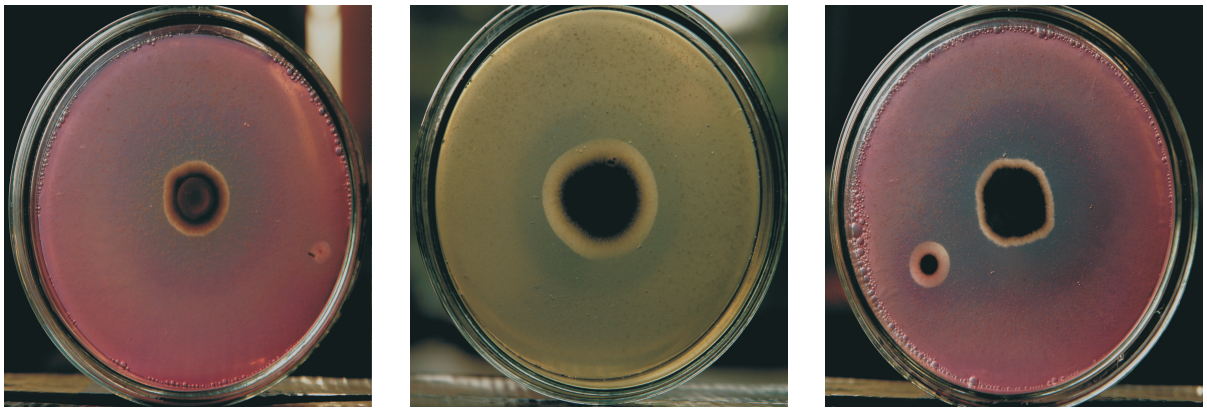

Plate 7: Potassium solubilization shown by clear zones around fungal colonies, on Aleksandrov medium by *Penicillium* Isolates from pomegranate orchard

Table 5: Evaluation of potash solubilizing *Penicillium* isolates for potash solubilization (*in vitro*)

Isolate No.	Solubilization Index			Isolate mean
	After 2 days	After 3 days	After 4 days	
F1	2.68	2.38	2.40	2.49b
F2	3.09	3.02	2.88	3.00
F3	2.58	2.65	2.69	2.64a
F4	2.37	2.27	2.19	2.28
F5	2.59	2.33	2.48	2.46b
F6	2.75	2.56	2.53	2.61a
		SEM (±)	CD (0.05)	
	Days	0.044	NS	
	Fungal isolates	0.062	0.20	
	Days X Fungal isolates	0.108	NS	

Effect of bioagents on total soluble sugars in fruits at harvest:

In a field trial in grower's field with var. Bhagwa, where bioagent treatments (Table 6) were used for control of bacterial blight, fruits were evaluated for TSS at harvest. Fifteen fruits/replication were used for TSS. *Pseudomonas fluorescence* isolate 2 recorded significantly highest TSS followed closely by PPFM and *P. fluorescence* isolate 1.

Table 6: Effect of bioagents on TSS in Bhagwa fruits at harvest

Bioagent	TSS (%)
PPFM	16.3*
*Pseudomonas fluorescence*_1	16.2*
Pseudomonas fluorescence--2	16.9*
Pseudomonas fluorescence--3	15.4
Trichoderma harzianum	16.1
Biomix	15.5
Untreated Control	15.2
Streptocycline	15.1
CD (0.05)	0.97
CV. %	4.00

Programme 2: Soil, Water and Nutrient Management in Pomegranate.

Project 2.1: Identification of suitable soils for sustained productivity of pomegranate.

2.1.1 : Performance of pomegranate orchards on different soil mixtures used for pit filling

The soil samples collected before the start of the experiment were analysed for different chemical properties. The results (Table 1). showed that Soil pH and EC varied from 7.32 to 8.33 and 0.12 to 0.18 respectively, which were in normal range for pomegranate cultivation. Black soils showed higher pH compared to light soils. Considerable increase in pH values was observed with the addition of sand. Organic carbon content of the samples was higher in black soil compared to light soils and drastic reduction took place with the mixing of sand. Calcium carbonate content in all the samples was within tolerable limit. But considerable increase took place with the addition of sand which might affect pomegranate performance.

Table 1: Chemical properties of the soil samples collected before the start of the experiment

Treatments	pH	EC (dS/m)	Organic carbon (%)	$CaCO_3$(%)
T_1- Light garvelly soil, 30cm	7.32	0.12	0.44	4.67
T_2-Light garvelly soil, 60 cm	7.37	0.14	0.38	4.27
T_3-Sandy loam soil 60 cm	7.50	0.14	0.38	3.09
T_4- Medium (loamy) soil 60	7.55	0.14	0.52	3.75
T_5- Black soil, 30 cm	8.02	0.16	0.79	8.79
T_6- Black soil, 60 cm	7.99	0.17	069	7.77
T_7- Black soil, 90 cm	7.82	0.18	0.62	7.81
T_8-Black soil, 120 cm	7.82	0.15	0.66	6.31
T_9- Black(50) + sand (50%)	8.33	0.11	0.28	19.24
T_{10}-Black (75%) sand (25%)	8.12	0.11	0.56	15.38
T_{11}-Weathered murrum,	7.70	0.16	0.43	6.61

Soil fertility status before the start of the experiment

The soil samples collected before the start of the experiment were analysed for soil fertility status The results (Table 2) showed that in general, the available nitrogen content was in higher range while phosphorus and potassium were in medium range. The micronutrients were also in sufficient range except Zn. Black soils revealed higher content of nitrogen and potassium while phosphorus was higher in light soils. Micronutrients such as iron and Manganese were higher in light soils while copper was higher in black soils. Much variation in zinc content was not observed amongst the treatments. Drastic reduction in soil macro- and micronutrient status took place with the addition of sand. Though the treatment where only weathered murrum was used for pit filling showed sufficient quantity of nutrients at least in initial stage, nutrient content was less when compared with other treatments.

Table 2: Fertility status of the soil samples collected before the start of the experiment

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
T_1- Light garvelly soil, 30cm	256.6	18.9	104.5	2.06	7.69	3.01	0.35
T_2-Light garvelly soil, 60 cm	275.6	17.1	106.4	2.08	7.40	2.69	0.32
T_3-Sandy loam soil 60 cm	280.3	16.8	100.8	2.45	7.22	2.55	0.34
T_4- Medium (loamy) soil 60	251.8	15.6	93.3	2.08	8.35	2.89	0.32
T_5- Black soil, 30 cm	332.6	12.2	210.9	1.00	7.45	3.86	0.30
T_6- Black soil, 60 cm	337.3	11.4	199.7	1.01	6.00	3.71	0.33
T_7- Black soil, 90 cm	313.6	13.0	213.8	1.17	6.88	3.95	0.41
T_8-Black soil, 120 cm	294.6	10.2	218.9	1.02	6.06	3.71	0.29
T_9- Black(50) + sand (50%)	190.0	10.9	100.8	1.68	3.49	1.71	0.20
T_{10}-Black (75%) sand (25%)	228.0	9.5	130.7	1.11	5.39	3.10	0.35
T_{11}-Weathered murrum,	237.6	10.2	91.5	1.54	7.23	3.63	0.31

Leaf nutrient content during first year of the experiment

The leaf samples collected after one year of the plantation were analysed for major and micronutrient content under different treatments . The results (Table 3) showed that there was not any fixed trend in leaf content with respect to N, Fe and Mn amongst different treatments, however, highest content of N and Mn was observed in the treatment where pits were filled with loamy soils and that of Fe was highest in black soil. In general, leaf phosphorus content was higher in light compared to black soils and highest in light gravelly soils. Black soil having varied depth were found to supply sufficient quantity of most of the nutrients for the growth of pomegranate plants as highest leaf nutrient content of K, Ca, Mg and Fe was recorded under these treatments. Pits filled with murrum only also found to supply sufficient quantity of nutrients atleast during the initial stage of the plant growth as surprisingly Cu uptake was highest in this treatment.

Vegetative growth of the plants during second year of the experiment

Vegetative growth parameters viz. plant height, plant spread of Bhagva variety were recorded during second year of the experiment (Table 4). The results revealed non-significant variation in plant height while in case of plant spread significant differences were observed amongst the treatments. Highest plant height and spread was recorded under pits filled with black soil up to 120 cm depth, while height was lower in the treatments of light gravelly soil or the mixture of 50% sand.

Table 3 : Leaf nutrient status as affected by different treatments (during first year)

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
T_1-Light garvelly soil, 30 cm	1.19	**0.17**	2.61	2.04	0.43	108.3	44.8	**35.8**	11.3
T_2-Light garvelly soil, 60 cm	1.20	0.14	2.39	2.08	0.43	103.5	45.7	29.0	10.9
T_3-Sandy loam soil 60 cm	1.21	0.15	2.48	2.33	0.50	102.9	46.0	30.9	15.5
T_4- Medium (loamy) soil 60	**1.32**	0.15	2.55	1.95	0.60	100.4	**48.0**	29.6	14.1
T_5- Black soil, 30 cm	1.16	0.12	**2.80**	1.85	0.55	**109.1**	43.2	31.0	14.1
T_6- Black soil, 60 cm	1.30	0.15	2.62	2.04	0.62	107.7	45.3	30.4	13.7
T_7- Black soil, 90 cm	1.13	0.13	2.57	2.28	0.43	100.0	44.7	30.2	13.1
T_8-Black soil, 120 cm	1.19	0.13	2.79	**2.36**	**0.67**	106.0	43.3	30.5	16.2
T_9- Black(50) + sand (50%)	0.77	0.11	2.59	1.97	0.53	104.8	45.0	34.7	14.7
T_{10}-Black (75%) sand (25%)	0.99	0.12	2.68	1.89	0.45	108.5	42.9	30.9	11.9
T_{11}-Weathered murrum,	1.05	0.13	2.50	2.28	0.65	108.1	47.1	29.2	**17.8**

Table 4 : Vegetative growth of pomegranate plants cv. Bhagva under different treatments.

Treatments	Plant height (cm)	Plant Spread (cm)		Average plant spread (cm)
		EW	NS	
T_1 – Light garvelly soil, 30cm	184.8	166.8	153.8	**160.3**
T_2 – Light garvelly soil, 60 cm	191.5	173.8	174.8	174.3
T_3 – Sandy loam soil 60 cm	197.0	186.5	190.7	188.6
T_4 – Medium (loamy) soil 60	**199.8**	189.0	173.2	181.1
T_5 – Black soil, 30 cm	182.0	186.3	162.7	174.5
T_6 – Black soil, 60 cm	179.2	183.2	149.3	166.3
T_7 – Black soil, 90 cm	188.0	184.2	174.2	179.2
T_8 – Black soil, 120 cm	**199.5**	201.3	194.8	**198.1**
T_9 – Black(50) + sand (50%)	185.7	162.2	166.1	164.1
T_{10} – Black (75%) sand (25%)	196.3	173.7	165.7	169.7
T_{11}– Weathered murrum,	189.8	164.1	198.5	181.3
C.D (5%)	NS	20.9	16.4	14.13

Vegetative growth parameters viz. plant height, plant spread of Ganesh variety recorded during second year of the experiment (Table 5) revealed significant variation in plant height and plant spread amongst the treatments. Highest plant height was recorded in black soil up to 60 cm depth while it was lower in case of light gravelly soil or soil mixed with 50% sand. Highest plant spread was recorded in the treatment where pits were filled with medium loamy soil.

Table 5 : Vegetative growth of pomegranate plants cv. Ganesh under different treatments.

Treatments	Plant height (cm)	Plant Spread (cm)		Average plant spread (cm)
		EW	NS	
T_1 – Light garvelly soil, 30cm	216.5	197.7	195.8	196.8
T_2 – Light garvelly soil, 60 cm	230.2	195.3	185.7	190.5
T_3 – Sandy loam soil 60 cm	248.2	188.3	203.0	195.7
T_4 – Medium (loamy) soil 60	238.0	214.7	221.3	**218.0**
T_5 – Black soil, 30 cm	212.2	173.3	184.8	179.1
T_6 – Black soil, 60 cm	**252.2**	209.2	201.2	205.2
T_7 – Black soil, 90 cm	232.3	223.5	168.5	196.0
T_8 – Black soil, 120 cm	227.5	206.8	201.0	203.9
T_9 – Black (50) + sand (50)	210.3	194.2	201.0	197.6
T_{10} – Black (75) + sand (25)	235.0	196.2	193.0	194.6
T_{11}– Weathered murrum,	228.7	219.8	202.8	211.3
C.D(5%)	24.6	22.2	23.2	19.3

2.1.2 : Performance of pomegranate under different planting systems.

This is the first year of the experiment. Plant vegetative growth parameters viz. plant height, plant spread were recorded during the year (Table 6). The results revealed that,height of the plant was highest in the treatment of pits of 0.6 x 0.6 x 0.6 m followed by continuous trenches. While plant spread was highest under continuous trenches of 1 x 1 m size.

Table 6 : Vegetative growth of pomegranate plants cv. Bhagva under different treatments.

Treatments	**Plant height (cm)**	**Plant spread (cm)**		**Average plant spread (cm)**
		EW	**NS**	
T_1 – Pit 1x1x1 m	137.5	120.8	141.8	131.3
T_2 – Pit 0.60x0.60x0.60 m	**156.5**	130.6	142.5	136.6
T_3 –Trenches 1 x 1 m	**151.4**	150.0	146.6	**148.3**
T_4 –Trenches 0.60 x 0.60 m	135.4	137.8	137.4	137.6
T_5 –Trapezoidal trenches 0.60 m deep 1.5 m top width	137.6	138.9	136.5	137.7
T_6 – Bedding system 0.60 m wide x 0.30 m deep x 0.30 m above ground	140.3	131.0	130.4	130.7
T_7 – Bedding system 0.60 m wide x 0.60 m deep x 0.30 m high above ground	127.0	127.0	134.5	130.7
CD (p=0.05)	12.9	13.5	7.7	8.6

Project 2.2 : Nutrient Management in Pomegranate

2.2.1 : Identification of Nutrient deficiency symptoms in pomegranate

Studies were carried out on nutrient deficiency symptoms in seedlings of pomegranate variety Bhagwa planted in the pots filled with white sand under green house conditions. Different combinations of nutrient solutions were supplied to induce deficiency symptoms of individual nutrients. Results obtained under different treatments are reported. **Nitrogen:** Deficiency symptoms first appeared on lower and mature leaves and subsequently, whole leaf turned yellow. Leaves became stiffer in strength, broke in to pieces on folding. Plants flowered early and produced more numbers of hermaphrodite flowers (27 flowers/plant). At advanced stage leaves became light brown followed by drying up from the tip (Fig.1)

Fig.1: Plants revealing nitrogen deficiency symptoms.

Phosphorus: Deficiency symptoms first appeaed on younger leaves which appeared slender, elongated and smaller in size. Leaf margins turned upwards and gave tunnel like shape (Fig.2) Yellowing of leaf started from tip only and other part remained green. (In N whole leaf becomes pale in colour). In advanced stages entire leaf became yellow followed by appearance of chlorotic spots which later on turned dark brown.Veins of the leaves also turned yellow, while in case of Ca veins remained green. Plant revealed growth gets stunted

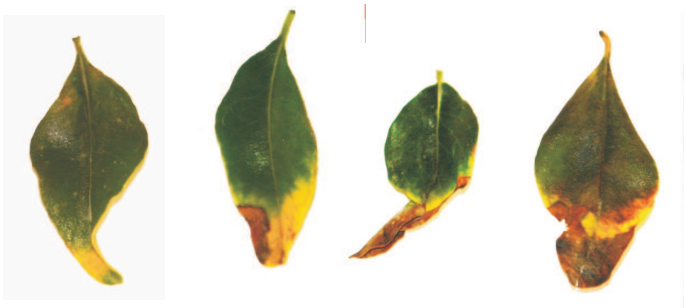

Fig.2: Leaves showing phosphorus deficiency.

Potassium: Deficiency symptoms first appeared on older leaves. Many brown spots appeared on dorsal side of leaves along the leaf margin starting from tip (Fig 3). Leaf margin became yellow followed by scorchy appearance.

Fig.3: Leaves revealing potassium deficiency.

Calcium: Symptoms first appeared on younger leaves. Interveinal yellowing started from leaf tip, advanced from margin towards midrib. Veins remained green during the initial stages, however, later on became yellow. Pinkish tinge appeared on the yellow portion of the leaf. Yellow portion of leaves turned dark brown and half of the leaf from tip dried up.

Fig.4: Leaves revealing calcium deficiency.

Magnesium: Leaf margin and vein appeared light green in color followed by grey patches appearing on the side margin of the leaves (Fig.5). This light grey color proceeded in inverted 'V' shape and subsequently covered the whole leaf and leaves showed drying up symptoms. The colour of dried leaves was grey while in case of Ca it was dark brown.

Fig.5: Leaves revealing magnisium deficiency

Sulfur: Deficiency symptoms first appeared on middle leaf with leaf veins becoming light green in color. Yellowing started on the middle of the leaf around the mid rib. First inter-veinal areas turned yellow in color and finally whole leaf became yellow.

Fig.5: Leaves revealing sulfur deficiency

Programme 3: Identification and Management of Diseases and Insect- Pests of pomegranate.

Project 3.1: Studies on Economically important diseases of pomegranate with special emphasis on Bacterial blight and their control.

Bacterial Blight

Surveillance: Surveys of Pomegranate orchards in Solapur, Pune, Nashik, Ahmednagar, Dhule, Osmanabad and Satara districts of Maharashtra conducted during 2008-09 revealed that blight was prevalent in 55% orchards of the state of which 10% were severely affected, 20% moderately and 25% were mildly affected by blight (Fig.1). No bacterial blight was observed in Dhule and Satara districts of the state. In Solapur bacterial blight was prevalent in 58.9% orchards of which 12.8% were severely affected, 20.54 were moderately affected and 25.64 were mildly affected. Ahmednagar district which was almost bacterial blight free until 2008, revealed severe blight infections in one orchard in Sangamner taluka during surveys conducted in July 2008.

Blight development at Research farm, Kegaon: At Kegaon farm, bacterial blight was though first noticed in May 2008 on 1 year old plant of cv. Bhagwa, critical observations revealed disease onset in April itself. Disease further spread to adjoining plants of the block and its severity reached 50% in the month of October. Blight severity revealed declining trend after October and reached 5.5% in March 2009 (Figure 2). Disease incidence, however, was maximum (100%) in the months of January and February 2009. Blight progress curve is depicted in Figure 2 by transforming severities to $\log_e (x/1-x)$ and plotting them against time (months) during 2008-09.

Blight Epidemiology:

Influence of Meteorological factors on bacterial blight development: Bacterial blight severity at different time intervals was correlated with meteorological factors (Table 1) to observe the influence of meteorological factors on blight progress during 2008-09. Data on disease severity (Y) from April 2008 to March 2009 (Fig.2) and meteorological factors, Max. Temperature (x1), Min. Temperature (x2), Av. Temperature (x 3), Max.RH (x 4), Min.RH (x5), Av.RH (x6) and Rain (x7) were analysed to determine the Correlation coefficient (r) between disease severity and individual meteorological factors (Table 2).

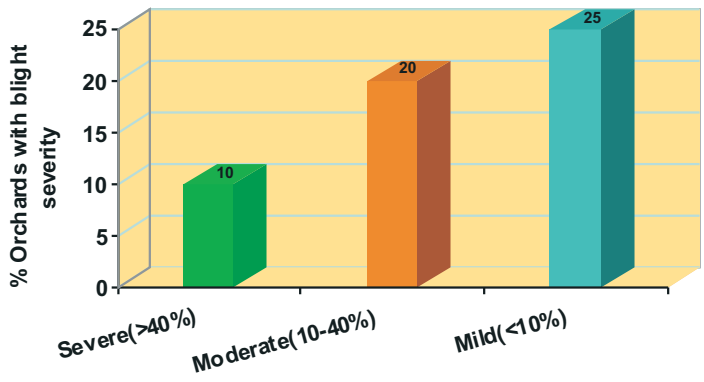

Fig.1:Bacterial blight severity in Maharashtra during 2008-09.

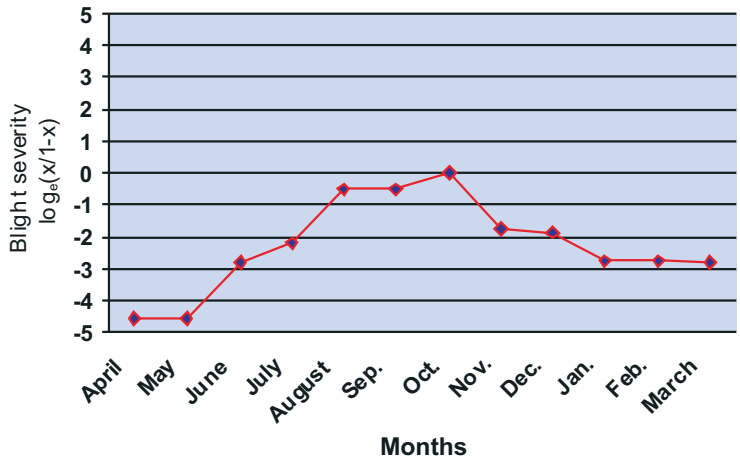

Fig.2: Bacterial blight severity during 2008-09 at Research Farm

Disease severity (Y) was negatively but significantly correlated (r=-0.59*) with high (afternoon) temperatures (X1), thereby, revealing that higher temperatures negatively influenced disease progress. Minimum (morning) temperatures (X2) and average temperatures (X3) had non-significant negative correlation with disease progress. The correlation coefficient (0.76**) between disease (Y) and Maximum (morning) humidity(X4) was highly significant and positively correlated, indicating that blight was highly favored by high humidities. Minimum (afternoon) humidity (X5) and Average RH (X6) also revealed significant and positive correlation with disease development. Rainfall showed significant and positive relationship with disease progress as evident from the correlation coefficient (0.59*) between blight severity and rainfall (X7). Study revealed that higher temperatures were negatively correlated with blight build up, where as relative humidity, and rainfall had significant and positive correlation, thereby, favoring blight development during the period.

Table 1: Meteorological parameters 2008-09 (Monthly averages)

Month	Temperature °C			RH %			Total Rainfall
	Max.	Min.	Av.	Max.	Min.	Av.	mm
April, 08	38.54	23.16	30.85	48.9	28.0	38.45	29.0
May, 08	39.68	23.85	31.76	53.06	22.97	38.01	15.6
June, 08	34.58	23.77	29.17	64.7	41.1	52.9	47.6
July, 08	33.05	23.34	28.19	69.97	50.23	60.1	160.6
August, 08	30.59	22.03	26.31	78.55	59.35	68.95	158.9
September, o8	30.36	21.48	25.92	82.6	63.6	73.1	214.6
October,08	32.67	19.58	26.12	68.39	40.14	54.26	57.3
November,08	31.25	18.47	24.86	64.8	42.06	53.43	76.7
December,08	30.48	16.17	23.32	63.68	36.32	50.00	2.2
January,09	31.29	15.99	23.64	62.77	31.42	47.09	0.0
February,09	35.03	18.72	26.87	50.5	26.93	38.71	0.0
March,09	37.6	21.31	29.45	54.58	38.03	46.30	5.2

Table 2: Correlation matrix of Bacterial blight with different meteorological parameters.

Blight severity	Correlation coefficient (r) with different Meteorological parameters						
	Max.T°C (X1)	Min.T °C (X2)	Av.T °C (X3)	Max.RH% (X4)	Min.RH% (X5)	Av..RH% (X6)	Rain mm (X7)
Y	-0.59*	-0.09	-0.41	0.76**	0.67*	0.73**	0.59*

*: 'r' values significant at P=0.05 ; **: 'r' values significant at P=0.01.

Regression models: Multiple Regression equations were developed using different interactions of meteorological factors on disease to observe their functional relationship (Table- 3). Regression equation (1) involving all the meteorological parameters (X1, X2, X3, X4, X5, X6 and X7) was found most suitable as most of the variations in disease severity (Y) were accounted for by its joint association with all the meteorological parameters (R^2=0.668). Regression analysis also revealed that two or three meteorological variables alone (Equations 5,6,7) were not adequate in predicting the disease severity. Different Regression models with their corresponding coefficient of determination are depicted in Table 3.

Table 3: Regression coefficient (b) and coefficient of determination (R^2) of different regression equations predicting bacterial blight during 2008-09.

S.No.	Regression equations	(R^2)
1	Y=-104.61+(48.50)X1+(44.98)X2+(-93.39)X3+(850.60)X4+(849.20)X5+(-1698.09)X6+(-0.02)X7	0.668
2	Y= -108.22+(5.74)X1+(2.65)X2+(-8.18)X3+(870.14)X4+(868.7)X5+(-1737.14)X6	0.661
3	Y= -203.7+(4.90)X1+(-3.93)X2+(2.31)X4+(0.012)X5+(0.014)X7	0.644
4	Y= -207.44+(4.836)X1+(-3.788)X2+(2.324)X4+(0.066)X5	0.640
5	Y= -101.25+(0.715)X1+(1.717)X4+(-0.052)X7	0.598
6	Y= -60.13+(1.41)X4+(-0.037)X7	0.586
7	Y= -18.38 + (-0.552)X3+(1.25)X6+(-0.046)X7	0.552

Y:Blight Severity; X1: Max.Temperature °C; X2:Min.Tempearture°C; X3: Average Tempearture °C; X4: Max.RH%; X5:Min RH%; X6:Average RH%; X7: Rainfall mm

Primary source of inoculum:. At Kegaon farm blight initiated in April 2008 on one year old cv Bhagwa plant which revealed slight stem and also foliage infection particularly adjacent to the infected stem. No other plant in the block had revealed any infection until then. Disease spread to other plants from the infector plant as more plants were found infected near the infector plant. The disease mainly spread along the direction of the wind from South West to North East direction as was evident from the disease gradient. By December 2008 about 80% plants of the block revealed blight. Study clearly revealed that the infected plant served as the source of inoculum in the plot and disease spread was mainly in the direction of the wind.

Survivability of *Xanthomonas axonopodis* pv.*punicae* : The blighted leaves collected from the diseased orchard at Hiraj in June 2007 were kept under laboratory conditions and observed periodically for survivability of the bacterium. After one year , the infected leaves collected from the orchard and also from the diseased plants revealed bacterial ooze under the microscope and isolations made on medium from such diseased leaves revealed growth of the pathogen, thereby indicating that bacterium can survive for one year in diseased leaves fallen on the ground. However, after 20 months of incubation under laboratory conditions (25.0°C - 40.0°C) blight infected leaves from diseased orchard though did reveal bacterial ooze under the microscope, the inoculum prepared from such leaves when sprayed onto healthy plants of cv Bhagwa did not cause any infection on inoculated plants under Net house conditions. The study is an indicator of the fact that though even after 20 months of incubation diseased leaves revealed bacterial ooze, the pathogen probably had reduced its virulence as it was unable to infect the inoculated plants.

Transmission of Bacterial Blight through Planting Material

Plants which were inoculated during January 2006 and produced severe blight symptoms on all above ground parts of the plant, were pruned removing old and infected twigs in the month of February 2008 and were maintained to observe progress of symptoms. The apparently healthy stems of these plants were also used for propagation. The hard wood cuttings were planted in pots. Transmission of BBD was observed through apparently healthy hard wood cuttings, which developed blight symptoms at the nodes after about 7 months, in 40% cuttings (table 4). This was followed by development of symptoms on the nearest leaf (Fig.3).

Table 4: Per cent transmission of bacterial blight through hard wood cuttings from infected plants

Treatment	Total Plants Infected (%)	Total Branches Infected (%)
T1: Sprayed mother Plants	100	100
T2: Cuttings from T1	40	27
Control: Cuttings from Healthy Orchard	0	0

Fig 3. Transmission of bacterial blight through apparently affected hard wood cuttings

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Fig 4. Transmission of bacterial blight through apparently affected hard wood cuttings

Screening of Germplasm for Bacterial blight resistance under Field conditions: 63 germplasm accessions in replicated numbers available at the Research centre were screened under natural blight epidemic conditions for blight development during 2008. The observations on severity were recorded in August, October and December months, 2008. The data were pooled and statistically analyzed employing RBD to differentiate and classify the accessions on the basis of blight severity (Table 6). Different accessions were grouped under three categories on the basis of their reaction to bacterial blight. Out of 63 accessions 6 were found partially resistant (Patna 5, Nana, 1182IC, 1198IC, 1199IC and 1205IC), 33 were susceptible and other 24 accessions were highly susceptible (Table 7).

Screening of Pomegranate Germplasm for Bacterial Blight Resistance in net houe

About 223 plants of germplasm material including Indigenous collections, crosses from IIHR, Bangalore, and varieties from MPKV were screened for bacterial blight resistance under net house conditions (Table 8). Plants were inoculated with 3 day old culture of *Xanthomonas axonopodis* pv. *punicae*, on Feb. 7, 2009. Plants were predisposed to high humidity 24 hrs before and 48 hrs. after inoculation, by covering pots with polythene bags. Symptoms started appearing after 8 to 10days. Out of 223 tested plants, 20 plants were found totally free from bacterial blight, 50 days after disease appeared on leaves. Ninety five plants (including 10-15 plants of 4 different crosses) recorded <1-2% disease severity. Among 3 commercial cultivars kept as control, all plants of Bhagwa and Arakta were highly susceptible recording 10-40% disease, where as in Ganesh almost 50% plants recorded <2% disease and rest recorded >2 %. Final evaluation will be done after plants bear fruits

Table 6: Bacterial blight severity in germ plasm accessions at research farm during 2008.

S.No	Name	Blight Severity (%) during 2008				*Genotype rating based on blight severity
		August	October	December	Pooled	
1.	Ganesh	0 (1)	18 (4.35)	24.66 (4.98)	14.22 93.44)	c
2.	Yercaud	0 (1)	18 (4.35)	31.33 (5.61)	16.44 (3.65)	c
3.	Nimali	12 (3.23)	18 (4.35)	24.66 (4.98)	18.22 (4.18)	c
4.	Kalpitya	7.83 (2.63)	5.5 (2.54)	18 (4.35)	10.44 (3.17)	b
5.	P. Arakta	31.33 (5.61)	18 (4.35)	18 (4.35)	22.44 (4.77)	d
6.	17/2	1.83 (1.51)	9.66 (3.14)	5.5 (2.54)	5.66 (2.39)	b
7.	Jodhpur collection	5.5 (2.54)	9.66 (3.14)	31.33 (5.61)	15.5 (3.76)	c
8.	Dholka	6 (2.11)	18 (4.35)	31.33 (5.61)	18.44 (4.02)	c
9.	G.137	0 (1)	13.83 (3.74)	38 (6.24)	17.27 (3.66)	c
10.	KRS	3.66 (2.02)	13.83 (3.74)	24.66 (4.98)	14.05 (3.58)	c
11.	Damini	35.5 (5.59)	31.33 (5.61)	38 (6.24)	34.94 (5.81)	d
12.	Jallore seedless	18 (4.35)	31.33 (5.61)	13.83 (3.74)	21.05 (4.56)	c
13.	Bhagwa	24.66 (4.98)	18 (4.35)	18 (4.35)	20.22 (4.56)	d
14.	Co.White	7.83 (2.63)	18 (4.35)	18 (4.35)	14.61 (3.77)	c
15.	Kabuli Yellow	0 (1)	5.5 (2.54)	24.66 (4.98)	10.05 (2.84)	b
16.	Jyothi	0 (1)	1.83 (1.51)	24.66 (5.81)	8.83 (2.77)	b
17.	Co-White	9.66 (3.14)	9.66 (3.14)	31.33 (5.61)	16.88 (3.96)	c
18.	Tabesta	9.66 (3.14)	38 (6.24)	38 (6.24)	28.55 (5.20)	d
19.	Surat Anar	18 (4.35)	31.33 (5.61)	38 (6.24)	29.11 (5.4)	d
20.	Bassein seedless	1.83 (1.51)	18 (4.35)	18 (4.35)	12.61 (3.40)	c
21.	Yercaud HRS	0 (1)	5.5 (2.54)	31.33 (5.61)	12.27 (3.05)	b
22.	Tabesta b	0 (1)	13.83 (3.74)	31.33 (5.61)	15.05 (3.45)	c
23.	Spin Sakaharin	13.83 (3.74)	24.66 (4.98)	38 (6.22)	25.5 (4.98)	d

S.No	Name	Blight Severity (%) during 2008				*Genotype rating based on blight severity
		August	October	December	Pooled	
24.	Bedana Suri	3.66 (2.02)	18 (4.35)	24.66 (5.61)	15.44 (3.99)	c
25.	Muscat	9.66 (3.14)	18 (4.35)	18 (4.35)	15.22 (3.94)	c
26.	Bosckalinsi	9.66 (3.14)	31.33 (5.61)	38 (6.24)	26.33 (4.99)	d
27.	Kabuli Canoor	3.66 (2.02)	31.33 (5.61)	38 (6.24)	24.33 (4.62)	d
28.	Bedana Sedana	0 (1)	20.5 (4.37)	31.33 (5.61)	17.27 (3.66)	c
29.	Patna 5	1.83 (1.51)	1.83 (1.51)	5.5 (2.54)	3.055 (1.85)	a
30.	Spendander	7.83 (2.63)	24.66 (4.98)	38 (6.24)	23.5 (4.61)	d
31.	Dorasta	24.66 (4.35)	38 (6.24)	38 (6.24)	33.55 (5.87)	e
32.	A.K. Anar	25.33 (6.24)	25.33 (6.24)	25.33 (6.24)	38 (6.24)	e
33.	Bedana Thinskin	7.83 (2.54)	18 (4.35)	31.33 (4.98)	16.05 (3.95)	c
34.	Maha	7.83 (2.63)	18 (4.35)	31.33 (5.61)	19.05 (4.19)	c
35.	P-23	0 (1)	1.83 (1.51)	31.33 (5.61)	11.05 (2.70)	b
36.	P-13	1.83 (1.51)	9.66 (3.14)	31.33 (5.57)	14.27 (3.41)	C
37.	Kasuri	3.66 (2.02)	24.66 (4.98)	18 (4.35)	15.44 (3.78)	c
38.	Alah	31.33 (5.61)	38 (6.24)	38 (6.24)	35.77 (6.03)	e
39.	Jodhpuri Red	9.66 (3.14)	18 (4.35)	38 (6.24)	21.88 (4.57)	d
40.	Gulesha Red	13.83 (3.74)	24.66 (4.98)	38 (3.24)	25.5 (4.98)	d
41.	P-26	0 (1)	5.5 (2.54)	24.66 (4.98)	10.05 (2.84)	b
42.	P-16	1.83 (1.51)	1.83 (1.51)	31.33 (5.61)	11.66 (2.87)	b
43.	Shirin Anar	7.83 (2.63)	27.16 (5.00)	24.66 (4.98)	19.88 (4.20)	c
44.	G.R.Pink	3.66 (2.02)	38 (6.24)	31.33 (5.61)	24.33 (4.62)	d
45.	Mridula	5.5 (2.54)	38 (6.24)	31.33 (5.61)	24.94 (4.79)	d
46.	1201 IC	3.66 (2.02)	3.66 (2.02)	18 (4.35)	8.44 (2.80)	b
47.	1203 IC	3.66 (2.54)	13.83 (3.74)	18 (4.35)	11.83 (3.54)	c
48.	1204 IC	5.5 (2.54)	5.5 (2.54)	18 (4.35)	9.66 (3.14)	b
49.	1205 IC	0 (1)	5.5 (1.51)	5.5 (2.54)	2.44 (1.68)	a
50.	1199 IC	1.83 (1.51)	1.83 (1.51)	5.5 (2.54)	3.05 (1.85)	a
51.	1198 IC	1.83 (1.51)	1.83 (1.51)	9.66 (3.14)	4.44 (2.05)	a
52.	1196 IC	1.83 (1.51)	9.66 (3.14)	13.83 (3.74)	8.44 (2.80)	b
53.	1194 IC	1.83 (1.51)	24.66 (4.98)	38 (6.24)	21.5 (4.24)	c
54.	Nana	0 (1)	0 (1)	3.66 (2.02)	1.22 (1.34)	a
55.	IC 318754	3.66 (2.54)	24.66 (4.98)	31.33 (5.61)	19.88 (4.37)	c
56.	IC 318723	5.5 (2.54)	18 (4.35)	31.33 (5.61)	18.27 (4.16)	c
57.	IC 318728	1.83 (1.51)	24.66 (4.98)	31.33 (5.61)	19.27 (4.03)	c
58.	IC 1182	1.83 (1.51)	1.83 (1.51)	5.5 (2.54)	3.05 (1.85)	a
59.	IC 318790	1.83 (1.51)	7.83 (2.63)	18 (4.35)	9.22 (2.83)	b
60.	IC 318803	1.83 (1.51)	13.83 (3.74)	25.33 (4.49)	13.66 (3.25)	b
61.	IC 318753	0 (1)	13.83 (3.74)	31.33 (5.61)	15.05 (3.45)	c
62.	IC 318779	1.83 (1.51)	18 (4.35)	31.33 (5.61)	17.05 (3.82)	c

S.No	Name	Blight Severity (%) during 2008				*Genotype rating based on blight severity
		August	October	December	Pooled	
63.	Yercaud	1.83 (1.51)	13.83 (3.74)	18 (4.35)	11.22 (3.20)	b
64.	IC 318705	0 (1)	18 (4.35)	31.33 (5.61)	16.44 (3.65)	c
65.	IC 318718	1.83 (1.51)	6 (2.11)	9.66 (3.14)	5.83 (2.25)	b
66.	IC 318720	1.83 (1.51)	7.83 (2.63)	27.16 (5.00)	12.87 (3.05)	b
	C.D at 5%	1.49	1.38.	1.44	1.03	
	C.V %	40.5	22.44	17.97	29.96	
Values in parantheses are transformed (n+1) values						

* a: 1.22 (1.34) - 5.83(2.25); b: 5.86 (2.39) - 19.88 (3.25); c: 12.61(3.40) 19.88 (4.37); d: 20.22 (4.56) 29.11(5.4); e : 33.55 (5.61) 38.0 (6.24)

Table 7: Reaction of Germplasm accessions to Bacterial blight under field conditions

Group	Av.Disease severity % (rating)	Accessions
(A): Partial Resistant	≤5.5	Nana, 1205IC, 1199IC, 1182IC, 1198IC, Patna 5.
(B):Moderately Susceptible	>5.5 - 18.0	17/2, P-23, Jyothi, 11961C, 1201 IC, 318790 IC, Kabuli Yellow, P-26, P -16, Yercaud, Jodhpur collection, 318720IC, 1204 IC, Kalpitya, Yercaud local, 318803IC, 318718IC. Ganesh, P -13, G-137, KRS, Co -white, Bassein Seedless, Tabesta, Bedana Suri, Muscat, Bedana Sedana, Bedana Thinskin, Kasuri, 1203IC, 318705IC, 318779IC, 318753IC
(C): Highly Susceptible	>18.0	Dholka, 318728IC, Jallore seedless, 318723IC, Nimali, Maha, Shirin Anar, 1194IC, 318754IC, Bhagwa, Jodhpuri Red, Spendanader, Kabuli Canoor, G.R.Pink, P.Arakta, Mridula, Gulesha Red, Spin Sakaharin, Bosckalinsi, Damini, Surat Anar, Dorasta, Alah, A.K.Anar

Screening of Chemicals, Antibiotics and Bioagents for the Control of Bacterial Blight Field Trials

Field trials in farmer's field were conducted to screen 6 antibiotics, 8 chemicals and 6 bioagents for the control of bacterial blight in *Hasta bahar* crop of pomegranate, variety Bhagwa. Fruits harvested in May 2008 were observed for bacterial blight infection. Among these 1 antibiotic -Chloramphenicol (Table 9), 3 chemicals copper hydroxide carbonate alone and with copper sulphate pentahydrate and Ammonium chloride (Table 9), 1 bioagent *Pseudomonas fluorescence* isolate -2 from NCIPM, N. Delhi. and 1 commercial formulation Bacterimax (Table 10), significantly reduced Bacterial blight incidence over untreated control and were at par with streptocycline. Severity was reduced by all the bioagents.

In Vitro Studies

Evaluation of 2-Bromo2-Nitropropane-1-3-Diol and Streptocycline: In *in vitro* studies to evaluate efficacy of different brands of 2-Bromo2-Nitropropane-1-3-Diol,. Bactronol-100 was best followed closely by Bactricell in inhibiting *Xanthomonas axonopodis pv punicae*. Bactrinashak was least effective among the three brands tested as depicted through inhibition zones formed by them (Table 11), however all three were superior to streptocycline

Table 8. Screening of Pomegranate Germplasm Material for Bacterial Blight on Inoculated Plants

Germplasm	Number of plants in each disease severity grade 50 days after disease appeared on leaves			
	Nil	< 2 %	>2-10 %	>10
(GxD)x(G)x(R)	1	15	8	1
(GxN)x(GxD)xR	1	12	3	5
K x R	2	14	6	3
N x R	2	10	11	-
Bhagwa	Nil	Nil	7	12
Arakta	Nil	Nil	2	3
Ganesh	Nil	6	3	5
Others	2 - J. Red 1 – Khandhari	1- J. Red 2- G. Red 1- Nana	1 - G. Red 2 - Yercaud 1 - Khandhar 3 - Kalpitya	1- J. Red 1- G. Red 1- JC-1
Total Plants	**09**	**61**	**47**	**32**
Indigenous Collection (IC Nos.)	IC-318743	IC-318702, IC-318724 IC-318728 IC-318734 (2) IC-318744 IC-318764 (2)	IC-318705 IC-318724(2 Nos) IC-318728 IC-318743 IC-318762 (3 Nos)	IC-318724 (2 Nos) IC-318734 (4 Nos) IC-318762 (2Nos)
Total Plants	**1**	**8**	**8**	**8**
Germplasm from MPKV, Rahuri	17/2, P- 16, Dholka, Yercaud (2 Nos) Bosaka Linsi, Shrin Anar, Jodhpur red, Jallore Seedless, Jyothi	Tabesta, G-137, KRS, Kabuli Yellow (2 Nos), AK Anar, Mnslal, Yercaud Local (2 Nos), GR Pink, Maha, Dorsata, Gulsha red, Nimali, Basein Seedless	17/2 (2 Nos.), G-137, Spin Sakaharin, Jalore Seedless Bedimashri, Kabuli Yellow, AK Anar, Manslal, Ganesh, Dholka (2 Nos.), Khandhari, P-26, GR Pink, Kasuri Bedana, Thinskin Alah, Shrin Anar Jodhpur Red (2 Nos)	Tabesta Basein seedless Co -White Kabuli Yellow
Total Plants	**10**	**15**	**20**	**4**
Over all Total	**20**	**84**	**75**	**44**

Table 9: Effect of antibiotics and chemicals on Bacterial Blight (May 2008)

	Treatment	BBD % Incidence
T1	Control	41.2
T2	Streptocycline 500ppm	20.9
T3	Streptomycin 500 ppm	30.4
T4	Oxytetracycline 500 ppm	36.2
T5	Chloramphenicol 500 ppm	29.7*
T6	Plantomycin 500 ppm	34.9
T7	Kasugamycin (2ml/L)	39.8
T8	Kaolin 2.5%	30.3
T9	Copper sulphate pentahydrate (0.25%)	30.1
T10	Copper hydroxide carbonate (0.25%)	15.8*
T11	Copper sulphate pentahydrate (0.13%)+ Copper hydroxide carbonate (0.13 %)	27.9
T12	Ammonium Chloride (0.25%)	27.5
T`13	Pronopol 500ppm	36.3
T14	Calfomil (0.2%)	36.7
T15	Acetic acid (0.8%)	30.6
	CD (0.05)	

Table 10 : Efficiency of Bioagents in Checking Bacterial Blight in Field

Treatment	BBD % Incidence	BBD Severity %
PPFM-pomegranate Solapur isolate (0.1%)	36.8	12.8
Pseudomonas fluorescence—1* (0.1%)	40.2	22.6
Pseudomonas fluorescence—2* (0.1%)	25.6*	6.9
Pseudomonas fluorescence—3* (0.1%)	32.8	10.3
Trichoderma harzianum (0.1%)	34.6	18.5
#Bacterimax (0.3%)	24.0*	9.2
Untreated Control	42.8	29.6
Streptocycline (500ppm)	16.3*	3.2
CD (0.05)	11.20	6.16

* From NCIPM., N. Delhi. All cultures grown for 1 wk. in selected broth media on shake culture
# maxEEma Biotech. Pvt. Ltd., Ahemdabad

Table 11: Effect of bactericides on BB Pathogen *in vitro*

Treatments	Size of inhibition zone (mm^2) at different doses				
	50ppm	100ppm	200ppm	400ppm	**Treatment Mean**
T1: Bactronol-100	28.7	32.0	33.3	37.3	32.8
T2: Bactricell	26.7	30.7	34.0	37.0	32.1
T3: Bactrinashak	21.3	24.7	26.7	29.7	25.6
T4: Streptocycline	20.3	21.7	23.0	24.3	22.3
T5: Captan	0.0	0.0	0.0	0.0	0.0
T6: Control	0.0	0.0	0.0	0.0	0.0
Dose Means	16.2	18.2	19.5	21.4	
CD (5%)	D	0.6			
	T	0.7			
	D x T	1.4			

In Vitro Studies for Bactericidal Activity of Bactronol and Streptocycline

In another *in vitro* study, growth of pure cultures of *Xanthomonas axonopodis pv punicae* was completely inhibited after 3 hours in 500 ppm of Bactronol-100, but in Streptocycline it was reduced after 19 hours. The recovery of bacterial blight pathogen from infected leaf samples treated with Bactronol-100 was reduced after 3 hours and no recovery could be made after 19 hours however, in Streptocycline recovery was reduced after 19 hours (Table 12).

Table 12: Effect of Streptomycin and Bactronol - 100 on Inhibition/bactericidal activity of BB

Time interval after treatment	**Infected Leaves**		**Pure Culture**	
Hours	Bactronol	Streptomycin	Bactronol	Streptomycin
0	*****	*****	***	*****
1	*****	*****	**	*****
2	*****	*****	*	*****
3	***	*****	No Growth	*****
4	***	*****	No Growth	*****
5	***	*****	No Growth	*****
6	***	*****	No Growth	*****
Overnight (19 hrs.)	No Growth	***	No Growth	*
Control	*****	*****	*****	*****

***** :Thick mucilaginous growth in a continuous streak
***: Moderate mucilaginous growth in a continuous streak
**: Slight growth in broken streaks
*: Traces (3-5 colonies)

Evaluation of Orchard Health Management Schedule in Farmer's Field:

A farmer's orchard having >1 ha area, 1000 plants with almost 100 % bacterial blight inidence, has been adopted for second consecutive year, to evaluate 'Orchard Health Management Schedule' in A*mbe Bahar*. The disease is under check till date march 31, 2009 the work is in progress (Fig5).

Fig 5: Adopted orchard where OHM schedule is being evaluated

Leaf and Fruit spots: Surveys revealed prevalence of different fruit spots throughout the year. However, fruit spot severity was higher during the rainy season from July to September months. Isolations revealed presence of fruit spot pathogens namely *Cercopsora punicae, Colletotrichum gloeosporioides, Alternaria alternata and Sphaceloma punicae*.

Pomegranate Scab caused by *Sphaceloma punicae* was recorded in severe proportion at Baramati, Pune (15%), Wadagi (30%), and Tuljapur (25%). The pathogenecity of different cultures from fruit spot isolations was studied and identity of causal organism comfirmed.

Symptoms: Pomegranate Scab was prevalent throughout the year. However, infections on fruits generally initiated in the early stages of their development under humid conditions. Symptoms were prominent as raised, rough brownish lesions of various shapes and sizes. Initially the lesions on fruits were small, circular to irregular, raised, brownish in colour. At times the spots were slightly sunken and light brown in colour at the centre and surrounded by a dark reddish brown margin. In advanced stages of infection the spots appeared as scattered protuberances or crater like outgrowths covering the entire fruit surface (Plate 1a,1b). The spots often coalesced and covered fruit rind with rough scaby eruptions. Isolations from the scab infected fruit tissues revealed growth of *Sphaceloma punicae.* The cultural growth was very slow as colonies appeared about 10 days after isolation at 26.0±°C. Colonies were circular to irregular, reddish brown in colour, compact and well raised above the surface of medium. Fungal growth revealed acervuli arising from a stroma like base and producing small, hyaline, 1 celled, ovoid to oblong conidia (Plate 2).

Plate 1a: Fruit showing initial scab symptoms.

1b:Fruits revealing severe scab symptoms

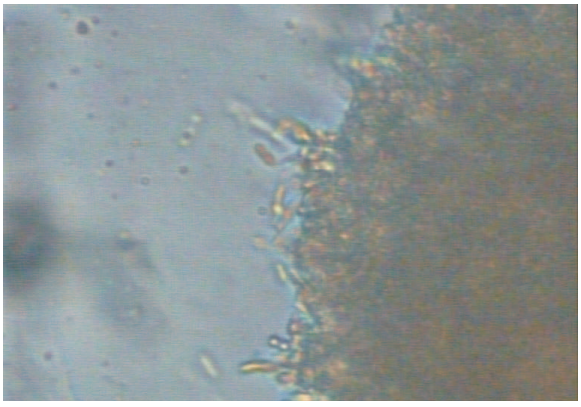


Plate 2: *Sphaceloma* acervulus in culture revealing conidia. (x400)

Seedling blight of Pomegranate: Pomegranate seedlings, 5 months old of cv Bhagwa, growing in pots in net house were found affected with blight disease in the month of October. The disease was so severe that it killed the seedlings of the entire pot in a week's time (Plate 3). The foliage of 5-6 months old plants also revealed water soaked symptoms in the initial stages and gave blighted appearance subsequently (Plate 4). The disease appeared and progressed at temperatures ranging between 19.5 32.6 °C, humidies between 40.1 68.3% and 57.0 mm rainfall. However, most infections were observed at temperature of 23.0°C and RH >80%.

Plate3:*Phytophthora* blight in nursery seedlings

Plate 4: Blighted foliage with *Phytophthora infections.*

The pathogen was isolated from diseased foliage on PDA medium, On the basis of Microscopic examination, cultural and pathogenicity studies, the causal organism of seedling blight was identified as *Phytophthora nicotianae.* Pathogen produced abundant sporangia in culture which were hyaline, spherical, ovoid to pyriform in shape with conspicuous papilla and measured 21.86 - 78.68µ X 21.09 - 45.40 µ (average size 37.89x 28.25µ). Sporangiophores were sparsely branched and formed sporangia either terminally or laterally (Plate 5). Hyphae also produced intercalary sporangia which were spherical in shape. Culture revealed both caducous and non-caducous sporangia. Sporangia germinated either through germtubes (Plate 7) or by forming zoospores (Plate 6) under moist (free water) conditions. The number of zoospores produced by sporangium generally varied between 6 to 40. Sexual reproduction was infrequent as oospores were observed seldom in culture. However, oospore production though rare, was through amphigynous antheridia (Plate 8).

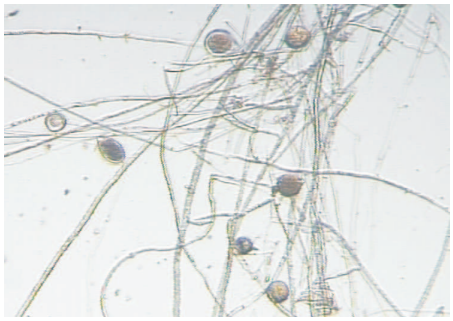
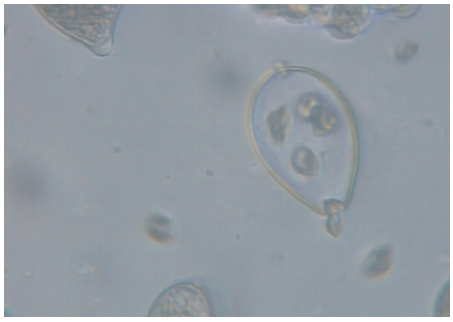


Plate 5: Sporangia in culture of *Phytophthor* through *nicotianae* causing bacterial blight. (x 100)z



late 6: Sporangium germination zoospores in culture.(x400)

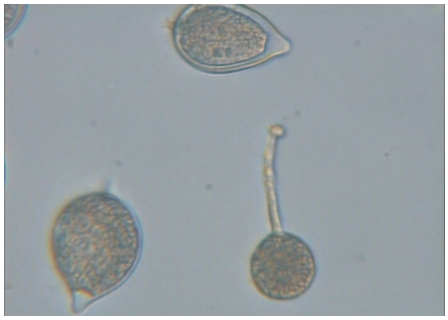


Plate 7: Sporangium germination through germ tube in culture. (x400)

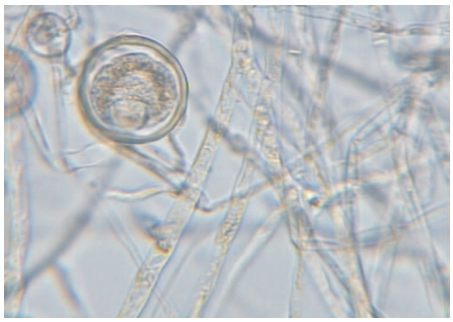


Plate 8; Oospore with amphigynous antheridium in culture. (x400)

Control: Seedling blight of pomegranate caused by *Phytophthora nicotianae* was effectively controlled by sprays of mancozeb (0.2%) at 10 days interval under Net house conditions.

Fruit rot: All rot causing 21 isolates collected were tested for pathogenisity. Ten isolates comprising species of *Phomopsis, Colletotrichum and Aspergillus* resulted in rots on artificial inoculations, however the first two pathogens were most commonly found to cause rot (Fig. 6).

Fig 6: Pathogenicity of rot causing organisms on detatched fruits

Project 3.2: Etiology, Epidemiology and Management of wilt of Pomegranate.

Wilt Severity: Survey of pomegranate orchards in Solapur, Osmanabad, Pune, Ahmednagar, Satara, Nashik and Dhule districts of Maharashtra during 2008-09 revealed that wilt was prevalent in 45% orchards of the State of which 5% orchards revealed wilt in moderate form and 40% in mild form.(Fig.1). In Dhule district wilt was prevalent in moderate to mild proportion (Plate 1) where as in districts of Osmanabad, Pune, A.nagar, Satara and Nashik wilt was observed in mild proportion only. In Solapur, wilt prevalence was 41.02% and disease was observed in moderate to mild proportion in 5.12 to 35.8% orchards, respectively.

Wilt Etiology: Samples of soil and infected plant parts were collected from the wilt affected pomegranate orchards during the surveys to study the disease etiology. About 35 samples comprising of soil from wilt infected orchards and infected plant parts were examined for the presence of the wilt pathogen, *C.fimbriata,* by making isolations on PDA medium and carrot slices. Besides isolations, infected plant parts were also examined under the microscope to observe the presence of *C.fimbriata.* The samples analysed were from Solapur, Osmanabad, Ahmednagar, Pune, Satara, Nashik and Dhule districts of Maharashtra and Koppal and Raichur districts of Karnatka. *C.fimbriata* was isolated from samples collected from Sonake, Kasegaon and Boholi villages in Pandharpur, Kegaon farm (Solapur), Sangamner (Ahmednagar) and village war (Dhule) . The isolations revealed presence of *C.fimbriata* in 7 samples (20.0 % samples) collected from different locations. All the isolates of *C.fimbriata* obtained during the year were homothallic and produced abundant perithcia with long necks (Plate 2). Perithecium produced large mass of ascospores which were released through its neck canal (Plate 3).

The samples from other wilt affected orchards revealed association of *Fusarium* spp (Plate 4) and *Phytophthora* spp. Some wilt infected orchards in village Ner (Dhule), Baramati (Pune) revealed *Fusarium* sp, and nematode infestations. The pathogenicity tests of *Fusarium* spp are in progress. Root knot nematodes were observed in soil samples brought from Tuljapur, Pandharpur and Karnataka. At NRCP farm plant revealing wilt symptoms showed presence of root knot nematodes and eggs in nodules formed on roots of the plant (Plate 5). Some wilted plants in Pandharpur revealed shot hole borer (*Xyleborus fernicatus)* infestation.

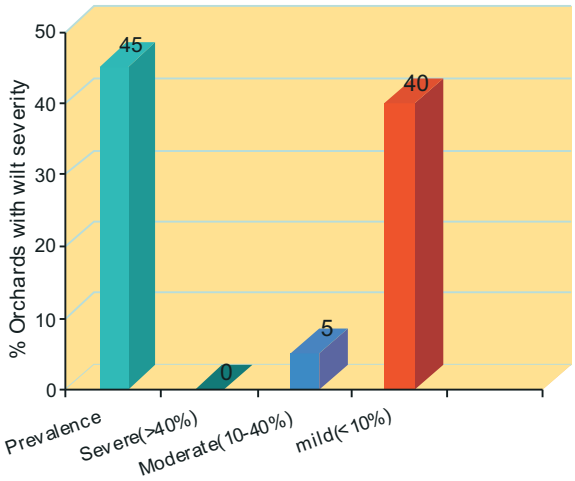


Fig.1: Wilt prevalence and severity in Maharashtra during 2008-09.

Plate 1: Severely wilt affected pomegranate orchard in Dhule district of Maharashtra during July, 2008.

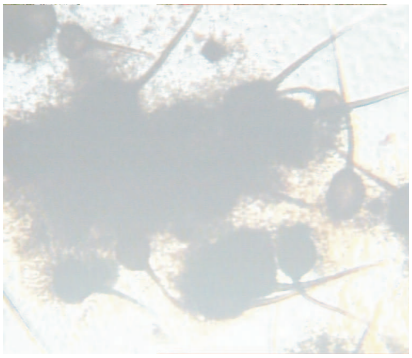


Plate 2: Perithecia in *C.fimbriata* culture (x40).

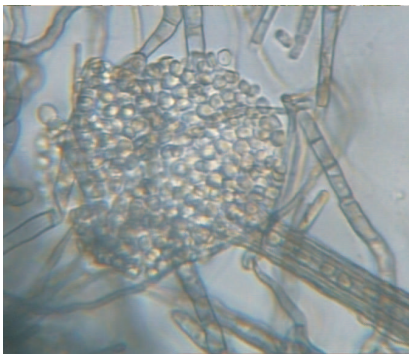


Plate3:Perithecial neck releasing ascospore mass.(x400)

Plate 4: Conidia of *Fusarium* sp. in culture (x400)

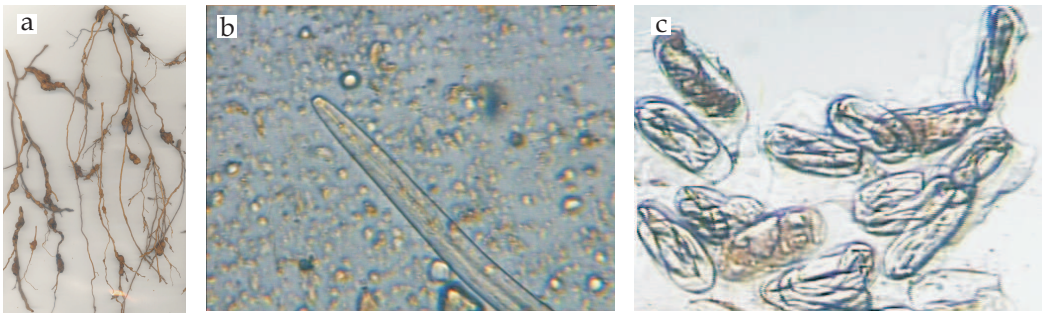


Plate 5. Plant affected with root knot nematode *Meloidogyne incognita revealing* (a) Root Knots (b) Nematode magnified to show stylet 400x (c) developing nematodes in egg sacs 400x

Pathogenicity tests: Results in Table 2 reveal that symptoms in inoculated plots started appearing after 30 days of inoculation in directly inoculated plants and also in treatment where inoculum was added to the soil by injuring the roots.

However, only one plant out of 8 had revealed wilt symptoms in the form of yellowing of leaves after 30 days of inoculations.. Data also reveal that symptom development was more rapid in T2 (injured roots) as 62.5% of the plants revealed wilting after 45 days as compared to T3 treatment where only 25.0% plants revealed wilting after 45 days. After 75 days T2 treatment revealed 87.5% wilting

followed by T3 (75%) and T1(37.5%). After 90 days of inoculation while there was complete wilting in T2 and T3 only 62.5% plants had revealed wilting in T1. After 135 days complete wilting (100%) was observed in T1, T2 and T3 treatments (Plate 2)

It is important to mention that the time period from symptom appearance to complete wilting varied in different plants. In same plant it took only 2 days for a plant to die from the day of symptom appearance, where as in others from appearance of partial wilt symptoms to complete wilt about 2 months were taken. No wilt symptoms were observed in any of the untreated (control) plants till the conclusion of the experiment (plate 3). Soil temperatures during the study period varied between 19.0°C to 39.0°C

Table 13: Development of wilt symptoms in inoculated potted plants during Pathogenicity tests.

Treatments	No.of plants	No of Plants revealing symptoms (%) after Days of inoculation								
		15	30	45	60	75	90	105	120	135
T1:Direct plant inoculation	8	0 (0)	1 (12.5)	2 (25.0)	3 (37.5)	3 (37.5)	5 (62.5)	5 (62.5)	7 (87.5)	8 (100)
T2: Soil inoculation with Root injury	8	0 (0)	1 (12.5)	5 (62.5)	5 (62.5)	7 (87.5)	8 (100)	8 (100)	8 (100)	8 (100)
T3: Soil inoculation without any injury	8	0 (0)	0 (0)	2 (25.0)	6 (75.0)	6 (75.0)	8 (100)	8 (100)	8 (100)	8 (100)
T4: Control	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Plate 2: Inoculated potted Pomegranate plants revealing complete wilting during pathogenicity test.

Plate 3: Healthy plants under control treatment of Pathogenicity test.

Epidemiology: a **Cultivars**: Wilt was observed on all important cultivars during the surveys viz. Bhagwa, Ganesh, Arakta and Mridula. b **Soil**: Surveys of different districts revealed wilt prevalence in all soil types from sandy to sandy loam and heavy black soils in Nashik district. c. **Crop season**: Disease was prevalent throught the year in all the three seasons. d.**Age:** Plants of all ages from 3 to 20 years were found susceptible to wilt.

Association of Insect-pests like shot hole borer, Stem borer and nematodes in wilt infected orchards is indicative of their probable role in spread of wilt pathogen *C.fimbriata.*

Survivability of wilt pathogen in soil: Preliminary studies were carried out on the survivability of *C.fimbriata* in soil. Wilt infected plants in pots were removed in the month of June and soil left in the pots as such. Isolations from such soils were made in the month of October from the same soil samples and also from the control plot (Healthy soil without *C.fimbriata* infection). Isolations revealed growth of *C.fimbriata* in soil collected from the wilt infected pots where as isolations from the control pots did not revealed any growth of *C.fimbriata*. Thus, studies revealed that wilt pathogen was able to survive for 4 months in the soil kept in the field conditions in absence of the host.

4. **Studies on Management of *C. fimbriata***: Two bioagent preparations namely Biohit (*Trichderma viride*) and Biomanarch (*Pseudomonas fluorescens*), an antibiotic Cycloheximide and a chemical Boric acid were evaluated against *C.fimbriata* under laboratory conditions through poisoned food technique.

Table 14: *In vtro* efficacy of Bioagents and chemicals against *C.fimbriata* causing wilt f pomegranate.

Treatment	Fungal growth (Av.colony diameter cm) after 14 days	Per cent growth inhibition after 14 days
T1: *Trichoderma viride* (0.1%)	0.63 (1.26)*	77.33
T2: *Trichoderma viride*(0.2%)	0.37(1.16)*	86.65
T3: *Pseudomonas fluorescens* (0.1%)	2.35 (1.81)	16.37
T4: *Pseudomonas fluorescens* (0.2%)	1.28 (1.47)*	54.55
T5: Cycloheximide (100ppm)	0.0 (1.0)*	100.0
T6: Cycloheximide(200 ppm)	0.0 (1.00*	100.0
T7: Boric acid (0.1%)	0.0 (1.0)*	100.0
T8: Boric acid(0.2%)	0.0 (1.0)*	100.0
T9: Control	2.81 (1.94)	-
C.D (5%)	0.246	
CV (%)	12.79	

Values in parantheses are $\sqrt{(n+1)}$ transformed values. *: Significant at CD(5%)

After 14 days of incubation *T.viride* gave 77.33% and 86.65% inhibition of growth and was found significantly superior over control. *P.fluorescens* gave significant inhibition of growth of *C.fimbriata* only at 0.2% concentration and was found ineffective at 0.1% concentration. Cycloheximide (100 and 200 ppm) and Boric acid (0.1% and 0.2%) gave 100% growth inhibition of the pathogen and were significantly superior over control. In summary, bioagent *T.viride* (0.1and 0.2%) cycloheximide (100 and 200 ppm) Boric acid (0.1 and 0.2%) were found significantly superior over control in inhibiting the pathogen's growth, where as *P.fluorescns* was found effective only at 0.2% concentration.

Screening of Germplasm for Wilt Resistance: 14 germplasm accessions available at the Research station have been evaluated against the wilt pathogen *C.fimbriata*. The following accessions were planted in a sick plot in November 2007 to observe their reaction to wilt pathogen. 1. Surekh Anar 2. Shiah sirin 3. Utthal 4. AHPGC-4 5. Tujets Ec-434T 6. Ganesh New 7. AHPGC-1 8. Crenado-de-Etcho 9. Malta 10. Jallore seedless 11 Kurvi 2K 2468 12. AHPGC-3 13. Bose kalish and 14. Achikdana. All the 14 accessions included in the studies were found susceptible to the wilt pathogen as they showed complete wilting in 5-6 months period (Plate 4)

Plate 4: Germplasm accessions revealing wilt symptoms in *C.fimbriata* infested sick plot.

Pathogenicity of wilt isolates

pathogenicity of 24 wilt isolates collected during two years was tested in pot culture studies using (i) stem base inoculation and (ii) soil inoculation on abraded roots. In the first method only two isolates resulted in complete wilting of plants in Variety Ganesh within 7-13 months after inoculation whereas in the second method 5 Wilt isolates resulted in complete wilting and death of plants of variety Bhagwa, within 1-5 months of adding inoculum. These isolates (W2, W3, W4A. W4B, W5, W9) include species of *Ceratocystis, Macrophomina*, *Fusarium* and 1unidentified isolate.

Transfer of Technology

Participation in Workshops/Meetings/Exhibitions/Lectures delivered.

Sl.No.	Topic/organizes	Venue an Date	Scientist/participants
1	Lecture on propagation of quality planting material in the NHM Workshop on nurseries	Sakhar Sankul Pune April 17, 2008	Dr. K. Dhinesh Babu
2	Agromet Advisory Service IMD Pune	IMD Pune April 22,2008	Dr.K.K.Sharma
3	'Field day' to demonstrate the technology for mitigating bacterial blight in adopted orchard at Hiraj, Solapur. NRCP Solapur.	NRCP Solapur April 26, 2008	Dr. V.T. Jadhav NRCP staff
4	Agriculture Clinic State Department of Agriculture, Pune	State Department of Agriculture, Pandharpur May 30, 2008	Dr.K.K.Sharma
5	Technical guidance to State Department Staff Maharashtra on Pomegranate Production and cultivation NRCP Solapur.	NRCP Solapur August ,2008	Dr. Ram Chandra Dr. K.K. Sharma
6	Pesticides residue monitoring in pomegranate APEDA, New Delhi	APEDA office Vashi, Mumbai. September 11,2008	Dr.K.K.Sharma
7	'Kisan Diwas' to celebrate NRCP's 4th Foundation day. NRCP Solapur	NRCP Solapur September 25, 2008	Dr. V.T. Jadhav NRCP staff
9	Meeting at National Horticulture Mission, Pune	Pune October 18, 2008	Dr.Ram Chandra
10	Residues Monitoring Procedure for pomegranate export APEDA New Delhi.	APEDA's office Vashi ,Mumbai October 31,2008	Dr.K.K.Sharma
11	Production ,Processing Export Standards for pomegranate	Pune December 5, 2008	Dr.Ram Chandra
8	Training to group of farmers from Gujarat on pomegranate production and protection. NRCP Solapur	NRCP Solapur December 22, 2008	Dr. Ram Chandra Dr. K.K. Sharma
12	Group meeting of farmers	Jafarabad ,Jalna December 24, 2008	Dr.Ram Chandra

Sl.No.	Topic/organizes	Venue an Date	Scientist/participants
13.	Pomegranate traceability training for pomegranate exporters organized by APEDA New Delhi.	Draksha Bhawan Nashik January, 19,2009	Dr.K.K.Sharma
14.	Buyer- Seller meet on the cluster formation for trade promotion of pomegranate APEDA New Delhi.	APMC, Pandharpur, Solapur January 30, 2009.	Dr. Ram Chandra Dr.K.K.Sharma
15.	Group meeting of farmers	Osmanabad January, 2009	Dr.Ram Chandra
16.	Lecture on 'Pomegranate cultivation and ongoing activities of NRCP to 25 students of Institute of management Mumbai. Educational Trust.	NRCP Solapur March 24, 2009	Dr. K. Dhinesh Babu
Dissemination of Technology through Mass Media			
17	Management of Pomegranate Orchards during rainy season	Annadata Programme on E-TV (Marathi) October 18,2008	Dr R.A Marathe
18	Production of planting material of pomegranate.	Annadata programme on E- TV (Marathi) October 23,2008.	Dr R.A Marathe

Dr HP Singh DDG (Hort) ICAR interacting with growers on the occasion of Field Day being celebrated to demonstrate technology for mitigatioin of pomegranate bacterial blight in April, 2008.

Director addressing the gathering during ICT workshop organized by NRCP&NCIPM on April 10, 2008

ADG (Hort) Visits Hiraj to observe orchard adopted by NRCP for rejuvenation in April 5,2008

RAC Chairman and Members visits Growers' orchard in Satara district on August 4,2008.

NRCP bacterial blight Staff visits adopted orchard at Pandharpur in November 2008.

Network project Scientists from different organizations visits NRCP farm to observe germplasm on December 17,2008.

Institutional Activities

Institute Research Council Meeting (IRC)

Institute Research Council meetings were organized twice during the year on April 5, 2008 (3rd IRC) and April 20, 2009 (4th IRC) by the Centre.

The third Research Council Meeting was held on 5th April, 2008 under the chairmanship of Dr V.T. Jadhav, Director NRCP and was attended by Dr S.N.Pandey ADG (Hort) ICAR who was a special invitee. Besides, all the Scientists of the Centre attended the meeting and presented their Project results. Two new projects were proposed and approved during the meeting.

The 4th SRC of the Centre was held on 27th April 2009. The Research achievements and work plan of ongoing 8 projects were presented during the meeting by the concerned scientists. Director informed that major emphasis should be given on organic farming with special reference to exploitation of bioagents for nutrition and plant protection as demand of the organic pomegranate would increase in the future.

The meeting was attended by the following members.

Institute Research Council			
1	Dr V.T.Jadhav	Director NRCP	Chairman
2	Dr (Mrs)Jyotsana Sharma	Principal scientist	Member
3	Dr K.K Sharma	Sr.Scientist	Member
4	Dr R.A. Marathe	Sr.Scientist	Member
5	Dr K.Dhinesh Babu	Scientist (Sr.Scale	Member
6	Dr Dr Ashis Maity	Scientist	Member
7	Dr Ram Chandra	Principal Scientist	Member-Secretary

Institute Management Committee (IMC)

The fourth IMC meting of the centre was held on January 27, 2009 at NRCP Solapur. The meeting was attended by the following members.

Institute Management Committee			
1	Dr V.T.Jadhav	Director NRCP	Chairman
2	Dr Ram Chandra	Principal scientist	Co-Member
3	Dr R.A Marathe	Sr.Scientist	Co-Member
4	Shri Prabhakar Chandane,	President, Pomegranate Growers Association, Pune Maharashtra	Member
5	Shri Vishwasrao Kachare	Progressive grower, Mohol	Member
6	Shri D.L.Tambale	DSAO,Dept. of Agriculture, Solapur	Member
7	Shri K.S.Sharma	AAO	Member-Secretary

Members gave their suggestions for the improvement and smooth functioning of the R & D of the NRCP. Some issues discussed during the meeting included, Confirmation of the proceedings of the 3rd IMC meeting, Review of action taken on the recommendations, Condemnation of vehicle and Substitution in the list of equipments.

Director chairing the IMC meeting on January 27, 2009.

Research Advisory Committee Meeting (RAC)

The third Research Advisory Committee Meeting of the NRCP was held on August 4 and 5, 2008 at NRCP Solapur to review the ongoing research work and provide inputs for further improvement of Research Programmes for enhancing pomegranate production and its utility through value addition. During the meeting Director highlighted the Centre's Research related activities and infrastructure development programmes which was followed by presentation of research achievements by the Scientists of their respective projects. The committee visited the NRCP farm at Kegaon and observed the experiments being carried out on various aspects of pomegranate production and protction, germplasm repository and development of water harvesting structures. Committee appreciated the expeditious development that had taken place in short period and congratulated the Director and his team for their strenuous efforts in the development of the farm. Committee members also visited pomegranate orchards in Satara district and were glad to observe the healthy and disease free crop of pomegranate. The members interacted with the growers to know their problems and suggested them various measures to enhance production and manage important diseases and insect-pests. The committee after having reviewed the work of the Centre came out with important recommendations to solve the problems related to pomegranate cultivation through micropropagation and genetic approach and fruits diversified use in value addition. The meeting was attended by the following members.

Research Advisory Committe			
1	Dr S.N Rao	Ex Director of Research AP Agricultural University,Hyderabad	Chairman
2	Dr V.T.Jadhav	Director NRCP Solapur	Member
3	Dr S.N.Pandey	ADG (Hort) ICAR	Member
4	Dr R.P.Kachru	Ex-ADG (Process.Eng.) ICAR	Member
5	Dr G.C.Srivastava	Ex-Prof. Physiology IARI, N.Delhi	Member
6	Dr D.M.Sawant	Assoc.Dean & Principal COA, Kolhapur	Member
7	Dr D.P.Waskar	Assoc.Dean & Principal COA, Badnapur	Member
8	Shri Prabhakar Chandane,	President, Pomegranate Growers Association, Pune Maharashtra	Member
9	Shri Vishwasrao Kachare	Progressive grower, Mohol	Member
10	Dr K.K.Sharma	Sr.Scientist	Member-Secretary

RAC meeting being chaired by Dr S..N.Rao ,Chairman at NRCP Solapur on August 5, 2008.

Foundation day

National Research Centre on Pomegranate Solapur celebrated its 4th foundation day on 25th September 2009 by organizing a Farmers' day at the Kegaon farm.. About 100 pomegranate growers from different parts of the State attended the function to acquaint themselves with existing technologies for producing good quality pomegranate with higher yields. Shri Prabhakar Budhwant, Superintendent of Police and Dr Jagdish Patil, Collector Solapur were invited as Chief guests during the function who addressed the gathering by highlighting the importance of Agriculture in the development of the Nation and were glad to observe the pomegranate plantation and water harvesting structures for efficient water use at the farm. Dr V.T.Jadhav Director, in his speech informed that every care is being taken to solve the major problems being faced by the growers in pomegranate production. He specifically mentioned the damage to pomegranate crop due to dreadful diseases like bacterial blight and wilt for which research work was underway to find out better and economic alternatives to existing chemicals for effective disease management. Scientists delivered lectures on different aspects of

pomegranate cultivation, management of diseases and insect-pests and nutritional value of pomegranate. Towards the end of the function, Scientists replied to various questions posed by the growers regarding several difficulties faced by them right from plantation to marketing of pomegranate.

SP and Collector Solapur , Chief guests visiting the NRCP Farm alongwith Dr V.T Jadhav Director on the Foundation day of NRCP on 25th September 2008.

Hindi Day

In order to encourage the use of National language Hindi in routine work of government offices , Hindi Week was organized by the NRCP during September 15 to 22, 2008. Dr D.K.Kathmale Associate Professor, ADR Solapur who was the chief guest on the occasion spoke on the role of Hindi language in the development of the Nation by citing examples from ancient Indian epics. Dr V.T Jadhav, Director opined his views mentioning that Hindi could play a vital role in strengthening the unity of the country where so many regional languages are existing in different States. The occasion was marked by participation of staff members with zeal in various competitions meant to encourage the use of Hindi , such as essay writing , quiz and debate contests, poem reciting and drafting of proposals etc. The 'Hindi Week' concluded with distribution of prizes to winner contestants of different competitions by the Chief guest on September 22, 2008.

Chief guest addressing the NRCP Staff on the occasion of Hindi Week celebrated at NRCP Solapur during 15.9.08 - 22.9.08.

Network Project Meetings on 'Mitigation of Bacterial blight in Maharashtra, Karnataka and Andhra Pradesh'.

Meeting of Scientists working on Network Project 'Mitigation of bacterial blight in Maharashtra, Karnataka and Andhra Pradesh' was convened by the NRCP Solapur to asses the progress of work made under the project on May 17, 2008 and December 17 2008. The meeting was attended by Dr Borkar Head, Plant pathology MPKV Rahuri, Maharashtra, Dr V.I. Benagi, Head, Plant Pathology UAS Dharwad Karnataka,Dr U.G.Kulkarni Assoc.Dean&Principal CoA Osmanabad, and all other scientists associated with the project from IIHR Bangalore, MAU, Parbhani and APHU Ananthpur. Besides, Scientists working on the project at NRCP Solapur also participated in the meeting. The progress report of various centres was presented by the respective Project Coordinators under the chairmanship of Dr V.T.Jadhav Project Director, Network project. Apart from progress report, financial aspects pertaining to different activities such as Training programmes , purchase of equipments and chemicals and expenditure on surveys were also discussed .

Director NRCP chairing the Network project meeting on mitigation of bacterial blight of pomegranate at NRCP Solapur on 17.12.08.

High level Meeting to Review the Research Progress on bacterial blight of Pomegranate.

A high level Meeting to review the progress of research work done on bacterial blight was organized by the NRCP Solapur in Mumbai on 5th February 2009. The meeting was chaired by Shri Sharad Chandra Pawar, Union minister of Agriculture. Other dignitaries who attended the meeting included Dr H.P. Singh DDG (Horticulture) ICAR, Managing Director, National Horticulture Mission Pune, Joint Secretary Ministry of Agriculture and Cooperatives and all the Scientists involved in research work on bacterial blight from SAUs and ICAR Institutes. Besides Scientists, meeting was also attended by officials of State Agriculture Department and progressive growers. The Status report on bacterial blight was presented by Dr V.T.Jadhav Director who described the historical background of the disease and major achievements of the work conducted on the disease at NRCP. Progress reports of the work being carried out at different centres were presented by the respective scientists of the institutes. After thorough discussion amongst the participants and interaction with the growers had taken place, the Agriculture Minister approved the extension of financial package for implementation of GMP to the pomegranate growers for the third consecutive year.

Union Agriculture Minister chairing the Meeting on Review of work on pomegranate bacterial blight held in Mumbai on February 6, 2009.

Participation of Scientists / Staff in Conferences /Courses /Meetings/ Symposia /Workshops/Trainings during 2008-09.

Sl No.	Title	Venue & Date	Name of the participant.
1	Workshop on ICT based surveillance of pests of pomegranate in Maharashtra State.	NRCP Solapur April 10, 2008	Dr.V.T.Jadhav Dr.Ram Chandra Dr.K.K.Sharma Dr.R.A.Marathe Dr.Jyotsana sharma Dr. K. Dhinesh babu Dr.Ashis Maity
2	Technical workshop on NETWORK project for mitigating bacterial blight disease of pomegranate.	NRCP Solapur May 17, 2008	Dr V.T.Jadhav Dr.K.K.Sharma Dr.R.A.Marathe Dr.Jyotsana sharma Dr. K. Dhinesh babu Dr.Ashis Maity
3	Organization of International Symposium on pomegranate.	College of Agriculture, Bijapur, Karnataka , June 23,2008	Dr.Ram chandra Dr.K.K.Sharma
4	National training on DNA sequencing of Agriculturally important microorganisms.	NBAIM, MAU, U.P. September 1 to 7, 2008	Dr.K. Dhinesh Babu
5	Pesticides residue monitoring in pomegranate.	APEDA office Vashi, Mumbai. September 11,2008	Dr.K.K.Sharma
6	Development of Horticultural crops in Maharashtra.	Sakhar Sankul ,Pune October 18,2008	Dr.V.T.Jadhav Dr.Ram chandra Dr.K.K.Sharma
7	Interactive meeting on post harvest Management of horticultural crops	IIHR Bangalore October 23-24,2008	Dr.K. Dhinesh Babu
8	Residues monitoring procedure for pomegranate export.	APEDA's office Vashi, Mumbai October 31,2008	Dr.K.K.Sharma
9	Winter school on hi-tech Production & Horticulture organized by ICAR, N. Delhi.	CIAH Bikaner November 4-24, 2008.	Dr.K. Dhinesh Babu
10	Production ,Processing, Export Standards for pomegranate.	Pune December 5,2008	Dr.Ram Chandra
11	Second International symposium on papaya.	TNAU, Coimbatore Madurai ,Tamilnadu December 9-12, 2008	Dr.K. Dhinesh Babu

12	Workshop on Review the progress under NETWORK project for mitigating bacterial blight disease.	NRCP ,Solapur December 17, 2008	Dr.V.T.Jadhav Dr. Ram Chandra Dr.K.K.Sharma Dr.R.A.Marathe Dr.Jyotsana sharma Dr. K. Dhinesh babu
13	High level meeting to Review Research work on pomegranate bacterial blight .	Chavan Centre Mumbai, February 6,2009	Dr.V.T.Jadhav Dr.Ram Chandra Dr.K.K.Sharma Dr.R.A.Marathe Dr.Jyotsana sharma Shri K.S. Sharma Shri Mahadev
14	Workshop on Agri-Horti grass species.	New Delhi March 25, 2009	Dr.Ram Chandra

Publications

Research Articles

1.K. Dhinesh Babu**,** L.C.De, R.K.Patel and Akath Singh. 2009**.** Genotypic amenability guava for patch budding. *Indian J. Hort*. 66(2): 264-266.

2.K. Dhinesh Babu, Ram Chandra, L.C. De, D.Paul, Akath Singh and R.K.Patel. 2007. Evaluation of guava selections for productivity and quality traits. *International Journal of Tropical Agriculture* 25 (1-2): 83-87 .

3. Marathe,R.A., P.R. Bharambe, R.Sharma and U.C.Sharma. 2009. Soil properties of vertisol and yield of sweet orange (*Citrus sinensis*) as influenced by integrated use of organic manures, inorganics and biofertilizers. *Indian journal of Agricultural Sciences* 79 (1): 3-7.

4. Marathe,R.A., P.R. Bharambe, R.Sharma and U.C.Sharma. 2009**.** Leaf nutrient composition, its correlation with yield and quality of sweet orange (*Citrus sinensis*) and soil microbial population as influenced by INM in vertisols of central India.*Indian Journal of Horticulture* 66 (1): (in press).

5. Sharma, K.K., Jyotsana Sharma, V.T. Jadhav and Ram Chandra. 2008. Bacterial blight of pomegranate and its management. *Indian Phytopath* 61 (3) : 380-81.

6. Sharma, K.K., Jyotsana Sharma and V.T. Jadhav. 2008. Prevalence and etiology of wilt of pomegranate. *Indian Phytopath* 61 (3): 381.

Papers presented in Symposia/workshops/Meetings/Conferences

1.Chandra,R,R.A.Marathe,V.T.Jadhav,K.K.Sharma,K.DhineshBabu.2008.
Appraisal of constraints of Pomegranate cultivation in Karnataka. 3rd Indian horticulture Congress, 'New R&D initiatives in Horticulture for Accelerated growth and prosperity' held from November 6-9,2008 at OUAT, Bhubaneshwar,Orissa. Abstract (p 252)

2.K. Dhinesh Babu, S. Sathiamoorthy and N. Chezhiyan. 2008. Standardization of protocol for elongation of microshoots of papaya. In: Book of abstracts of Second International symposium on Papaya, 9-12 December, 2008 organized by Tamil Nadu Agricultural University, Coimbatore and International Society for Horticultural Science, Leuven, Belgium at Madurai, India (S-III-2) p.44

3.K. Dhinesh Babu, R.K.Patel, Akath Singh, D.S.Yadav, L.C. De and B.C. Deka. 2008. Seed germination, seedling growth and vigour of papaya under north eastern India.In : Book of Abstracts of Second International symposium on Papaya, 9-12 December, 2008 organized

by Tamil Nadu Agricultural University, Coimbatore and International Society for Horticultural Science, Leuven, Belgium at Madurai, India (S-IVA-7) p.73

4.Marathe,R.A., P.R. Bharambe, R.Sharma and U.C.Sharma. 2008. Leaf nutrient composition, its correlation with yield and quality of sweet orange (*Citrus sinensis*) and soil microbial population as influenced by INM in vertisols of central India. Abstract. Third Indian Horticulture Congress,November 6-9,2008, Bhuvaneshwar, Orissa, p 220.

Technical Bulletins

1.Marathe,R.A. 2009. Dalimb Bahuguni Aushadhi Phal . *Technical Bulletin*, National Research Centre on Pomegranate Solapur.

Chapters in Books

1.N. K. Parameswaran and **K. Dhinesh Babu**. 2009. Polyembryony and its prevalence in horticultural crops. *In: Basics of Horticulture (Ed. K V Peter)* New India Publishing Agency, New Delhi. p.11-22 (Recommended as a Text and reference to PG students in Horticulture as per Revised ICAR PG Syllabus 2008)

Other Publications (Scientific/Teaching Reviews)

1.K. Dhinesh Babu**,** Amit Nath, L.C. De, B.C. Deka and K.M. Bujarbaruah **.** 2008. Guava (*Psidium guajava* L.). *In: Underutilized and underexploited horticultural crops* (K. V. Peter, Ed.), New India Publishing Agency, New Delhi, India

2.Marathe,R.A., V.T.Jadhav and R.Singh. 2008. Soil and Nutrient aspects in Pomegranate (*Punica granatum* L.) *Environment and Ecology* 27 (2): 630-37

Compilations

1.Ram Chandra, Jyotsana Sharma and R.A.Marathe. 2008. *Annual Report* 2007-08. National Research Centre on Pomegranate, Solapur.62p.

2. Jadhav, V.T., Jyotsana Sharma, K.K.Sharma and R.A.Marathe. 2009. *Training Manuals for State Government and State Agricultural University officers*, National Research Centre on Pomegranate. 43 p.

3.Jadhav, V.T., Jyotsana Sharma, K.K.Sharma and R.A.Marathe. 2009. *Training Manual for Farmers and Nursery Men.*, National Research Centre on Pomegranate.34 p.

4. Jadhav, V.T., Jyotsana Sharma, K.K.Sharma and R.A.Marathe. 2009. *Prashiksan Pustika Rajys Sarkar va Krishi Vidyapeeth adhikaryansathi*, National Research Centre on Pomegranate.47 p.

5. Jadhav, V.T., Jyotsana Sharma, K.K.Sharma and R.A.Marathe. 2009. *Prashiksan Pustika Phalvatika va bagayatdransathi.*, National Research Centre on Pomegranate. 38 p.

Awards/Recognitions

- Dr Ram Chandra, Principal scientist, received HIS Gold Medal for 2007-08 for work in the field of medicinal and aromatic plants from Horticulture Society of India.

Distinguished Guests during 2008-09

Name	Designation/Address	Date
Dr S.N.Pandey	ADG (Hort) ICAR,New Delhi.	April 5,2008
Dr O.M.Bambawale	Director ,NCIPM New Delhi.	April 10,2008
Dr H.P. Singh	DDG (Hort) ICAR New Delhi	April 26, 2008
Dr C.D.Mayee	Chairman, ASRB, New Delhi.	August11,2008
Dr V.S. Korikantimath	Director, ICAR Research complex Goa.	April 21,2009

Dr S.N.Pandey ADG (Hort) ICAR observing experiments on his visit to NRCP on April 5,2008.

Dr O.M.Bambawale Director NRCM N.Delhi delivering lecture on ICT based surveillance during April 10,2008.

Dr H.P.Singh DDG (Hort) ICAR interacting with scientists during his visit to NRCP Solapur on April 26,2007.

Dr C.D Mayee Chairman ASRB N.Delhi interacting with Scientists during his visit to NRCP Solapur on August 11,2008.

Research Programmes and Projects

Programmes and Project No.	Title	Principal Investigator (PI) and Associates
Programme 1.Improvement and production in Pomegranate		
Project 1.1.	Survey, collection,evaluation, propagation and improvement of pomegranate	Dr. Ram Chandra (PI) Dr. R.A. Marathe Dr. Jyotsana Sharma Dr. V.T. Jadhav Er, D.T. Meshram Dr. K. Dhinesh Babu
Project 1.2.	Improvement of pomegranate : Flower biology of Pomegranate	Dr. K. Dhinesh Babu (PI) Dr. Ram Chandra Dr. Jyotsana Sharma
Project 1.3.	Exploitation of bioagents in pomegranate productivity	Dr. V.T. Jadhav (PI) Dr. Ram Chandra Dr. Jyotsana Sharma Dr. R.A. Marathe Dr. Ashis Maity
Programme 2. Soil, Water and Nutrient Management in Pomegranate		
Project 2.1.	Identification of Suitable soils for Sustained productivity of pomegranate	Dr. R.A. Marathe (PI) Dr. Ram Chandra Dr. V.T. Jadhav
Project 2.2	Nutrient Management in pomegranate	Dr. R.A. Marathe (PI) Dr. Ram Chandra Dr. V.T. Jadhav
Project 2.3.	Water Management in pomegranate orchards under different soil types.	Dr. R.A. Marathe (PI) Dr. Ram Chandra Dr. V.T. Jadhav
Programme 3:.Management of Diseases and Insect Pests of Pomegranate		
Project 3.1.	Studies on Economically Important Diseases of pomegranate with special emphasis on bacterial blight and their Control.	Dr. Jyotsana Sharma (PI) Dr. K.K. Sharma Dr. V.T. Jadhav
Project 3.2.	Etiology, Epidemiology and Management of wilt of pomegranate	Dr. K.K. Sharma (PI) Dr. Jyotsana Sharma Dr. V.T. Jadhav
Externally Funded Project		
	NETWORK P ROJECT ON 'Mitigating Bacterial Blight of pomegranate' in Maharashtra, Karnataka and Andhra Pradesh (National Horticulture Mission)	Dr. V.T. Jadhav (Project Director) Dr. Jyotsana Sharma (Project Coordinator) Additional Coordinators Dr. K.K. Sharma Dr. R.A. Marathe Dr. K.Dhinesh Babu

Personnel

Name	Designation
RMP	
Dr. V.T. Jadhav	**Director**
Scientific Staff	
Dr. Ram Chandra	Principal Scientist (Horticulture)
Dr. (Mrs) Jyotsana Sharma	Principal Scientist (Pathology)
Dr. K.K. Sharma	Sr. Scientist (Pathology)
Dr. R.A. Marathe	Sr. Scientist (Soil Science)
Dr. K. Dhinesh Babu	Scientist Sr. Scale (Fruit Science)
Dr. D.T. Meshram	Scientist (Soil and water conservation Agricultural Engineering)
Dr. Ashis Maity	Scientist (Soil Science)
Technical Staff	
Shri. Dinakar Chaudhari	T-3 Field Technician
Shri. Mahadev Gogaon	T-1 Field Technician
Shri. Govind Anirudh Solanki	T-1 Field Technician
Administrative Staff	
Shri. K.S. Sharma	Assistant Administrative Officer
Shri. R.B. Rai	Assistant
Supporting Staff	
Shri. Shilendrasing Shivpising Bayas	Skilled Support Staff
Shri. Vishal Shankar Gangane	Skilled Support Staff

Staff Position

Sr. No.	Category	Sanctioned posts	Filled up posts	Vacant posts
1.	RMP	1	1	Nil
2.	Scientific	9	7	2
3.	Technical	4	3	1
4.	Administrative	5	2	3
5.	Supporting	2	2	-
Total		21	15	6

Recruitments/Promotions/Relievings/Sabbatical leave

Recruitments

Scientist

Dr. Ashis Maity joined NRCP as scientist (Soil Science) on May 16, 2008.

Technical

Shri. Govind Anirudh Solanki joined NRCP as T1 field Technician on November 12, 2008.

Promotions

Scientist

Dr. (Mrs). Jyotsana Sharma promoted from Sr. Scientist to Principal Scientist w.e.f. 27.07.2007

Transfers/Reliving

Shri. Amol Kumar Rathod, LDC, relinquished the post and was relieved on January 7, 2009.

Shri Jayant Jagannath Kulkarni , Technical T-3 , relinquished the post and was relieved on January 24,2009.

Sabbatical Leave

Er. D.T. Mesharam Scientist (Soil and water conservation Agricultural Engineering) has been on sabbatical leave since 2007 to undertake Doctor of Philosophy programme in Agricultural engineering from MPUAST, Udaipur Rajasthan.

Financial Outlay, 2008-09

Head	Rs. in lakhs					
	BE		RE		Actual utilization	
A. Recurring	**Plan**	**Non Plan**	**Plan**	**Non Plan**	**Plan**	**Non Plan**
Pay and Allowances	1.00	65.00	--	64.80	--	73.86
TA	5.00	1.00	1.00	1.80	1.00	1.80
Contingencies	68.00	40.0	70.00	45.00	70.00	45.00
HRD	1.0	--	0.0	0.0	0.0	0.0
Information an Technology	3.0	--	0.0	0.0	0.0	0.0
Total (A)	78.00	106	71.00	111.60	71.00	120.65
B. Non. Recurring				--		
Equipments	47.00	0.0	110.23	--	110.23	--
Works, Repairs and Maintenance	100.00	2.0	55.27		55.27	--
Land	--				--	
Library books/Journals	10.00		10.00		10.00	--
Vehicle	--		--		--	
Furniture / Fixture	15.0		3.50		3.50	--
Others		2.00	--			
Total (B)	172	4.00	179	0.00	179.0	0.00
Grand Total (A +B)	250.00	110.00	250.00	111.60	250.00	120.65

Meteorological observations, 2008-09, NRCP Solapur

Month	Temperatures °C		Relative Humidity %		Pan Evaporation mm	Total Rainf all mm	Wind Velocity Kmp hr	Sunshine hrs
	Max.	Min.	Max.	Min.				
April	38.53	23.13	48.90	28	10.71	29.0	7.88	9.17
May	37.74	22.67	54.74	29.52	12.92	15.6	12.15	8.49
June	34.58	23.75	64.70	41.1	9.89	47.6	15.22	2.38
July	33.05	23.34	69.97	50.23	7.69	160.6	14.33	5.40
August	30.52	22.03	78.55	59.35	4.91	142.7	10.72	4.77
September	30.36	21.48	82.60	63.6	3.95	169.4	8.05	5.31
October	32.67	19.59	68.39	40.81	5.09	57.3	7.15	8.69
November	31.25	18.47	65.73	42.7	3.74	76.7	7.69	7.34
December	30.48	16.17	64.61	35.55	3.03	2.2	6.23	8.73
January	31.29	16.02	62.77	31.42	4.45	0.0	6.41	9.14
February	35.03	18.72	50.50	26.93	6.70	0.0	6.87	9.65
March	34.6	21.31	54.58	38.03	10.66	5.2	8.28	8.65

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