# Annual Report
# 2011-12


**National Research Centre on Pomegranate**

**Solapur**-413 255 Maharashtra

(Indian Council of Agricultural Research)

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# Preface

Research programmes undertaken by the Centre and achievements accomplished under these during 2011-12 are being enumerated in the present sixth Annual Progress Report of the NRCP. It may not be an exaggeration to mention that the research achievements of the year have been satisfactory particularly in view of the working space and experiment plots constraints as the centre at present is housed in the Centre on Rabi Sorghum and is in the process of shifting to its new building at Kegaon soon.

Necessary steps have been ensured to disseminate the established achievements to the growers and other stakeholders involved in the pomegranate industry. The Centre has collected and maintained about 345 germplasm accessions which are indigenous as well as exotic and the work on germplasm enhancement and hybridization for developing improved varieties resistant to important diseases and insect-pests may yield positive results in the time to come. Integrated disease and pest management (IDPM) schedule has been successfully implemented in coordination with SAUs and other ICAR Institutes in growers' adopted orchards in the States of Maharashtra, Karnataka and Andhra Pradesh for mitigating dreaded disease like bacterial blight and other important diseases and insect-pests. NRCP has been imparting necessary trainings to the extension staff of the State Agriculture Department and KVKs for monitoring important diseases and insect-pests under the CROPSAP.

Being a newly established Centre, Infrastructure and land development activities have been a key issue for its smooth functioning and it is with pleasure to mention that enervating task has almost been completed. Newly constructed Office-cumlaboratory building is ready for occupation by the Centre and also undulating and forest land provided to the Centre has been developed and cleared up for pomegranate plantation and experiments on different aspects of pomegranate production are in progress. Necessary measures have been taken to meet the water scarcity problem for irrigation purpose by developing water harvesting structures and renovating the already existing dug-wells. All this strenuous exercise has been possible only due to the perseverance of the staff of NRCP for which I am grateful.

I express my profound gratitude to Dr S. Ayyappan DG, ICAR & Secretary DARE, Dr H.P. Singh, DDG (Hort.), ICAR and Dr S.N. Pandey (Former ADG, ICAR) & Member RAC for their persistent support in the overall development of the Centre.

(V.T.Jadhav)
Director

June 14, 2012
Solapur

# Contents

# Introduction

National Research Centre on Pomegranate was established in September, 2005 at Solapur district of Maharashtra by the Indian Council of Agricultural Research to explore the vast potential of pomegranate in the country for its enhanced quality production through concerted research programmes. Pomegranate (*Punica granatum* L.) is an ancient plant belonging to the sub-family punicoideae of family Lythraceae and is known for its nutraceutical properties and health benefits. Pomegranate, because of its adaptability to varied climatic and soil conditions is well suited to grow in tropical and sub-tropical regions of the country. Globally, at present, India is one of the leading countries in pomegranate acreage (107 thousand ha) and production (743 thousand t) and the crop is commercially grown in the states of Maharashtra, Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu and to some extent in some other states of the country also.

Major Research programmes of the Centre focus on germplasm enhancement, breeding varieties for improved qualitative and quantitative traits and resistant to biotic (bacterial blight disease) and abiotic (fruit cracking, sun scald) stresses, production of healthy, disease free planting material through Tissue culture, studies on important diseases and insect-pests of pomegranate and their integrated management, improving soil, nutrient and water use efficiency for sustainable production, post harvest management for value addition and transfer of technology to farmers and other stakeholders involved in pomegranate industry. The Centre has its library having about 1470 books and subscription to 18 Journals (17 scientific and 1administrative), besides there is an Agricultural Knowledge Management Unit (AKMU). National Research Centre on Pomegranate has about 59.3 ha of land at two locations of Kegaon and Hiraj villages for executing its Research and Development activities. The entire Kegaon block and some part of Hiraj block have been cleared up and developed into experimental plots with drip irrigation facilities installed where studies on different aspects of pomegranate production are underway. Office-cum-laboratory building of the Centre has been recently constructed and the office of the NRCP which at present is housed in Centre on Rabi Sorghum, Shelgi, Solapur will be shifted to its newly constructed building in due course of time.

The NRCP is situated at Kegaon on Solapur Pune highway and is about 12 kms from the City Bus stand and 15 Kms from Railway station. It is located at 17° 68' N and 75° 91' E at an altitude of 457 m above m.s.l. The average minimum and maximum temperatures during the year range between 14.8 to 40.3 ° C respectively, with average rainfall of 693.5.mm, mainly occurring during the south-west monsoon season from June to October months.

The centre has been entrusted with following mandate.

## 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.

## Financial Outlay, 2011-12

| Head of Account | Rupees in lakhs | | | |
|---|---|---|---|---|
| | Plan | | Non-Plan | |
| | RE | Expenditure | RE | Expenditure |
| A. Recurring | | | | |
| Estt. Charges | - | - | 126.82 | 124.72 |
| T.A | 3.50 | 3.50 | 2.05 | 2.05 |
| Other Charges | 29.95 | 29.95 | 102.44 | 102.44 |
| Total A | 33.45 | 33.45 | 231.31 | 229.21 |
| B. Non -Recurring | | | | |
| Equipment | 135.55 | 135.55 | 3.50 | 3.50 |
| Major Works | 233.64 | 233.64 | - | - |
| Library | 3.02 | 3.02 | - | - |
| Furniture | 94.34 | 94.34 | - | - |
| Total B | | | | |
| C. P Loan s & Advances. | - | - | 1.80 | 1.80 |
| D. Pension | - | - | 2.92 | 2.33 |
| Grand Total (A+B+C+D) | 500.00 | 500.00 | 239.53 | 236.89 |

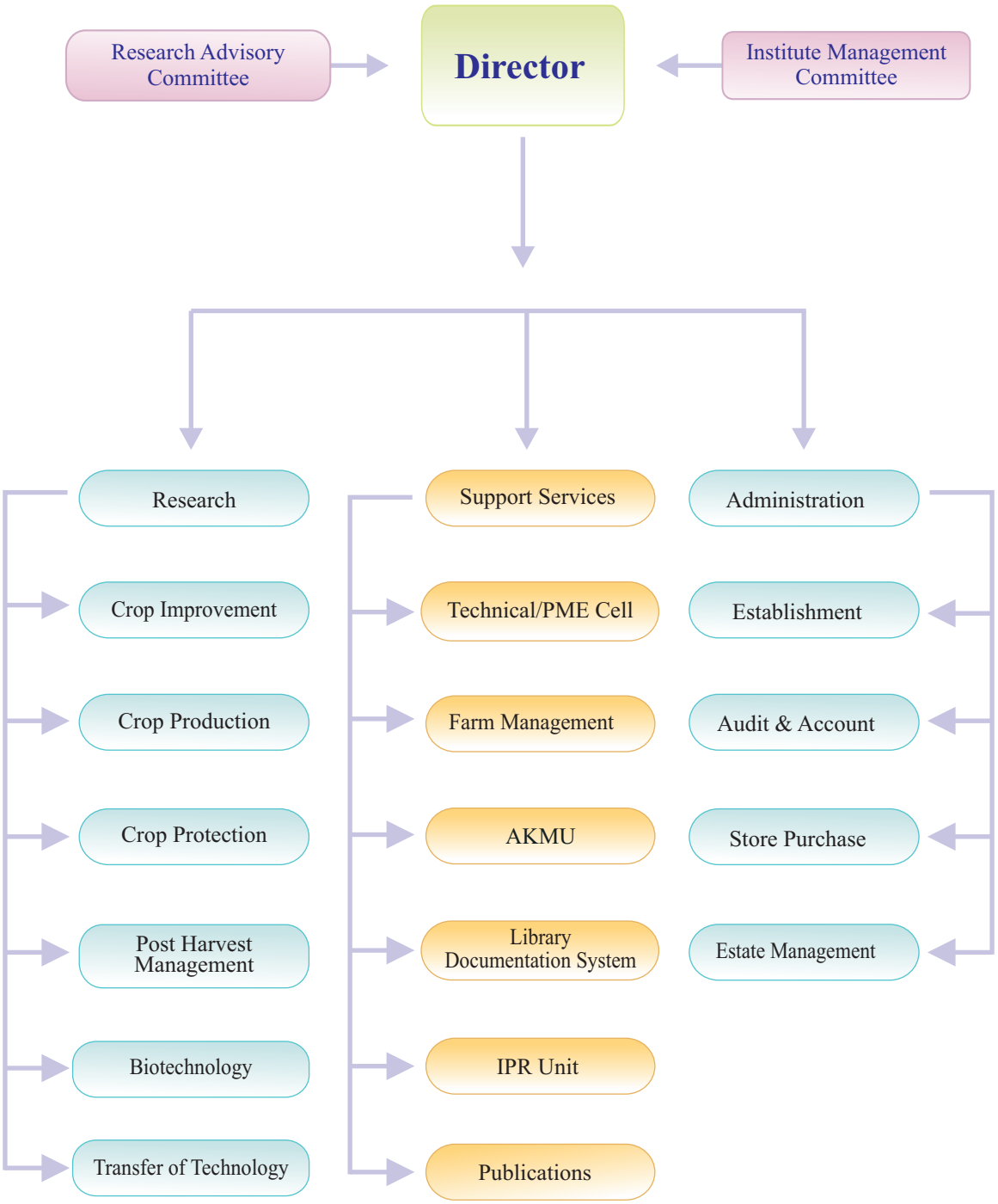
## Revenue Receipts, 2011-12

| Items | Achievements Amount (Rs) |
|---|---|
| 1. Income from Farm Produce | 63,703.00 |
| 2. Income from Royalty and Publications | 70,380.00 |
| 3. Income from Other Sources | 85,350 |
| 4. Interest on loans and advances | 4,700.00 |
| 5. Interest earned on short term deposits | 3,29,810.00 |
| 6. Recovery of loans and advances | 35,600.00 |
| Total Revenue Receipts | 5,89,543.00 |

## Summary Statement of Manpower as on 31.03.2012

| Category | Sanctioned during XI$^{th}$ plan | Staff in position | Vacant Posts |
|---|---|---|---|
| RMP | 1 | 1 | 0 |
| Scientific | 10 | 9 | 1 |
| Technical | 6 | 5 | 1 |
| Administrative | 11 | 5 | 6 |
| Supporting | 2 | 2 | 0 |
| Total | 30 | 22 | 8 |

# Organizational Setup



# Executive Summary

## Improvement

1. **Germplasm enhancement and evaluation:** During the year, fifteen pomegranate accessions were collected from Maharashtra and Orissa. The exotic accessions introduced from University of California, USDA, ARS revealed 86% survivability after one and half year of planting at NBPGR Regional Station Bhowali. The plant height ranged from 49-180 cm. Evaluation of two year old 58 accessions of pomegranate revealed maximum variation with respect to plant spread (EW and SN) followed by thorn length (17.2%).
2. **Evaluation of gamma irradiated population:** In gamma irradiated population of cv. Ganesh, 5 genotypes with marked variability were identified for further evaluation. These were genotypes No. 335 with bigger fruit (448g each) and high aril recovery (72.84%), genotype No. 403 with attractive red rind colour and more TSS and genotype No. 470 having red rind and aril colour than cv. Ganesh. Out of the identified gamma irradiated cv. Bhagawa genotypes, R-65 revealed attractive rind colour with high TSS (17.04° Brix) and genotype R-14 observed to develop attractive red rind colour at higher temperatures of 35.0°C and above.
3. **Variability in seedling population of F3 hybrids:** Studies on variability of F3 population revealed that in general variability was more than 20% in plant height, spread and number of fruits /tree, fruit weight, calyx length, 100 aril weight, rind thickness irrespective of genotypes (hybrids) and as such hybrids seedlings population was highly heterozygous.
4. **Evaluation of bacterial blight tolerant varieties/hybrids:** Four bacterial blight tolerant varieties namely Nana, Daru, Kalpitya and Nayana differed significantly for various qualitative and quantitative traits. Cv. Nayana revealed maximum fruit weight (256.5g), TSS/acid ratio (36.2) and 100 aril weight (32.5g). Four pomegranate hybrids developed at IIHR Banagalore using Ruby as pollen parent were evaluated for vegetative growth, physico-chemical parameters in comparison to cv. Bhagawa. Hybrids revealed better plant height and spread and higher TSS/acid ratio than cv. Bhagawa.
5. **Flower induction in pomegranate:** Out of 14 treatments on flower induction, the treatment consisting of micronutrient mixture 1.5g/l + Nitrobenzene 20% resulted in maximum fruit set (66.9%) which was observed to be at par with IAA 20ppm (64.1%) and Ammonium nitrate 0. 5% (64.07%).

## Production

6. ***In vitro* propagation of pomegranate:** Studies on *in vitro* propagation of pomegranate revealed that nodal segments on MS medium (1.0mg/IBPA + 0.1mg/l NAA) took minimum days (9.8) to sprout along with the highest culture establishment (72 %).
7. **Influence of chemical defoliants on flowering behavior**: Treatment comprising of 0.5% dormex + 0.2% curacron + 1% urea enhanced production of hermaphrodite flowers (87.2%) over control (72.2%).
8. **Influence of chemical defoliants on flowering behavior on old and new shoots**: Effect of chemical defoliants was studied on

production of male and hermaphrodite flowers on old and new shoots in cv. Bhagawa at 30 to 120 days after spraying (DAS). Study revealed that at 30 DAS no flowering was recorded on new shoots but hermaphrodite flowers were almost in equal proportion. However, on subsequent dates male and hermaphrodite flowers decreased on old shoots. At 60 DAS proportion of male flowers on young shoots was more as compared to proportion of hermaphrodite flowers and at 90 days maximum hermaphrodite flowers (47.5%) were recorded which decreased slightly at 120 DAS.

9. **Performance of pomegranate orchards on different soil mixtures used for pit filling**: Plant height and spread (E-W) varied non-significantly amongst the treatments, though plant spread (N-S) showed significant differences and was highest under pits filled with the black clayey soil having depth of 90 and 120 cm in cvs Ganesh and Bhagawa, respectively. In general, vegetative growth performance of plants was better in the black clayey soils as compared to light textured soils.
10. **Physico-chemical properties of different soil mixtures:** Analysis of soil samples for physico-chemical properties revealed that soil pH, EC, Organic carbon and calcium carbonate content were higher in black clayey soils compared to light textured soils. Addition of sand to black clayey soils revealed considerable increase in calcium carbonate content. Nutrients like N, P, K, Cu and Mn were higher in black clayey soils, while available Fe was more in light textured soils. Availability of macro and micro nutrients was sufficient in case of pits filled with only murrum.
11. **Performance of pomegranate under different planting systems:** Study on pomegranate plantation done under different planting systems as continuous trenches and broad bed and furrow having different depths and normal pits, revealed that plant height varied non-significantly from 107.3-136.6 cm while average plant spread showed significant variation from 107.6-141.1 cm amongst the treatments. Plants grown on continuous trenches of 1x1m followed by bedding system revealed maximum vegetative growth.
12. **Influence of deficiency of nutrients on leaf nutrient content of plants:** Studies conducted by artificially creating the deficiency of N, P, K, Fe and Cu nutrients recorded significant influence on the plant and resulted in lowest content of these nutrients in the leaves of pomegranate plants in respective treatments. Deficiency of P adversely affected the uptake of different nutrients such as N, K, Ca, Mg and Mn; Mn adversely affected the uptake of P; Cu adversely affected the Mg and Fe content while B affected Cu and Fe content in the leaves of pomegranate.
13. **Response of Organic sources on growth, yield and quality of pomegranate:** There were significant differences amongst various organic sources on plant height over the control**.** Vermicompost treatment resulted in highest plant height followed by green manuring with sunhemp. However, significant differences were not evident under organic manures and inorganic fertilizer treatments with regard to vegetative growth of the plants.

14. **Water management in pomegranate:** Application of irrigation water through six drippers (2 l/h) fixed on two laterals placed on both sides of the plants as well as through perforated pipe encircling the plant resulted in increased uptake of nutrients in the plants, where as two dripper system revealed comparatively lower leaf nutrient content. Application of irrigation water equivalent to 60% of ETc resulted in highest content of N, P, Ca, Mg and Fe where as application of irrigation water equivalent to 0.30 ETc resulted in decreased uptake of most of the nutrients.
15. **Estimation of Reference crop Evapotranspiration (ETr, mm)**: The yearly reference crop evapotranspiration (ETr) calculated by using Penman-Monteith method was maximum in May and minimum in December and weekly minimum and maximum ETr ranged between 25.6-59.8 mm. The weekly water to be applied through drip irrigation system at 90% efficiency from April, 2011 to March, 2012 ranged from 14.3-41.2 l/week/tree for 1 year old pomegranate plant. It gradually increased or decreased during different development stages of pomegranate tree due to variation of reference crop evapotranspiration, pan coefficient, wetted area and crop coefficient values.
16. **Micronutrient status of pomegranate soils**: Analysis of soils of Solapur district under pomegranate cultivation revealed that 55.0 and 6.67% soil samples were low in DTPA-extractable Zn and Fe content, respectively. Leaf analysis revealed that 70.0, 45.0, and 35.0 % samples were low in Zn, Mn and Cu content, respectively. Analysis of soil samples from Nashik district revealed that 5.0% samples were low in Zinc while 50.0% soils were marginal in Zn content.
17. **Effect of potassium solubilizing fungi, *Penicillium pinophilum* and K-feldsper on growth and nutrient uptake by plant:** Significant increase was observed on uptake of K, P and N due to combined application of K-feldspar and fungal strain (*P. pinophilum*) than untreated plants.
18. **Effect of microorganisms consortium on nutrient uptake and growth of the plants:** Inoculation of microbial consortium consisting of *Azospirillum brasilense* and *Pseudomonas fluorescens* and *Penicillium pinophilum* resulted in significant increase in total biomass of plants under pot culture study.

## Protection

19. **Diseases: Bacterial Blight: Identification of blight pathogen employing PCR technique:** During the year 17 *Xanthomonas axonopodis* pv. *punicae* isolates were added from Maharashtra, 4 from IARI, 9 from Andhra Pradesh (AP) and 5 from North Karnataka. Eight out of nine AP isolates were confirmed to be *X. axonopodis* pv. *punicae* through PCR by IARI.
20. **Variability in *Xanthomonas axonopodis pv. pun icae* isolates:** *X. axonopodis* pv. *punicae* isolates from different regions were found to show great variability as some isolates showed larger lesions, more chlorosis and more leaf fall than others in pot culture studies.
21. **Blight development in relation to meteorological factors:** Correlation of meteorological factors with blight development revealed that disease severity was positively and significantly correlated with weekly hour temperatures ranging

between 25.0-35.0°C at Relative humidity ≥50.0%. Regression analysis comprising of weekly hour temperatures 25.0-35.0°C at RH> 50.0% and rainfall gave the best fit for predicting disease severity.

22. **Management of bacterial blight and fruit spots:** In field trial with 15 different schedules using combinations of different effective antibiotics, bactericides and botanicals, 4 schedules were found significantly better in reducing bacterial blight and 3 at par with the OHM schedule using streptocycline, COC and Bordeaux mixture. The schedule using the combination of streptocycline, Copper oxychloride and Bronopal was most effective. In a separate study bactericide bactronol was found more effective at 1000ppm concentration than at lower concentration of 500 and 750ppm in managing bacterial blight. Under field trials fungicides azoxystrobin and pyraclostrobin significantly reduced pomegranate scab (*Sphaceloma punicae*), where as pyraclostrobin was effective in reducing *Cercospora punicae* fruit spots.

23. **Pomegranate wilt prevalence, severity and management:** During the year wilt was prevalent in 54.0% orchards of the state with av. incidence of 7.6%. *Ceratocystis fimbriata* was found to be the major cause of wilt as the pathogen was found associated with 86.3% of the wilt affected samples from different locations. All the isolates of the *C. fimbriata* were found homothallic. Wilt was managed successfully in wilt affected (2.16% incidence) adopted orchard in Solapur by soil drenching the plant basin of affected plants and adjacent healthy plants with carbendazim (0.2%) + chlorpyriphos (0.2%) at monthly intervals, as the treatment revealed no new infections.

24. **Insect-pests:** Incidence of fruit borer (*Deudorix isocrates*) was around 10.0% in Solapur and Nashik districts of Maharashtra. Fruit borer showed positive correlation with rainfall on cvs Bhagawa and Ganesh. Shot hole borer (*Xylosandrus compactus*) and hairy caterpillars (*Olene mendosa*, *Somena scintillans* and *Euproctis fraterna*) were noticed for the first time on pomegranate. Amongst the sucking pests, thrips *(Scrirthothrips dorsalis*) infestation varied between 10.0- 50.0% in Solapur and Nashik districts of Maharashtra. Correlation analysis of thrips population revealed negative correlation with temperature, humidity and rainfall.

## Post Harvest Management

25. **Effect of lac formulations on shelf life of pomegranate:** Studies carried out to observe the effect of lac formulations on shelf life of pomegranate fruits revealed that pre-harvest sprays of different lac formulations increased the shelf life of fruits of cv. Bhagawa upto 20.5 days as compared to control where shelf life was only upto 16.0 days. Post harvest dips of fruits of cv. Bhagawa in different lac formulations increased the shelf life to 23.3 days under SH2-100% followed by SH1-50% (22.7days) as compared to control (16.7 days).

26. **Maturity indices for fruit harvesting:** Studies on maturity indices revealed that fruits of cv. Bhagawa may be harvested around 180 days after anthesis (DAA) when the TSS/acid ratio reaches 32.31. On the other hand fruits of cv. Ganesh can be harvested around 154 days after anthesis when TSS/acid ratio reaches 37.11.

# Research Achievements

## Programme 1: Pomegranate Improvement

### Project 1.1: Survey, collection, evaluation, characterization and conservation of pomegranate (*Punica granatum* L).

**Germplasm enhancement and multiplication:** Fifteen accessions of pomegranate were collected from Maharashtra and Orissa. These accessions were multiplied by stem cuttings/ seeds.

**Evaluation of germplasm :** The exotic accessions of pomegranate introduced from University of California, USDA, ARS, National Clonal Germplasm Repository, Davis, California were evaluated for their survival and growth parameters at NBPGR Regional Station, Bhowali, Uttarakhand. After 1½ years of planting 86% accessions survived. The plant height ranged from 49-180cm and its coefficient of variation (CV) was 22.84%.

Two year old 58 accessions of pomegranate were evaluated for their growth parameters (Table 1a). Plant height (cm), plant spread EW (cm) and NS (cm), stem diameter (cm), stem girth (cm) and thorn length (cm) ranged from 140.3-277.0, 101.7-248.5, 98.7-273.5, 4.0-8.5, 12.3-26.4 and 3.7-11.7 in different accessions (Table 1 b). Maximum variation (19.8-21.5%) was recorded with respect to plant spread (EW and NS) followed by thorn length (17.2%). In general, the growth performance of wild accessions collected from Uttarakhand, Himachal Pradesh and Jammu Kashmir were vigorous.

**Table 1 a : Growth performance of pomegranate accessions**

| Accessions | Plant height (cm) | Plant spread (cm) | | Stem Dia. (cm) | Stem girth (cm) | Thorn length (cm) |
|---|---|---|---|---|---|---|
| | | EW | NS | | | |
| IC- 318762 | 238.0 | 238.7 | 225.7 | 6.6 | 21.8 | 7.0 |
| IC-318724 | 244.7 | 221.3 | 202.0 | 6.8 | 22.9 | 8.4 |
| IC-318705 | 243.3 | 222.0 | 207.7 | 7.5 | 21.3 | 9.5 |
| IC-318734 | 262.3 | 239.3 | 242.7 | 8.5 | 23.5 | 8.5 |
| IC-318764 | 221.0 | 217.0 | 240.7 | 6.6 | 20.8 | 8.1 |
| IC-318743 | 238.3 | 197.7 | 224.0 | 6.4 | 20.7 | 9.5 |
| IC-318706 | 232.0 | 213.7 | 234.0 | 7.1 | 21.7 | 10.2 |
| IC-318735 | 248.7 | 218.0 | 201.0 | 7.0 | 22.9 | 8.1 |
| IC-318744 | 226.7 | 224.3 | 199.3 | 6.4 | 20.7 | 8.9 |
| IC-318740 | 244.7 | 215.3 | 252.7 | 6.2 | 19.8 | 8.5 |
| IC-318702 | 214.7 | 213.3 | 211.3 | 6.4 | 20.7 | 7.6 |
| IC-318766 | 251.7 | 204.0 | 208.3 | 6.6 | 20.9 | 10.0 |
| IC-318712 | 270.7 | 224.7 | 228.0 | 8.3 | 26.4 | 8.0 |
| IC-318716 | 221.7 | 192.7 | 159.7 | 6.5 | 20.8 | 8.2 |
| IC-318707 | 222.3 | 190.3 | 211.0 | 7.1 | 22.6 | 8.9 |
| IC-318733 | 212.5 | 235.0 | 211.0 | 5.7 | 17.1 | 9.4 |
| IC-318749 | 238.3 | 202.7 | 188.0 | 5.8 | 19.1 | 8.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| IC- 524027 | 253.7 | 213.3 | 184.7 | 5.9 | 19.1 | 7.5 |
| 1197* | 262.3 | 207.3 | 192.7 | 5.7 | 19.1 | 6.8 |
| IC-524030 | 277.0 | 247.0 | 255.5 | 5.9 | 19.7 | 9.2 |
| IC-524026 | 214.0 | 194.7 | 177.7 | 5.8 | 18.4 | 8.0 |
| IC-540192 | 222.5 | 126.0 | 126.0 | 4.7 | 15.7 | 6.8 |
| IC-540195 | 190.0 | 114.0 | 112.5 | 4.0 | 12.3 | 8.4 |
| 1268* | 218.5 | 205.0 | 212.5 | 5.9 | 19.2 | 8.8 |
| 1290* | 191.0 | 176.5 | 193.5 | 5.5 | 17.6 | 8.7 |
| 1294* | 210.5 | 173.5 | 186.0 | 5.3 | 16.5 | 8.4 |
| 1295* | 242.0 | 219.7 | 203.0 | 6.5 | 20.8 | 9.0 |
| 1296* | 221.7 | 218.3 | 195.3 | 5.5 | 19.2 | 8.3 |
| 1297* | 175.0 | 207.5 | 190.5 | 4.8 | 18.8 | 10.5 |
| 1298* | 194.7 | 196.0 | 201.7 | 6.6 | 20.0 | 9.6 |
| 1299* | 252.5 | 248.5 | 273.5 | 7.0 | 22.2 | 10.1 |
| Double Flower | 143.0 | 101.7 | 98.7 | 4.2 | 13.7 | 6.8 |
| Amalidana | 140.3 | 122.0 | 115.7 | 4.3 | 13.1 | 7.8 |
| Kerala Collection | 202.0 | 177.5 | 192.0 | 5.7 | 18.5 | 9.0 |
| Karnataka Collection -2 | 180.3 | 166.7 | 158.7 | 5.3 | 16.5 | 7.3 |
| EC-24686 | 217.0 | 180.3 | 171.0 | 6.2 | 20.8 | 8.3 |
| China Orange | 174.3 | 145.7 | 138.3 | 5.8 | 20.0 | 9.6 |
| IC-24685 | 217.7 | 194.7 | 199.7 | 6.9 | 22.0 | 7.1 |
| EC-104348 | 200.5 | 144.5 | 145.5 | 4.3 | 13.7 | 7.0 |
| Uttkal | 192.7 | 157.3 | 169.0 | 5.3 | 16.5 | 7.3 |
| Ganesh New | 184.0 | 160.3 | 163.3 | 7.1 | 22.0 | 8.9 |
| AHPGC-1 | 177.5 | 110.0 | 115.0 | 4.0 | 13.2 | 3.7 |
| Jallore Seedless | 176.3 | 148.7 | 124.0 | 4.9 | 16.7 | 8.9 |
| Kuravi-2k 24684 | 211.0 | 201.0 | 209.0 | 5.6 | 16.7 | 5.5 |
| Boskalin | 266.0 | 181.5 | 179.5 | 7.3 | 21.2 | 5.6 |
| Achikdona | 218.0 | 175.5 | 119.0 | 5.7 | 15.8 | 5.0 |
| Saharanpur | 214.7 | 171.3 | 181.7 | 6.7 | 21.4 | 11.7 |

*Collector's number

Table 1 b : Variability in pomegranate accessions

| Parameter | Range | Mean | SD | CV (%) |
|---|---|---|---|---|
| Plant height (cm) | 140.3-277 | 212.7 | 33.4 | 15.7 |
| Plant spread EW (cm) | 101.7-248.5 | 184.9 | 36.6 | 19.8 |
| Plant spread NS (cm) | 98.7-273.5 | 183.1 | 39.4 | 21.5 |
| Stem diameter (cm) | 4-8.5 | 6.0 | 1.0 | 15.9 |
| Stem girth (cm) | 12.3-26.4 | 19.2 | 2.8 | 14.5 |
| Thorn length (cm) | 3.7-11.7 | 8.2 | 1.4 | 17.2 |

Thirty one accessions of 1½ year old collected from Uttarakhand were also evaluated for their growth parameters. Plant height, plant spread (EW and NS directions), leaf area, leaf length and width ranged from 215.0-333.7cm, 128.3-266.7cm and 121.7-263.0cm, 4.2-8.9cm$^2$, 3.3-6.2cm and 1.0-1.6cm, respectively (Table 2a,b). However, maximum variability (20.19%) was recorded in leaf area followed by plant spread (17.99-18.49%).

Table 2a : Variability in wild pomegranate accessions

| Accessions | Plant height (cm) | Plant spread EW (cm) | Plant spread NS (cm) | Leaf area cm$^2$ | Leaf length (cm) | Leaf Width (cm) |
|---|---|---|---|---|---|---|
| IC - 540193 | 287.0 | 250.0 | 227.0 | 5.4 | 4.1 | 1.2 |
| IC - 540194 | 317.3 | 239.7 | 258.3 | 4.3 | 3.8 | 1.1 |
| IC - 540196 | 304.3 | 229.0 | 221.7 | 7.0 | 5.1 | 1.3 |
| IC - 540197 | 291.3 | 160.7 | 159.0 | 6.3 | 4.5 | 1.3 |
| IC - 540198 | 278.0 | 227.0 | 232.0 | 7.8 | 6.2 | 1.2 |
| IC - 540199 | 222.0 | 168.3 | 198.7 | 8.7 | 6.2 | 1.3 |
| IC - 540200 | 248.3 | 189.7 | 230.7 | 8.9 | 5.3 | 1.6 |
| IC - 540201 | 258.3 | 265.0 | 253.3 | 7.1 | 5.0 | 1.4 |
| IC - 540203 | 328.3 | 254.0 | 243.3 | 6.2 | 4.5 | 1.3 |
| IC - 556880 | 324.0 | 233.3 | 241.7 | 4.8 | 4.3 | 1.1 |
| IC - 556881 | 310.0 | 263.3 | 251.7 | 7.3 | 5.6 | 1.2 |
| IC - 556882 | 270.0 | 165.7 | 160.3 | 5.7 | 4.1 | 1.3 |
| IC - 556884 | 275.0 | 265.3 | 263.0 | 6.3 | 4.9 | 1.2 |
| IC - 556885 | 333.7 | 128.3 | 121.7 | 6.7 | 5.4 | 1.2 |
| IC - 556886 | 278.3 | 223.3 | 230.0 | 6.7 | 4.8 | 1.4 |
| IC - 556887 | 298.3 | 200.0 | 185.0 | 7.1 | 4.4 | 1.5 |
| IC - 556888 | 275.0 | 221.7 | 201.7 | 6.3 | 4.1 | 1.5 |
| IC - 556889 | 280.0 | 175.0 | 175.0 | 6.1 | 4.3 | 1.4 |
| IC - 556890 | 273.7 | 223.3 | 188.7 | 4.2 | 3.9 | 1.0 |
| IC - 556891 | 276.7 | 173.3 | 165.0 | 4.6 | 3.3 | 1.3 |
| IC - 556892 | 266.7 | 210.0 | 196.7 | 4.3 | 3.5 | 1.2 |
| IC - 556893 | 271.7 | 213.3 | 191.7 | 4.8 | 3.7 | 1.2 |
| IC - 556894 | 281.7 | 205.0 | 178.3 | 5.0 | 4.0 | 1.3 |
| IC - 556895 | 270.0 | 217.5 | 232.5 | 4.5 | 3.6 | 1.2 |
| IC - 556896 | 258.3 | 231.7 | 238.3 | 5.9 | 4.5 | 1.2 |
| IC - 556897 | 283.3 | 266.7 | 253.3 | 6.8 | 4.9 | 1.3 |
| IC - 556898 | 215.0 | 188.3 | 190.0 | 6.1 | 4.4 | 1.3 |
| IC - 556899 | 228.3 | 128.3 | 138.3 | 5.2 | 4.6 | 1.1 |
| IC - 556900 | 217.7 | 158.3 | 183.3 | 6.7 | 4.4 | 1.4 |
| IC - 556901 | 241.7 | 208.3 | 203.3 | 7.0 | 5.0 | 1.4 |
| IC - 524029 | 290.0 | 240.0 | 245.0 | 5.5 | 3.7 | 1.4 |
| CD (P=0.05) | 71.34 | 33.68 | 39.94 | 0.86 | 0.59 | 0.10 |

Table 2 b : Variability in pomegranate accessions

| Parameter | Range | Mean | SD | CV (%) |
|---|---|---|---|---|
| Plant height (cm) | 215.0-333.7 | 275.93 | 30.69 | 11.12 |
| Plant spread EW (cm) | 128.3-266.7 | 210.43 | 38.91 | 18.49 |
| Plant spread NS (cm) | 121.7-263.0 | 208.34 | 37.48 | 17.99 |
| Leaf area $cm^2$ | 4.2-8.9 | 6.11 | 1.23 | 20.19 |
| Leaf length ( cm) | 3.3-6.2 | 4.52 | 0.73 | 16.12 |
| Leaf width (cm) | 1.0-1.6 | 1.28 | 0.13 | 10.27 |

**Evaluation of gamma irradiated population of cv. Ganesh :** Seeds of cv Ganesh were treated with 3-30 kR gamma rays and seedlings were raised and subsequently planted in the field for evaluation. Fruits were harvested from 3 year old trees and evaluated for their physico-chemical characters. In 21kR population, maximum variation (CV 31.89%) was noted with respect to fruit weight. However, mean fruit weight was maximum (250.09g) with 3kR and fruit length and fruit diameter remained maximum with 24kR population (Table 3a). Hundred aril weight, aril length and width showed low variation (2.12-17.06%) (Table 3b). Nine kR population showed highest variation in calyx length (41.03%). Mean rind thickness ranged from 0.26-0.32cm with CV values 0f 8.89-43.43%. Similarly, mean rind % ranged from 26.21-34.28 in different treatments. However, its CV was lowest (7.15%) with 24kR (Table 3c). There was little variation in mean TSS values among the treatments and their CV values were also low which ranged from 2.47-6.92%. Acidity and aril% showed CV values from 2.74-21.45% in different treatments. However, maximum mean TSS (14.95°brix), acidity (0.4%) and aril% (73.4%) were recorded in 6kR, 15kR and 6kR population, respectively (Table 3d). Five genotypes were identified from the population for further evaluation. Out of selected genotypes, no. 335 has bigger fruits (448g each) with high aril recovery (72.84%). No. 403 has bigger fruits with attractive red rind colour and more TSS. However, no. 470 has red rind and aril colour as compared to Ganesh (Fig. 1).

Table 3 a: Variation in weight, length and diameter of fruit of gamma irradiated population of Ganesh

| Irradiation dose | Fruit weight (g) | | | | Fruit length (cm)z | | | | Fruit diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| 0 KR (67) | 105.0-450.0 | 245.66 | 56.41 | 22.96 | 5.64-9.55 | 7.64 | 0.73 | 9.56 | 5.78-9.80 | 8.10 | 0.70 | 8.60 |
| 3 KR (72) | 153.60-405.0 | 250.09 | 47.83 | 19.13 | 6.21-9.60 | 7.64 | 0.66 | 8.65 | 6.94-10.55 | 8.10 | 0.68 | 8.37 |
| 6 KR (64) | 145.0-390.0 | 245.32 | 50.72 | 20.67 | 6.37-8.88 | 7.48 | 0.60 | 7.96 | 6.81-9.55 | 8.07 | 0.63 | 7.79 |
| 9 KR (44) | 115.0-228.54 | 228.54 | 45.24 | 19.80 | 6.10-9.55 | 7.54 | 0.70 | 9.30 | 6.52-8.76 | 7.97 | 0.51 | 6.43 |
| 12 KR (48) | 60.0-345.0 | 222.68 | 55.73 | 25.03 | 4.70-9.55 | 7.29 | 0.93 | 12.78 | 5.30-9.70 | 7.74 | 0.87 | 11.28 |
| 15 KR (31) | 151.84-295.0 | 215.00 | 39.31 | 18.29 | 6.0-8.41 | 7.23 | 0.57 | 7.83 | 6.51-9.55 | 7.85 | 0.68 | 8.67 |
| 18 KR (17) | 112- 255 | 192.60 | 46.12 | 23.95 | 5.49-8.14 | 7.00 | 0.71 | 10.16 | 6.19-8.61 | 7.40 | 0.72 | 9.76 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 KR (5) | 180-273 | 180.41 | 57.53 | 31.89 | 5.86-8.01 | 6.98 | 0.86 | 12.36 | 6.58-8.04 | 7.19 | 0.60 | 8.40 |
| 24 KR (2) | 217-238.00 | 227.67 | 15.08 | 6.63 | 7.67-7.83 | 7.75 | 0.12 | 1.53 | 7.65-8.93 | 8.29 | 0.91 | 10.94 |
| 27 KR | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 KR | - | - | - | - | - | - | - | - | - | - | - | - |

*Values in parenthesis is the number of bearing plants

Table 3b : Variation in 100 aril weight, aril length and width of fruit of gamma irradiated population of Ganesh

| Irradiation dose | 100 aril weight (g) | | | | Aril length (cm) | | | | Aril width (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| 0 KR (67) | 24.06-42.28 | 31.89 | 4.00 | 12.53 | 1.0-1.15 | 1.09 | 0.02 | 2.12 | 0.52-0.73 | 0.59 | 0.04 | 6.19 |
| 3 KR (72) | 21.18-43.12 | 31.31 | 3.81 | 12.16 | 0.94-1.21 | 1.08 | 0.04 | 3.79 | 0.52-0.73 | 0.60 | 0.03 | 5.75 |
| 6 KR (64) | 19.92-46.01 | 33.46 | 4.81 | 14.39 | 1.02-1.38 | 1.08 | 0.05 | 4.56 | 0.55-0.67 | 0.60 | 0.03 | 5.07 |
| 9 KR (44) | 23.43-48.90 | 32.12 | 4.98 | 15.52 | 1.03-1.29 | 1.08 | 0.04 | 3.89 | 0.55-0.68 | 0.60 | 0.03 | 5.44 |
| 12 KR (48) | 22.43-49.40 | 30.99 | 4.86 | 15.67 | 1.00-1.16 | 1.08 | 0.03 | 2.67 | 0.54-0.70 | 0.59 | 0.03 | 5.78 |
| 15 KR (31) | 23.17-40.27 | 30.06 | 5.09 | 16.93 | 1.03-1.20 | 1.09 | 0.04 | 3.76 | 0.54-0.66 | 0.59 | 0.03 | 4.85 |
| 18 KR (17) | 23.40-39.66 | 30.35 | 5.18 | 17.06 | 1.01-1.13 | 1.08 | 0.02 | 2.25 | 0.55-0.65 | 0.59 | 0.03 | 5.41 |
| 21 KR (5) | 21.93-31.01 | 26.32 | 4.01 | 15.25 | 0.99-1.13 | 1.07 | 0.05 | 4.68 | 0.51-0.62 | 0.57 | 0.05 | 8.00 |
| 24 KR (2) | 25.55-32.10 | 28.83 | 4.63 | 16.06 | 1.07-1.08 | 1.08 | 0.01 | 0.54 | 0.58-0.59 | 0.59 | 0.01 | 0.83 |
| 27 KR | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 KR | - | - | - | - | - | - | - | - | - | - | - | - |

*Values in parenthesis is the number of bearing plants

Table 3c : Variation in Calyx length, rind thickness and rind % of fruit of gamma irradiated population of Ganesh

| Irradiation dose | Calyx length (cm) | | | | Rind thickness (cm) | | | | Rind % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| 0 KR (67) | 0.5-2.65 | 1.60 | 0.45 | 28.02 | 0.15-0.42 | 0.30 | 0.07 | 24.03 | 17.02-42.70 | 26.21 | 4.74 | 18.09 |
| 3 KR (72) | 0.80-2.50 | 1.62 | 0.36 | 21.97 | 0.17-0.53 | 0.32 | 0.07 | 23.56 | 14.66-40.34 | 27.09 | 4.77 | 17.60 |
| 6 KR (64) | 0.90-2.70 | 1.68 | 0.32 | 18.93 | 0.15-0.52 | 0.30 | 0.08 | 28.35 | 19.01-37.75 | 26.60 | 4.48 | 16.86 |
| 9 KR (44) | 0.45-2.75 | 1.47 | 0.60 | 41.03 | 0.16-0.39 | 0.26 | 0.06 | 22.28 | 4.65-27.58 | 27.58 | 4.65 | 16.86 |
| 12 KR (48) | 0.45-2.55 | 1.58 | 0.47 | 29.63 | 0.13-0.49 | 0.28 | 0.09 | 32.49 | 6.13-40.45 | 27.11 | 6.53 | 24.08 |
| 15 KR (31) | 0.49-2.80 | 1.74 | 0.48 | 27.66 | 0.17-0.42 | 0.28 | 0.07 | 25.82 | 16.76-38.84 | 27.92 | 4.59 | 16.42 |
| 18 KR (17) | 0.71-2.11 | 1.63 | 0.37 | 22.51 | 0.17-0.42 | 0.27 | 0.08 | 29.94 | 15.42-42.33 | 28.67 | 7.14 | 24.89 |
| 21 KR (5) | 0.76-1.90 | 1.48 | 0.43 | 28.91 | 0.28-0.35 | 0.31 | 0.03 | 8.89 | 26.64-41.70 | 34.28 | 6.99 | 20.39 |
| 24 KR (2) | 1.60-1.98 | 1.79 | 0.27 | 15.30 | 0.21-0.39 | 0.30 | 0.13 | 43.43 | 26.3-29.1 | 27.70 | 1.98 | 7.15 |
| 27 KR | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 KR | - | - | - | - | - | - | - | - | - | - | - | - |

*Values in parenthesis is the number of bearing plants

Table 3d: Variation in TSS, acidity and aril% of fruit of gamma irradiated population of Ganesh

| Irradiation dose | TSS °Brix | | | | Acidity % | | | | Aril % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| 0 KR (67) | 10.35-16.35 | 14.42 | 0.86 | 5.93 | 0.21-0.56 | 0.39 | 0.06 | 16.48 | 57.30-82.98 | 73.79 | 4.74 | 6.43 |
| 3 KR (72) | 13.16-16.12 | 14.66 | 0.72 | 4.93 | 0.23-0.60 | 0.39 | 0.07 | 17.28 | 59.66-85.34 | 72.91 | 4.77 | 6.54 |
| 6 KR (64) | 12.91-17.01 | 14.95 | 0.67 | 4.48 | 0.21-0.68 | 0.38 | 0.08 | 21.36 | 62.65-80.99 | 73.40 | 4.48 | 6.11 |
| 9 KR (44) | 13.04-16.64 | 14.73 | 0.69 | 4.70 | 0.24-0.55 | 0.39 | 0.08 | 19.69 | 57.85-80.90 | 72.42 | 4.65 | 6.42 |
| 12 KR (48) | 12.30-16.23 | 14.78 | 0.86 | 5.82 | 0.17-0.56 | 0.38 | 0.08 | 21.45 | 59.55-93.87 | 72.89 | 6.53 | 8.96 |
| 15 KR (31 ) | 13.42-15.60 | 14.51 | 0.59 | 4.09 | 0.24-0.56 | 0.40 | 0.08 | 20.04 | 61.36-83.24 | 72.08 | 4.59 | 6.36 |
| 18 KR (17 ) | 13.43-15.51 | 14.39 | 0.74 | 5.15 | 0.24-0.43 | 0.35 | 0.05 | 14.49 | 57.67-84.58 | 71.33 | 7.14 | 10.01 |
| 21 KR (5) | 13.88-16.20 | 14.76 | 1.02 | 6.92 | 0.36-0.45 | 0.41 | 0.04 | 10.04 | 58.30-73.36 | 65.72 | 6.99 | 10.64 |
| 24 KR (2) | 13.29-13.76 | 13.53 | 0.33 | 2.47 | 0.38-0.41 | 0.39 | 0.03 | 6.37 | 70.9-73.7 | 72.30 | 1.98 | 2.74 |
| 27 KR | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 KR | - | - | - | - | - | - | - | - | - | - | - | - |

*Values in parenthesis is the number of bearing plants


Fig. 1 Variability in fruit characters of gamma irradiated population of Ganesh

**Evaluation of gamma irradiated population of cv. Bhagawa :** The gamma irradiated seeds of cv. Bhagawa were raised in polythene bags and subsequently transferred in cemented pots. Three year old seedlings raised in cemented pots were planted in the field for evaluation. After one year of planting, fruiting was observed during 2011 and more than 75% plants came into bearing. However, fruits were harvested during January-April, 2012, and their physico-chemical properties were recorded. Seven genotypes were identified from different gamma irradiated population for further evaluation (**Fig. 2**). Out of the identified genotypes, R6-5 has very attractive colour of rind with high TSS (17.04 °brix). Similarly, R6-55 has bigger fruits with dark red arils and high TSS (16.49 °brix). However, R14-14A found to develop attractive red colour of rind when temperature is high (above 35°C). This trait may be incorporated in breeding programme as a donor for breeding of varieties suitable for cultivation during summer season.

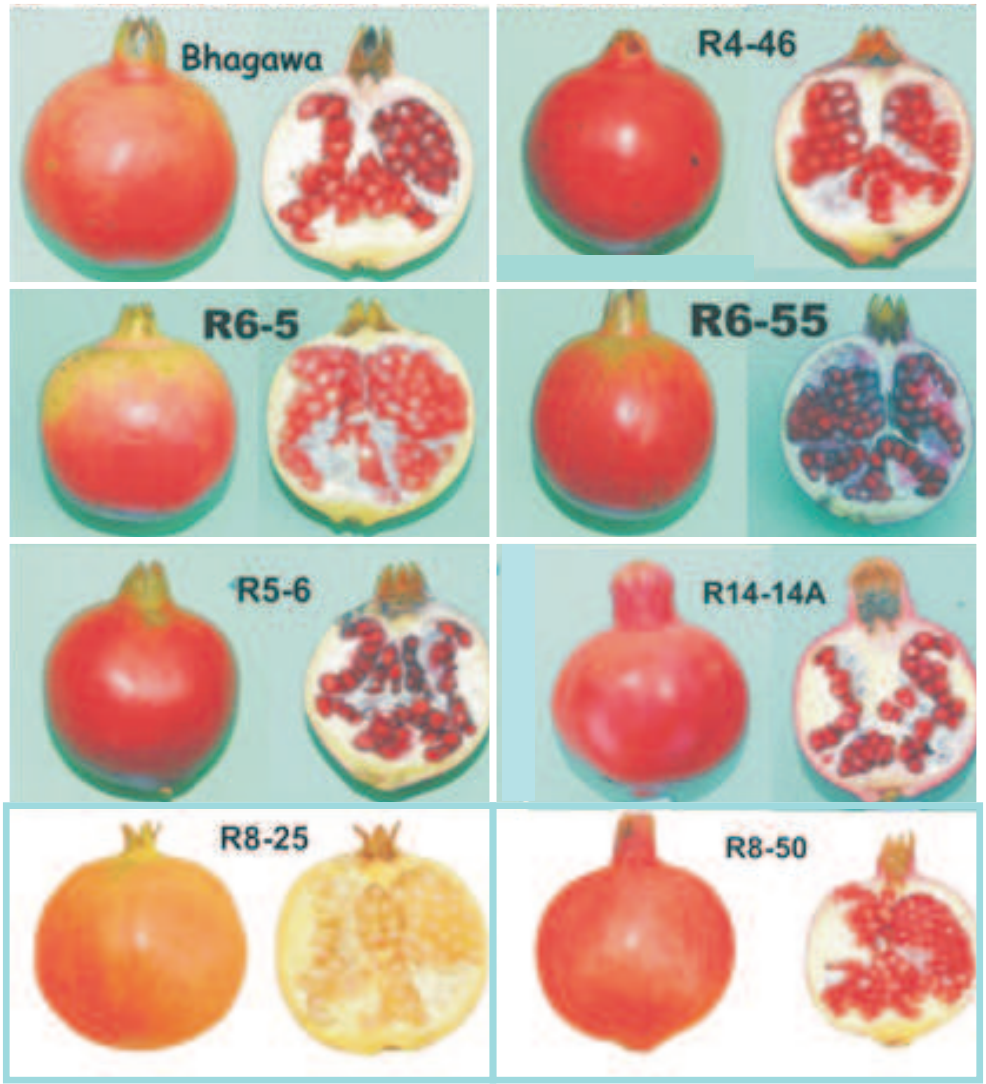



Fig. 2 Variability in fruit characters of gamma irradiated population of Bhagawa

**Variability study in seedling population of F3 hybrids :** In order to study variation pattern in F3 population, fruits were selected from bearing trees of F2 population of different hybrids having dwarf to medium plant height. The open pollinated fruits obtained from five F2 hybrid population (H-25, Ruby Self; H-12, H-7, H-35 and H-34, progeny of Ganesh x Nana) were taken and the seeds were sown for raising of F3 seedlings. The seedlings were planted in the field. Fruiting was started after one year of planting. Plant growth, fruiting behaviour and various physico-chemical properties of fruits were recorded (Table 4a, 4b, 4c, 4d, 4e, 4f). In general, variation was more than 20% in plant height, spread, number of fruits per tree, fruit weight, calyx length, 100 aril weight, rind thickness and rind% irrespective of genotypes (hybrids). This indicated that hybrid seedling population was highly heterogenous. Interestingly, the plant population was consisted of dwarf (<1m), medium (1-1.5m) and semi tall (< 2m) types. Two genotypes having bigger fruits, low rind, high aril recovery (70-72.5%) with high TSS (16.7-17.0 °brix) have been identified (Fig. 3). However, their further evaluation in subsequent years is needed.

Table 4a : Variation in plant height (cm) and spread (cm) of F3 hybrid population

| Hybrid | Plan t height (cm) | | | | Average plant spread (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 58-180 | 100.53 | 34.96 | 34.77 | 52.5-172.5 | 96.88 | 31.43 | 32.45 |
| H-12 | 60-125 | 136.2 | 49.66 | 36.46 | 60.5-200 | 128.37 | 45.24 | 35.24 |
| H-7 | 45-200 | 118.65 | 42.76 | 36.04 | 38-201.5 | 102.56 | 43.75 | 42.66 |
| H-35 | 58-170 | 108.25 | 32.62 | 30.13 | 39.5-131 | 94.5 | 27.56 | 29.16 |
| H-34 | 115-170 | 145.11 | 13.73 | 9.46 | 92.5-155 | 127.08 | 15.51 | 12.20 |

H-25 (N=17); H12 (N=18); H7 (N=17); H35 (N=19); H34 (N=19), Values in parentheses are number of plants

Table 4b : Variation in number of fruits, fruit weight (g) and fruit length (cm) of F3 hybrid population

| Hybrid | No. of fruits | | | | Fruit weight (g) | | | | Fruit length (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 1-41 | 16.8 | 11.22 | 66.91 | 104.1-180.4 | 136.0 | 18.63 | 13.71 | 5.05-7.02 | 6.3 | 0.51 | 8.07 |
| H-12 | 1-48 | 10.5 | 5.34 | 50.84 | 68.5-283.7 | 134.8 | 57.89 | 42.95 | 5.09-8.29 | 6.3 | 0.91 | 14.52 |
| H-7 | 2-38 | 10.0 | 5.05 | 50.50 | 54.5-308.0 | 189.7 | 79.61 | 41.96 | 4.25-8.50 | 7.1 | 1.29 | 18.37 |
| H-35 | 1-33 | 11.0 | 5.63 | 51.16 | 82.0-336.4 | 157.0 | 90.85 | 57.88 | 5.50-8.74 | 6.6 | 1.16 | 17.67 |
| H-34 | 4-44 | 10.5 | 5.34 | 50.84 | 102.6-292.6 | 192.8 | 54.05 | 28.04 | 5.98-8.59 | 7.2 | 0.72 | 10.03 |

Table 4c : Variation in fruit diameter (cm) and calyx length (cm) of F3 hybrid population

| Hybrid | Fruit Dia. (cm) | | | | Calyx length (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 4.40-7.07 | 6.16 | 0.65 | 10.60 | 0.80-2.65 | 1.47 | 0.48 | 32.76 |
| H-12 | 4.88-8.27 | 6.27 | 0.93 | 14.78 | 0.80-2.35 | 1.62 | 0.49 | 30.58 |
| H-7 | 4.20-8.65 | 6.84 | 1.26 | 18.38 | 0.8-1.95 | 1.36 | 0.36 | 26.70 |
| H-35 | 5.09-8.33 | 6.23 | 1.19 | 19.16 | 0.47-1.28 | 0.92 | 0.24 | 26.12 |
| H-34 | 5.78-9.20 | 7.14 | 0.79 | 11.03 | 0.75-2.92 | 1.68 | 0.50 | 29.61 |

Table 4d : Variation in 100 aril weight and size of arils of F3 hybrid population

| Hybrid | 100 aril wt (g) | | | | Aril length (cm) | | | | Aril width (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 18.56-32.20 | 24.82 | 3.86 | 15.53 | 0.93-1.17 | 1.04 | 0.05 | 4.67 | 0.55-0.60 | 0.58 | 0.02 | 2.84 |
| H-12 | 11.0-40.25 | 19.80 | 7.79 | 39.32 | 0.88-1.10 | 0.99 | 0.07 | 7.37 | 0.41-0.59 | 0.52 | 0.06 | 10.78 |
| H-7 | 8.37-42.80 | 29.49 | 9.16 | 31.07 | 0.87-1.13 | 1.05 | 0.06 | 6.10 | 0.38-0.65 | 0.59 | 0.06 | 10.64 |
| H-35 | 7.63-33.13 | 21.51 | 8.26 | 38.42 | 0.68-1.09 | 0.93 | 0.14 | 15.00 | 0.43-0.62 | 0.54 | 0.07 | 12.43 |
| H-34 | 18.0-37.0 | 28.78 | 5.33 | 18.52 | 0.87-1.13 | 1.02 | 0.08 | 7.92 | 0.56-0.65 | 0.59 | 0.02 | 3.81 |

Table 4e : Variation in TSS and rind thickness of F3 hybrid population

| Hybrid | TSS °Brix | | | | Rind thickness (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 13.56-17.05 | 15.15 | 1.04 | 6.87 | 0.18-0.33 | 0.28 | 0.04 | 13.03 |
| H-12 | 13.51-17.11 | 15.35 | 0.97 | 6.31 | 0.13-0.30 | 0.22 | 0.07 | 30.17 |
| H-7 | 11.90-16.25 | 14.83 | 1.50 | 10.11 | 0.12-0.41 | 0.28 | 0.10 | 36.50 |
| H-35 | 12.45-17.79 | 14.52 | 1.88 | 12.95 | 0.12-0.38 | 0.25 | 0.08 | 33.09 |
| H-34 | 14.79-17.96 | 16.38 | 0.88 | 5.39 | 0.16-0.39 | 0.25 | 0.06 | 22.98 |

Table 4f : Variation in aril% and rind % of F3 hybrid population

| Hybrid | Aril % | | | | Rind % | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| H-25 | 59.93-73.60 | 67.76 | 3.93 | 5.80 | 26.40-40.07 | 32.24 | 3.93 | 12.18 |
| H-12 | 69.09-78.38 | 73.09 | 2.84 | 3.89 | 21.62-30.91 | 26.91 | 2.84 | 10.57 |
| H-7 | 54.05-84.41 | 71.65 | 7.54 | 10.53 | 15.59-45.95 | 28.35 | 7.54 | 26.61 |
| H-35 | 58.55-73.72 | 68.26 | 5.50 | 8.06 | 26.28-41.45 | 31.74 | 5.50 | 17.34 |
| H-34 | 65.40-83.73 | 74.26 | 4.51 | 6.07 | 16.27-34.60 | 25.60 | 4.76 | 18.58 |

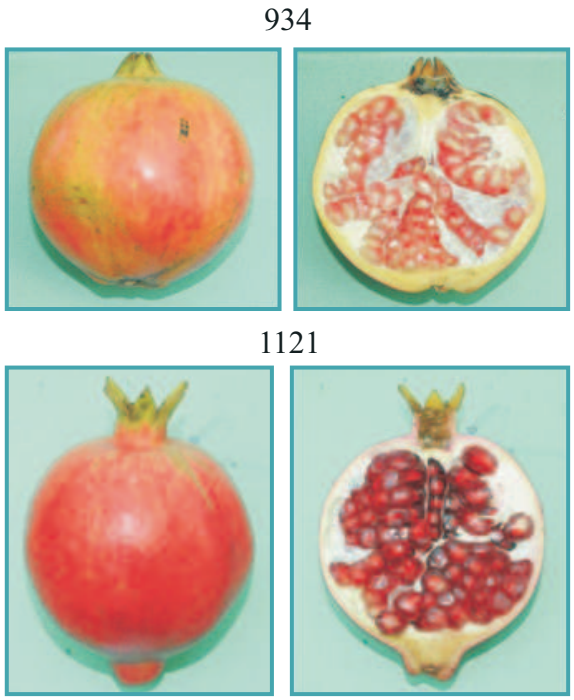



Fig. 3 Two genotypes identified from F3 population

**Variation study in seedling population of NRCP collections :** The seedling population of different accessions collected from Maharashtra, Karnataka and Andhra Pradesh were raised in polythene bags and after one year planted in the field for evaluation. Growth and physico-chemical traits were recorded in 9 seedling population of NRCP collections (Table 5a,b,c,d,e,f). NRCP-33 recorded maximum plant height (174.5cm) while variation in plant height and plant spread was more with NRCP-32. NRCP-31 had bigger fruits with more fruit size and TSS (Table 5a). However, NRCP-42 showed low variation in fruit weight (CV 4.36%) and recorded thicker rind (0.41cm) with high rind recovery (43.26%). NRCP-43 recorded highest mean calyx length and NRCP-33 showed maximum variation in calyx length (CV 32%) and rind thickness (22.83%). However, it showed highest 100 aril weight (40.05g) and aril recovery (71.36%). Coefficient of variation was higher in NRCP-25 with respect to 100 aril weight (27.27%), aril length (10.51%) and width (10.08%). TSS values ranged from 15.31-16.76 °brix in different collections but variation in their TSS values was low (CV 0.77-7.84%).

Table 5a : Variation in plant height (cm) and spread EW (cm) of NRCP collections

| Selection | Plant height (cm) | | | | Average plant spread (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 136-168 | 148.5 | 12.76 | 8.59 | 142.50-175.0 | 157.75 | 13.18 | 8.35 |
| NRCP-24 | 146-189 | 168.5 | 15.24 | 9.05 | 21.3-190.5 | 183.92 | 18.47 | 10.04 |
| NRCP-25 | 141-180 | 155 | 15.31 | 9.88 | 145.50-178.0 | 159.42 | 10.62 | 6.66 |
| NRCP-26 | 152-217 | 169.83 | 24.90 | 14.66 | 151.0-197.0 | 173.75 | 17.50 | 10.07 |
| NRCP-31 | 145-189 | 158.33 | 25.26 | 15.95 | 120.0-176.0 | 138.92 | 21.79 | 15.69 |
| NRCP-32 | 90-168 | 148.17 | 30.02 | 20.26 | 81.0-162.50 | 135.92 | 28.20 | 20.75 |
| NRCP-33 | 156-200 | 174.50 | 15.22 | 8.72 | 138.5-174.5 | 158.00 | 15.83 | 10.02 |
| NRCP-43 | 113-187 | 150.50 | 26.04 | 17.30 | 110.0-173.0 | 154.58 | 24.05 | 15.56 |
| NRCP-42 | 144-158 | 151.67 | 6.83 | 4.50 | 115.0-172.0 | 153.92 | 19.87 | 12.91 |

Table 5b : Variation in fruit weight (g) and length (cm) of NRCP collections

| Selection | Fruit weight (g) | | | | Fruit length (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 143.20-290.10 | 195.41 | 57.41 | 29.38 | 6.55-8.26 | 7.17 | 0.68 | 9.52 |
| NRCP-24 | 137.20-264.48 | 203.35 | 45.19 | 22.22 | 6.05-8.08 | 7.32 | 0.79 | 10.82 |
| NRCP-25 | 112.48-231.00 | 176.95 | 58.03 | 32.80 | 5.60-7.65 | 6.82 | 1.05 | 15.47 |
| NRCP-26 | 126.05-264.50 | 194.75 | 54.29 | 27.88 | 6.41-8.18 | 7.33 | 0.73 | 9.97 |
| NRCP-31 | 172.11-308.12 | 246.25 | 45.74 | 18.58 | 7.11-8.71 | 7.91 | 0.53 | 6.71 |
| NRCP-32 | 160.08-209.95 | 193.35 | 22.59 | 11.68 | 6.66-7.56 | 7.18 | 0.38 | 5.28 |
| NRCP-33 | 172.50-289.17 | 228.04 | 55.95 | 24.54 | 7.04-8.30 | 7.66 | 0.62 | 8.11 |
| NRCP-43 | 130.74-173.83 | 151.03 | 15.97 | 10.57 | 6.28-7.02 | 6.66 | 0.28 | 4.20 |
| NRCP-42 | 162.80-183.67 | 175.22 | 7.64 | 4.36 | 6.68-7.15 | 7.00 | 0.19 | 2.77 |

Table 5c : Variation in fruit diameter (cm) and calyx length (cm) of NRCP collections

| Selection | Fruit diameter (cm) | | | | Calyx length (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 6.30-7.55 | 6.90 | 0.55 | 7.94 | 1.01-1.72 | 1.47 | 0.27 | 18.39 |
| NRCP-24 | 6.75-8.04 | 7.31 | 0.47 | 6.36 | 1.08-2.50 | 1.77 | 0.51 | 28.75 |
| NRCP-25 | 5.75-7.80 | 6.78 | 0.81 | 11.93 | 1.21-2.16 | 1.67 | 0.45 | 26.97 |
| NRCP-26 | 5.96-8.02 | 6.97 | 0.80 | 11.47 | 1.35-1.90 | 1.57 | 0.23 | 14.40 |
| NRCP-31 | 7.03-8.08 | 7.72 | 0.39 | 5.03 | 0.71-1.61 | 1.34 | 0.33 | 24.66 |
| NRCP-32 | 6.73-7.06 | 6.90 | 0.17 | 2.52 | 1.02-1.86 | 1.41 | 0.42 | 29.99 |
| NRCP-33 | 6.32-7.87 | 6.96 | 0.73 | 10.52 | 0.47-1.09 | 0.90 | 0.29 | 32.00 |
| NRCP-43 | 6.11-7.03 | 6.61 | 0.38 | 5.76 | 1.49-2.47 | 1.89 | 0.37 | 19.70 |
| NRCP-42 | 6.23-7.50 | 6.79 | 0.55 | 8.17 | 0.95-1.80 | 1.34 | 0.27 | 20.34 |

Table 5d : Variation in 100 aril weight and size of NRCP collections

| Selection | 100 aril wt (g) | | | | Aril length (cm) | | | | Aril width (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 27.10-34.70 | 30.63 | 3.12 | 10.18 | 0.97-1.09 | 1.05 | 0.04 | 4.02 | 0.56-0.61 | 0.58 | 0.02 | 3.40 |
| NRCP-24 | 18.87-38.33 | 30.61 | 7.66 | 25.02 | 0.89-1.10 | 1.01 | 0.10 | 9.74 | 0.58-0.70 | 0.65 | 0.05 | 8.14 |
| NRCP-25 | 15.79-34.91 | 27.75 | 7.57 | 27.27 | 0.84-1.11 | 1.02 | 0.11 | 10.51 | 0.56-0.68 | 0.60 | 0.05 | 8.34 |
| NRCP-26 | 21.41-38.03 | 32.36 | 7.02 | 21.71 | 1.04-1.08 | 1.06 | 0.02 | 1.66 | 0.57-0.63 | 0.60 | 0.03 | 4.57 |
| NRCP-31 | 19.53-36.44 | 30.41 | 6.28 | 20.66 | 0.95-1.08 | 1.04 | 0.05 | 4.87 | 0.56-0.65 | 0.60 | 0.03 | 5.17 |
| NRCP-32 | 22.49-40.00 | 32.28 | 7.29 | 22.58 | 1.0-1.10 | 1.05 | 0.04 | 4.05 | 0.57-0.61 | 0.59 | 0.02 | 3.13 |
| NRCP-33 | 35.67-43.13 | 40.05 | 3.33 | 8.31 | 1.05-1.11 | 1.08 | 0.03 | 2.38 | 0.58-0.66 | 0.61 | 0.04 | 5.78 |
| NRCP-43 | 20.76-32.50 | 27.06 | 5.03 | 18.59 | 0.96-1.07 | 1.03 | 0.04 | 4.14 | 0.54-0.68 | 0.59 | 0.06 | 10.08 |
| NRCP-42 | 28.67-35.0 | 32.13 | 2.48 | 7.73 | 1.04-1.10 | 1.07 | 0.02 | 2.16 | 0.56-0.68 | 0.59 | 0.04 | 7.06 |

Table 5e : Variation in TSS and rind thickness of NRCP collections

| Selection | TSS (°brix) | | | | Rind thickness (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 15.17-16.45 | 15.70 | 0.44 | 2.78 | 0.29-0.34 | 0.32 | 0.02 | 4.75 |
| NRCP-24 | 13.60-16.58 | 15.62 | 1.22 | 7.84 | 0.28-0.43 | 0.36 | 0.06 | 16.60 |
| NRCP-25 | 14.0-16.71 | 15.46 | 1.10 | 7.10 | 0.31-0.43 | 0.37 | 0.05 | 14.55 |
| NRCP-26 | 14.26-16.36 | 15.52 | 0.93 | 5.97 | 0.30-0.41 | 0.34 | 0.04 | 12.68 |
| NRCP-31 | 16.41-17.32 | 16.76 | 0.38 | 2.24 | 0.28-0.44 | 0.36 | 0.07 | 18.81 |
| NRCP-32 | 16.38-16.65 | 16.53 | 0.13 | 0.77 | 0.25-0.31 | 0.27 | 0.02 | 8.74 |
| NRCP-33 | 15.44-17.53 | 16.61 | 0.89 | 5.38 | 0.24-0.41 | 0.31 | 0.07 | 22.83 |
| NRCP-43 | 14.69-16.45 | 15.31 | 0.68 | 4.46 | 0.24-0.34 | 0.30 | 0.04 | 13.11 |
| NRCP-42 | 14.92-16.01 | 15.44 | 0.38 | 2.44 | 0.30-0.56 | 0.41 | 0.09 | 21.04 |

Table 5f : Variation in aril and rind % of NRCP collections

| Selection | Aril (%) | | | | Rind (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | CV (%) | Range | Mean | SD | CV (%) |
| NRCP-23 | 52.63-74.94 | 64.77 | 7.50 | 11.58 | 25.06-47.37 | 35.23 | 7.50 | 21.29 |
| NRCP-24 | 47.07-70.02 | 56.74 | 10.24 | 18.05 | 29.98-52.93 | 43.26 | 10.24 | 23.67 |
| NRCP-25 | 54.73-63.35 | 60.67 | 3.52 | 5.81 | 36.65-45.27 | 39.33 | 3.52 | 8.96 |
| NRCP-26 | 61.87-68.53 | 64.30 | 2.98 | 4.63 | 31.47-38.13 | 35.70 | 2.98 | 8.34 |
| NRCP-31 | 64.44-73.12 | 68.90 | 2.95 | 4.28 | 26.88-35.56 | 31.10 | 2.95 | 9.48 |
| NRCP-32 | 67.34-72.35 | 69.63 | 2.33 | 3.35 | 27.65-32.66 | 30.37 | 2.33 | 7.68 |
| NRCP-33 | 65.82-80.72 | 71.36 | 6.48 | 9.08 | 19.28-34.18 | 28.64 | 6.48 | 22.61 |
| NRCP-43 | 62.26-71.39 | 66.66 | 3.78 | 5.67 | 28.61-37.74 | 33.34 | 3.78 | 11.35 |
| NRCP-42 | 61.07-72.51 | 67.35 | 4.49 | 6.66 | 27.49-38.93 | 32.65 | 4.49 | 13.74 |

**Influence of chemical defoliants on flowering behaviour :** Different concentrations of curacron (profenophos), ethrel and dormex (hydrogen cynamide) were tested for defoliation in pomegranate cv. Bhagawa grown in pots. Production of male and hermaphrodite flowers was recorded at periodical intervals between 30-120 days after spraying (DAS). There was no significant difference among the treatments on production of male and hermaphrodite flowers at 30-60 DAS and 60-90 DAS (Table 6). However, significant influence of chemicals was noted at 90-120 DAS. In general, male flower production was more at 30-60 DAS and decreased progressively at 60-90 DAS and 90-120 DAS. Higher dose of curacron (1.2%) and ethrel (0.3-0.5%) and dormex (0.5-1.0%) helped producing more (84.73-89.59%) hermaphrodite flowers at 90-120 DAS significantly. However, cumulative data of flowering between 30-120 DAS indicated that higher dose of curacron (1.2%) and all the concentrations of ethrel and dormex showed higher % of hermaphrodite flowers (60.92-66.12%) significantly over control.

Table 6 : Effect of chemical defoliants on production of male and female flowers during 2010-11

| Treatment | 30-60 DAS (%) | | 60-90 DAS (%) | | 90-120 DAS (%) | | 30-120 DAS* (%) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Control | 62.61 | 37.39 | 51.27 | 48.73 | 40.95 | 59.05 | 51.61 | 48.39 |
| Curacron (0.4%) | 57.82 | 42.18 | 47.19 | 52.81 | 24.71 | 75.29 | 43.24 | 56.76 |
| Curacron (0.8%) | 64.98 | 35.02 | 46.75 | 53.25 | 25.26 | 74.74 | 45.66 | 54.34 |
| Curacron (1.2%) | 53.12 | 46.88 | 43.33 | 56.67 | 12.85 | 87.15 | 36.43 | 63.57 |
| Ethrel (0.3%) | 57.62 | 42.38 | 46.67 | 53.33 | 10.41 | 89.59 | 38.23 | 61.77 |
| Ethrel (0.4%) | 50.00 | 50.00 | 44.44 | 55.56 | 12.30 | 87.70 | 35.58 | 64.42 |
| Ethrel (0.5%) | 55.00 | 45.00 | 32.62 | 67.38 | 14.02 | 85.98 | 33.88 | 66.12 |
| Dormex (0.5%) | 51.33 | 48.67 | 40.71 | 59.29 | 15.13 | 84.87 | 35.72 | 64.28 |
| Dormex (1.0%) | 56.27 | 43.73 | 45.70 | 54.30 | 15.27 | 84.73 | 39.08 | 60.92 |
| Dormex (1.5%) | 49.17 | 50.83 | 40.64 | 59.36 | 20.55 | 79.45 | 36.79 | 63.21 |
| CD (P=0.05) | NS | NS | NS | NS | 5.45 | 5.45 | 6.74 | 6.74 |

*Average of 30-120 DAS (Days after spraying)

**Standardization of chemicals for defoliation in pomegranate:** A field trial was conducted for standardization of optimum concentration of chemical defoliants in pomegranate cv. Ganesh. Nine treatments including control were taken for the present study. Among different treatments, 0.5% Dormex + 0.2% Curacron + 1% Urea or 1.0% Dormex or 0.4% Ethrel or 0.1% Ethrel + 0.1% Dormex + 0.2% Curacron were found effective in defoliation of leaves at 15 DAS (Table 7a). Defoliation in these treatments ranged from 81.1-94.2 % and their values were at par to each other. However, emergence of new sprouts was better in 0.5% Dormex + 0.2% Curacron + 1% Urea or 1% dormex alone at 15DAS and 21 DAS. Interestingly, 0.4% Ethrel or 0.5% Dormex or 1.0% Dormex or 0.2% Ethrel + 0.25% Dormex or 0.5% Dormex + 0.2% Curacron + 1% Urea have enhanced production of hermaphrodite flowers over control (Table 7b). The percent of hermaphrodite flowers ranged from 80.1-87.2% in these treatments and were at par to each other with respect to production of hermaphrodite flowers.

Table 7a : Effect of chemical defoliants on % defoliation and sprouting in pomegranate cv. Ganesh

| Treatment | Defoliation at | | Sprouting at | |
|---|---|---|---|---|
| | 7 DAS | 15 DAS | 15 DAS | 21 DAS |
| 0.2% Ethrel | 40.6 | 71.1 | 22.3 | 70.0 |
| 0.4% Ethrel | 46.7 | 87.9 | 20.6 | 70.2 |
| 0.5% Dormex | 33.3 | 65.8 | 24.1 | 61.3 |
| 1.0% Dormex | 48.3 | 88.3 | 42.8 | 83.9 |
| 0.2% Ethrel + 0.25% Dormex | 41.1 | 70.6 | 19.4 | 67.5 |
| 0.1% Ethrel + 0.1% Dormex + 0.2% Curacron | 30.6 | 81.1 | 25.9 | 65.1 |
| 0.2% Ethrel + 0.2% Curocron + 1% Urea | 40.6 | 72.4 | 19.9 | 62.5 |
| 0.5% Dormex + 0.2% Curacron + 1% Urea | 53.9 | 94.2 | 45.0 | 90.5 |
| Control | 5.0 | 10.3 | 2.6 | 12.4 |
| CD (P=0.05) | 8.67 | 5.91 | 3.84 | 10.81 |

Table 7b: Effect of defoliants on induction of male and hermaphrodite flowers in cv. Ganesh at 90 DAS

| Treatment | % Male | % hermaphrodite |
|---|---|---|
| 0.2% Ethrel | 20.5 | 79.5 |
| 0.4% Ethrel | 19.0 | 81.0 |
| 0.5% Dormex | 19.9 | 80.1 |
| 1.0% Dormex | 19.2 | 80.8 |
| 0.2% Ethrel + 0.25% Dormex | 17.9 | 82.1 |
| 0.1% Ethrel + 0.1% Dormex + 0.2% Curac ron | 19.5 | 80.5 |
| 0.2% Ethrel + 0.2% Curocron + 1% Urea | 21.8 | 78.2 |
| 0.5% Dormex + 0.2% Curacron + 1% Urea | 12.8 | 87.2 |
| Control | 27.8 | 72.2 |
| CD (P=0.05) | 6.45 | 6.45 |

**Flowering behaviour on old and new shoots** : After chemical defoliation, production of male and hermaphrodite flowers on old (above 6 month age) and new (below 6 month age) shoots were observed in pomegranate cv. Bhagawa at 30 , 60, 90 and 120 days after spraying (DAS). At 30 DAS no flowering was recorded on new shoots but on old shoots male and hermaphrodite flowers were almost in equal proportion (Fig. 4). However, on subsequent dates male and hermaphrodite flower production decreased on old shoots. At 60 DAS, proportion of male flower on young shoots was more as compared to

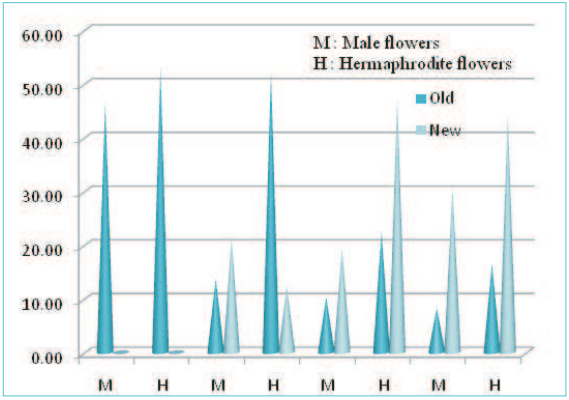



Fig. 4 : Flowering behaviour on young and old shoots of cv. Bhagawa

hermaphrodite flowers and at 90 days maximum hermaphrodite flowers (47.53%) were recorded which decreased slightly at 120 DAS.

**Performance of pomegranate rind of cv. Ganesh and Bhagawa for natural dying of cotton :** A collaborative study with CIRCOT and NRCP was initiated for waste utilization of pomegranate rind. Cotton is generally pretreated with tannin containing substances and then with salts of metals like aluminum, iron etc. to make it receptive towards natural dyes. Traditionally, dried fruits of Harda (*Terminalia chebula*) were used for this purpose and presently tannic acid is often employed for this purpose. As pomegranate rind is considered to be rich in tannins, it can be used in place of Harda for mordanting of cotton. Performance of pomegranate rind samples of Bhagawa and Ganesh varieties as mordant for dyeing of cotton with natural red dye manjith was therefore evaluated and compared with Harda and tannic acid mordants (**Table 8a, b, c**). Dried rind samples of Bhagawa and Ganesh and Harda fruit samples contained 20, 36 and 50% tannin on dry weight basis. Since pomegranate rind samples of varieties Bhagawa and Ganesh

contain good amount of tannin can successfully be used for mordanting of cotton in place of Harda or tannic acid for dyeing with natural dyes. Tannin content of variety Ganesh was higher and samples mordanted with it showed higher colour yield in dyeing trials conducted with manjith. These rind samples also appear to contain some yellow natural colourant. Thus, these can also be used as yellow natural dye for cotton with good fastness properties. However, Ganesh was better in this regard.

Table 8 a : Colour parameters of mordanted cotton fabric samples

| Tannin mordant | K/S at | λ max | Colour coordinates (CIELab 1976) | | | | |
|---|---|---|---|---|---|---|---|
| used | λ max | (nm) | L* | a* | b* | C* | H* |
| Tannic acid | 0.44 | 420 | 83.49 | 0.95 | 13.74 | 13.77 | 85.99 |
| Harda | 4.53 | 420 | 73.29 | 0.33 | 35.90 | 35.90 | 89.44 |
| Bhagawa | 2.67 | 420 | 73.80 | 2.39 | 30.60 | 30.69 | 85.51 |
| Ganesh | 5.27 | 420 | 71.84 | 1.96 | 38.86 | 38.92 | 87.14 |

Table 8 b : Colour parameters of mordanted and manjit dyied cotton fabric samples

| Tannin mordant | K/S at | λ max | Colour coordinates (CIELab 1976) | | | | |
|---|---|---|---|---|---|---|---|
| used | λ max | (nm) | L* | a* | b* | C* | H* |
| Tannic acid | 5.74 | 510 | 46.05 | 35.59 | 17.17 | 37.31 | 17.42 |
| Harda | 6.96 | 510 | 46.50 | 32.40 | 22.21 | 39.28 | 34.42 |
| Bhagawa | 4.79 | 510 | 47.26 | 32.54 | 18.90 | 37.62 | 30.12 |
| Ganesh | 8.32 | 510 | 44.28 | 32.91 | 23.74 | 40.58 | 35.76 |

Table 8 c : Colourfastness properties of mordanted samples

| Tannin mordant used | CF to Washing | | | CF to light | CF to acidic per spiration | | | CF to alkaline perspiration | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Colour change | Staining | | | Colour change | Staining | | Colour change | Staining | |
| | | C | W | | | C | W | | W | C |
| Harda | 4d | 4-5 | 5 | >5 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 |
| Bhagawa | 4d | 4-5 | 5 | 4 | 3 | 4-5 | 4-5 | 4 | 4-5 | 4-5 |
| Ganesh | 4d | 4-5 | 5 | >5 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 |

CF-Colourfastness, C-Cotton, W-wool, d-darker

## Project 1.2: Improvement of pomegranate

### Evaluation of commercial varieties:

Seven commercial varieties of pomegranate were evaluated for their vegetative growth, quantitative and qualitative traits under field condition during the third year of planting (Table1a-c & Fig.1). The cultivars differed significantly from each other for most of the traits. Plant height was highest in G-137 (230.65 cm) whereas it was lowest in Ruby (167.61cm). The yield/tree was highest in Jalore Seedless (13.20 kg) closely followed by G-137 (13.15 kg). The TSS/acid ratio was highest in Ganesh (35.68). The 100 aril weight was highest in Bhagwa (35.03g).

Table.1a. Evaluation of commercial varieties of pomegranate for vegetative growth

| Variety | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Bhagwa | 167.96 | 163.49 | 158.98 | 8.10 | 37.75 | 122.83 |
| Ganesh | 197.43 | 168.97 | 169.93 | 7.45 | 48.31 | 154.65 |
| Ruby | 167.61 | 175.53 | 171.71 | 6.45 | 52.58 | 164.16 |
| Jalore Seedless | 186.05 | 185.26 | 184.68 | 7.74 | 50.61 | 162.58 |
| G-137 | 230.60 | 203.87 | 199.73 | 8.40 | 49.78 | 158.93 |
| Arakta | 211.25 | 189.56 | 183.42 | 7.83 | 51.01 | 162.11 |
| Mridula | 206.92 | 208.44 | 193.03 | 7.92 | 60.95 | 188.44 |
| CD (5%) | 16.08 | 13.49 | 14.85 | 0.67 | 1.75 | 10.60 |

Table.1b. Evaluation of commercial varieties of pomegranate for quantitative traits

| Variety | No. fruits/tree | Fruit weight (g) | Yield/tree (kg) | Fruit length (mm) | Fruit diameter (mm) | Rind thickness (mm) | Rind weight (g) |
|---|---|---|---|---|---|---|---|
| Bhagwa | 28.2 | 313.33 | 8.84 | 81.12 | 80.84 | 3.02 | 130.84 |
| Ganesh | 28.0 | 325.50 | 9.11 | 83.64 | 85.12 | 2.28 | 109.87 |
| Ruby | 26.9 | 301.78 | 8.11 | 77.40 | 79.28 | 2.60 | 80.69 |
| Jalore Seedless | 41.2 | 320.56 | 13.20 | 83.16 | 84.32 | 2.40 | 90.82 |
| G-137 | 39.6 | 332.17 | 13.15 | 85.24 | 86.48 | 2.88 | 111.52 |
| Arakta | 35.4 | 277.83 | 9.84 | 75.64 | 77.08 | 2.42 | 69.66 |
| Mridula | 32.8 | 292.15 | 9.58 | 74.20 | 79.40 | 2.48 | 72.94 |
| CD (5%) | 6.26 | 22.33 | 0.99 | 0.84 | 1.31 | 0.31 | 4.08 |

Table.1c. Evaluation of commercial varieties of pomegranate for qualitative traits

| Variety | 100 aril weight (g) | 100 aril juice volume (ml) | 100 aril juice weight (g) | No. of arils/fruit | Aril length (mm) | Aril length (mm) | TSS (°Brix) | Titrable acidity (%) | TSS/ acid ratio |
|---|---|---|---|---|---|---|---|---|---|
| Bhagwa | 35.03 | 23.0 | 23.3 | 519.30 | 10.94 | 6.86 | 15.88 | 0.50 | 31.76 |
| Ganesh | 26.25 | 22.5 | 23.5 | 730.00 | 10.54 | 6.62 | 16.06 | 0.45 | 35.68 |
| Ruby | 31.92 | 24.83 | 25.33 | 616.67 | 10.22 | 6.49 | 15.80 | 0.46 | 34.35 |
| Jalore | | | | | | | | 0.45 | 35.82 |
| Seedless | 28.84 | 25.17 | 25.67 | 714.00 | 10.64 | 6.78 | 16.12 | | |
| G-137 | 27.10 | 25.83 | 26.33 | 711.67 | 10.61 | 6.84 | 16.10 | 0.51 | 31.57 |
| Arakta | 30.25 | 18.00 | 18.50 | 666.00 | 9.76 | 6.28 | 15.36 | 0.45 | 34.13 |
| Mridula | 30.60 | 20.67 | 21.17 | 678.20 | 9.68 | 6.42 | 15.48 | 0.46 | 33.65 |
| CD (5%) | 2.35 | 2.73 | 2.76 | 35.69 | 0.29 | 0.27 | 0.26 | NS | 0.78 |


Cultivar G-137

Fig.1. Evaluation of commercial varieties of pomegranate

**Evaluation of bacterial blight tolerant varieties**

Four bacterial blight tolerant varieties of pomegranate were evaluated for their vegetative growth, quantitative and qualitative traits (Table 2a-c & Fig.2). The varieties differed significantly for various traits. The cultivars differed significantly from each other for most of the traits. Plant height was highest in Daru (148.39 cm) whereas it was lowest in Nana (29.00 cm). The yield/tree was highest in Nayana (4.10 kg) followed by Kalpitiya (3.55 kg). The titrable acidity was highest in Nana (4.72%). The TSS/acid ratio was highest in Nayana (36.26).

Table.2a. Evaluation of bacterial blight tolerant varieties of pomegranate for vegetative growth

| Variety | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Nana | 29.00 | 27.53 | 26.13 | 5.53 | 11.67 | 41.47 |
| Daru | 148.39 | 149.83 | 139.28 | 6.11 | 47.68 | 147.11 |
| Kalpitiya | 139.00 | 124.00 | 121.00 | 3.50 | 41.46 | 135.00 |
| Nayana | 123.71 | 97.14 | 102.86 | 4.43 | 26.35 | 110.29 |
| CD (5%) | 34.94 | 51.12 | 58.44 | 0.22 | 0.74 | 29.46 |

Table. 2b. Evaluation of bacterial blight tolerant varieties of pomegranate for quantitative traits

| Variety | No .fruits /tree | Fruit weight (g) | Yield/tree (kg) | Fruit length (mm) | Fruit diameter (mm) | Rind thickness (mm) | Rind weight (g) |
|---|---|---|---|---|---|---|---|
| Nana | 53.6 | 33.02 | 1.75 | 40.26 | 40.49 | 1.12 | 9.52 |
| Daru | 5.0 | 150.24 | 0.75 | 62.50 | 61.90 | 3.20 | 60.50 |
| Kalpitiya | 15.5 | 228.88 | 3.55 | 70.94 | 71.76 | 3.12 | 88.09 |
| Nayana | 16.0 | 256.50 | 4.10 | 76.19 | 75.09 | 2.96 | 96.50 |
| CD (5%) | 4.82 | 17.15 | 0.59 | 1.20 | 0.37 | 0.29 | 9.76 |

Table.2c. Evaluation of bacterial blight tolerant varieties of pomegranate for qualitative traits

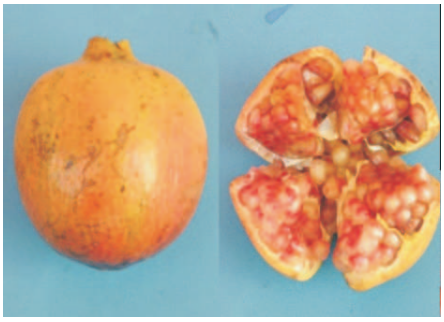
| Variety | 100 aril weight (g) | 100 aril juice volume (ml) | 100 aril juice weight (g) | No. arils/fruit | Aril length (mm) | Aril width (mm) | TSS (°Brix) | Titrable acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|
| Nana | 14.25 | 11.25 | 11.75 | 150 | 7.00 | 4.62 | 12.35 | 4.72 | 2.62 |
| Daru | 30.04 | 17 | 17.5 | 270 | 9.89 | 6.74 | 17.55 | 2.19 | 8.01 |
| Kalpitiya | 29.44 | 14 | 14.82 | 450 | 8.93 | 5.59 | 16 | 0.58 | 27.58 |
| Nayana | 32.50 | 25 | 26.5 | 405 | 10.44 | 7.55 | 16.32 | 0.45 | 36.26 |
| CD (5%) | 1.84 | 1.95 | 1.98 | 23.31 | 0.20 | 0.17 | 0.27 | 0.24 | 1.98 |

**Evaluation of other pomegranate varieties**

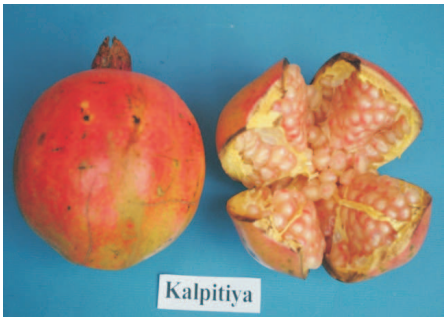
Eleven varieties of pomegranate were evaluated for their vegetative growth and physico-chemical parameters in comparison with Bhagwa (Table 3a-c & Fig.3). The varieties differed significantly for vegetative and other physico-chemical parameters.

Plant height was highest in Yercaud-1 (281.2 cm) whereas it was lowest in Amlidana (91.33 cm). The yield/tree was highest in Kabul Yellow (9.44 kg). The TSS/acid ratio of Kerala Local, Kasuri, KRS and Muskat were comparable with that of Bhagwa (31.76).


Nana



Daru




Kalpitiya


Nayana

Fig.2. Evaluation of bacterial blight tolerant varieties of pomegranate

Table.3a. Evaluation of pomegranate varieties for vegetative growth

| Variety | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Bhagwa | 167.96 | 163.49 | 158.98 | 8.10 | 37.75 | 122.83 |
| Amlidana | 91.33 | 83.67 | 95.00 | 3.33 | 34.63 | 113.3 |
| B.Sedana | 208.6 | 169.6 | 161.4 | 11.2 | 41.04 | 127.6 |
| Dholka | 204.67 | 169.33 | 178.33 | 7.00 | 54.13 | 177.3 |
| Jodhpur | 246.4 | 196.4 | 208.4 | 10.4 | 41.852 | 130.8 |
| Jyothi | 181.5 | 170 | 152.5 | 7.5 | 50.66 | 160 |
| Kabul Yellow | 236.8 | 215.2 | 226.8 | 8.2 | 70.572 | 202 |
| Kasuri | 180.5 | 183 | 235 | 7.5 | 46.63 | 140 |
| Kerasla Local | 142 | 137.6 | 125.2 | 6.2 | 35.35 | 116 |
| KRS | 239 | 235 | 227.2 | 6.6 | 79.61 | 218.8 |
| Muskat | 242 | 232 | 228 | 12 | 94.94 | 260 |
| Yercaud -1 | 281.2 | 209.8 | 227.6 | 11.2 | 59.542 | 164.4 |
| CD (5%) | 20.16 | 16.55 | 16.46 | 1.20 | 1.68 | 15.24 |

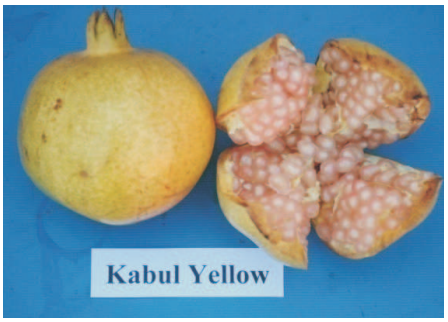
Table.3b. Evaluation of pomegranate varieties for quantitative traits

| Variety | No. fruits/tree | Fruit weight (g) | Yield/tree (kg) | Fruit length (mm) | Fruit diameter (mm) | Rind thick (mm) | Rind weight (g) |
|---|---|---|---|---|---|---|---|
| Bhagwa | 28.2 | 313.33 | 8.84 | 281.1 | 80.84 | 3.02 | 130.84 |
| Amlidana | 29.6 | 228 | 6.75 | 68 | 70 | 2.53 | 73.5 |
| B.Sedana | 30 | 110 | 3.3 | 40 | 50 | 2.6 | 55 |
| Dholka | 26.3 | 171.75 | 4.52 | 66.24 | 67.42 | 2.64 | 77.5 |
| Jodhpur | 10 | 153.5 | 1.35 | 59.6 | 65.05 | 2.51 | 52 |
| Jyothi | 16 | 286.6 | 4.59 | 74.73 | 80.13 | 4.1 | 100 |
| Kabul Yellow | 38 | 248.66 | 9.44 | 74.67 | 76.88 | 3.25 | 88.05 |
| Kasuri | 21 | 316.57 | 7.63 | 82.53 | 87.48 | 4.25 | 137 |
| Kerla Local | 25.3 | 315.20 | 7.97 | 87.68 | 75.51 | 3.6 | 143.5 |
| KRS | 19.3 | 326.22 | 7.07 | 81.44 | 87.86 | 2.58 | 113.5 |
| Muskat | 72 | 315 | 8.82 | 87.26 | 86.65 | 2.19 | 131.5 |
| Yercaud -1 | 10.2 | 200 | 2.04 | 68.20 | 69.56 | 1.71 | 53.5 |
| CD (5%) | 5.73 | 11.89 | 0.64 | 0.90 | 1.24 | 0.38 | 4.52 |

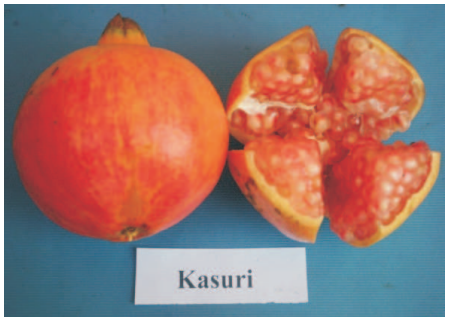
Table.3c. Evaluation of pomegranate varieties for qualitative traits

| Variety | 100 aril weight (g) | 100 aril juice volume (ml) | 100 aril juice weight (g) | No. of arils/fruit | Aril length (mm) | Aril width (mm) | TSS ($^0$B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|
| Bhagwa | 35.03 | 23.0 | 23.3 | 519.30 | 10.94 | 6.86 | 15.88 | 0.50 | 31.76 |
| Amlidana | 36.5 | 22 | 22.5 | 320 | 10.28 | 7.24 | 16.60 | 2.11 | 7.86 |
| B.Sedana | 41.5 | 26.5 | 27 | 80 | 12.53 | 8.19 | 14.18 | 1.11 | 12.81 |
| Dholka | 30 | 19.5 | 20 | 375 | 10.41 | 6.96 | 15.41 | 0.53 | 29.01 |
| Jodhpur | 20 | 11 | 11.6 | 420 | 8.79 | 5.4 | 14.78 | 0.55 | 26.85 |
| Jyothi | 33.5 | 19.5 | 20 | 440 | 9.17 | 6.44 | 15.2 | 0.48 | 31.66 |
| Kabul Yellow | 26 | 17 | 18 | 620 | 8.55 | 590 | 15.06 | 0.51 | 29.41 |
| Kasuri | 38.5 | 27.5 | 28 | 620 | 10.32 | 6.05 | 15.3 | 0.48 | 31.87 |
| Kerala Local | 45 | 32.5 | 33 | 335 | 10.63 | 7.38 | 15.32 | 0.48 | 31.91 |
| KRS | 39.5 | 27 | 27.5 | 530 | 10.19 | 6.06 | 15.1 | 0.48 | 31.45 |
| Muscat | 40.5 | 27 | 27.5 | 710 | 10.42 | 6.9 | 15.15 | 0.48 | 31.56 |
| Yercaud -1 | 40 | 20.5 | 21 | 285 | 10.41 | 7.09 | 16.51 | 0.61 | 27.06 |
| CD | 2.65 | 2.83 | 2.80 | 37.20 | 0.32 | 0.28 | 0.28 | 0.32 | 1.36 |


Jyothi




Kabul Yellow




Kasuri


Kerala Local

Fig.3. Evaluation of other pomegranate varieties

**Evaluation of Ruby hybrids of pomegranate**

Four pomegranate hybrids developed at IIHR, Bangalore using Ruby as pollen parent were evaluated for their vegetative growth, physico-chemical parameters at NRCP, Solapur (Table 4a-4c& Fig.4 ) and the results in comparison to Bhagwa are as follows.

Plant height was highest in Nayana x Ruby (303.4cm) whereas it was lowest in Bhagwa (167.96 cm). The yield/tree was highest in Nayana x Ruby (13.35 kg). The TSS/acid ratio of was highest in {(Gxn)x(GxD)}xR.

Table.4a. Evaluation of Ruby hybrids for vegetative growth

| Hybrid | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Bhagwa | 167.96 | 163.49 | 158.98 | 8.10 | 37.75 | 122.83 |
| {(GxD)xG}xR | 289.40 | 242.80 | 243.00 | 6.90 | 86.97 | 262.60 |
| KxR | 303.30 | 271.00 | 269.40 | 7.10 | 76.78 | 240.00 |
| NxR | 298.30 | 278.70 | 272.20 | 7.00 | 96.46 | 285.17 |
| {(Gxn)x(GxD)}xR | 203.78 | 195.00 | 205.00 | 5.89 | 56.81 | 177.80 |
| CD (5%) | 13.20 | 12.49 | 17.22 | 0.35 | 1.35 | 11.93 |

Table.4b. Evaluation of Ruby hybrids for quantitative traits

| Hybrid | No. fruits/tree | Fruit weight (g) | Yield/tree (kg) | Fruit length (mm) | Fruit diameter (mm) | Rind thickness (mm) | Rind weight (g) |
|---|---|---|---|---|---|---|---|
| Bhagwa | 28.2 | 313.33 | 8.84 | 81.12 | 80.84 | 3.02 | 130.84 |
| {(GxD)xG}xR | 37.4 | 228.7 | 7.72 | 68.81 | 72.76 | 2.80 | 84.5 |
| KxR | 40 | 309.0 | 12.36 | 78.09 | 82.65 | 2.48 | 91.5 |
| NxR | 43 | 310.5 | 13.35 | 79.22 | 77.01 | 2.36 | 92.5 |
| {(Gxn)x(GxD)}xR | 41.0 | 252.5 | 10.35 | 72.11 | 77.86 | 2.28 | 76.5 |
| CD (5%) | 3.96 | 4.34 | 0.37 | 2.06 | 1.08 | 0.37 | 9.55 |

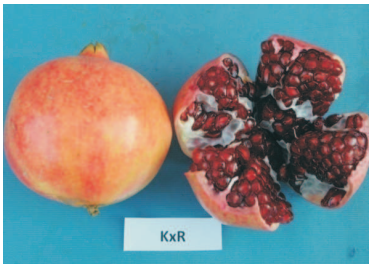
Table. 4c. Evaluation of Ruby hybrids for qualitative traits

| Hybrid | 100 aril weight (g) | 100 aril juice volume (ml) | 100 aril juice weight (g) | No. of arils/fruit | Aril length (mm) | Aril width (mm) | TSS (°Brix) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|
| Bhagwa | 35.03 | 23.0 | 23.3 | 519.30 | 10.94 | 6.86 | 15.88 | 0.50 | 31.76 |
| {(GxD)xG}xR | 33.5 | 21.5 | 23 | 416 | 9.94 | 6.87 | 16.96 | 0.45 | 37.86 |
| KxR | 35.5 | 25.0 | 26 | 560 | 10.78 | 7.02 | 16.48 | 0.45 | 36.79 |
| NxR | 36.0 | 24.5 | 25.5 | 556 | 10.86 | 7.08 | 14.85 | 0.38 | 38.67 |
| {(Gxn)x (GxD)}xR | 34.0 | 22 | 23.5 | 502 | 10.06 | 6.83 | 16.28 | 0.38 | 42.39 |
| CD (5%) | NS | 1.25 | 1.29 | 31.74 | 0.29 | 0.12 | 0.39 | NS | 0.99 |

(G- Ganesh, D- Daru, K- Kalpitiya, n-Nana, N- Nayana, R- Ruby)


[(GxD)xG]xR


{(Gxn)x(GxD)}xR




KxR


NxR

Fig.4. Evaluation of Ruby hybrids

### Evaluation of other pomegranate hybrids

Eight pomegranate hybrids were assessed for various physico-chemical parameters in comparison with Bhagwa (Table 5a-c & Fig.5 ). Sweet 7/10 and sweet 6/7 were found to be sweet types.

Plant height was highest in {[(Gxn)xD]x (Gxn) x B-HB (242.50 cm) whereas it was lowest in Bhagwa (167.96 cm). The yield/tree was highest in HA (9.41 kg). The TSS/acid ratio was highest in {(Gxn)x(GxD)}xR.

Table.5a. Evaluation of bacterial blight tolerant hybrids for vegetative growth

| Hybrid | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Bhagwa | 167.96 | 163.49 | 158.98 | 8.10 | 37.75 | 122.83 |
| Bx3/3{(Gxn)xD} -MR | 203.69 | 184.46 | 202.38 | 7.54 | 47.26 | 15.40 |
| Bx3/3{(Gxn)xD} -R | 188.67 | 140.67 | 147.67 | 5.67 | 48.11 | 16.53 |
| Bx{(Gxn)xD} -HA | 221.30 | 211.10 | 213.70 | 6.50 | 54.60 | 16.52 |
| {[(Gxn)xD]x (Gxn) x B-HB | 242.50 | 205.90 | 217.80 | 6.60 | 72.80 | 22.68 |
| Sour 6/4 | 153.25 | 159 | 144.5 | 3.25 | 43.31 | 13 |
| Sour 6/5 | 210.60 | 173.20 | 170.00 | 3.60 | 52.59 | 16.48 |
| Sweet 6/7 | 183.6 | 194.2 | 190.2 | 4.6 | 51.86 | 18.04 |
| Sweet 7/10 | 100.33 | 78.67 | 50.33 | 3.33 | 21.57 | 6.27 |
| CD (5%) | 14.08 | 12.48 | 13.85 | 0.76 | 1.80 | 11.20 |

Table.5b. Evaluation of bacterial blight tolerant hybrids for quantitative traits

| Hybrid | No. fruits/tree | Fruit weight (g) | Yield/ tree (kg) | Fruit length (mm) | Fruit diameter (mm) | Rind thickness (mm) | Rind weight (g) |
|---|---|---|---|---|---|---|---|
| Bhagwa | 28.2 | 313.33 | 8.84 | 81.12 | 80.84 | 3.02 | 130.84 |
| Bx3/3 {(Gxn)xD} -MR | 37.0 | 237.1 | 8.77 | 71.79 | 72.28 | 2.12 | 99.0 |
| Bx3/3 {(Gxn)xD} -R | 26.6 | 242.0 | 6.44 | 75.84 | 75.47 | 2.57 | 91.5 |
| Bx{(Gxn)xD}-HA | 32.2 | 292.3 | 9.41 | 78.94 | 79.47 | 3.22 | 124.0 |
| {[(Gxn)xD]x (Gxn) x B-HB | 31.4 | 284.8 | 8.94 | 78.85 | 78.38 | 3.07 | 117.5 |

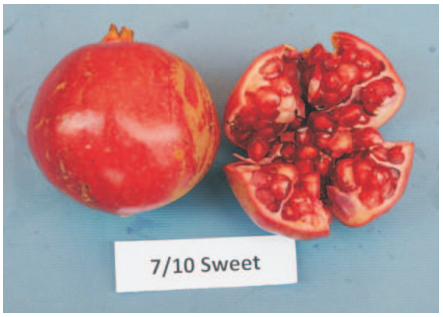
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sour 6/4 | 29.3 | 202.3 | 5.93 | 68.19 | 70.83 | 3.28 | 72.0 |
| Sour 6/5 | 39.0 | 202.5 | 7.90 | 68.3 | 69.19 | 2.33 | 73.5 |
| Sweet 6/7 | 19.0 | 190.5 | 3.62 | 63.58 | 67.05 | 2.14 | 89.5 |
| Sweet 7/10 | 19.0 | 172.2 | 3.27 | 62.1 | 66.57 | 2.06 | 69.0 |
| CD (5%) | 1.92 | 4.99 | 0.72 | 1.98 | 1.56 | 0.09 | 7.85 |

Table.5c. Evaluation of bacterial blight tolerant hybrids for qualitative traits

| Hybrid | 100 aril weight (g) | 100 aril juice volume (ml) | 100 aril juice weight (g) | No. arils/fruit | Aril length (mm) | Aril width (mm) | TSS (ºBrix) | Titrable acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|
| Bhagwa | 35.03 | 23.0 | 23.3 | 519.30 | 10.94 | 6.86 | 15.88 | 0.50 | 31.76 |
| Bx3/3 {(Gxn)xD, MR | 39 | 27.5 | 28 | 455 | 11.14 | 6.94 | 16.46 | 3.67 | 4.49 |
| Bx3/3 {(Gxn)xD}, R | 25 | 16.5 | 17 | 530 | 8.82 | 6.06 | 14.53 | 4.43 | 3.28 |
| Bx{(Gxn) xD, HA | 38.05 | 25.2 | 26.5 | 474 | 10.58 | 7.25 | 15.3 | 3.62 | 4.23 |
| {[(Gxn)xD ]x (Gxn) x B, HB | 43 | 25 | 26 | 230 | 11.31 | 7.28 | 16.23 | 1.83 | 8.87 |
| Sour 6/4 | 36 | 23.5 | 24 | 420 | 10.05 | 6.07 | 14.22 | 3.62 | 3.93 |
| Sour 6/5 | 34.5 | 22.5 | 24 | 485 | 9.95 | 6.32 | 15.34 | 3.49 | 4.40 |
| Sweet 6/7 | 45.5 | 29 | 29.5 | 347 | 10.66 | 6.81 | 16.3 | 0.45 | 36.38 |
| Sweet 7/10 | 48.5 | 31.5 | 32 | 310 | 10.67 | 7.5 | 15.33 | 0.41 | 37.02 |
| CD (5%) | 1.52 | 1.71 | 1.74 | 20.21 | 0.31 | 0.16 | 0.37 | 0.14 | 1.16 |

(B- Bhagwa, G- Ganesh, D- Daru, n-Nana, R- Ruby, MR- moderately tolerant to bacterial blight, R- tolerant to bacterial blight)


6/7 sweet




7/10 sweet

Fig.5. Evaluation of other hybrids of pomegranate

### Evaluation of NRCP hybrids

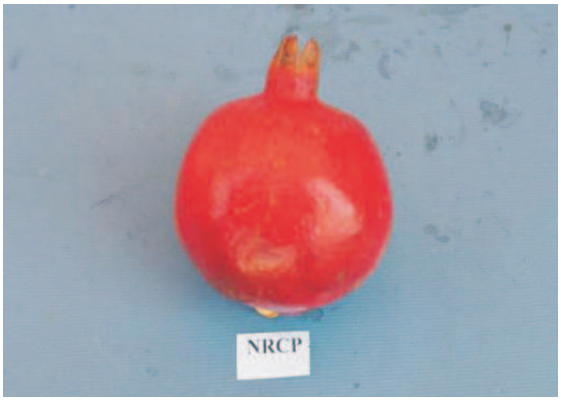
In comparison to Bhagwa, twenty NRCP hybrids [Bx3/3 {(Gxn) xD}] were assessed for vegetative traits, and physico-chemical parameters (Table 6a-b & Fig.6). Based on TSS/acid ratio, Hybrid -6, 14 were found to be superior to Bhagwa for fruit quality whereas Hybrid-5,10 were on par with Bhagwa. Hybrid-2, 8 were found to be sub-acidic in taste. NRCP-6 had highest TSS/acid ratio (39.88)

Table.6a. Evaluation of NRCP hybrids for vegetative growth

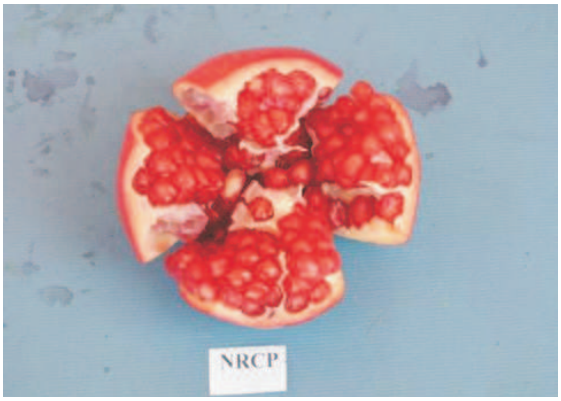
| Variety | Plant height (cm) | Spread E-W (cm) | Spread N-S (cm) | No. of branches | Diameter (mm) | Girth (mm) |
|---|---|---|---|---|---|---|
| Bhagwa | 167.9 | 163.4 | 158.9 | 8.1 | 37.75 | 122.8 |
| NRCP 1 | 353.0 | 293.0 | 246.0 | 10.0 | 63.91 | 210 |
| NRCP 2 | 231.0 | 241.0 | 238.0 | 10.0 | 48.11 | 160 |
| NRCP 3 | 276.0 | 232.4 | 238.5 | 13.0 | 53.95 | 170.2 |
| NRCP 4 | 272.0 | 262.0 | 233.0 | 10.0 | 60.94 | 190 |
| NRCP 5 | 279.2 | 271.0 | 259.5 | 11.0 | 54.12 | 180 |
| NRCP 6 | 215.0 | 242.0 | 247.0 | 9.0 | 48.35 | 150.2 |
| NRCP 7 | 211.0 | 254.0 | 252.0 | 10.0 | 49.89 | 140 |
| NRCP 8 | 335.0 | 282.8 | 248.3 | 11.0 | 41.59 | 130 |
| NRCP 9 | 278.0 | 252.0 | 268.0 | 10.0 | 56.85 | 188.5 |
| NRCP 10 | 259.0 | 258.0 | 251.2 | 9.2 | 48.56 | 150 |
| NRCP 11 | 212.4 | 222.2 | 221.6 | 11.0 | 59.5 | 210 |
| NRCP 12 | 262.0 | 253.0 | 255.0 | 10.0 | 58.74 | 180.6 |
| NRCP 13 | 282.0 | 276.0 | 256 | 10.0 | 52.94 | 180 |
| NRCP 14 | 280.0 | 262.4 | 252.4 | 11.0 | 49.57 | 170 |
| NRCP 15 | 272.0 | 257.0 | 242.0 | 12.0 | 45.68 | 160.3 |
| NRCP 16 | 276.2 | 268.0 | 272.5 | 9.0 | 49.28 | 250 |
| NRCP 17 | 236.0 | 208.6 | 231.0 | 12.0 | 68.35 | 240 |
| NRCP 18 | 281.0 | 273.0 | 228.0 | 11.0 | 45.99 | 170.2 |
| NRCP 19 | 217.5 | 219.7 | 206.2 | 10.0 | 66.27 | 230 |
| NRCP 20 | 216.0 | 209.0 | 204 | 8.0 | 50.58 | 140.4 |
| CD | 15.30 | 13.49 | 14.85 | 0.67 | 1.75 | 10.60 |

Table.6b. Evaluation of NRCP hybrids for physico-chemical parameters

| NRCP hybrid no. | Fruit weight (g) | Fruit length ( mm) | Fruit diameter (mm) | Rind thickness (mm) | 100 Aril weight (g) | 100Aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS ( ºB) | Acidity (%) | TSS/ acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bhagwa | 313.33 | 81.12 | 80.84 | 3.02 | 35.03 | 23.0 | 10.94 | 6.86 | 15.88 | 0.50 | 31.76 |
| NRCP I215 | 74.05 | 71.93 | 3.96 | 33.5 | 16.5 | 9.2 | 7.22 | 17.22 | 3.58 | | 4.82 |
| NRCP 2 | 224.33 | 93.08 | 85.24 | 3.11 | 25.50 | 8 | 7.37 | 6.61 | 16.22 | 0.704 | 23.03 |
| NRCP 3 | 169 | 70.15 | 75.19 | 3.3 | 30 | 14 | 10.15 | 6.88 | 17.13 | 3.04 | 5.63 |
| NRCP 4 | 127 | 66.03 | 63.92 | 2.77 | 29.5 | 17 | 11.17 | 5.92 | 15.69 | 5.76 | 2.72 |
| NRCP 5 | 108.2 | 63.11 | 63.33 | 2.13 | 22.5 | 10 | 8.7 | 5.09 | 15.88 | 0.512 | 31.01 |
| NRCP 6 | 181.75 | 64.9 | 71.09 | 3.21 | 38.5 | 22 | 10.33 | 6.19 | 17.55 | 0.44 | 39.88 |
| NRCP 7 | 162.33 | 69.52 | 69.16 | 2.86 | 43 | 23.50 | 10.35 | 8.14 | 16.59 | 1.15 | 14.42 |
| NRCP 8 | 239.17 | 79.43 | 80.60 | 3.81 | 34.50 | 19 | 10.57 | 6.70 | 18.17 | 0.83 | 21.89 |
| NRCP 9 | 200 | 65.48 | 76.85 | 3.91 | 33.5 | 16.5 | 9.93 | 7.64 | 15.9 | 2.62 | 6.07 |
| NRCP 10 | 169.25 | 73.13 | 68.95 | 2.14 | 25.50 | 8 | 9.28 | 6.91 | 16.08 | 0.51 | 31.52 |
| NRCP 11 | 224.5 | 70.67 | 76.24 | 2.99 | 25.5 | 14 | 9.92 | 7.1 | 14.85 | 4.28 | 3.46 |
| NRCP 12 | 327.75 | 64.99 | 85.28 | 2.3 | 42 | 24.5 | 11.18 | 8.24 | 16.9 | 4.8 | 3.52 |
| NRCP 13 | 315.25 | 86.75 | 85.31 | 3.55 | 45 | 24 | 9.92 | 7.73 | 18.28 | 2.04 | 8.96 |
| NRCP 14 | 233.5 | 89.54 | 75.9 | 2.36 | 44.5 | 21.5 | 10.25 | 7.09 | 17.79 | 0.45 | 39.53 |
| NRCP 15 | 217.33 | 75.01 | 72.91 | 2.73 | 34.0 | 18.50 | 9.28 | 6.40 | 15.75 | 3.58 | 4.39 |
| NRCP 16 | 171 | 62.42 | 71.23 | 3.03 | 33 | 16 | 10.42 | 7.42 | 15.81 | 2.36 | 6.70 |
| NRCP 17 | 176.75 | 72.7 | 72.64 | 2.83 | 36 | 22 | 12.5 | 7.48 | 16.65 | 2.3 | 7.24 |
| NRCP 18 | 374 | 84.93 | 91.51 | 2.48 | 53 | 26 | 12.1 | 7.98 | 17.46 | 2.88 | 6.06 |
| NRCP 19 | 163 | 57.27 | 55.84 | 1.65 | 26.5 | 12.5 | 11.13 | 7.14 | 13.79 | 0.70 | 19.7 |
| NRCP 20 | 205.25 | 69.06 | 72.42 | 3.36 | 29 | 12 | 10.15 | 6.52 | 16.34 | 1.6 | 10.21 |
| CD | 20.16 | 0.96 | 1.40 | 0.369 | 2.6 | 2.82 | 0.32 | 0.26 | 0.34 | 0.26 | 0.84 |




NRCP-6




NRCP-6

Fig.6. Evaluation of NRCP hybrids

**Hybridization for bacterial blight tolerance & raising F1hybrid seedlings**

Four commercial cultivars (Ganesh, Bhagwa, Ruby, Jalore Seedless) were crossed with three bacterial blight resistant/tolerant varieties (nana, Kalpitiya, Nayana) during the month of February (Table 7 & Fig.7 ). Fruit set was ranging from 31.3 % to 66.7%. The cross 'Ganesh x Nayana' recorded the highest fruitset (66.7%). This was closely followed by Ganesh x Kalpitiya (62.5%) & Ruby x Kalpitiya (62.5%).

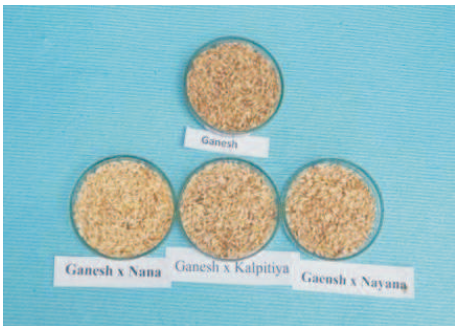
The F1 hybrid seeds of 12 crosses involving 4 commercial varieties (Ganesh, Bhagwa, Ruby, Jalore Seedless) and 3 bacterial blight tolerant varieties (nana, Kalpitiya, Nayana) done during last year were sown in pots to raise the F1 hybrid seedlings. The F1 hybrid seedlings were transferred to polybags and maintained under shade in the nursery.

Table 7. Fruitset due to hybridization in pomegranate

| Name of the crossing | No. of flowers crossed | No. of fruits obtained | Fruit set (%) |
|---|---|---|---|
| Ganesh x nana | 25 | 11 | 44.0 |
| Ganesh x Kalpitiya | 16 | 10 | 62.5 |
| Ganesh x Nayana | 15 | 10 | 66.7 |
| Bhagwa x nana | 25 | 10 | 40.0 |
| Bhagwa x Ka lpitiya | 25 | 10 | 40.0 |
| Bhagwa x Nayana | 15 | 8 | 53.3 |
| Ruby x nana | 20 | 9 | 45.0 |
| Ruby x Kalpitiya | 16 | 10 | 62.5 |
| Ruby x Nayana | 16 | 6 | 37.5 |
| Jalore Seedless x nana | 20 | 8 | 40.0 |
| Jalore Seedless x Kalpitiya | 15 | 7 | 46.2 |
| Jalore Seedless x Nayana | 16 | 5 | 31.3 |
| CD (p=0.05) | | | 10.24 |

Fruitset due to hybridization

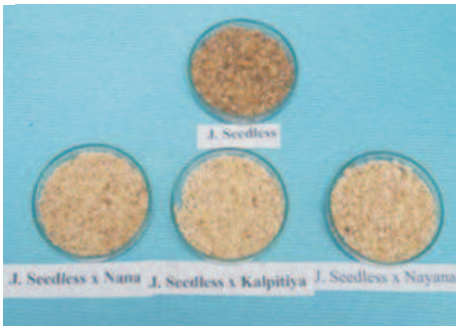

Fruits of 12 different crosses




F1 hybrid seeds of Ganesh crosses


F1 hybrid seeds of Bhagwa crosses


F1 hybrid seeds of Ruby crosses




F1 hybrid seeds of J. Seedless cros

Fig.7. Hybridization for bacterial blight tolerance in pomegranate

### Flower induction in pomegranate

Flower induction in pomegranate cv. Bhagwa was undertaken by resorting to foliar spray of different growth regulators & chemicals under farmer's field during hasth bahar in Sangdari (Table 8). The treatments differed significantly with respect to fruitset. Out of the 14 treatments, the fruit set was highest in Micronutrient mix 1.5g/l + Nitrobenzene 20% (66.96%) which is on par with IAA 20ppm (64.90%) and Ammonium Nitrate 0.05% (64.07%). The fruitset was minimum in control (45.23%).

### Susceptibility of different hybrids to bacterial blight

Six hybrid crosses in pomegranate with 609 plants were screened using challenge inoculation method. Sixty plants of hybrid [Bhagawa (Ganesh x nana)] x Daru, 13 plants of Bhagwa x 3/3 [(Ganesh x nana) x Daru, 12 of Bhagwa x 3/5 [(Ganesh x nana) x Daru and 10 of NRCP Hybrid were found free from bacterial blight after challenge inoculation with local strain of *X. axonopodis punica* (Table 9). Those found free have been subjected to challenge inoculation again with a different isolate.

Table.8. Induction of flowering through foliar spray of growth regulators and chemicals

| Treatment | No. of hermaphrodite flowers/ tree | No. of fruits / tree | Fruitset (%) |
|---|---|---|---|
| IAA 10ppm | 159.33 | 94.33 | 59.20 |
| IAA 20ppm | 151.00 | 98.00 | *64.90* |
| NAA 10ppm | 159.66 | 102.00 | 63.88 |
| NAA 20ppm | 161.33 | 96.66 | 59.91 |
| TIBA 10ppm | 188.00 | 98.00 | 52.12 |
| TIBA 20ppm | 184.66 | 94.16 | 50.99 |
| Micronutrient mix : 1. 5g/l | 173.66 | 99.00 | 57.00 |
| Nitrobenzene 20% : 1.5ml/l | 165.00 | 96.00 | 58.18 |
| Micronutrient mix 1.5g/l + | 148.33 | | |
| Nitrobenzene 20% : 1.5g/l | | 99.33 | 66.96 |
| 6-BAP :10mg/l + | 175.00 | | |
| Magnesium sulphate 0.5g/l | | 88.00 | 50.28 |
| AgNo3 25ppm | 167.00 | 94.00 | 56.28 |
| AgNo3 50ppm | 148.66 | 80.33 | 54.03 |
| Ammonium nitrate 0.50% | 132.16 | 85.00 | 64.07 |
| Ammonium nitrate 1.00% | 139.16 | 88.16 | 63.35 |
| Control | 140.00 | 63.33 | 45.23 |
| CD (p=0.05) | 4.89 | 3.13 | 4.20 |

Table 9: Susceptibility of different hybrids to bacterial blight

| Hybrid | Total | Wilted | Screened | Bacterial Blight Scale | | | |
|---|---|---|---|---|---|---|---|
| | | | | Free | SS | MS | HS |
| Bhagwa x 3/3 [(Ganesh x nana) x Daru lot 1 | 199 | 61 | 138 | 13 | 3 | 39 | 83 |
| Bhagwa x 3/3 [(Ganesh x nana) x Daru] lot 2 | 100 | 0 | 100 | 0 | 9 | 50 | 41 |
| [Bhagawa x (Ganesh x Nana)] x D aru ---- HA | 130 | 50 | 80 | 60 | 7 | 13 | 0 |
| {[Ganesh x nana ) x Daru] x [(Ganesh x nana)] } x Bhagwa ----HB | 125 | 51 | 74 | 0 | 15 | 54 | 5 |
| Bhagwa x 3/5 [(Ganesh x nana) x Daru | 35 | 18 | 17 | 12 | 1 | 4 | 0 |
| NRCP HYBRID | 20 | 5 | 15 | 10 | 5 | 0 | 0 |
| | 609 | | | | | | |
| *screened in net ho use | | | | | | | |

## Programme 2: Pomegranate Production

### Project 2.1: Propagation of pomegranate through conventional and non-conventional methods

**Studies related to stem cutting**

**Propagation of potential rootstocks through stem cutting:** Eight promising accessions of pomegranate were selected based on their tolerance/lesser susceptibility towards bacterial blight and multiplied through stem cutting in order to assess cutting success/rooting abilities so that after their screening against other biotic and abiotic factors and compatibility testing with commercial cultivars they can be proposed as rootstocks for pomegranate. Sprouting success ranged from 63.33 to 100.00 % and 56.67 to 80.00% at 30 and 45 days after planting (DAP), respectively. Different accessions showed great variations for cutting success (%), which ranged from 36.67 to 80.00, 20.00 to 76.67 and 16.66 to 70.00 at 60, 90 and 120 DAP, respectively. RC/PV/1295 registered consistently higher cutting success (Table 1). However, these results are preliminary and rootstocks can only be recommended after their screening against other biotic and abiotic stresses and compatibility testing with scion of commercial cultivars and field evaluation.

**Multiplication of promising pomegranate germplasm using hardwood cutting**

**Effect of different chemicals and growth regulator concentration on success of pomegranate cuttings:** Pomegranate cuttings of cv. Bhagawa were used, the cuttings were 20-22 cm long, 8-10mm in diameter and 6-8 months old. The objective behind this experiment was to replace some quantity of the costlier growth regulator with low cost

Table 1: Sprouting and cutting success (%) of potential rootstocks

| Rootstock | Reaction to bacterial blight | Sprouting Success (%) | | Cutting Success (%) | | |
|---|---|---|---|---|---|---|
| | | 30 DAP | 45 DAP | 60 DAP | 90 DAP | 120 DPA |
| RC/PV/1295 | Partially Resistant | 63.33 | 80.00 | 80.00 | 76.67 | 70.00 |
| RC/PV/1296 | Partially Resistant | 80.00 | 66.67 | 56.67 | 53.33 | 50.00 |
| RC/PV/1297 | Partially Resistant | 96.67 | 66.67 | 50.00 | 46.67 | 46.67 |
| IC 318706 | Partially Resistant | 93.33 | 73.33 | 46.67 | 36.67 | 36.67 |
| IC 318707 | Partially Resistant | 100.00 | 73.33 | 73.33 | 63.33 | 56.67 |
| IC 318724 | Partially Resistant | 73.33 | 56.67 | 53.33 | 50.00 | 50.00 |
| IC 318743 | Partially Resistant | 86.67 | 56.67 | 36.67 | 20.00 | 16.67 |
| IC 318766 | Partially Resistant | 90.00 | 56.67 | 40.00 | 26.67 | 23.33 |
| CD (P=0.05) | ---- | 16.53 | 10.11 | 10.66 | 16.36 | 14.86 |

chemicals. IBA 2000 ppm with 1 per cent $ZnSO_4$ gave the highest cutting success at 90 (71.43%) and 120 DAP (67.86%) and this treatment was better than IBA 4000 ppm (Table 2).

**Effect of surface sterilizing agent on success of stem cutting:** Two surface sterilizing agents Mercuric chloride 0.1% (X) and Sodium hypochlorite 1.0% (Y) were tried in this experiment to eliminate the microbes inhabiting the stem surface and just underneath region (especially bacterium *Xanthomonas axonopodis* pv. *punicae*). The experiment was also carried out to find out inhibitory effect (if any) of surface sterilizing agents on cutting success. Cuttings treated with surface sterilant Y for 10 minutes registered sprouting and cutting success at par with untreated control (Table 3, Fig.1).

Table 2: Effect of different chemicals and growth regulator concentration on success of pomegranate cuttings

| Treatment | Sprouting (%) | Cutting (%) | | |
|---|---|---|---|---|
| | 30 DAP | 60 DAP | 90 DAP | 120 DAP |
| Control | 92.86 | 74.96 | 50.00 | 42.86 |
| IBA 2000ppm + Borax 1 % for 5 min. | 82.15 | 67.86 | 57.16 | 57.16 |
| IBA 2000ppm + $ZnSO_4$ 1 % for 5 min. | 92.86 | 71.46 | 71.43 | 67.86 |
| IBA 2000ppm + $ZnSO_4$ 1 % + Borax 1% for 5 min. | 89.26 | 82.14 | 67.86 | 60.76 |
| IBA 4000ppm for 30 seconds | 82.15 | 67.86 | 60.72 | 57.15 |
| CD (P=0.05) | NS | NS | 8.64 | 8.98 |

Table 3: Effect of surface sterilizing agents on performance of stem cutting

| Treatment | Sprouting Success (%) | | Cutting success (%) | |
|---|---|---|---|---|
| | 30 DAP | 45 DAP | 60 DAP | 90 DAP |
| Control (T0) | 95.00 | 80.00 | 77.50 | 67.50 |
| X for 3 min. (T1) | 87.00 | 47.00 | 40.00 | 40.00 |
| X for 4 min. (T2) | 85.00 | 50.00 | 47.50 | 27.50 |
| Y for 10min.(T3) | 62.50 | 90.00 | 82.50 | 80.00 |
| Y for 12min.(T4) | 70.00 | 65.00 | 62.50 | 77.50 |
| CD (P=0.05) | 13.41 | 13.75 | 17.07 | 18.05 |

X (Mercuric chloride 0.1%) and Y ( Sodium hypochlorite 1.0%) are surface sterilizing agents

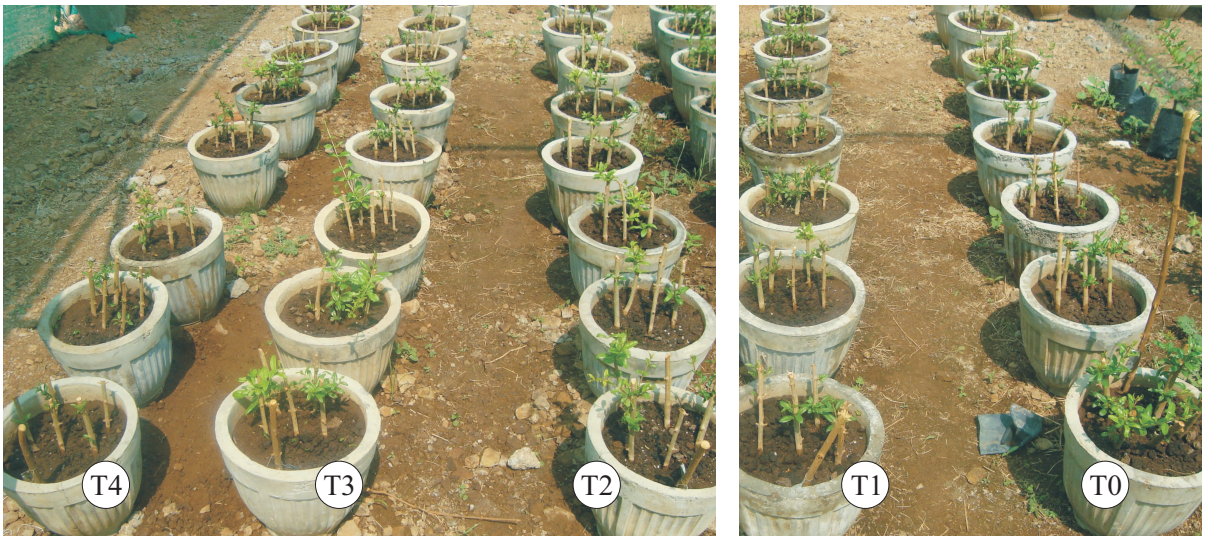


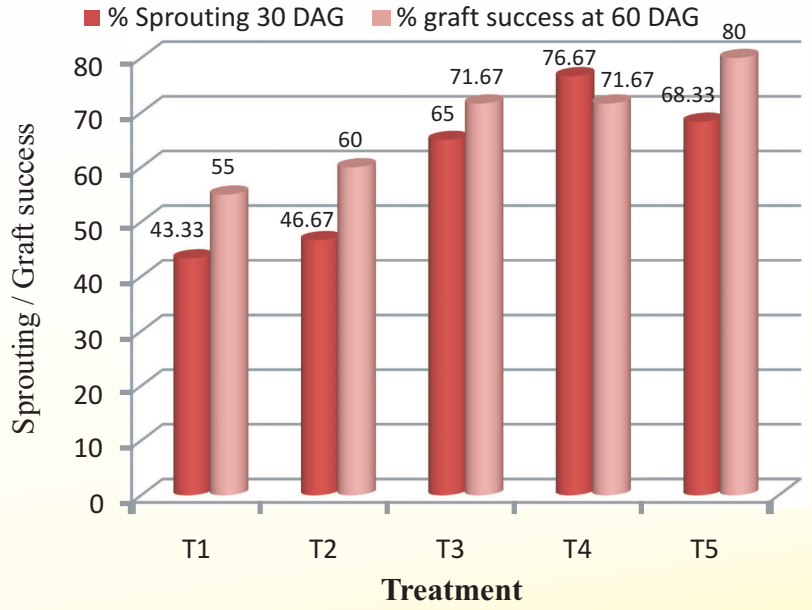

Fig.1: Sprouted cuttings of cv. Bhagawa after surface sterilization

### Studies related to Grafting

**Growth performance of grafted plants as influenced by length of different size of cuts on scion :** The growth performance of six month old wedge grafted plants using different size of cuts on scion were evaluated during 2011 and 2012. The treatment consisted of five size of cuts viz. 2,3,4,5,6cm made on scion prior to grafting on rootstocks. Plant height, scion length, number of leaf/plant were influenced by different size of cuts on scion significantly. In general, plant growth in terms of height, scion length and number of leaves/plant, shoot and root and dry biomass were significantly enhanced with longer cuts on scion (Table 4). This Indicates that availability of more surface area at scion and rootstock joint caused better graft union. However, diameter and girth at graft union could not be influenced by size of cut on scion. It is inferred that 3-6 cm cut on scion may be made at the time of wedge grafting. During 2012, four to six cm long cut on scion stick gave high sprouting (65.00-76.67%) and graft success (71.67-80.00%) (Fig. 2).

Table 4 : Growth performance of wedge grafted plants in cv. Bhagawa at 6 month during 2011

| Treatment | Plant height (cm) | Scion length (cm) | No. of leaves/plant | Dry biomass (g/plant) | |
|---|---|---|---|---|---|
| | | | | Shoot | Root |
| 2cm cut on scion | 41.15 | 28.11 | 61.29 | 10.32 | 9.51 |
| 3 cm cut on scion | 50.75 | 37.85 | 71.15 | 15.16 | 12..33 |
| 4cm cut on scion | 55.15 | 38.65 | 70.35 | 16.09 | 12.22 |
| 5cm cut on scion | 54.45 | 38.55 | 77.25 | 16.68 | 12.01 |
| 6cm cut on scion | 60.4 | 43.95 | 75.9 | 16.43 | 11.24 |
| CD (P=0.05) | 7.48 | 6.4 | 8.13 | 2.00 | 1.33 |




T1 : 2 cm cut on scion; T2 : 3cm cut on scion; T3 : 4 cm cut on scion; T4 : 5 cm cut on scion; T5 : 6 cm cut on scion

Fig. 2 . Effect of length of cut on scion in relation to sprouting (%) and graft success (%)

**Growth performance of scion stock using different rootstocks :** Five seedling rootstocks namely NRCP-24, Dholka, Yercaud, Ganesh and Bhagawa were grafted using Bhagawa as scion. The growth performance of 1 year grafted plants was recorded and presented in Table 5. Plant height was significantly better when Dholka, Yercaud, Ganesh and Bhagawa were used as rootstocks. However, diameter at graft union and scion height were non-significant. Field performance of these rootstocks are yet to be evaluated.

Table 5 : Performance of grafted plants on different rootstocks

| Rootstocks | Plant height (cm) | Diameter (cm) at graft union | | | Scion height (cm) |
|---|---|---|---|---|---|
| | | Lower | Middle | Upper | |
| NRCP-24 | 77.75 | 1.19 | 1.49 | 1.25 | 61.28 |
| Dholka | 118.88 | 1.20 | 1.48 | 1.28 | 103.16 |
| Yercaud | 104.38 | 1.26 | 1.56 | 1.34 | 86.96 |
| Ganesh | 128.38 | 1.11 | 1.39 | 1.10 | 106.69 |
| Bhagawa | 113.00 | 1.28 | 1.50 | 1.31 | 89.00 |
| CD (P=0.05) | 24.03 | NS | NS | NS | NS |

### *In vitro* propagation studies

**Effect of different pretreatments on culture establishment:** To establish contamination free cultures of pomegranate cv. Bhagawa, nodal segments (2 cm long and approximately 20 days old) were treated with different fungicide and antibiotic for variable durations. Carbendazim (0.1%) + Metalyxyl M 4% + Mancozeb 64%( 0.1%) + Streptocycline 0.02% for 30 min. gave significantly higher culture establishment (60 per cent) (Table 6).

**Effect of different concentrations of BAP on culture establishment:** After standardization of type, size and stage of explant ( 2 cm long, tender green nodal segment) to be taken for *in vitro* propagation and various pretreatments need to be given to explants [Carbendazim 0.1% + (Metalyxyl M 4% + Mancozeb 64%) 0.1% + Streptocycline 0.02%] for 30 min. followed by treatment with surface sterilizing agent and rinsing 3-4 times with autoclaved water, the culture establishment study was initiated under which culture establishment medium for pomegranate nodal segments was standardized using full strength MS medium + 200mg/l activated charcoal supplemented with different concentrations of 6- benzylaminopurine and 0.1 mg/l NAA. Nodal segments on MS (1.0 mg/l BAP+ 0.1 mg/l NAA) took minimum days to sprout (9.80) along with the highest culture establishment (72 per cent) (Table 7).

Standardization of multiplication and rooting stages are under process.

Table 6: Effect of different fungicide and antibiotic treatments on *in vitro* culture establishment

| Treatment | Contamination (%) | Culture establishment*(%) | Necrosis along with contamination (%) |
|---|---|---|---|
| Control | 80.00 | 4.00 | 16.00 |
| C+M+S for 30 min. | 6.00 | 60.00 | 34.00 |
| C+M+S for 1 h. | 6.00 | 40.00 | 54.00 |
| C+M+Cy for 30 min. | 34.00 | 32.00 | 34.00 |
| C+M+Cy for 1 h. | 32.00 | 26.00 | 40.00 |
| C+M+Cy+S for 30 min. | 6.00 | 22.00 | 58.00 |
| CD (P=0.05) | 9.97 | 7.80 | 16.73 |

C: Carbendazim (0.1%); M: Metalaxyl 4% + Mancozeb 64% (0.1%); S: Streptocycline (0.02%);Cy: Cycloheximide (0.01%).
*Explants remained green for 25 days after inoculation with or without sprouting

Table 7: Effect of different concentrations of 6-BAP on culture establishment

| Treatment | Days to sprout initiation | Culture establishment (%) | Contamination (%) | Necrosis (%) |
|---|---|---|---|---|
| MS (0.0 mg/l BAP+ 0.1 mg/l NAA) | 17.20 | 28.00 | 6.00 | 66.00 |
| MS (0.5 mg/l BAP+ 0.1 mg/l NAA) | 10.00 | 58.00 | 6.00 | 36.00 |
| MS (1.0 mg/l BAP+ 0.1 mg/l NAA) | 9.80 | 72.00 | 6.00 | 22.00 |
| MS (1.5 mg/l BAP+ 0.1 mg/l NAA) | 9.80 | 62.00 | 4.00 | 34.00 |
| MS (2.0 mg/l BAP+ 0.1 mg/l NAA) | 8.20 | 48.00 | 8.00 | 44.00 |
| MS (2.5 mg/l BAP+ 0.1 mg/l NAA) | 9.8 | 38.00 | 0.00 | 62.00 |
| CD (P=0.05) | 5.57 | 7.95 | N.S | 7.98 |

Fig.3A. Green explants 25 DAI

Fig.3B. Phenol exudation from explant

Fig.3C. Sprouting of Explants

Fig.3D. Explants ready to be excised and inoculation on proliferation medium

## Project 2.2: Exploitation of bio inoculants in pomegranate productivity

**Effect of potassium solubilizing fungi, *Penicillium pinophilum* and K-feldspar on growth and nutrient uptake by pomegranate.**

A pot culture experiment was also conducted to evaluate the effectiveness of *P. pinophilum* (NFCCI 2498) strain in combination with K-feldspar on nutrient availability and their uptake by pomegranate plants. Soil analysis data at the completion of experiment indicated that application of K-feldspar enhanced ($p<0.05$) available soil K content compared to control (247.98 mg $kg^{-1}$ soil) (Table 1). Inoculation of *P. pinophilum* with K-feldspar irrespective of application rate caused increase ($p<0.05$) in available soil K content (268.88 mg $kg^{-1}$) over non-inoculated treatments (244.44 mg $kg^{-1}$). Similarly, soil inoculation of *P. pinophilum* with K-feldspar also enhanced ($p<0.05$) available soil phosphorus content (27.92 mg $kg^{-1}$) compared to non-inoculated treatments (16.22 mg $kg^{-1}$) (Table 1). However, no significant interaction effect on available soil K and P content was observed due to combined application of K-feldspar and fungal strain.

**Table 1** Effect of K-feldspar as influenced by *P. pinophilum* (NFCCI 2498) strain on soil available potassium and phosphorus content (mg $kg^{-1}$)

| Treatment | Available potassium (mg $kg^{-1}$) | | | Available phosphorus (mg $kg^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Fungal culture | | Mean | Fungal culture | | Mean |
| | Without *P. pinophilum* | With *P.pinophilum* | | Without *P.pinophilum* | With *P.pinophilum* | |
| Rate of K-feldspar (mg K $kg^{-1}$ soil) | | | | | | |
| $P_0$ (0 mg K $kg^{-1}$) | 237.19 | 258.75 | 247.98 | 13.81 | 24.94 | 19.38 |
| $P_1$ (50 mg K $kg^{-1}$) | 243.33 | 273.33 | 258.33 | 15.65 | 27.18 | 21.42 |
| $P_2$ (100 mg K $kg^{-1}$) | 248.33 | 273.75 | 261.05 | 18.44 | 31.75 | 25.10 |
| $P_3$ (200 mg K $kg^{-1}$) | 248.89 | 269.72 | 259.31 | 16.95 | 27.78 | 22.36 |
| Mean | 244.44 | 268.88 | | 16.22 | 27.92 | |
| LSD ($P$= 0.05) | | | | | | |
| Rate of K-feldspar | 4.96 | | | 1.40 | | |
| Fungal culture | 3.50 | | | 0.99 | | |
| Rate of K-feldspar X Fungal culture | NS | | | NS | | |

Application of K-feldspar resulted into increase ($p<0.05$) in K-uptake by pomegranate (Table 2) over control. The uptake of K enhanced significantly with increase in rate of K-feldspar application up to 100 mg K $kg^{-1}$ soil (72.77 g $plant^{-1}$) and further increase in rate of K-feldspar to the tune of 200 mg K $kg^{-1}$ soil did not increase K-uptake further significantly. Inoculation of K-feldspar with fungal strain *P. pinophilum* attributed significantly ($p<0.05$) higher K-uptake (69.87 g $plant^{-1}$) than non-inoculated treatments (60.37 g $plant^{-1}$). The results indicated that bio-intervention of K-feldspar with *P. pinophilum* strain performed well in enhancing the K-uptake by pomegranate plant. Significant synergistic effect on K-uptake was noticed owing to combined application of K-feldspar and fungal strain than the K-uptake obtained by them individually. Application of K-feldspar @ 200 mg K $kg^{-1}$ soil when inoculated with *P. pinophilum* recorded the highest K-uptake (79.78 g $plant^{-1}$) by pomegranate plant.

Similarly, inoculation of K-feldspar with *P. pinophilum* caused significant increase in P-uptake (21.09 g $plant^{-1}$) (Table 2) than non-inoculated treatments (15.89 g $plant^{-1}$). The uptake of P increased with the increase in rate of K-feldspar application up to 100 mg K $kg^{-1}$ soil. Significant interaction effect on P-uptake was observed due to combined use of K-feldspar and fungal strain.

Further data on N-uptake (Table 2) revealed that N-uptake by pomegranate got enhanced with the increase in rates of K-feldspar application up to 100 mg K $kg^{-1}$ soil (91.63 g $plant^{-1}$) thereafter it declined at 200 mg K $kg^{-1}$ soil. Soil inoculation of K-feldspar with *P. pinophilum* significantly ($p<0.05$) increased N-uptake by plant (97.16 g $plant^{-1}$) over non-inoculated treatments (77.15 g $plant^{-1}$). The highest N-uptake (105.37 g $plant^{-1}$) by the plant was recorded when *P. pinpphilum* inoculated with 100 mg K $kg^{-1}$ soil K-feldspar.

**Effect of solarization on nutrient availability, enzyme activity and growth of pomegranate (*Punica granatum* L) air-layered on various potting mixtures**

*Soil fertility:* Soil fertility of potting medium was assessed just after solarization and at 180 days after planting (DAP) of pomegranate. The data (Table 3 and 4) revealed that solarization of two components (*i.e.* soil and sand) and all the components in soil-sand-FYM potting medium decreased mineralizable nitrogen but increased available phosphorus and potassium content. The increase was the maximum, when non-solarized FYM was mixed with solarized soil-sand. This increasing trends in available phosphorus and potassium content persisted even up to 180 DAP in soil (S)-sand (S)-FYM (NS) medium. DTPA extractable Cu got increased in solarized soilsand-FYM medium but decreased in soil (S)-sand (S)-FYM (NS) medium in comparison with non-solarized one. Over a period of 180 days of crop grown, there was increase in DTPA extractable Fe, Mn and Cu in solarized soil-sand-FYM medium. In soil-sand-vermicompost medium, solarization of two components (*i.e.* soil and sand) and all the components decreased mineralizable nitrogen at 0 DAP but at 180 DAP, there was increase in mineralizable nitrogen in solarized soil-sand-vermicompost medium. Solarization of soil and sand in the said medium increased available phosphorus both at 0 DAP and 180 DAP whereas, solarization of all the components in the said medium decreased available phosphorus content at 0 DAP. Available potassium content got reduced both at 0 DAP and 180 DAP upon

solarization of two components (*i.e.* soil and sand) and all the components of said medium. The data also indicate that DTPA extractable micronutrient (Fe, Mn, Cu and Zn) status got increased in solarized soil-sand-vermicompost medium over non-solarized one. With soil-sand as potting medium, solarization of both the components decreased available phosphorus and potassium content. Over a period of 180 days of crop growth, there was increase in mineralizable nitrogen and decrease in available phosphate content of solarized soil-sand medium in comparison with non-solarized one. With the passage of time and crop uptake, DTPA extractable Mn, Cu and Zn content got reduced in solarized soil-sand medium (Table 4).

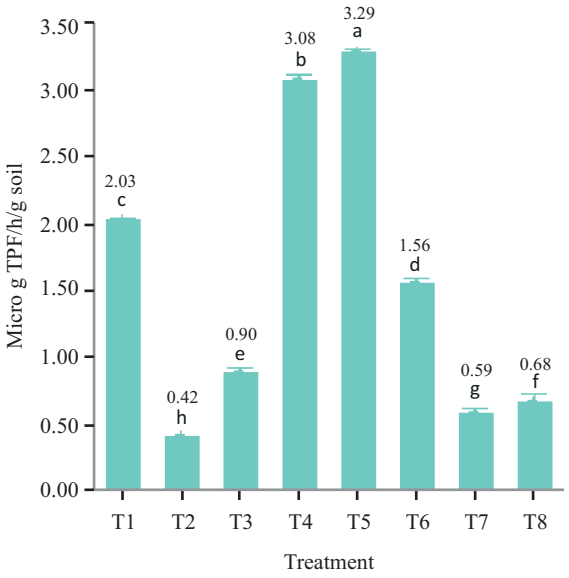



Fig 1 Influence of solarization on dehydrogenase enzyme activity of various potting media (T1- Non-solarized soil + non-solarized sand + non-solarized FYM ; T2-Solarized soil + solarized sand + solarized FYM ; T3- Solarized soil + solarized sand + non-solarized FYM; T4- Non-solarized soil + non-solarized sand + non-solarized vermicompost; T5- Solarized soil + solarized sand + solarized vermicompost; T6- Solarized soil + solarized sand + non-solarized vermicompost; T7- Non-solarized soil + non-solarized sand; T8- Solarized soil + solarized sand). Data are averages (± SE) of three replicates. Significant differences ($p < 0.05$) are indicated by different letters.

*Enzyme Activity*

*Dehydrogenase activity:* The data in figure 1 indicate that solarization of two components (i.e. soil and sand) and all the components in soil-sand-FYM media caused reduction in dehydrogenase activity. The lowest dehydrogenase activity was recorded in solarized soil-sand-FYM medium. On the other hand, dehydrogenase activity increased in solarized soil-sand-vermicompost medium but decreased in soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand potting medium, solarization increased dehydrogenase activity (Fig 1).

*Alkaline and acid phosphatase activity:* Mixing of FYM with solarized soil-sand resulted in higher alkaline phosphatase activity at 0 DAP in comparison with that in non-solarized soil-sand-FYM medium. But, solarization of all the components in soil-sand-FYM medium caused reduction in alkaline phosphatase activity while comparing with that in non-solarized soil-sand-FYM medium (Fig 2). With soil-sand-vermicompost medium, solarization of two components (*i.e.* soil and sand) and all the components enhanced alkaline phosphatase activity at 0 DAP over non-solarized one and maximum alkaline phosphatase activity was noted in soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand potting medium, alkaline phosphatase activity got decreased upon solarization.

Solarization of all the components in soil-sand-FYM medium increased acid phosphatase

activity over that observed in soil (S)-sand (S)-FYM (NS) and non-solarized soil-sand-FYM media at 0 DAP (Fig 2). With soil-sand-vermicompost medium, solarization of two components and all the components increased acid phosphatase activity over non-solarized one. In soil-sand medium, solarization caused reduction in acid phosphatase activity.

*Nutrient uptake:* The nutrient uptake data (Table 5) showed that mixing of FYM with solarized soil-sand enhanced N, P and K uptake by plant over non-solarized and solarized soil-sand-FYM medium. There was no significant increase in Fe-uptake by plant upon solarization but solarization of two components (*i.e.* soil and sand) and all the components of soil-sand-FYM medium increased Mn, Cu and Zn uptake by plant. With soil-sand-vermicompost medium, solarization of two components (*i.e.* soil and sand) and all the components caused reduction in N, K, Fe, Mn & Zn uptake by plant. In addition, there was reduction in P uptake by plant in solarized soil-sand-vermicompost medium. In soil-sand medium, plant uptake of major nutrients *viz.* N, P and K and micronutrients *viz.* Fe, Mn, Cu and Zn got reduced upon solarization of the said medium.

*Plant growth:* Combining FYM with solarized soil-sand resulted in higher shoot, root and total biomass production as compared to non-solarized and solarized soil-sand-FYM medium (Table 6). Maximum plant biomass was recorded with soil (S)-sand (S)-FYM (NS) followed by solarized and non-solarized soil-sand-FYM medium. But plant response was quite different with vermicompost in the medium. Higher shoot, root and total biomass were recorded in non-solarized soil-sand-vermicompost medium as compared with that observed in solarized soil-sand-vermicompost and soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand medium solarization decreased shoot and root dry mass production. This in-turn resulted in higher total biomass production in non-solarized soil-sand medium.

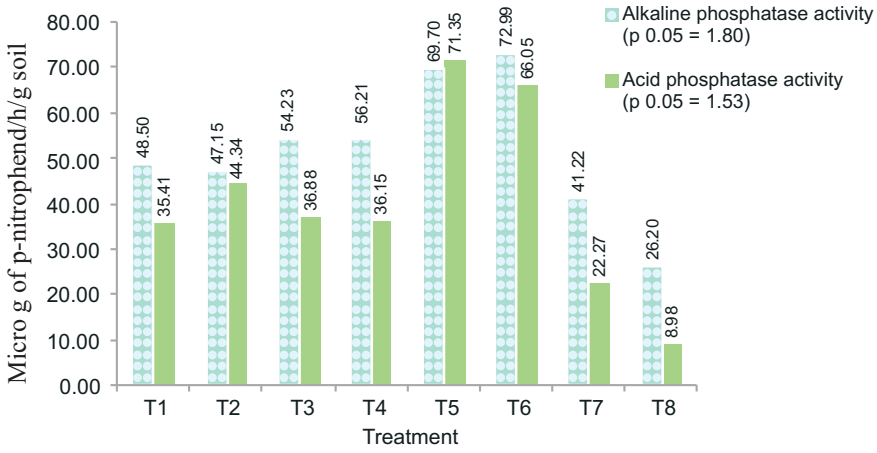



Fig 2 Influence of solarization on alkaline and acid phosphatase enzyme activity of various potting media (T1- Non-solarized soil + non-solarized sand + non-solarized FYM ; T2-Solarized soil + solarized sand + solarized FYM ; T3- Solarized soil + solarized sand + non-solarized FYM; T4- Non-solarized soil + non-solarized sand + non-solarized vermicompost; T5- Solarized soil + solarized sand + solarized vermicompost; T6- Solarized soil + solarized sand + non-solarized vermicompost; T7- Non-solarized soil + non-solarized sand; T8- Solarized soil + solarized sand)

Table 2 Effect of K-feldspar as influenced by *P. pinophilum* (NFCCI 2498) strain on major nutrients uptake (g plant$^{-1}$) by omegranate

| Treatment | N-uptake (g plant $^{-1}$) | | | P-uptake (g plant$^{-1}$) | | | K-uptake (g plant$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fungal culture | | Mean | Fungal culture | | Mean | Fungal culture | | Mean |
| | Without *P. pinophilum* | With *P. pinophilum* | | Without *P.pinophilum* | With *P.pinophilum* | | Without *P.pinophilum* | With *P.pinophilum* | |
| Rate of K -feldspar (mg K kg$^{-1}$ soil) | | | | | | | | | |
| $P_0$ (0 mg K kg$^{-1}$) | 73.55 | 90.96 | 82.26 | 14.46 | 19.39 | 16.93 | 52.67 | 58.62 | 55.65 |
| $P_1$ (50 mg K kg$^{-1}$) | 77.51 | 93.75 | 85.63 | 16.06 | 21.82 | 18.93 | 56.35 | 63.49 | 59.91 |
| $P_2$ (100 mg K kg$^{-1}$) | 77.90 | 105.37 | 91.63 | 16.80 | 23.44 | 20.11 | 67.95 | 77.61 | 72.77 |
| $P_3$ (200 mg K kg$^{-1}$) | 79.66 | 98.58 | 89.12 | 16.21 | 19.75 | 17.97 | 64.48 | 79.78 | 72.14 |
| Mean | 77.15 | 97.16 | | 15.89 | 21.09 | | 60.37 | 69.87 | |
| LSD ($P$= 0.05) | | | | | | | | | |
| Rate of K -feldspar | 2.40 | | | 0.60 | | | 2.37 | | |
| Fungal culture | 1.71 | | | 0.43 | | | 1.69 | | |
| Rate of K -feldspar X Fungal culture | 3.41 | | | 0.85 | | | 3.37 | | |

Table 3 Influence of solarization on available major nutrient content (mg /kg) of various potting mixtures

| Treatment | 0 DAP | | | 180 DAP | | |
|---|---|---|---|---|---|---|
| | Available N | Available P | Available K | Available N | Available P | Available K |
| Soil (NS) + sand (NS) + FYM (NS), (1:1:1) | 96.76 | 1.46 | 53.02 | 72.80 | 0.78 | 91.00 |
| Soil (S) + sand (S) + FYM (S), (1:1:1) | 81.67 | 1˙60 | 76˙83 | 74˙12 | 0˙77 | 100˙75 |
| Soil (S) + sand (S) + FYM (NS), (1:1:1) | 89.13 | 2.16 | 101.83 | 76.69 | 1.03 | 105.00 |
| Soil (NS) + sand (NS) + Vermicompost (NS), (1:1:1) | 152.06 | 2.59 | 163.00 | 118.30 | 1.03 | 127.33 |
| Soil (S) + sand (S) + Vermicompost (S), (1:1:1) | 140.39 | 1.73 | 42.17 | 132.30 | 1.05 | 43.25 |
| Soil (S) + sand (S) + Vermicompost (NS), (1:1:1) | 102.82 | 6.44 | 38.00 | 99.55 | 1.51 | 48.84 |
| Soil (NS) + sand (NS), (1:1) | 58.95 | 1.36 | 82.17 | 56.46 | 0.48 | 71.93 |
| Soil (S) + sand (S), (1:1) | 58.49 | 0.93 | 61.00 | 63.13 | 0.40 | 70.08 |
| SE(m) ± | 1.39 | 0.03 | 2.27 | 2.36 | 0.02 | 1.24 |
| CD ($P$ = 0.05) | 2.94 | 0.06 | 4.80 | 5.01 | 0.05 | 2.63 |

Table 4 Effect of solarization on DTPA extractable micronutrients content (mg $kg^{-1}$) of various potting media

| Treatment | 0 DAP | | | | 180 DAP | | | |
|---|---|---|---|---|---|---|---|---|
| | DTPA extractable | | | | DTPA extractable | | | |
| | Fe | Mn | Cu | Zn | Fe | Mn | Cu | Zn |
| Soil (NS) + sand (NS) + FYM (NS), (1:1:1) | 13.77 | 25.03 | 3.17 | 3.81 | 15.11 | 23.46 | 10.36 | 4.77 |
| Soil (S) + sand (S) +FYM (S), (1:1:1) | 15.01 | 27.73 | 3.99 | 3.15 | 17.29 | 31.45 | 17.24 | 5.16 |
| Soil (S) + sand (S) +FYM (NS), (1:1:1) | 12.53 | 30.56 | 2.74 | 4.23 | 11.75 | 26.19 | 10.77 | 5.17 |
| Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1) | 28.62 | 28.96 | 3.34 | 5.51 | 28.73 | 29.57 | 10.66 | 7.57 |
| Soil (S) + sand (S) + vermicompost (S)' (1:1:1) | 62·71 | 38·18 | 5·86 | 7·24 | 32·89 | 22·02 | 12·67 | 6·38 |
| Soil (S) + sand (S) + vermicompost (NS), (1:1:1) | 12.00 | 44.62 | 3.11 | 5.58 | 7.44 | 19.00 | 9.57 | 5.14 |
| Soil (NS) + sand (NS), (1:1) | 8.81 | 19.11 | 2.30 | 1.65 | 7.05 | 14.67 | 11.32 | 2.10 |
| Soil (S) + sand (S), (1:1) | 9.14 | 23.81 | 2.54 | 1.59 | 6.46 | 11.94 | 7.43 | 1.51 |
| SE(m) ± | 1.20 | 3.56 | 0.16 | 0.33 | 0.49 | 1.11 | 0.55 | 0.23 |
| CD ($P = 0.05$) | 2.55 | 7.55 | 0.34 | 0.69 | 1.03 | 2.35 | 1.17 | 0.49 |

Table 5 Effect of solarization on nutrient uptake by pomegranate air-layer raised on various potting mixtures

| Treatment | N | P | K | Fe | Mn | Cu | Zn |
|---|---|---|---|---|---|---|---|
| | (g/ plant) | | | (mg/ plant) | | | |
| Soil (NS) + sand (NS) + FYM (NS), (1:1:1) | 22.80 | 7.78 | 3.55 | 3.70 | 0.90 | 1.28 | 0.53 |
| Soil (S) + sand (S) + FYM (S), (1:1:1) | 22.31 | 7.20 | 4.07 | 3.57 | 1.56 | 1.95 | 0.67 |
| Soil (S) + sand (S) + FYM (NS), (1:1:1) | 31.05 | 13.39 | 5.27 | 3.89 | 1.70 | 1.79 | 0.82 |
| Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1) | 48.20 | 12.55 | 7.59 | 7.28 | 2.77 | 3.07 | 1.37 |
| Soil (S) + sand (S) + vermicompost (S), (1:1:1) | 38.74 | 9.95 | 5.97 | 5.30 | 2.37 | 3.11 | 1.08 |
| Soil (S) + sand (S) + vermicompost (NS), (1:1:1) | 37.54 | 13.43 | 6.53 | 5.15 | 2.28 | 2.18 | 1.09 |
| Soil (NS) + sand (NS), (1:1) | 16.31 | 6.32 | 2.81 | 2.86 | 1.26 | 1.53 | 0.54 |
| Soil (S) + sand (S), (1:1) | 11.78 | 3.02 | 1.76 | 2.24 | 0.78 | 1.01 | 0.31 |
| SE(m) ± | 0.80 | 0.45 | 0.18 | 0.15 | 0.06 | 0.08 | 0.05 |
| CD ($P = 0.05$) | 1.70 | 0.96 | 0.38 | 0.32 | 0.12 | 0.16 | 0.11 |

Table 6 Effect of solarization on biomass production and physiological parameters of pomegranate air-layer

| Treatment | Above ground biomass (g/plant) | Root biomass (g/plant) | Total plant Biomass (g/plant) | Leaf area ($cm^2$ $plant^{-1}$) | Chlorophyll meter reading (SPAD value) | Photosynthesis rate (μ mol $CO_2$ $m^{-2}$ $sec^{-1}$) | Transpiration rate (m mol $H_2O$ $m^{-2}$ $sec^{-1}$) |
|---|---|---|---|---|---|---|---|
| Soil (NS) + sand (NS) +FYM (NS), (1:1:1) | 20.49 | 6.09 | 26.57 | 1499.70 | 29.55 | 4.86 | 1.58 |
| Soil (S) + sand (S) + FYM (S), (1:1:1) | 23.49 | 8.00 | 31.49 | 1610.13 | 36.15 | 5.06 | 1.51 |
| Soil (S) + sand (S) + FYM (NS), (1:1:1) | 30.44 | 10.91 | 41.34 | 2029.40 | 37.49 | 5.31 | 1.31 |
| Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1) | 49.53 | 19.83 | 69.35 | 2627.93 | 39.70 | 4.93 | 0.93 |
| Soil (S) + sand (S) + vermicompost (S), (1:1:1) | 39.81 | 16.83 | 56.64 | 1873.72 | 33.09 | 4.53 | 1.04 |
| Soil (S) + sand (S) + vermicompost (NS), (1:1:1) | 37.66 | 17.38 | 55.04 | 2580.81 | 35.60 | 4.68 | 0.97 |
| Soil (NS) + sand (NS), (1:1) | 17.54 | 8.19 | 25.73 | 1002.59 | 28.68 | 4.87 | 1.29 |
| Soil (S) + sand (S), (1:1) | 11.75 | 5.56 | 17.31 | 576.85 | 26.20 | 3.10 | 0.58 |
| SEm ± | 0.33 | 0.23 | 0.47 | 29.51 | 0.28 | 0.04 | 0.04 |
| CD ($P$ = 0.05) | 0.70 | 0.48 | 0.99 | 62.56 | 0.60 | 0.09 | 0.09 |

**Effect of microorganisms and their consortium on nutrient uptake and growth of pomegranate**.

Based of number of experiments five microorganisms *viz. Azospirillum brasilense*, *Pseudomonas fluorescens*, Pink pigmented facultative methylotrophs (PPFM), *Pseudomonas striata* and *Penicillium pinophilum* were selected for developing a microbial consortium and the effect of this microbial consortium on nutrient uptake, growth and physiology of pomegranate was evaluated under pot culture study. The results of the study revealed that except *Pseudomonas striata*, all other microorganisms significantly increased plant shoot biomass (Table 7). Similarly, inoculation of *Azospirillum brasilense*, *Pseudomonas fluorescens* and *Penicillium pinophilum* caused significant increase in total biomass production. The extent of increase in plant biomass was much higher with the application of microbial consortium with or without insoluble sources of P and K than those of recorded with individual microorganisms.

Table 7 Effect of microrganisms and their consortium on plant biomass partitioning

| Treatment | Shoot biomass (g plant$^{-1}$) | Root biomass (g plant$^{-1}$) | Total biomass (g plant$^{-1}$) |
|---|---|---|---|
| Control | 52.64 | 23.56 | 76.20 |
| *Azospirillum bras ilense* | 56.21 | 22.86 | 79.06 |
| *Pseudomonas fluorescens* | 59.44 | 24.46 | 83.90 |
| PPFM | 55.57 | 21.39 | 76.95 |
| *Pseudomonas striata* | 53.36 | 21.92 | 75.28 |
| *Penicillium pinophilum* | 59.94 | 22.44 | 82.38 |
| Rock phosphate @ 200 mg P $_2O_5$ kg$^{-1}$ soil | 50.87 | 18.25 | 69.12 |
| Potassium feldspar @ 200 mg $K_2O$ kg$^{-1}$ soil | 52.22 | 25.97 | 78.19 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ kg$^{-1}$ soil | 56.77 | 23.44 | 80.21 |
| *Penicillium pinophilum* + Potassium feldspar @ 200 mg $K_2O$ kg$^{-1}$ soil | 60.73 | 27.51 | 88.24 |
| Microbial consortium | 61.23 | 27.94 | 89.22 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ kg$^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ kg$^{-1}$ soil | 67.45 | 27.25 | 94.70 |
| Recommended fertilizer dose | 72.48 | 29.30 | 101.78 |
| CD (P = 0.05) | 2.62 | 2.78 | 3.68 |

Further application of microbial consortium resulted significantly higher increase in total leaf area, leaf area index, chlorophyll meter reading (SPAD value), stomatal conductance and photosynthetic rate than those of recorded with individual microorganisms (Table 8&9).

There has been significant increase in available N content in PPFM, *Pseudomonas fluorescens*, *Penicillium pinophilum* and microbial consortium inoculation (Table 10). However there was significant reduction in available N content in *Penicillium pinophilum* + potassium feldspar, *Pseudomonas striata* + rock phosphate and fertilizer application pots.

Except *Azospirillum brasilense*, all microorganisms individually or in consortium resulted in significant increase in soil available P content (Table 10). On the contrary, there was significant reduction in available P content in fertilizer application pots. Inoculation of *Penicillium pinophilum* with K-feldspar either singly or in consortium resulted significant increase in available K content of soil but the maximum increase in available K content was noted in fertilizer application pots.

Inoculation of *Pseudomonas fluorescens*, PPFM, *Pseudomonas striata* and *Penicillium pinophilum* either singly or in consortium resulted in significant increase in DTPA extractable Fe content of soil (Table 11).

Table 8 Effect of microorganisms and their consortium on total leaf area, leaf area index and relative leaf moisture content.

| Treatment | Total leaf area ($cm^2$) | Leaf area index (LAI) | Relative leaf moisture content (%) |
|---|---|---|---|
| Control | 1218.40 | 0.68 | 44.68 |
| *Azospirillum brasilense* | 1367.39 | 0.78 | 46.99 |
| *Pseudomonas fluorescens* | 1519.65 | 0.73 | 47.00 |
| PPFM | 1428.13 | 0.85 | 51.60 |
| *Pseudomonas striata* | 1290.14 | 0.88 | 47.72 |
| *Penicillium pinophilum* | 1580.70 | 0.72 | 47.49 |
| Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 1634.82 | 0.76 | 46.92 |
| Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 1515.31 | 0.72 | 46.36 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 1631.28 | 0.79 | 50.21 |
| *Penicillium pinophilum* + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 1791.73 | 0.87 | 50.51 |
| Microbial consortium | 1820.99 | 0.88 | 47.47 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 2185.66 | 1.03 | 49.12 |
| Recommended fertilizer dose | 2112.76 | 0.95 | 51.42 |
| CD (P = 0.05) | 151.37 | 0.10 | 1.06 |

Table 9 Effect of microorganisms and their consortium on chlorophyll meter reading, stomatal conductance and photosynthetic rate.

| Treatment | Chlorophyll meter reading (SPAD) | Stomatal conductance (mol $H_2O$ $m^{-2}s^{-1}$) | Photosynthetic rate (μ mol $CO_2$ $m^{-2}s^{-1}$) |
|---|---|---|---|
| Control | 50.99 | 0.125 | 7.96 |
| *Azospirillum brasilense* | 55.45 | 0.124 | 8.83 |
| *Pseudomonas fluorescens* | 56.13 | 0.126 | 9.08 |
| PPFM | 59.76 | 0.133 | 8.97 |
| *Pseudomonas striata* | 57.46 | 0.118 | 8.30 |
| *Penicillium pinophilum* | 58.13 | 0.137 | 10.02 |
| Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 50.75 | 0.109 | 8.37 |
| Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 53.20 | 0.116 | 8.25 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 58.41 | 0.133 | 10.51 |
| *Penicillium pinophilum* + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 56.27 | 0.146 | 11.06 |
| Microbial consortium | 60.41 | 0.134 | 11.20 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 61.91 | 0.146 | 11.45 |
| Recommended fertilizer dose | 72.59 | 0.148 | 12.31 |
| CD (P = 0.05) | 1.63 | 0.002 | 0.38 |

Table 10 Effect of microorganisms and their consortium on available major nutrient content of soil

| Treatment | Available major nutrients | | |
|---|---|---|---|
| | N (mg $kg^{-1}$) | P (mg $kg^{-1}$) | K (mg $kg^{-1}$) |
| Control | 147.65 | 16.82 | 326.67 |
| *Azospirillum brasilense* | 145.79 | 18.21 | 326.39 |
| *Pseudomonas fluorescens* | 154.35 | 19.29 | 328.06 |
| PPFM | 161.28 | 21.12 | 276.94 |
| *Pseudomonas striata* | 145.79 | 21.62 | 322.50 |
| *Penicillium pinophilum* | 152.95 | 21.20 | 336.67 |
| Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 148.87 | 17.61 | 321.67 |
| Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 147.93 | 17.92 | 320.56 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 137.57 | 21.57 | 337.64 |
| *Penicillium pinophilum* + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 140.14 | 21.24 | 418.89 |
| Microbial consortium | 154.75 | 21.26 | 395.00 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 151.90 | 20.59 | 447.78 |
| Recommended fertilizer dose | 137.04 | 14.53 | 508.33 |
| CD (P = 0.05) | 3.84 | 1.60 | 6.52 |

Higher DTPA extractable Fe content was noted with PPFM and *Pseudomonas fluorescens*. Similarly, there was significant enhancement in DTPA-extractable Mn content upon inoculation with microorganisms used in consortium.

However, higher increase in DTPA-extractable Mn content was noted when *Penicillium pinophilum* was inoculated with K-feldspar. Inoculation of PPFM, *Penicillium pinophilum* and *Pseudomonas striata* either singly or in consortium resulted marginal increase in DTPA-extractable Zn content and higher DTPA-extractable Zn content was noted with consortium inoculation.

Increase in alkaline phosphatase activity was noted upon inoculation with *Pseudomonas striata* and *Penicillium pinophilum* either singly or in consortium. Higher alkaline phosphatase activity was observed when they were inoculated with insoluble mineral sources (Table 12). Except *Azospirillum brasilense*, inoculation of all microorganisms either singly or in consortium resulted increase in acid phosphatase activity. Higher acid phosphatase activity was noted when *Penicillium pinophilum* and *Pseudomonas striata* inoculated with insoluble mineral sources.

Table 11 Effect of microorganisms and their consortium on DTPA extractable micronutrient content of soil

| Treatment | DTPA-extractable micronutrients | | | |
|---|---|---|---|---|
| | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
| Control | 3.19 | 4.65 | 2.27 | 3.39 |
| *Azospirillum brasilense* | 2.83 | 5.90 | 2.31 | 3.07 |
| *Pseudomonas fluorescens* | 8.42 | 9.26 | 2.49 | 2.95 |
| PPFM | 8.53 | 11.92 | 2.98 | 3.05 |
| *Pseudomonas striata* | 5.95 | 6.61 | 2.79 | 2.86 |
| *Penicillium pinophilum* | 6.26 | 10.02 | 2.82 | 3.38 |
| Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 2.89 | 4.75 | 2.36 | 3.27 |
| Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 2.92 | 4.86 | 2.32 | 3.35 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 5.25 | 7.84 | 2.81 | 2.39 |
| *Penicillium pinophilum* + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 6.61 | 15.09 | 2.94 | 3.03 |
| Microbial consortium | 6.39 | 8.99 | 3.43 | 2.38 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 6.40 | 8.34 | 2.96 | 2.63 |
| Recommended fertilizer dose | 5.75 | 14.80 | 2.92 | 2.85 |
| CD (P = 0.05) | 0.18 | 0.48 | 0.23 | 0.23 |

Table 12 Effect of microorganisms and their consortium on alkaline and acid phosphatase activity in soil

| Treatment | Alkaline phosphatase activity (µg p-nitrophenol $h^{-1}$ $g^{-1}$ of soil) | Acid phosphatase activity (µg p-nitrophenol $h^{-1}$ $g^{-1}$ of soil) |
|---|---|---|
| Control | 29.05 | 10.31 |
| *Azospirillum brasilense* | 38.89 | 11.50 |
| *Pseudomonas fluorescens* | 29.90 | 24.47 |
| PPFM | 30.78 | 24.08 |
| *Pseudomonas str iata* | 46.29 | 26.25 |
| *Penicillium pinophilum* | 39.25 | 27.16 |
| Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 35.42 | 19.73 |
| Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 35.49 | 23.28 |
| *Pseudomonas striata* + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil | 55.82 | 32.94 |
| *Penicillium pinophilu m* + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 55.88 | 34.61 |
| Microbial consortium | 55.12 | 21.66 |
| Microbial consortium + Rock phosphate @ 200 mg $P_2O_5$ $kg^{-1}$ soil + Potassium feldspar @ 200 mg $K_2O$ $kg^{-1}$ soil | 54.99 | 32.51 |
| Recommended fertilizer dose | 34.77 | 15.45 |
| CD (P = 0.05) | 3.53 | 2.47 |

## Project 2.3 : Identification of suitable soils for sustained productivity of Pomegranate

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

The experiment is in progress at research farm of NRCP. Pits of 5 x 5 ft were dug and refilled with different types of soil as murrum, gravelly, loamy and black soils having varied depths. Different layers were placed to simulate natural condition and pomegranate plants were planted. The experiment has been conducted in two sets using Ganesh and Bhagwa varieties separately.

### Vegetative growth parameters

Plant vegetative growth parameters in terms of plant height and plant spread (cv. Ganesh) were recorded during March 2012. The results revealed that height of the plant varied non-significantly from 156.8 to 204.8 cm amongst the treatments (Table 1). The highest plant height was recorded in black clayey soil having 60 cm depth while it was lowest in pits filled with only murrum treatment. Plant spread (N-S) significantly varied from 149.7 to 181.7 cm which was maximum under black clayey soil having 90 cm depth. Plant spread (E-W) and average plant spread showed non-significant variation.

Similarly, growth parameters of 'Bhagwa' variety in terms of plant height and plant spread (E-W) revealed non-significant variation amongst the treatments (Table 2). While plant spread (N-S) and average plant spread was significantly highest under pits filled with black clayey soil having depth of 120 cm.

In general, it was observed that vegetative growth performance of pomegranate plants was better in the black clayey soils compared to light textured soils.

Table 1. Influence of soil mixtures used for pit filling on growth parameters cv. Ganesh

| Treatments | Plant height (cm) | Plant spread (cm) | | |
|---|---|---|---|---|
| | | E-W | N-S | Average |
| Gravelly soil 30 cm depth | 170.0 | 169.8 | 176.7 | 173.3 |
| Gravelly soil 60 cm depth | 173.7 | 158.7 | 160.2 | 159.4 |
| Sandy loam 60 cm depth | 168.5 | 162.8 | 161.0 | 161.9 |
| Loamy soil 60 cm depth | 184.0 | 164.5 | 166.5 | 165.5 |
| Black, clayey soil 30 cm depth | 175.0 | 173.0 | 166.0 | 169.5 |
| Black, clayey soil 60 cm depth | 204.8 | 175.3 | 166.7 | 171.0 |
| Black, clayey soil 90 cm depth | 195.7 | 156.8 | 181.7 | 169.3 |
| Black, clayey soil 120 cm depth | 171.3 | 162.3 | 149.7 | 156.0 |
| Black, clayey soil (50% ) + sand (50%) | 178.7 | 144.7 | 161.3 | 153.0 |
| Black, clayey soil (75%) + sand (25%) | 174.7 | 174.3 | 176.8 | 175.6 |
| Weathered murrum | 156.8 | 146.0 | 150.2 | 148.1 |
| CD (p=0.05) | NS | NS | 19.4 | NS |

Table 2. Influence of soil mixtures used for pit filling on growth parameters cv. Bhagawa

| Treatments | Plant height (cm) | Plant spread (cm) | | |
|---|---|---|---|---|
| | | E-W | N-S | Average |
| Gravelly soil 30 cm depth | 131.8 | 127.5 | 130.0 | 128.8 |
| Gravelly soil 60 cm depth | 118.3 | 120.0 | 103.3 | 111.7 |
| Sandy loam 60 cm depth | 139.2 | 133.3 | 129.2 | 131.3 |
| Loamy soil 60 cm depth | 138.3 | 136.7 | 134.2 | 135.4 |
| Black, clayey soil 30 cm depth | 137.3 | 151.5 | 140.3 | 145.9 |
| Black, clayey soil 60 cm depth | 127.5 | 141.7 | 141.7 | 141.7 |
| Black, clayey soil 90 cm depth | 137.5 | 135.8 | 130.8 | 133.3 |
| Black, clayey soil 120 cm depth | 141.7 | 155.0 | 152.5 | 153.8 |
| Black, clay ey soil (50%) + sand (50%) | 140.0 | 133.3 | 135.8 | 134.6 |
| Black, clayey soil (75%) + sand (25%) | 145.8 | 146.7 | 140.8 | 143.8 |
| Weathered murrum | 134.2 | 124.5 | 118.3 | 121.4 |
| CD (p=0.05) | NS | NS | 15.3* | 17.3* |

**Soil physico-chemical properties**

Soil samples were collected during fourth year of the experimentation (October 2010) and analysed for different physico-chemical properties as pH, EC, organic carbon, calcium carbonate and soil fertility in terms of available major and micro-nutrients content in the soil. Most of the properties showed significant variation except pH and available Mn (Table 3). The data revealed that soil pH, EC, organic carbon and calcium carbonate content was higher in black clayey soils compared to light textured soils. Considerable increase in calcium carbonate content was observed with the addition of sand. Similarly soil available N, P, K, Cu and Mn content was high in black clayey soil while available Fe was more in light textured soils. Addition of sand recorded considerable decrease in soil fertility status. It was also observed that availability of major and micro-nutrients was sufficient in case of pits filled with only murrum.

Table 3: Soil physico-chemical properties and fertility status under different treatments

| Treatments | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| Gravelly soil 30 cm depth | 7.85 | 0.371 | 0.85 | 2.69 | 285.2 | 24.3 | 486.5 | 10.10 | 5.51 | 2.57 | 14.14 |
| Gravelly soil 60 cm depth | 7.85 | 0.422 | 0.98 | 3.46 | 296.6 | 32.9 | 494.4 | 9.24 | 7.72 | 1.77 | 14.70 |
| Sandy loam 60 cm depth | 7.90 | 0.413 | 0.73 | 3.71 | 319.1 | 34.7 | 557.1 | 10.62 | 6.66 | 2.06 | 14.38 |
| Loamy soil 60 cm depth | 7.88 | 0.375 | 0.83 | 3.54 | 297.7 | 40.3 | 524.4 | 13.31 | 6.60 | 1.83 | 16.29 |
| Black, clayey soil 30 cm depth | 8.05 | 0.336 | 1.12 | 9.55 | 290.4 | 42.6 | 581.1 | 10.84 | 4.64 | 1.59 | 10.00 |
| Black, clayey soil 60 cm depth | 8.04 | 0.404 | 0.95 | 8.46 | 329.8 | 40.6 | 761.6 | 12.95 | 8.06 | 1.39 | 12.80 |

| Treatments | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| Black, clayey soil 90 cm depth | 7.93 | 0.449 | 1.09 | 8.07 | 364.9 | 43.4 | 692.2 | 12.67 | 6.63 | 1.58 | 15.75 |
| Black, clayey soil 120 cm depth | 7.88 | 0.494 | 1.39 | 10.32 | 367.1 | 47.1 | 709.5 | 19.20 | 6.80 | 1.27 | 16.15 |
| Black, clayey soil (50%) + sand (50%) | 8.00 | 0.303 | 0.93 | 13.21 | 265.9 | 14.3 | 497.1 | 13.05 | 5.03 | 1.49 | 10.92 |
| Black, clayey soil (75%) + sand (25%) | 7.88 | 0.431 | 1.43 | 12.35 | 325.9 | 32.7 | 559.7 | 13.17 | 5.35 | 1.54 | 15.67 |
| Weathered murrum | 7.68 | 0.583 | 0.79 | 3.67 | 313.8 | 31.4 | 449.3 | 13.96 | 5.92 | 1.43 | 17.03 |
| CD (p=0.05) | NS | 0.051* | 0.36* | 1.82* | 27.3* | 6.8* | 46.1* | 2.45* | 1.9 | 0.44* | NS |

### Leaf nutrient content

Leaf samples of both Ganesh and Bhagwa varieties of pomegranate were collected on 11.10.2010 and analysed for various macro and micro-nutrient content. The data showed significant variation for almost all the nutrients except Mg (Table 4 & 5). In case of Ganesh variety highest N content was recorded in light textured shallow gravelly soil followed by black clayey soil mixed with sand. Both these treatments provided better aeration and drainage conditions in the soil. Similarly P, Ca, Cu and Fe content was more in light textured soils. Black clayey or heavy textured soils recorded higher content of K, Zn and Mn in the leaves. In case of Bhagwa variety highest N, P, K and Mn content was observed in black clayey or heavy textured soils while Ca, Mg, Cu, Zn and Fe content was observed in light textured soils. In spite of comparatively lower nutrient availability in the soils, pits filled with only murrum and black soil mixed with 50% sand also recorded sufficient quantity of nutrients in the leaves of both the varieties.

Table 4 : Nutrient content in the leaves of pomegranate cv. Ganesh as affected by different treatments

| Treatments | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| Gravelly soil 30 cm depth | 2.14 | 0.153 | 0.81 | 1.58 | 0.56 | 144.5 | 28.6 | 113.8 | 34.6 |
| Gravelly soil 60 cm depth | 2.03 | 0.143 | 0.86 | 1.67 | 0.51 | 130.4 | 27.8 | 122.7 | 32.2 |
| Sandy loam 60 cm depth | 2.04 | 0.175 | 0.82 | 1.92 | 0.51 | 114.1 | 27.9 | 112.0 | 30.9 |
| Loamy soil 60 cm depth | 1.80 | 0.193 | 0.82 | 1.67 | 0.51 | 104.4 | 23.9 | 110.3 | 29.5 |
| Black, clayey soil 30 cm depth | 2.01 | 0.135 | 0.88 | 1.17 | 0.56 | 97.5 | 26.5 | 105.5 | 41.2 |
| Black, clayey soil 60 cm depth | 2.03 | 0.148 | 0.90 | 1.33 | 0.54 | 94.2 | 27.3 | 105.2 | 41.9 |
| Black, clayey soil 90 cm depth | 2.02 | 0.134 | 0.80 | 1.42 | 0.56 | 91.4 | 28.9 | 102.2 | 39.3 |
| Black, clayey soil 120 cm depth | 2.01 | 0.174 | 0.95 | 1.58 | 0.66 | 99.0 | 29.7 | 103.1 | 40.1 |
| Black, clayey soil (50%) + sand (50%) | 2.11 | 0.168 | 0.86 | 1.67 | 0.61 | 62.9 | 22.4 | 87.2 | 33.9 |
| Black, clayey soil (75%) + sand (25%) | 2.04 | 0.124 | 0.85 | 1.58 | 0.41 | 79.1 | 27.9 | 96.3 | 34.7 |
| Weathered murrum | 1.86 | 0.198 | 0.53 | 1.75 | 0.61 | 104.0 | 23.3 | 104.9 | 36.7 |
| CD (p=0.05) | 0.18 | 0.03* | 0.13* | 0.37 | NS | 21.1* | 3.35* | 14.4 | 6.88 |

Table 5 : Nutrient content in the leaves of pomegranate cv. Bhagwa as affected by different treatments

| Treatments | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | | (ppm) | | |
| Gravelly soil 30 cm depth | 1.85 | 0.139 | 0.89 | 2.75 | 0.61 | 145.9 | 29.5 | 184.0 | 038 |
| Gravelly soil 60 cm depth | 1.90 | 0.127 | 0.80 | 2.08 | 0.57 | 153.0 | 27.0 | 180.7 | 422 |
| Sandy loam 60 cm depth | 1.86 | 0.123 | 0.84 | 2.17 | 0.71 | 130.9 | 32.6 | 176.0 | 621 |
| Loamy soil 60 cm depth | 1.77 | 0.119 | 0.85 | 1.92 | 0.71 | 116.9 | 26.1 | 155.2 | 627 |
| Black, clayey soil 30 cm depth | 2.02 | 0.138 | 0.82 | 2.50 | 0.66 | 84.7 | 27.1 | 144.2 | 325 |
| Black, clayey soil 60 cm depth | 2.00 | 0.148 | 1.04 | 2.00 | 0.71 | 88.8 | 26.9 | 132.4 | 037 |
| Black, clayey soil 90 cm depth | 1.97 | 0.149 | 0.86 | 1.83 | 0.61 | 109.9 | 23.7 | 154.5 | 923 |
| Black, clayey soil 120 cm depth | 1.95 | 0.123 | 0.95 | 1.50 | 0.66 | 95.0 | 27.6 | 144.7 | 728 |
| Black, clayey soil (50%) + sand (50%) | 1.65 | 0.089 | 0.98 | 1.33 | 0.56 | 87.5 | 23.3 | 121.9 | 129 |
| Black, clayey soil (75%) + sand (25%) | 1.85 | 0.165 | 0.95 | 1.42 | 0.66 | 122.9 | 26.4 | 124.0 | 327 |
| Weathered murrum | 1.86 | 0.112 | 0.76 | 1.75 | 0.66 | 127.3 | 22.9 | 122.0 | 222 |
| CD (p=0.05) | 0.12* | 0.02* | 0.14 | 0.38* | NS | 10.2* | 4.04* | 18.2* | 6.4* |

**Performance of pomegranate under different planting systems**

In this experiment, pomegranate plantation was done under different planting systems as Continuous trenches and Broad bed and furrow having different depths along with normal pits. Vegetative growth performance in terms of plant height and plant spread was recorded during March 2012 (Table 6). The results revealed that plant height non-significantly varied from 107.3 to 136.6 cm while average plant spread showed significant variation from 107.6 to 141.1 cm amongst the treatments. Highest vegetative growth was observed in the plants grown on continuous trenches of 1 x 1 m followed by bedding system treatments.

Table 6. Influence of various planting system on vegetative growth of pomegranate cv. Bhagawa

| Treatments | Plant ht (cm) | Plant spread (cm) | | |
|---|---|---|---|---|
| | | N-S | E-W | Average |
| Pits 1 x 1 x 1 m | 129.0 | 122.9 | 126.1 | 124.5 |
| Pits 0.6 x 0.6 x 0.6 m | 126.0 | 125.4 | 123.6 | 124.5 |
| Continuous trenches 1 x 1 m | 136.6 | 136.3 | 145.9 | 141.1 |
| Continuous trenches 0.6 x 0.6 m | 120.5 | 112.3 | 114.4 | 113.4 |
| Trapezoidal trench 0.6 m deep 1.5 m top | 107.3 | 110.9 | 104.3 | 107.6 |
| Bedding 0.6 x 0.30 x 0.30 m above ground | 123.9 | 115.9 | 113.4 | 114.6 |
| Bedding 0.60 x 0.60 x0.30 m above ground | 135.0 | 132.5 | 128.4 | 130.5 |
| CD (p=0.05) | NS | NS | 22.7 | 19.0 |

## Project 2.4 : Nutrient Management in Pomegranate

### Identification of nutrient deficiency symptoms in pomegranate

An experiment was conducted under green house conditions using pomegranate seedlings planted in the pots filled with white inert sand. All essential major and micronutrients were supplied through Hogland's solution in control plots while deficiency of every single nutrient was artificially created by omitting that particular nutrient in the treatment. Leaf and stem samples were collected at the end of the experimentation and analysed for major and micro-nutrients contents.

The data on leaf nutrient content (Table 1) revealed that deficiency of N, P, K, Fe and Cu nutrients recorded significant influence on the plant resulted in to lowest content of these nutrients in the leaves of pomegranate plant in the respective treatments. But such a strong impact was not observed in case of Ca, Mg, Mn and Zn nutrients. Deficiency of P adversely affected the uptake of majority of nutrients as N, K, Ca, Mg and Mn; Mn adversely affected the uptake of P; Cu adversely affected Mg and Fe content while B adversely affected Cu and Fe content in the leaves of pomegranate.

Similarly nutrient content in the stem of the pomegranate plants (Table 2) revealed that deficiency of N, P and K resulted into lower content of these nutrients in the stem of the plants while deficiency of Ca, Mg, Fe, Mn, Cu and Zn does not have much influence and maintained sufficient quantity of these nutrients in the stem in respective treatments. Deficiency of boron adversely affected the uptake of Mg, Fe, Mn, Cu and Zn in the stem of pomegranate plant. Similarly deficiency of P adversely affected the uptake of Ca;, Mg adversely affected K uptake; S adversely affected Mn and Zn uptake; Cu adversely affected Mg uptake while deficiency of Zn adversely affected Mn uptake in the stem of pomegranate plant.

### Response of various organics sources of nutrients on growth, yield and quality of Pomegranate

The experiment is under progress at the research farm of NRC on Pomegranate. In this experiment nutrients had been supplied through various organic sources as farmyard manure, vermicompost, poultry manures and various green manures as Sunhemp, Glyricidia, Karanj and Neem leaves. To find out the actual effect of various organics, inorganic fertilizer has been applied as a check in one of the treatment. The inorganic fertilizers were applied as per the recommended dose while various organics were applied on N equivalent basis.

### Vegetative growth of the plants

Vegetative growth of the plants in terms of plant height and plant spread was measured during December 2011 (Table 3). As compared to control, height of plant was significantly highest in vermicompost treatment followed by green manuring with sunhemp. While plant spread was highest under green manuring with sunhemp treatment though the results were non-significant. Unlike initial years much difference in plant growth was not observed amongst the application of inorganic fertilizers and organic manure treatments.

Table 1 : Leaf nutrient content as affected by deficiencies of different nutrients (Antagonistic / Synergistic effects)

| Nutrient content → | N | P | K | Ca | Mg | Fe | Mn | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Deficient nutrient ↓ | (%) | | | | | (ppm) | | | |
| N | 2.34 | 0.14 | 3.80 | 2.74 | 0.68 | 290.9 | 216.4 | 22.20 | 28.10 |
| P | 3.35 | 0.04 | 3.08 | 1.99 | 0.54 | 248.4 | 119.6 | 17.38 | 29.00 |
| K | 3.74 | 0.10 | 1.31 | 2.61 | 0.75 | 227.7 | 217.7 | 16.75 | 27.08 |
| Ca | 3.38 | 0.12 | 4.49 | 1.99 | 0.46 | 297.3 | 223.0 | 14.60 | 26.55 |
| Mg | 3.54 | 0.13 | 5.02 | 2.10 | 0.55 | 230.5 | 191.9 | 12.50 | 26.75 |
| S | 3.50 | 0.11 | 4.40 | 2.46 | 0.64 | 365.5 | 198.2 | 13.58 | 24.20 |
| Fe | 3.43 | 0.15 | 5.13 | 2.79 | 0.72 | 144.0 | 190.6 | 8.45 | 30.75 |
| Mn | 3.59 | 0.09 | 4.61 | 2.58 | 0.60 | 236.5 | 199.3 | 9.00 | 27.55 |
| Cu | 3.51 | 0.13 | 4.84 | 2.42 | 0.55 | 151.9 | 194.0 | 8.15 | 24.50 |
| Zn | 3.69 | 0.15 | 5.25 | 2.63 | 0.66 | 371.4 | 195.3 | 10.35 | 25.15 |
| B | 3.64 | 0.12 | 4.60 | 2.68 | 0.63 | 212.8 | 227.9 | 8.28 | 29.90 |
| Mo | 3.73 | 0.08 | 3.84 | 2.34 | 0.58 | 233.8 | 192.1 | 8.68 | 31.20 |
| ALL | 3.58 | 0.14 | 4.78 | 2.23 | 0.61 | 290.4 | 156.0 | 9.23 | 26.80 |
| CD (p=0.05) | 0.62* | 0.058* | 0.79* | 0.44* | 0.14 | 87.0* | 47.1* | 3.88* | NS |

Table 2 : Stem nutrient content as affected by deficiencies of different nutrients (Antagonistic / Synergistic effects)

| Nutrient content → | N | P | K | Ca | Mg | Fe | Mn | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Deficient nutrient ↓ | (%) | | | | | (ppm) | | | |
| N | 1.45 | 0.325 | 2.00 | 2.05 | 0.53 | 245.7 | 170.6 | 39.8 | 51.4 |
| P | 2.00 | 0.040 | 1.13 | 1.94 | 0.43 | 323.4 | 182.4 | 39.8 | 53.0 |
| K | 2.68 | 0.327 | 0.45 | 1.67 | 0.46 | 268.0 | 177.8 | 31.2 | 52.4 |
| Ca | 2.89 | 0.345 | 0.99 | 1.96 | 0.48 | 303.4 | 160.1 | 36.3 | 53.9 |
| Mg | 2.34 | 0.307 | 0.90 | 2.28 | 0.51 | 397.3 | 196.0 | 31.7 | 40.4 |
| S | 2.69 | 0.259 | 1.16 | 1.75 | 0.45 | 206.8 | 94.3 | 27.2 | 31.0 |
| Fe | 2.60 | 0.527 | 1.43 | 2.18 | 0.50 | 257.6 | 176.4 | 35.7 | 50.5 |
| Mn | 3.14 | 0.385 | 1.36 | 1.91 | 0.51 | 236.4 | 114.2 | 30.3 | 41.5 |
| Cu | 2.83 | 0.401 | 1.33 | 1.95 | 0.41 | 215.1 | 172.6 | 28.7 | 41.3 |
| Zn | 3.16 | 0.377 | 1.20 | 2.13 | 0.46 | 217.4 | 93.3 | 26.5 | 34.0 |
| B | 2.74 | 0.336 | 1.41 | 1.75 | 0.41 | 184.8 | 109.9 | 24.9 | 31.2 |
| Mo | 3.09 | 0.379 | 1.37 | 1.80 | 0.45 | 241.3 | 134.1 | 27.3 | 48.7 |
| ALL | 2.27 | 0.310 | 1.53 | 1.86 | 0.46 | 266.3 | 134.3 | 29.9 | 38.0 |
| CD | 0.385* | 0.08* | 0.339* | NS | NS | 78.6* | 47.1* | 7.59* | 10.8* |
| (p=0.05) | | | | | | | | | |

Table 3. Plant growth parameters as affected by application of nutrients through different organic sources

| Treatments | Plant Height (cm) | Plant spread (cm) | | |
|---|---|---|---|---|
| | | East -West | North – South | Average |
| Farmyard manure | 117.4 | 120.1 | 112.2 | 116.1 |
| Vermicompost | 128.7 | 114.7 | 108.2 | 111.5 |
| Poultry manure | 117.0 | 108.7 | 118.5 | 113.6 |
| Green Manuring with sunhemp ( *insitu*) | 125.8 | 122.8 | 127.4 | 125.1 |
| Green Manuring with Glyricidia (*exsitu*) | 117.3 | 115.5 | 117.0 | 116.3 |
| Green Manuring with Karanj (*exsitu*) | 118.3 | 121.0 | 108.0 | 114.5 |
| Green Manuring with Neem (*exsitu*) | 124.1 | 112.5 | 119.5 | 116.1 |
| Inorganic fertilizer | 123.1 | 118.0 | 124.1 | 121.1 |
| Control | 102·5 | 101·4 | 97·5 | 100·9 |
| CD (p=0.05) | 12.0 | NS | NS | NS |

**Soil physico-chemical properties**

Soil samples collected during October 2011 were analysed for different physico-chemical properties and soil fertility status. Almost all the properties except $CaCO_3$ content showed significant variation amongst the treatments (Table 4). It was observed that there was slight decrease in soil pH values in case of organic manuring treatments while soil EC values were higher under control and inorganic fertilizer treatments. Organic carbon content was significantly highest under farmyard manuring treatment which significantly increases availability of P, Cu, Zn and Mn nutrients in soil. Availability of N was highest in vermicompost treatment while available Fe was in inorganic fertilizer treatment.

Table 4 : Soil physico-chemical properties as affected by different treatments of organic manures

| Treatments | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| Farmyard manure | 7.65 | 0.463 | 1.18 | 6.78 | 346.0 | 64.4 | 578.7 | 15.13 | 2.30 | 15.6 | 8.44 |
| Vermicompost | 7.62 | 0.548 | 0.58 | 7.17 | 297.2 | 28.4 | 280.0 | 12.89 | 0.79 | 14.6 | 6.60 |
| Poultry manure | 6.69 | 0.483 | 0.68 | 8.44 | 345.9 | 56.4 | 451.7 | 9.33 | 1.39 | 16.3 | 5.17 |
| Green Manuring with sunhemp(*insitu*) | 6.27 | 0.404 | 0.76 | 7.29 | 359.6 | 26.5 | 406.9 | 9.18 | 0.74 | 15.9 | 5.44 |
| Green Manuring with Glyricidia(*exsitu*) | 7.44 | 0.510 | 0.68 | 8.14 | 298.1 | 28.7 | 399.5 | 12.86 | 0.84 | 16.9 | 6.25 |
| Green Manuring with Karanj (*exsitu*) | 7.60 | 0.556 | 0.65 | 8.02 | 327.4 | 25.0 | 308.0 | 12.17 | 0.73 | 17.8 | 5.26 |
| Green Manuring with Neem (*exsitu*) | 7.66 | 0.384 | 0.57 | 7.38 | 313.4 | 24.7 | 362.1 | 10.46 | 0.61 | 19.8 | 7.91 |
| Inorganic fertilizer | 7.62 | 0.596 | 0.46 | 7.38 | 334.1 | 29.1 | 555.1 | 14.33 | 0.94 | 20.3 | 6.55 |
| Control | 7.74 | 0.614 | 0.42 | 8.66 | 259.2 | 20.1 | 298.7 | 7.10 | 0.63 | 17.3 | 5.22 |
| CD (p=0.05) | 0.22* | 0.09* | 0.11* | NS | 35.1* | 8.78* | 73.2* | 2.11* | 0.28* | 1.73* | 1.21* |

### Response of application of farmyard manure in liquid form (slurry) on pomegranate performance

This experiment has been started during this year at the research farm of NRC on Pomegranate. The experiment comprises of application of well decomposed and raw farmyard manure in the form of slurry in comparison with normal practice adopted by the farmers. To find out chelation effects, micronutrients were applied after mixing with raw and well decomposed farmyard manure. Similarly different microbial inoculants were added in the slurry. Preparation of experimental layout, collection of initial soil and leaf samples, recording of vegetative growth observations were done and various treatments were imposed as per the experimental design.

## Project 2.5: Micronutrient management for sustainable growth, yield and quality of pomegranate

### Survey of pomegranate orchards in Solapur and Nashik district for appraisal of micronutrient status in soil and plant.

Pomegranate orchards in four talukas viz. Mohol, Pandharpur, Sangola and Madha of Solapur district have been surveyed for collection of soil and plant samples. Soil properties and available micronutrient content are given in Tables 1,2, 3.

**Mohol**: Soils were neutral to alkaline in nature with pH ranging from 6.92-8.36, having free $CaCO_3$ content 1.72-17.20% and organic C content 0.20-2.07%. DTPA-extractable Zn content ranged from 0.17-1.51 ppm, Fe content 3.81-10.61 ppm, Mn content 4.06-11.31 ppm and Cu content 3.01-19.05 ppm. The data revealed that 64.71% and 5.88% soil samples were low in DTPA-extractable Zn and Fe content respectively.

**Pandharpur**: Soils were neutral to strongly alkaline in nature with pH ranging from 6.89 8.57, having free $CaCO_3$ content 3.04-16.84% and organic C 0.36-2.10%. DTPA-extractable Zn content varied from 0.01-3.99 ppm, Fe content 5.10-14.22 ppm, Mn content 3.62-21.15 ppm and Cu content 2.52-60.40 ppm. The data implied that 42.31% soil samples were low in DTPA-extractable Zn content.

**Sangola**: Soils were alkaline in nature with pH varying from 7.72-8.17, having free $CaCO_3$ content 5.68-22.72% and organic C 0.57-2.10%. DTPA-extractable Zn content ranged from 0.16-0.85 ppm, Fe content 3.76-7.91 ppm, Mn content 2.28-9.04 ppm and Cu content 1.78-8.13 ppm. The data summarized that 63.64% and 27.27% soil samples were low in DTPA-extractable Zn and Fe content respectively.

**Madha:** Soils were slightly alkaline in nature with pH ranging from 7.55-7.97, having free $CaCO_3$ content 5.55-15.04% and organic C 0.56-1.93%. DTPA-extractable Zn content varied from 0.22-0.57 ppm, Fe content 5.38-8.81 ppm, Mn content 3.06-8.11 ppm and Cu content 1.85-9.22 ppm. The data revealed that 66.67% soil samples were low in DTPA-extractable Zn content.

Table 1: Soil physicochemical properties of pomegranate orchards in Solapur district

| Taluka | DTPA - extractable Zn (ppm) | | | Per cent sample low in Zn | DTPA-extractable Fe (ppm) | | | Per cent sample low in Fe |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | CV(%) | | Range | Mean | CV (%) | |
| Mohol | 0.17-1.51 | 0.59 | 74.86 | 64.71 | 3.81-10.61 | 6.64 | 27.61 | 5.88 |
| Pandharpur | 0.01-3.99 | 0.76 | 107.46 | 42.31 | 5.10-14.22 | 7.89 | 31.95 | - |
| Sangola | 0.16-0.85 | 0.44 | 54.06 | 63.64 | 3.76-7.91 | 5.90 | 24.54 | 27.27 |
| Madha | 0.22-0.57 | 0.43 | 31.66 | 66.67 | 5.38-8.81 | 6.97 | 16.19 | - |

*Data in parenthesis are co-efficient of variation in per cent

Table 2: DTPA-extractable Zn and Fe content of pomegranate orchard soil in Solapur district

| Taluka | DTPA -extractable Mn (ppm) | | | DTPA –extractable Cu (ppm) | | |
|---|---|---|---|---|---|---|
| | Range | Mean | CV (%) | Range | Mean | CV (%) |
| Mohol | 4.06-11.31 | 6.67 | 2.16 | 3.01-19.05 | 7.33 | 58.69 |
| Pandharpur | 3.62-21.15 | 8.47 | 53.65 | 2.52-60.40 | 11.44 | 119.08 |
| Sangola | 2.28-9.04 | 5.11 | 43.84 | 1.78-8.13 | 3.66 | 50.67 |
| Madha | 3.06-8.11 | 5.70 | 28.95 | 1.85-9.22 | 4.00 | 66.67 |

Table 3: DTPA-extractable Mn and Cu content of pomegranate orchard soil in Solapur district

| Taluka | No. of orchards surveyed | pH (1: 2, soil:water) | Organic C (%) | Free $CaCO_3$ (%) |
|---|---|---|---|---|
| Mohol | 17 | 6.92-8.36 (4.87) | 0.20-2.07 (63.33) | 1.72-17.20 (68.30) |
| Pandharpur | 26 | 6.89-8.57 (5.40) | 0.36-2.10 (48.11) | 3.40-16.84 (55.24) |
| Sangola | 11 | 7.72-8.17 (1.82) | 0.57-2.10 (30.23) | 5.68-22.72 (39.75) |
| Madha | 6 | 7.55-7.97 (2.05) | 0.56-1.93 (57.43) | 5.55-15.04 (41.93) |

The results of leaf analysis for micronutrient content are summarized in Tables 4,5.

*Mohol:* Zinc content in leaf samples varied from 5.80-20.20 ppm, Fe content 76.60-111.60 ppm, Mn content 7.60-133.80 ppm and Cu content 18.00-461.00 ppm respectively. The data revealed that 58.82%, 47.06% and 11.76% leaf samples were low in Zn, Mn and Cu content respectively. More importantly, 17.65% and 29.41% leaf samples were deficient in Zn and Mn content respectively. Maximum variability was found in Cu content followed by Mn, Zn and Fe content.

*Pandharpur:* Zinc content in leaf samples ranged from 6.00-26.20 ppm, Fe content 74.80-114.20 ppm, Mn content 1.20-131.20 ppm and Cu content 4.00-231.00 ppm respectively. The data summarized that 69.23%, 46.15% and 34.62% leaf samples were low in Zn, Mn and Cu content respectively. It was also noted that 26.92%, 23.08% and 7.69% leaf samples were deficient in Zn, Mn and Cu content respectively. However, maximum variability was observed in Cu content followed by Mn, Zn and Fe content.

*Sangola:* Zinc content in leaf samples varied from 5.00-19.00 ppm, Fe content 91.40-108.60 ppm, Mn content 1.40-57.20 ppm and Cu content 11.00-47.00 ppm respectively. The data revealed that 81.82%, 36.36% and 63.64% leaf samples were low in Zn, Mn and Cu content respectively. It was further implied that 45.45% and 36.36% leaf samples were deficient in Zn and Mn content respectively. Maximum variability was observed in Mn content followed by Zn, Cu and Fe content.

*Madha:* Zinc content in leaf samples ranged from 6.80-15.63 ppm, Fe content 86.35-109.20 ppm, Mn content 1.20-57.60 ppm and Cu content 6.00-40.26 ppm respectively. The data summarized that 83.33%, 50.00% and 50.00% leaf samples were low in Zn, Mn and Cu content. Moreover, 16.67%, 16.67% and 33.33% leaf samples were deficient in Zn, Mn and Cu content respectively. Maximum variability was observed in Mn

content followed by Cu, Fe and Zn content.

Over all 55.00% and 6.67% soil samples in Solapur district under pomegranate cultivation have been found low in DTPA-extractable Zn and Fe content respectively. Leaf analysis revealed that 70.00%, 45.00% and 35.00% leaf samples were low in Zn, Mn and Cu content respectively. The data also revealed that 26.67%, 26.67% and 6.67% leaf samples were deficient in Zn, Mn and Cu content respectively.

Table 4: Leaf Zn and Fe content in pomegranate orchards of Solapur district

| Taluka | Mn content | | Per cent sample low in Mn | Per cent sample deficient in Mn | Cu content | | Per cent sample low in Cu | Per cent sample deficient in Cu |
|---|---|---|---|---|---|---|---|---|
| | Range (ppm) | CV (%) | | | Range | CV (%) | | |
| Mohol | 7.60-133.80 | 82.06 | 17.65 | 29.41 | 18.00-461.00 | 82.64 | 11.76 | - |
| Pandharpur | 1.20-131.20 | 84.03 | 23.08 | 23.08 | 4.00-231.00 | 88.26 | 26.92 | 7.69 |
| Sangola | 1.40-57.20 | 59.99 | - | 36.36 | 11.00-47.00 | 43.09 | 63.64 | - |
| Madha | 1.20-57.60 | 32.32 | 33.33 | 16.67 | 6.00-40.26 | 58.69 | 16.67 | 33.33 |

Table 5: Leaf Mn and Cu content in pomegranate orchards of Solapur district

| Taluka | Zn content | | Per cent sample low in Zn | Per cent sample deficient in Zn | Fe content | | Per cent sample low in Fe | Per cent sample deficient in Fe |
|---|---|---|---|---|---|---|---|---|
| | Range (ppm) | CV(%) | | | Range | CV (%) | | |
| Mohol | 5.80-20.20 | 37.17 | 41.18 | 17.65 | 76.60-111.60 | 12.20 | - | - |
| Pandharpur | 6.00-26.20 | 40.46 | 42.31 | 26.92 | 74.80-114.20 | 8.90 | - | - |
| Sangola | 5.00-19.00 | 43.44 | 36.36 | 45.45 | 91.40-108.60 | 5.12 | - | - |
| Madha | 6.80-15.63 | 31.84 | 66.67 | 16.67 | 86.35-109.20 | 8.29 | - | - |

Pomegranate orchards in three talukas viz. Satana, Deola, and Malegaon of Nashik district have been surveyed for collection of soil and plant samples. Soil properties and available micronutrient content are given below (Table 6,7,8).

*Satana:* Soils were slightly to moderately alkaline in nature with pH ranging from 7.49-7.75, having free $CaCO_3$ content 5.83-22.51% and organic C content 0.13-1.79%. DTPA-extractable Zn content ranged from 0.29-4.87 ppm, Fe content 5.1-8.93 ppm, Mn content 6.94-59.31 ppm and Cu content 2.86-14.17 ppm. The data revealed that 12.5 % soil samples were low in DTPA-extractable Zn content.

*Deola:* Soils were moderately to strongly alkaline in nature with pH ranging from 7.58-7.90, having free $CaCO_3$ content 4.97-14.23% and organic C content 0.36-1.98%. DTPA-extractable Zn content ranged from 0.76-5.49 ppm, Fe content 8.3-15.21 ppm, Mn content 15.37-43.87 ppm and Cu content 3.24-12.72 ppm. The data revealed that soils were sufficient with DTPA extratable Zn, Fe, Mn and Cu content.

*Malegaon:* Soils were moderately alkaline in nature with pH ranging from 7.57-7.62, having free $CaCO_3$ content 7.04-14.11% and organic C content 0.36-1.30%. DTPA-extractable Zn content ranged from 0.56-4.58 ppm, Fe content 6.19-9.36ppm, Mn content 7.64-33.44 ppm and Cu content 1.85-11.76 ppm. The data revealed that soils were sufficient with DTPA extratable Zn, Fe, Mn and Cu content.

Table 6 Soil physicochemical properties of pomegranate orchards in Nashik district

| Taluka | No. of orchards surveyed | pH (1: 2, soil:water) | Organic C (%) | Free $CaCO_3$ (%) |
|---|---|---|---|---|
| Satana | 8 | 7.49-7.75 (1.01) | 0.13-1.79 (53.04) | 5.83-22.51 (42.15) |
| Deola | 6 | 7.58-7.90 (1.51) | 0.36-1.98 (50.69) | 4.97-14.23 (44.81) |
| Malegaon | 6 | 7.57-7.62 (0.24) | 0.36-1.30 (49.38) | 7.04-14.11 (27.06) |

*Data in parenthesis are co-efficient of variation in per cent

Table 7 DTPA-extractable Zn and Fe content of pomegranate orchard soil in Nashik district

| Taluka | DTPA - extractable Zn (ppm) | | | Per cent sample low in Zn | DTPA -extractable Fe (ppm) | | |
|---|---|---|---|---|---|---|---|
| | Range | Mean | CV (%) | | Range | Mean | CV (%) |
| Satana | 0.29-4.87 | 1.76 | 89.15 | 12.5 | 5.1-8.93 | 7.19 | 17.80 |
| Deola | 0.76-5.49 | 1.93 | 98.65 | - | 8.3-15.21 | 11.79 | 25.28 |
| Malegaon | 0.56-4.58 | 2.73 | 63.98 | | 6.19-9.36 | 6.88 | 17.88 |

Table 8 DTPA-extractable Mn and Cu content of pomegranate orchard soil in Nashik district

| Taluka | DTPA -extractable Mn (ppm) | | | DTPA– extractable Cu (ppm) | | |
|---|---|---|---|---|---|---|
| | Range | Mean | CV (%) | Range | Mean | CV (%) |
| Satana | 6.94-59.31 | 27.57 | 64.75 | 2.86-14.17 | 5.34 | 68.99 |
| Deola | 15.37-43.87 | 24.64 | 45.25 | 3.24-12.72 | 6.38 | 53.41 |
| Malegaon | 7.64-33.44 | 17.61 | 59.04 | 1.85-11.76 | 7.00 | 72.85 |

The results of leaf analysis for micronutrient content of Nashik district are summarized below (Table 9, 10).

*Satana:* Zinc content in leaf samples varied from 7.00-37.4 ppm, Fe content 60.40-132.2 ppm, Mn content 18.00-39.6 ppm and Cu content 5.40-18.2 ppm respectively. The data revealed that 62.50% leaf samples were low in Zn, 50.00% low in Mn and 75.00 % low in Cu content. More importantly, 12.50% and 25.00% leaf samples were deficient in Zn and Cu content respectively. Maximum variability was found in Zn content followed by Cu, Mn and Fe content.

*Deola:* Zinc content in leaf samples ranged from 9.20-62.4 ppm, Fe content 83.8-140.4 ppm, Mn content 25.40-67.4 ppm and Cu content 8.20-18.20 ppm respectively. The data summarized that 66.67% leaf samples were low in Zn, 50.00 % low in Mn and 100 % low in Cu content. However, maximum variability was observed in Zn content followed by Mn, Cu and Fe content.

*Malegaon:* Zinc content in leaf samples ranged from 9.60-26.00 ppm, Fe content 71.2-115.6 ppm, Mn content 23.0-38.40 ppm and Cu content 5.00-11.00 ppm respectively. The data revealed that 33.33% leaf samples were low in Zn, 66.67% low in Mn and 66.67 % low in Cu content. More importantly, 33.33% leaf samples were deficient in Cu content. Maximum variability was found in Zn content followed by Cu, Mn and Fe content.

Over all 5.00% soil samples in Nashik district under pomegranate cultivation were low in DTPA-extractable Zn content while 50.00% orchards soils were marginal in DTPA-extractable

Zn content. Leaf analysis revealed that 55.00% leaf samples were low in Mn 60.00% low in Zn and 100.00% low in Cu content respectively.

Table 9: Leaf Zn and Fe content in pomegranate orchards of Nashik district

| Taluka | Mn content | | Per cent sample low in Mn | Per cent sample deficient in Mn | Cu content | | Per cent sample low in Cu | Per cent sample deficient in Cu |
|---|---|---|---|---|---|---|---|---|
| | Range (ppm) | CV (%) | | | Range (ppm) | CV (%) | | |
| Satana | 18.00-39.6 | 25.56 | 50.00 | - | 5.40-18.2 | 37.85 | 75.00 | 25.00 |
| Deola | 25.40-67.4 | 43.37 | 50.00 | - | 8.20-18.20 | 35.12 | 100.00 | - |
| Malegaon | 23.0-38.40 | 22.98 | 66.67 | - | 5.00-11.00 | 27.33 | 66.67 | 33.33 |

Table 10: Leaf Mn and Cu content in pomegranate orchards of Nashik district

| Taluka | Zn content | | Per cent sample low in Zn | Per cent sample deficient in Zn | Fe content | | Per cent sample low in Fe | Per cent sample deficient in Fe |
|---|---|---|---|---|---|---|---|---|
| | Range (ppm) | CV (%) | | | Range (ppm) | CV (%) | | |
| Satana | 7 00-37.4 | 71.13 | 62.50 | 12.50 | 60.40-132.2 | 22.91 | - | - |
| Deola | 9.20-62.4 | 95.68 | 66.67 | - | 83.8-140.4 | 19.17 | - | - |
| Malegaon | 9.60-26.00 | 34.32 | 33.33 | - | 71.2-115.6 | 18.78 | - | - |

## Project 2.6 : Water management in pomegranate orchards under different soil types

The project comprises of four experiments is in progress from last three years. This year different treatments under various experiments were imposed from December 2011. Initial vegetative growth observations of each plant were recorded and compiled as per the treatments (Table 1).

Table 1 : Initial plant vegetative growth observation under different experiments and treatments under water management project

| Treatments | Plant height (cm) | | Plant spread (cm) (East - West) | | Plant spread (cm) (North – South) | |
|---|---|---|---|---|---|---|
| | Light textured soil | Heavy textured soil | Light textured soil | Heavy textured soil | Light textured soil | Heavy textured soil |
| Expt. : Irrigation in pomegranate orchards using varied number of drippers | | | | | | |
| 2 Drippers | 110.1 | 100.6 | 111.3 | 92.9 | 101.5 | 86.3 |
| 3 Drippers | 109.8 | 100.7 | 100.5 | 115.0 | 95.1 | 92.8 |
| 4 Drippers | 114.1 | 114.0 | 110.3 | 125.4 | 102.4 | 114.2 |
| 2 Laterals | 119.0 | 116.9 | 118.6 | 108.8 | 104.9 | 108.3 |
| Perforated pipe | 121.1 | 108.7 | 106.9 | 107.7 | 108.3 | 105.3 |
| Expt. : Frequency of irrigation in pomegranate orchards grown on different soil types | | | | | | |
| Daily | 122.8 | 118.6 | 122.0 | 118.7 | 115.6 | 108.3 |
| After 1 day | 109.0 | 113.3 | 120 | 104.4 | 112 | 105.7 |
| After 2day | 124.9 | 115.3 | 121.1 | 108.4 | 119.4 | 106.0 |
| After 3 day | 133.4 | 125.1 | 136.1 | 122.9 | 135.3 | 112.3 |
| After 4 day | 126.2 | 128.1 | 120.6 | 130.9 | 123.0 | 121.3 |
| After 5 day | 121.1 | 133.6 | 119.0 | 124.3 | 108.9 | 122.2 |
| Expt. : Performance of different micro -sprinklers in pomegranate | | | | | | |
| 4 Dripper | 100.1 | 109.1 | 114.4 | 113.9 | 112.0 | 114.9 |
| Microjet 180o | 120.0 | 90.6 | 131.6 | 90.6 | 127.8 | 100.8 |
| Microjet 360o | 105.1 | 97.8 | 93.5 | 102.3 | 102.5 | 88.7 |
| Surface irrigation | | | | | | |
| Double ring | 98.1 | 110.4 | 93.9 | 108.6 | 99.6 | 108.3 |
| Expt. : Irrigation requirement of pomegranate orchards under different soil types. | | | | | | |
| E Tc 0.30 | 126.4 | 114.7 | 119.9 | 96.8 | 122.0 | 98.2 |
| E Tc 0.40 | 147.5 | 120.1 | 131.7 | 109.3 | 143.8 | 108.9 |
| E Tc 0.50 | 120.4 | 113.4 | 103.1 | 101.3 | 113.4 | 101.9 |
| E Tc 0.60 | 123.7 | 109.0 | 98.3 | 98.4 | 106.1 | 101.3 |
| E Tc 0.70 | 132.0 | 128.9 | 122.6 | 114.0 | 121.8 | 124.9 |
| E Tc 0.80 | 115.8 | 118.9 | 86.9 | 100.8 | 84.5 | 101.7 |
| E Tc 0.90 | 99.7 | 103.8 | 87.7 | 94.7 | 88.6 | 100.3 |

### Irrigation in pomegranate orchards using varied number of drippers

The experiment is in progress at research farm of NRC on Pomegranate. This year various treatments were imposed from December 2011 for which same amount of irrigation water on the basis of Pan Evaporation has been applied through varying number of drippers and laterals. The chlorophyll content in the leaves and moisture content in the soil under different treatments were measured during the period.

### Soil physico-chemical properties

To find out the effect of different treatments on soil properties, soil samples were collected during October 2010 from both sets of experiments having light and heavy textures soils and analysed for different soil physico-chemical properties (Table 2 & 3). In both types of soils almost all the properties showed non-significant variation amongst the treatments except available Fe in light textured soil.

Table 2 : Soil physico-chemical properties as influenced by various treatment in pomegranate orchards grown on heavy textured soil

| Treatments | pH | EC (dS/m) | Organic Carbon (%) | $CaCO_3$ (kg/ha) | N (ppm) | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 Drippers | 8.35 | 0.279 | 0.63 | 13.06 | 240.4 | 4.6 | 505.9 | 6.28 | 0.95 | 9.44 | 9.00 |
| 3 Drippers | 8.34 | 0.279 | 0.66 | 13.06 | 217.6 | 5.3 | 509.8 | 7.51 | 0.93 | 8.95 | 8.98 |
| 4 Drippers | 8.25 | 0.259 | 0.52 | 12.38 | 249.9 | 6.2 | 493.6 | 5.52 | 0.84 | 9.41 | 9.44 |
| 2 Laterals | 8.40 | 0.253 | 0.60 | 12.77 | 227.4 | 6.7 | 516.0 | 6.24 | 0.99 | 9.31 | 9.24 |
| Perforated pipe | 8.49 | 0.273 | 0.55 | 12.48 | 230.3 | 7.8 | 524.0 | 5.06 | 0.92 | 8.08 | 8.55 |
| CD (p=0.05) | NS | NS | NS | NS | NS | NS | NS | 1.26 | NS | NS | NS |

Table 3 : Soil physico-chemical properties as influenced by various treatments in pomegranate orchards grown on light textured soil

| Treatments | pH | EC (dS/m) | Organic Carbon (%) | $CaCO_3$ (%) | N (kg/ha) | P (kg/ha) | K (kg/ha) | Cu (ppm) | Zn (ppm) | Fe (ppm) | Mn (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 Drippers | 7.60 | 0.244 | 0.38 | 2.63 | 274.9 | 11.1 | 501.6 | 1.87 | 0.43 | 3.61 | 6.39 |
| 3 Drippers | 7.60 | 0.273 | 0.36 | 2.62 | 272.5 | 10.7 | 476.0 | 1.68 | 0.31 | 3.57 | 6.09 |
| 4 Drippers | 7.85 | 0.272 | 0.48 | 3.64 | 253.2 | 11.8 | 495.6 | 1.93 | 0.43 | 2.72 | 5.01 |
| 2 Laterals | 7.76 | 0.224 | 0.50 | 3.08 | 263.7 | 11.1 | 531.0 | 1.85 | 0.40 | 3.26 | 5.21 |
| Perforated pipe | 7.68 | 0.218 | 0.42 | 4.11 | 282.9 | 11.1 | 553.6 | 1.84 | 0.34 | 2.04 | 4.54 |
| CD (p=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | 0.71* | NS |

### Leaf nutrient status

To find out the effect of various treatments on nutrient uptake in the plants, leaf samples were collected during October 2010 from both the sets of experiments grown on light and heavy textured soils and analysed for different macro and micro-nutrient contents. The leaf nutrient data from heavy textured soils revealed significant variation in N, K, Zn and Mn content while other nutrients as P, Ca, Mg, Cu and Fe showed non-significant variation (Table 4). In light textured soil only N and K content showed significant variation (Table 5). Application of irrigation water through six drippers (2 lph) fixed on two laterals placed on both side of the plants as well as perforated pipe encircling the plant resulted in to increased uptake of nutrients in the plants. While in two dripper system, nutrients content were comparatively low in both the sets of experiments.

### Frequency of irrigation in pomegranate orchards grown on different soil types

The experiment is in progress at research farm of NRC on Pomegranate. This year various treatments were imposed from December 2011. Irrigation water on the basis of Pan Evaporation has been applied to pomegranate plants at different intervals as daily, cumulative water after 1, 2, 3, 4 and 5 days. The chlorophyll content in the leaves and moisture content in the soil under different treatments were measured during the period.

### Soil physico-chemical properties

To find out the effect of different treatments on soil properties, soil samples were collected during October 2010 from both sets of experiments having light and heavy textures soils and analysed for different soil physico-chemical properties. In heavy textured soil almost all the parameters (Table 6) showed non-significant variation amongst the treatments except available K and Fe which was more in less irrigation interval treatments.

In light textured soil (Table 7), EC, $CaCO_3$, available K, Cu, Zn, Fe and Mn showed significant variation while pH, organic carbon, available N and P showed non-significant variation amongst the treatments. Available K and Zn content was highest under daily irrigation treatment; P and Mn in irrigation after one day treatment while available Cu and Fe in irrigation after 2 days treatment. As such any fixed trend was not observed for nutrient availability but it decreases with the increased irrigation interval.

Table 4 : Leaf nutrient content as influenced by varied number of drippers used to irrigate pomegranate orchards grown on heavy textured soil

| Treatments | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| 2 Drippers | 1.70 | 0.106 | 0.65 | 1.69 | 0.57 | 107.7 | 27.4 | 123.9 | 67.2 |
| 3 Drippers | 2.01 | 0.137 | 0.77 | 1.56 | 0.57 | 101.8 | 26.9 | 152.0 | 63.8 |
| 4 Drippers | 1.92 | 0.137 | 0.65 | 1.69 | 0.57 | 113.4 | 32.8 | 162.2 | 65.0 |
| 2 Laterals | 2.04 | 0.160 | 0.70 | 1.81 | 0.69 | 116.4 | 27.1 | 143.5 | 69.1 |
| Perforated pipe | 2.00 | 0.137 | 0.80 | 2.00 | 0.52 | 125.7 | 36.0 | 151.3 | 72.2 |
| CD (p=0.05) | 0.19 | NS | 0.103 | NS | NS | NS | 6.1 | NS | 4.6 |

Table 5 : Leaf nutrient content as influenced by varied number of drippers used to irrigate pomegranate orchards grown on light textured soil

| Treatments | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| 2 Drippers | 1.99 | 0.14 | 0.49 | 1.56 | 0.57 | 78.1 | 25.9 | 118.6 | 50.9 |
| 3 Drippers | 2.16 | 0.15 | 0.62 | 2.00 | 0.63 | 77.3 | 26.8 | 125.1 | 61.8 |
| 4 Drippers | 2.14 | 0.14 | 0.62 | 2.25 | 0.58 | 69.7 | 27.5 | 122.6 | 52.2 |
| 2 Laterals | 2.36 | 0.17 | 0.56 | 1.75 | 0.54 | 81.5 | 28.4 | 140.1 | 62.7 |
| Perforated pipe | 2.22 | 0.15 | 0.58 | 1.75 | 0.57 | 75.0 | 30.2 | 132.2 | 53.5 |
| CD (p=0.05) | 0.20 | NS | 0.062* | NS | NS | NS | NS | NS | NS |

Table 6: Soil physic-chemical properties as influenced by irrigation intervals under pomegranate orchards grown on heavy textured soil.

| Treatments Irrigation Interval | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| Daily | 8.44 | 0.26 | 0.54 | 13.2 | 229.1 | 11.7 | 477.2 | 5.13 | 0.74 | 9.03 | 9.04 |
| After 1 day | 8.47 | 0.30 | 0.58 | 13.3 | 239.1 | 12.6 | 485.8 | 5.35 | 0.84 | 8.70 | 10.16 |
| After 2 days | 8.54 | 0.31 | 0.56 | 12.5 | 226.4 | 12.1 | 465.3 | 5.24 | 0.87 | 8.31 | 10.28 |
| After 3 days | 8.51 | 0.30 | 0.63 | 13.3 | 229.3 | 10.2 | 450.3 | 5.73 | 0.79 | 8.06 | 10.08 |
| After 4 days | 8.53 | 0.28 | 0.61 | 11.5 | 223.4 | 10.6 | 441.7 | 5.81 | 0.81 | 8.91 | 10.36 |
| After 5 days | 8.55 | 0.33 | 0.69 | 12.7 | 215.6 | 14.7 | 433.2 | 5.48 | 0.88 | 8.46 | 10.96 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | 34 | NS | NS | 0.59 | NS |

Table 7 : Soil physico-chemical properties as influenced by irrigation intervals under pomegranate orchards grown on light textured soil

| Treatments Irrigation Interval | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| Daily | 7.72 | 0.22 | 0.31 | 6.13 | 255.7 | 10.5 | 485.0 | 1.82 | 0.38 | 1.51 | 5.85 |
| After 1 day | 7.63 | 0.22 | 0.36 | 6.34 | 267.2 | 11.2 | 469.2 | 2.33 | 0.36 | 1.69 | 7.19 |
| After 2 days | 7.61 | 0.18 | 0.28 | 7.34 | 264.7 | 9.7 | 468.3 | 2.75 | 0.41 | 1.76 | 6.17 |
| After 3 days | 7.65 | 0.18 | 0.30 | 7.56 | 268.0 | 8.7 | 440.4 | 1.88 | 0.29 | 1.71 | 5.61 |
| After 4 days | 7.80 | 0.18 | 0.37 | 7.43 | 259.5 | 9.5 | 439.0 | 2.12 | 0.33 | 1.53 | 5.33 |
| After 5 days | 7.70 | 0.17 | 0.32 | 7.41 | 246.3 | 10.9 | 428.9 | 1.71 | 0.32 | 1.64 | 5.24 |
| CD (0.05) | NS | 0.03* | NS | 1.10 | NS | NS | 24.8* | 0.38* | 0.08 | 0.17 | 1.17 |

### Leaf nutrient status

To find out the effect of various treatments on nutrient content in the plants, leaf samples were collected during October 2010 from both the sets of experiments grown on light and heavy textured soils and analysed for different macro and micro-nutrient contents.

The leaf nutrient data from light textured soils revealed significant variation in N, P, K, Cu and Fe content while other nutrients as Ca, Mg, Zn and Mn showed non-significant variation (Table 8). Highest content of P, Mg, Zn and Mn was recorded under irrigation interval after 2 days treatment while N and K content was more under 3 days interval treatment. Except Ca, uptake of most of the nutrient decreases with the increased irrigation interval of 4 or 5 days.

In heavy textured soils, leaf content of N, P, K and Fe showed significant variation while it was non-significant in case of Ca, Mg, Cu, Zn and Mn content. (Table 9). Application of irrigation water on daily basis recorded highest uptake of Zn and Fe while N, K, Ca and Mg uptake was more in 2 days irrigation interval. Highest uptake of Cu and Mn was observed in case of 4 days irrigation intervals.

Table 8 : Leaf nutrient content as influenced by irrigation intervals in pomegranate orchards grown on light textured soil

| Irrigation Interval | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| Daily | 2.10 | 0.14 | 0.69 | 1.53 | 0.46 | 85.8 | 25.4 | 115.4 | 58.4 |
| After 1 day | 2.07 | 0.17 | 0.74 | 1.63 | 0.51 | 103.7 | 26.0 | 137.3 | 56.0 |
| After 2 days | 2.19 | 0.18 | 0.64 | 1.75 | 0.58 | 72.5 | 30.8 | 123.7 | 61.4 |
| After 3 days | 2.24 | 0.16 | 0.75 | 1.88 | 0.54 | 91.6 | 28.2 | 116.0 | 56.9 |
| After 4 days | 2.06 | 0.13 | 0.62 | 1.94 | 0.49 | 88.5 | 27.5 | 102.9 | 57.9 |
| After 5 days | 1.97 | 0.12 | 0.57 | 1.95 | 0.52 | 95.1 | 26.5 | 107.0 | 55.1 |
| CD (0.05) | 0.16 | 0.03* | 0.07* | NS | NS | 7.8* | NS | 14.8* | NS |

Table 9 : Leaf nutrient content as influenced by irrigation intervals in pomegranate orchards grown on heavy textured soil

| Treatments Irrigation Interval | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| Daily | 1.98 | 0.151 | 0.88 | 1.60 | 0.50 | 85.2 | 30.6 | 134.6 | 65.0 |
| After 1 day | 1.98 | 0.134 | 0.84 | 1.69 | 0.45 | 89.3 | 29.3 | 115.9 | 64.2 |
| After 2 days | 2.09 | 0.163 | 0.93 | 1.73 | 0.56 | 87.5 | 26.7 | 123.2 | 63.4 |
| After 3 days | 1.99 | 0.164 | 0.87 | 1.64 | 0.49 | 83.9 | 25.8 | 118.0 | 62.5 |
| After 4 days | 1.97 | 0.153 | 0.73 | 1.64 | 0.46 | 90.5 | 29.1 | 109.5 | 69.0 |
| After 5 days | 1.77 | 0.128 | 0.64 | 1.60 | 0.42 | 82.0 | 26.4 | 106.5 | 65.7 |
| CD (0.05) | 0.17 | 0.011* | 0.16 | NS | NS | NS | NS | 16.0 | NS |

### Irrigation requirement of pomegranate orchards under different soil types.

The experiment is in progress at research farm of NRC on Pomegranate. This year various treatments were imposed from December 2011. Irrigation water equivalent to 30, 40, 50, 60, 70, 80, and 90 % of Pan Evaporation (E.Tc.) has been applied to pomegranate plants. The chlorophyll content in the leaves and moisture content in the soil under different treatments were measured during the period.

### Soil physico-chemical properties

To find out the effect of different treatments on soil properties, soil samples were collected during October 2010 from both sets of experiments having light and heavy textures soils and analysed for different soil physico-chemical properties. In heavy textured soil almost all the parameters (Table 10) showed significant variation amongst the treatments except pH, organic carbon and available N content in the soil. Similarly in light textured soils (Table 11) most of the properties showed significant variation except N, P and Zn content. Any fixed trend of nutrient availability was not observed with regard to quantity of irrigation water. However it was observed that nutrient availability was not adversely affected in the treatment where only 30 % of the recommended quantity of water has been applied.

### Leaf Nutrient Status

To find out the effect of various treatments on nutrient content in the plants, leaf samples were collected during October 2010 and analysed for different macro and micro-nutrient contents. The leaf nutrient data from light textured soils revealed significant variation in N, K, Cu and Mn content while other nutrients as P, Ca, Mg, Zn and Fe showed non-significant variation (Table 12). Highest content of N, P, Ca, Mg and Fe was recorded under application of irrigation water equivalent to 60% of E.Tc. Application of irrigation water equivalent to 0.30 E.Tc resulted in to decreased uptake of most of the nutrients.

Table 10 : Soil physico-chemical properties as influenced by quantity of irrigation water to pomegranate grown on heavy textured soil

| Treatments | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| E Tc 0.30 | 8.64 | 0.293 | 0.66 | 13.6 | 222.1 | 12.8 | 571.4 | 5.18 | 1.05 | 7.03 | 10.72 |
| E Tc 0.40 | 8.64 | 0.281 | 0.70 | 12.6 | 226.4 | 12.7 | 615.8 | 7.15 | 1.20 | 6.05 | 12.29 |
| E Tc 0.50 | 8.69 | 0.261 | 0.72 | 14.2 | 230.3 | 13.9 | 568.4 | 5.55 | 0.96 | 4.39 | 9.65 |
| E Tc 0.60 | 8.63 | 0.377 | 0.67 | 13.8 | 217.9 | 14.5 | 508.0 | 8.83 | 2.59 | 6.12 | 10.33 |
| E Tc 0.70 | 8.63 | 0.452 | 0.73 | 11.6 | 226.4 | 21.4 | 571.2 | 7.84 | 2.59 | 5.87 | 10.30 |
| E Tc 0.80 | 8.62 | 0.487 | 0.76 | 12.1 | 229.8 | 16.6 | 563.0 | 7.33 | 3.01 | 4.68 | 12.28 |
| E Tc 0.90 | 8.67 | 0.436 | 0.73 | 11.1 | 224.7 | 15.4 | 555.6 | 8.61 | 2.98 | 4.96 | 13.08 |
| CD (0.05) | NS | 0.05* | NS | 1.71* | NS | 1.88* | 53.1 | 1.18* | 0.27* | 0.78* | 1.34* |

Table 11 : Soil physico-chemical properties as influenced by quantity of irrigation water supplied to pomegranate orchards grown on light textured soil

| Treatments | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| E Tc 0.30 | 7.44 | 0.160 | 0.30 | 1.56 | 324.0 | 13.2 | 523.4 | 2.29 | 0.35 | 1.84 | 7.26 |
| E Tc 0.40 | 7.56 | 0.174 | 0.33 | 1.70 | 301.4 | 11.5 | 486.4 | 2.50 | 0.31 | 1.77 | 7.11 |
| E Tc 0.50 | 7.41 | 0.140 | 0.41 | 1.81 | 304.8 | 11.1 | 529.2 | 3.20 | 0.34 | 4.05 | 7.30 |
| E Tc 0.60 | 7.42 | 0.140 | 0.29 | 1.61 | 302.0 | 10.9 | 455.3 | 2.93 | 0.33 | 3.90 | 6.59 |
| E Tc 0.70 | 7.53 | 0.199 | 0.40 | 2.48 | 293.4 | 11.8 | 513.6 | 3.55 | 0.40 | 3.76 | 6.71 |
| E Tc 0.80 | 7.58 | 0.193 | 0.37 | 2.15 | 286.4 | 11.9 | 501.0 | 3.22 | 0.34 | 3.69 | 6.23 |
| E Tc 0.90 | 7.63 | 0.191 | 0.41 | 1.90 | 295.8 | 12.3 | 496.9 | 3.31 | 0.38 | 3.79 | 6.41 |
| CD (0.05) | 0.12* | 0.043 | 0.056* | 0.55 | NS | NS | 20.9* | 0.25* | NS | 0.20* | 0.42* |

Table 12 : Leaf nutrient content as influenced by quantity of irrigation water supplied to pomegranate orchards grown on light textured soil

| Quantity of Irrigation Water | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| E Tc 0.30 | 1.86 | 0.146 | 0.49 | 2.06 | 0.57 | 106.6 | 28.3 | 115.6 | 78.2 |
| E Tc 0.40 | 2.09 | 0.147 | 0.55 | 2.21 | 0.50 | 109.1 | 29.7 | 119.9 | 80.7 |
| E Tc 0.50 | 2.15 | 0.158 | 0.61 | 2.19 | 0.50 | 105.8 | 27.6 | 123.0 | 70.5 |
| E Tc 0.60 | 2.25 | 0.159 | 0.65 | 2.38 | 0.59 | 105.2 | 28.1 | 129.3 | 60.3 |
| E Tc 0.70 | 2.19 | 0.148 | 0.63 | 2.00 | 0.49 | 124.9 | 27.9 | 118.1 | 66.7 |
| E Tc 0.80 | 2.11 | 0.155 | 0.64 | 2.19 | 0.53 | 119.7 | 28.7 | 112.3 | 70.5 |
| E Tc 0.90 | 2.06 | 0.144 | 0.67 | 1.81 | 0.61 | 109.3 | 28.8 | 114.3 | 72.5 |
| CD 5% | 0.15* | NS | 0.07* | NS | NS | 13.1 | NS | NS | 8.7* |

### Performance of different micro-sprinklers in pomegranate

The experiment is in progress at research farm of NRC on Pomegranate. This year various treatments were imposed from December 2011. Irrigation water was applied through micro-sprinklers, four drippers and compared with surface method of irrigation. The chlorophyll content in the leaves and moisture content in the soil under different treatments were measured during the period.

### Soil physico-chemical properties

To find out the effect of different treatments on soil properties, soil samples were collected during October 2010 from both sets of experiments having light and heavy textures soils and analysed for different soil physico-chemical properties.

In both soil types almost all the parameters (Table 13 & 14) showed significant variation amongst the treatments except organic carbon, $CaCO_3$ and available N content in heavy textures

soil and $CaCO_3$, available N and Zn content in light textured soil. Increase in soil pH and EC values were observed under surface method of irrigation in both soil types. While major and micro-nutrients content was better under 4 dripper system of irrigation followed by surface method of irrigation. Micro-sprinkles were not much effective with regard to nutrient availability in soil as compared to other methods.

### Leaf nutrient status

To find out the effect of various treatments on nutrient content in the plants, leaf samples were collected during October 2010 and analysed for different macro and micro-nutrient contents. The leaf nutrient data from light textured soils revealed significant variation in P, K, Ca, Cu and Mn content while other nutrients as N, Mg, Zn and Fe showed non-significant variation (Table 15). Higher P, Ca and Fe content was recorded under 4 dripper system of irrigation while N and K uptake was highest under surface method of irrigation. As such no fixed trend was observed amongst various treatments for uptake of the nutrients.

Table 13: Soil physic-chemical properties as influenced by various methods of irrigation in pomegranate orchards grown on heavy textured soil

| Methods of Irrigation | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| 4 Dripper | 8.31 | 0.47 | 0.81 | 12.3 | 276.9 | 18.8 | 587.1 | 10.50 | 3.08 | 4.84 | 16.6 |
| Microjet 180o | 8.62 | 0.50 | 0.80 | 11.4 | 287.7 | 16.3 | 484.7 | 9.04 | 2.68 | 6.08 | 16.1 |
| Microjet 360o | 8.65 | 0.50 | 0.69 | 11.7 | 284.8 | 15.8 | 537.3 | 8.59 | 2.60 | 5.92 | 15.7 |
| Surface irrigation Double ring | 8.70 | 0.55 | 0.80 | 10.7 | 261.9 | 17.7 | 517.9 | 9.40 | 2.71 | 6.25 | 19.0 |
| CD (p=0.05) | 0.12* | 0.042* | NS | NS | NS | 2.0 | 25.0* | 1.29 | 0.18* | 0.30* | 0.77* |

Table 14 : Soil physico-chemical properties as influenced by various methods of irrigation in pomegranate orchards grown on light textured soil

| Methods of Irrigation | pH | EC (dS/m) | Organic Carbon | $CaCO_3$ | N | P | K | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (kg/ha) | | | (ppm) | | | |
| 4 Dripper | 7.50 | 0.143 | 0.47 | 2.58 | 266.8 | 7.6 | 573.4 | 3.88 | 0.53 | 3.65 | 6.96 |
| Microjet 180o | 7.67 | 0.126 | 0.56 | 2.42 | 262.8 | 7.8 | 565.5 | 3.64 | 0.46 | 3.21 | 6.13 |
| Microjet 360o | 7.59 | 0.164 | 0.49 | 2.50 | 254.3 | 8.0 | 553.3 | 3.82 | 0.44 | 3.28 | 5.65 |
| Surface irrigation Double ring | 8.08 | 0.174 | 0.41 | 2.37 | 240.8 | 9.8 | 521.7 | 4.18 | 0.48 | 3.20 | 6.73 |
| CD (p=0.05) | 0.23* | 0.023* | 0.055* | NS | NS | 1.03* | NS | 0.31 | NS | 0.26* | 0.60* |

Table 15 : Leaf nutrient content as influenced by methods of irrigation to pomegranate orchards grown on light textured soil

| Methods of Irrigation | N | P | K | Ca | Mg | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | (ppm) | | | |
| 4 Dripper | 2.16 | 0.138 | 0.65 | 2.00 | 0.52 | 97.5 | 26.5 | 123.8 | 76.6 |
| Microjet180o | 2.06 | 0.113 | 0.56 | 1.55 | 0.58 | 110.6 | 27.0 | 115.8 | 79.8 |
| Microjet 360o | 2.13 | 0.119 | 0.70 | 1.70 | 0.58 | 86.2 | 28.4 | 114.8 | 77.9 |
| Surface irrigation Doublering | 2.24 | 0.155 | 0.78 | 1.50 | 0.46 | 82.9 | 26.9 | 110.0 | 65.8 |
| CD 5% | NS | 0.02* | 0.07* | 0.30 | NS | 13.3* | NS | NS | 6.5* |

## Project 2.7: Effect of mulches and irrigation level on yield, quality and WUE of pomegranate (*Punica granatum* L.)

### Month wise climatic Parameters at Experimental site

The daily observations of climatic parameters (i.e. maximum temperature ($T_{max}$, $^0$C), minimum temperature ($T_{min}$, $^0$C), maximum relative humidity ($RH_{max.}$, %), minimum relative humidity ($RH_{mix.}$, %), wind speed at height of 2 m (WS, km/hr), actual sun shine hours (SS, hours), pan evaporation (Epan, mm) and rainfall (R, mm)) were analyzed from April, 2011- to March, 2012 and their monthly average are shown in Table. 1. The climate of the study area is semiarid eco region with well-defined summer (March-June), rainy season (July-October) and mild winter (November-February). The twelve-monthly precipitation of the study area is 594.40 mm of which nearly 86.47 % is received during monsoon period (July - October). The mean annual air temperature is 26.73 $^0$C. The mean air summer temperatures is 29.4 $^0$C, while mean winter air temperature is 24.25 $^0$C, indicating that the area falls under hyperthermic soil temperatures regime. May is the hottest month with mean daily maximum and minimum temperatures of 41.9 $^0$C and 24.0 $^0$C, respectively. January is the coldest month with mean daily maximum and minimum of 33.4 $^0$C and 9.8 $^0$C, respectively. The mean monthly maximum temperature ranges between 30.4 $^0$C to 38.7 $^0$C, while the minimum monthly temperature varies between 15.2 $^0$C to 23.1 $^0$C. The mean monthly maximum relative humidity ranges between 49.1 to 86.3 %, while the minimum monthly relative humidity varies between 24.4 to 62.4 %. The mean monthly maximum and minimum wind speed, sunshine hour and evaporation vary from 6.7 14.7 Km/hr, 4.3 9.8 hr and 4.2 12.7 mm, respectively. Average monthly variations of climatic parameters for the estimation of ETr are presented in Table.1.

### Estimation of Reference Crop Evapotr-anspiration (ETr, mm)

The daily climatic data for the period of April, 2011 to March, 2012 were used to determine daily and weekly reference crop evapotranspiration (ETr) by using Penman-

Monteith Method. The weekly ETr values are presented in Fig.1. Figure shows that the trend of variation of average ETr values over the year. The yearly reference crop evapotranspiration (ETr) obtained are 1978.70 mm. The ETr was maximum in May (19-21 SMW) and minimum in December (49-52 SMW). The weekly minimum and maximum ETr ranged from 25.6 to 59.8 mm.

Table 1: Climatic parameters at experimental site

| Months | $T_{max}$ (°C) | $T_{min}$ (°C) | $RH_{max.}$(%) | $RH_{mix.}$ (%) | WS (Km/hr) | SS (Hours) | Epan (mm) | R (mm) |
|---|---|---|---|---|---|---|---|---|
| April,2011 | 37.9 | 21.9 | 62.8 | 26.3 | 8.6 | 9.3 | 10.5 | 15.8 |
| May | 38.7 | 23.1 | 65.4 | 24.4 | 10.8 | 8.9 | 10.9 | 45.4 |
| June | 34.1 | 22.3 | 76.5 | 43.6 | 14.7 | 6.3 | 7.4 | 19.2 |
| July | 31.2 | 21.5 | 86.2 | 55.2 | 12.5 | 4.5 | 5.4 | 185.5 |
| August | 30.4 | 21.9 | 86.3 | 62.4 | 11.1 | 4.3 | 4.2 | 211.2 |
| September | 31.7 | 21.5 | 84.7 | 52.7 | 9.7 | 6.1 | 5.0 | 66.3 |
| October | 32.4 | 21.6 | 78.6 | 45.7 | 7.5 | 7.7 | 4.8 | 51.0 |
| November | 31.7 | 18.4 | 73.8 | 33.1 | 8.2 | 9.0 | 5.6 | 0.0 |
| December | 30.8 | 16.0 | 73.0 | 32.2 | 6.7 | 9.1 | 5.7 | 0.0 |
| January | 30.5 | 15.2 | 71.1 | 29.5 | 6.9 | 9.5 | 6.5 | 0.0 |
| February | 33.9 | 17.7 | 52.6 | 25.9 | 6.7 | 9.8 | 8.4 | 0.0 |
| March,2012 | 37.5 | 19.5 | 49.1 | 25.3 | 8.0 | 9.5 | 12.7 | 0.0 |
| Range | 30.4-38.7 | 15.2-23.1 | 49.1-86.3 | 24.4-62.4 | 6.7-14.7 | 4.3- 9.8 | 4.2-12.7 | 0.0-211.2 |
| SD | 3.03 | 2.64 | 12.30 | 13.33 | 2.53 | 2.04 | 2.76 | 73.39 |
| CV(%) | 9.07 | 13.19 | 17.16 | 35.06 | 27.31 | 25.98 | 37.97 | 148.17 |

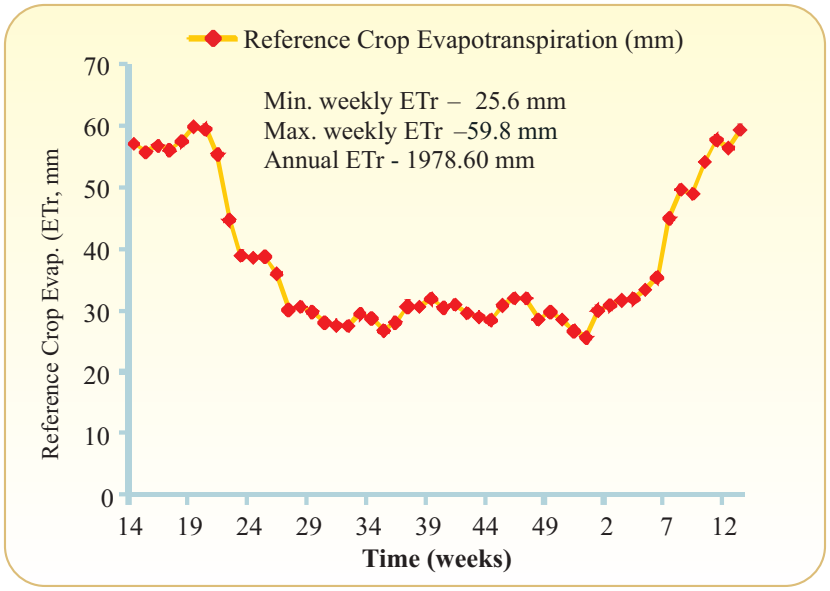



Fig. 1: Weekly ETr (mm) values from April, 2011 to March, 2012 at Experimental site

### Development of crop coefficient (Kc) values

Five numbers of representative plants were randomly selected from experimental plot. Plywood board of 2.5 x 2.5 m sizes with grid marking of size 10 x 10 cm was prepared for the estimation of shaded area. Shaded area was measured at solar noon hour (12.00AM). To measure the shaded area, a plywood board was kept below the canopy as shown in Fig.2 and the total number of grids that were measured of shaded area. The shaded area was then calculated as the total number of grids times the area of each grid. The weekly crop coefficient value was then computed by using equation ($K_c$=0.014x+0.08). The crop coefficient curve for pomegranate tree in 1st year is presented in Fig.3. Figure indicates that the values of crop coefficient increases from 0.13 to 0.28 due to the development, maturation of the leaf surface and increased number of leaves; foliage and water sprout of the tree during first year. The Kc values increases linearly from 14st to 44th weeks due to increases in number of leaves, water sprout, luxors and shaded area as observed from the representative trees. The crop coefficient (0.28-0.25) reduced in the 45th week due to removal of the flowers, disease fruits, excess water sprout, foliage clumping and management practices.

Fig.2: Plywood board kept below the canopy for the estimation of shaded area

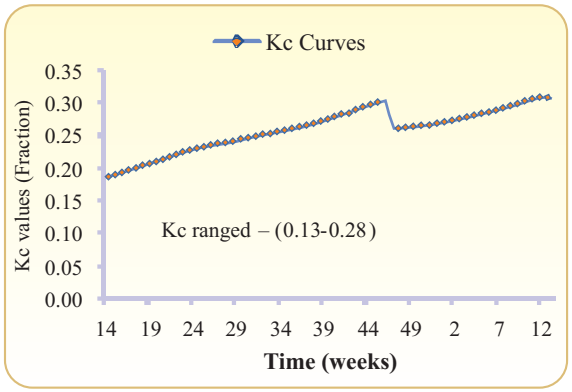



Fig. 3: Crop coefficient curve for 1st year pomegranate tree

### Determination of monthly shaded area (SA), wetted area (WA) and leaf area index (LAI)

The variation of shaded area, wetted area and leaf area index at area per plant for the pomegranate tree of 1st year with respect to month is presented in Table 2. It is seen from the table that shaded area, wetted area and leaf area index increases rapidly from April to October months due to increase in foliage, number of leaves and its area. After November shaded area, wetted area and LAI decreases due to removing of water sprout, leaves, foliage crumbling as a result of management practices. Later shaded area, wetted area and LAI slowely increases because of emergence of new leaves as a result of application of inputs including irrigation water.

Table 2: Monthly shaded area, wetted area and leaf area index

| Months | APP($m^2$) | SA ($m^2$) | WA (%) | NL | TA ($m^2$) | $LAI_{APP}$ |
|---|---|---|---|---|---|---|
| April,2011 | 18.00 | 0.94 | 5.22 | 2389.0 | 1.4 | 0.08 |
| May | 18.00 | 1.00 | 5.56 | 4359.9 | 2.3 | 0.13 |
| June | 18.00 | 1.23 | 6.83 | 5455.0 | 3.2 | 0.18 |
| July | 18.00 | 1.30 | 7.22 | 5565.0 | 3.5 | 0.19 |
| August | 18.00 | 1.42 | 7.89 | 6345.0 | 4.3 | 0.24 |
| September | 18.00 | 1.62 | 9.00 | 7234.0 | 4.8 | 0.27 |
| October | 18.00 | 1.73 | 9.61 | 9234.0 | 6.4 | 0.35 |
| November | 18.00 | 1.64 | 9.11 | 9645.0 | 6.8 | 0.38 |
| December | 18.00 | 1.84 | 10.22 | 10678.0 | 7.2 | 0.40 |
| January | 18.00 | 2.20 | 12.22 | 11656.0 | 7.8 | 0.43 |
| February | 18.00 | 2.43 | 13.50 | 11989.0 | 8.2 | 0.45 |
| March,2012 | 18.00 | 2.58 | 14.33 | 11678.0 | 8.7 | 0.48 |

(Spacing-4.5 x 4 m)

**Note:** (APP-Area per plant ($m^2$), SA Shaded area ($m^2$), PSA - Percentage of shaded area ($m^2$), NL-Number of leaves (Nos.), TA-Total area of leaves ($m^2$), Kc Crop coefficient (Fraction) and $LAI_{SA}$- Leaf area index at Solar noon hour ($m^2/m^2$))

**Estimation of Pomegranate Evapotranspiration (ETp, litres/day/tree)**

The weekly water to be applied through drip irrigation system at 90 % efficiency from April, 2011 to March, 2012 ranged from 14.3-41.2 liters/week/tree for 1st old age of pomegranate tree. It gradually increases or decreases during different development stages of pomegranate tree due to the variation of reference crop evapotranspiration, pan coefficient, wetted area and crop coefficient values. Lower Kc values represent slower plant growth and lower plant canopy cover, indicating lower ETp. The seasonal values of water to be applied to pomegranate tree are 1364.2 liters/year/tree. (Fig.4).

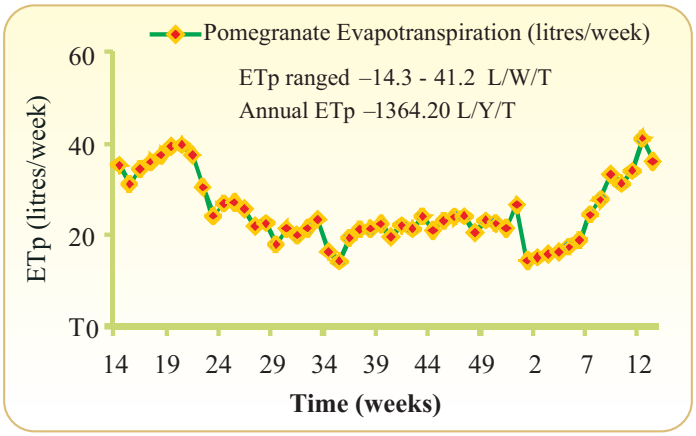



Fig.4: Weekly pomegranate evapotranspiration (liters/week) of 1st old age tree

### Relationship between crop coefficient (Kc) and leaf area index (LAI)

The relationship between Kc and LAI of 1st year pomegranate tree presented in Fig. 5. It is seen from the graphs that Kc linearly increases with LAI. The relationship is Kc = 0.342 LAI + 0.123 ($R^2$=0.85). As $r^2$ more than 0.60, this relationship would also provide the Kc values for know values of leaf area index (LAI).

### Growth parameters

Bhagava cv. of pomegranate was evaluated for their growth parameters (Table 3). Plant height, plant spread (EW & SE), stem diameter, stem girth and thorn length ranged from 70 to 145 cm, 65 to 130 cm, 75 to 140 cm, 1.8 to 3.8 cm, 1.5 to 3.3 cm and 2.0 to 4.5 cm.

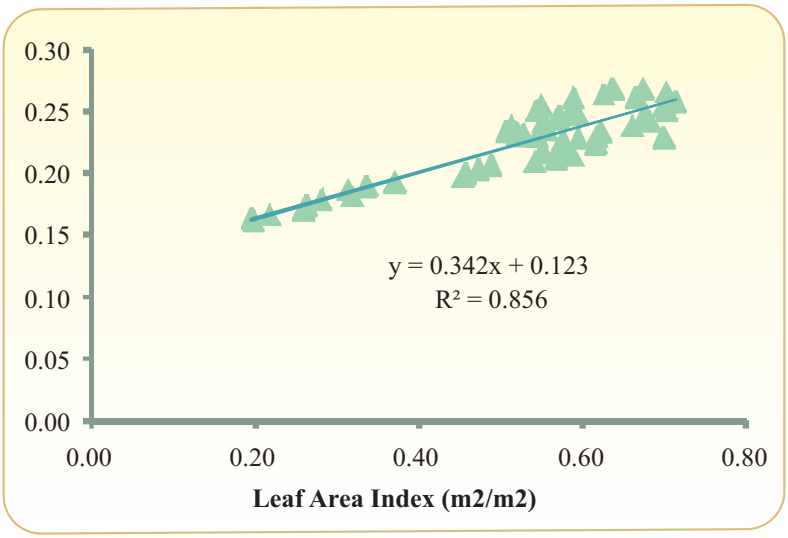



Fig. 5: Relationship between Kc and LAI

Table: 3: Growth performance of experimental plot

| Days | Plant height (cm) | Plant spread (cm) | | Steam diameter (cm) | Steam girth (cm) | Thorn length (cm) |
|---|---|---|---|---|---|---|
| | | EW | SE | | | |
| 0-60 | 70.0 | 65.0 | 75.0 | 1.8 | 1.5 | 2.0 |
| 60-120 | 80.0 | 81.0 | 85.0 | 2.2 | 1.7 | 2.5 |
| 120-180 | 95.0 | 92.0 | 95.0 | 2.6 | 1.9 | 2.9 |
| 180-240 | 110.0 | 105.0 | 110.0 | 3.0 | 2.2 | 3.2 |
| 240-300 | 132.0 | 115.0 | 120.0 | 3.4 | 2.8 | 3.8 |
| 300-365 | 145.0 | 130.0 | 140.0 | 3.8 | 3.3 | 4.5 |

## Programme 3: Pomegranate Protection (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 prevalence and severity:** During the year 2011-12 blight surveys were conducted in the districts of Solapur, Beed and Nashik. Bacterial blight was prevalent in 81.81% of orchards in Solapur followed by Nashik (33.33%) and Beed (20.0%) districts. However, av. disease severity was quite low and was 23.45%, 19.7% and 7.28% in Solapur Beed and Nashik districts, respectively (Table-1). In general, bacterial blight was prevalent in 45.9% of the orchards and its severity ranged between 5.5 - 39.2% ( av. severity of 16.8%). Blight was observed in mild form in 16.2% orchards and in moderate proportion in 29.7% orchards.

**Influence of Meteorological factors on blight development:** Bacterial blight development and meteorological factors for the period March,2011 to February, 2012 were analyzed performing correlation and regression analysis. The weekly hour averages of temperatures between 25.0-35.0°C and Relative Humidity ≥ 50.0% and weekly rainfall were found positively and significantly correlated with blight severity (Table 2). Regression analysis of these factors i.e temperatures 25.0 - 35.0°C at RH≥ 50.0% accompanied by rain gave best regression fit for blight severity (Table 3).

Table 1: Bacterial blight Prevalence and Severity in Solapur, Beed and Nashik districts of the state during 2011-12.

| Sl.No | District | Orchards surveyed | Bacterial blight prevalence (%) | Blight Severity av.(range)% | Orchards with Blight severity | | |
|---|---|---|---|---|---|---|---|
| | | | | | Mild | Moderate | Severe |
| 1 | Solapur | 11 | 9 (81.8) | 23.4 (11.7-39.2) | 0 (0) | 9 (81.8) | 0(0) |
| 2 | Beed | 5 | 1(20.0) | 19.7 | 0(0) | 1(20.0) | 0(0) |
| 3 | Nashik | 21 | 7.0 (33.3) | 7.28 (5.5-18.0) | 6.0 (28·5) | 1.0(4.76) | 0(0) |
| | Total | 37 | 17(45.9) | 16.8(5.5-39.2) | 6(16.2) | 11(29.7) | 0(0) |

Table 2: Correlation matrix between blight severity and different meteorological factors during 2011-12.

| Correlation matrix | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| - | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V9 |
| V1 | 1.00 | 0.691 | 0.38 | 0.882 | 0.723 | 0.509 | 0.705 | 0.645 |
| V2 | 0.691 | 1.00 | 0.829 | 0.763 | 0.883 | 0.692 | 0.398 | 0.742 |
| V3 | 0.38 | 0.829 | 1.00 | 0.432 | 0.738 | 0.743 | 0.212 | 0.567 |
| V4 | 0.882 | 0.763 | 0.432 | 1.00 | 0.868 | 0.615 | 0.716 | 0.608 |
| V5 | 0.723 | 0.883 | 0.738 | 0.868 | 1.00 | 0.889 | 0.494 | 0.644 |
| V6 | 0.509 | 0.692 | 0.743 | 0.615 | 0.889 | 1.00 | 0.358 | 0.502 |

| Correlation matrix | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| - | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V9 |
| V7 | 0.705 | 0.398 | 0.212 | 0.716 | 0.494 | 0.358 | 1.00 | 0.381 |
| V9 | 0.645 | 0.742 | 0.567 | 0.608 | 0.644 | 0.502 | 0.381 | 1.00 |

V1:Weekly hr temperatures (25.0-35.0°C) at RH>80.0%; V2:Weekly hr temperatures (25.0-35.0°C) at RH >50.0%;V3:Weekly hr temperatures (25.0-35.0°C) at RH>80.0%; V4: Weekly hr temperatures (15.0-40.0°C) at RH>80.0%;V5: Weekly hr temperatures (15.0-40.0°C) at RH>50.0%; V6: Weekly hr temperatures (15.0-40.0°C) at RH>30.0%;V7: Weekly hour rainfall; V9: Blight severity.

Table 3: Regression analysis of meteorological factors with blight severity.

| Sl. No. | Regression Model s | Coefficient of determination ($R^2$) |
|---|---|---|
| 1 | Blight severity = - 0.004+ (0.084) x V2+(0.008) x V7 + 0.460 | 0.558 |
| 2 | Blight severity = - 0.004 + (0.099) x V2 + 0.464 | 0.540 |
| 3 | Blight severity = - 0.124 + (0.051) x V5 + 0.526 | 0.415 |
| 4 | Blight severity = - 0.103 + (0.054) x V5 + (0.003) x V7 + 0.532 | 0.415 |
| 5 | Blight severity = 0.0306 +(0.424) x V1+ 0.527 | 0.410 |

**Collection of isolates for phenotypic and genotypic studies:**

During the year 17 *Xanthomonas axonopodis punicae* isolates were added from Maharashtra,1 from IARI, 9 (AP series) from Andhra Pradesh and 5 from North Karnataka (K series). Maharashtra isolates were obtained through isolations from bacterial blight affected plant parts collected during surveys or brought by farmers for identification. The AP and Karnataka isolates were obtained through isolations from affected plant parts received from Andhra Pradesh and Karnataka. The isolates were confirmed to be *Xanthomonas axonopodis* pv. *punicae* on the basis of growth after 72 hours at 30°C, Fuscan production and pathogenicity tests and stored. AP isolates were sent to IARI for further genotypic studies. As per results provided by IARI all except AP4 isolate were reported to be PCR positive with dnaK gene which is specific for *X. axonopodis punicae* . AP4 was a mixed culture with another fast growing bacteria in it. AP3 has been subjected to a detailed analysis which involves sequencing of 9 different genes in the genome by IARI. Results of sequencing are awaited.

Isolates from different regions were found to show variability in bacterial blight incidence and severity in pot culture studies (Table 4 and Fig 1&2). Some isolates showed larger lesions, more chlorosis and more leaf fall than others It can be seen that the incidence and severity of bacterial blight was highest with isolates from Karnataka followed by Maharashtra and lowest in Andhra Pradesh. The highest incidence in 9 different AP Isolates ranged from 5.15-19.61% and severity from 17.20-25.0%, whereas corresponding values for Maharashtra isolates (Sangli, Solapur, Beed, Ambajagoi) were 26-33.5% and 21.40-35.60% and for Karnataka 17.33-44.67% and 22.60-35.20%.

Table 4. Bacterial blight incidence and severity in pathogenicity tests of isolates collected during surveys

| Isolate code | Place of collection | Incidence % | Severity on infected units | |
|---|---|---|---|---|
| | | | Disease Index | Severity% |
| Isolates from Maharashtra | | | | |
| XAP-52 | Hiraj, S. Solapur, Dongre farm | 33.00 | 2.09 | 21.80 |
| XAP 54 | Hiraj, S. Solapur, Dongre farm | 36.12 | 2.41 | 28.20 |
| XAP 61 | Javalgaon, Barshi | 38.10 | 2.45 | 29.01 |
| XAP 78 | Kurul, Mohol | 33.26 | 2.34 | 26.8 |
| XAP-79 | Orchard 2, Village Bharaj, Tk. Ambajog ai, Beed | 33.67 | 2.22 | 24.40 |
| XAP-80 | Orchard 1, Village Bharaj, Tk. Ambajogai, Beed | 26.33 | 2.16 | 23.20 |
| XAP-81 | Hoal, Tk. Kej, Beed | 30.00 | 2.54 | 30.80 |
| XAP-82 | Village Sankh, Tk. Jat, Dist. Sangli | 37.50 | 2.07 | 21.40 |
| XAP-83 | Boramani | 31.33 | 2.78 | 35.60 |
| | Average | 33.26 | 2.34 | 26.8 |
| Isolates from district Anantpur (Andhara Pradesh) | | | | |
| AP-1 | Kota Palli | 10.41 | 1.89 | 18.89 |
| AP-2 | Kane Kal | 19.61 | 2.25 | 25.00 |
| AP-3 | Rekulakunta | 10.15 | 2.23 | 24.60 |
| AP-4 | Madaksira | 08.88 | 1.95 | 19.49 |
| AP-5 | Kanekal Cross | 07.16 | 1.93 | 19.29 |
| AP-6 | Kecse Palli | 09.47 | 2.19 | 23.80 |
| AP-8 | Nayana Palli | 10.39 | 1.72 | 17.23 |
| AP-9 | Penukonada | 10.36 | 1.82 | 18.20 |
| AP-10 | Rekulakunta | 5.15 | 2.21 | 24.20 |
| | Average | 10.18 | 2.02 | 21.19 |
| Isolates from North Karnataka | | | | |
| KA1 | Rona, district Gadag | 17.33 | 2.13 | 22.60 |
| KA3 | Yelubarga, district Koppal | 44.67 | 2.69 | 33.80 |
| KA4 | Jumnal, district Bijapur | 30.33 | 2.78 | 35.60 |
| KA5 | Kanamadi, district Bijapur | 21.00 | 2.41 | 28.20 |
| KA8 | Laladagi, district Bagalkot | 32.33 | 2.76 | 35.20 |
| | Average | 29.13 | 2.55 | 31.08 |

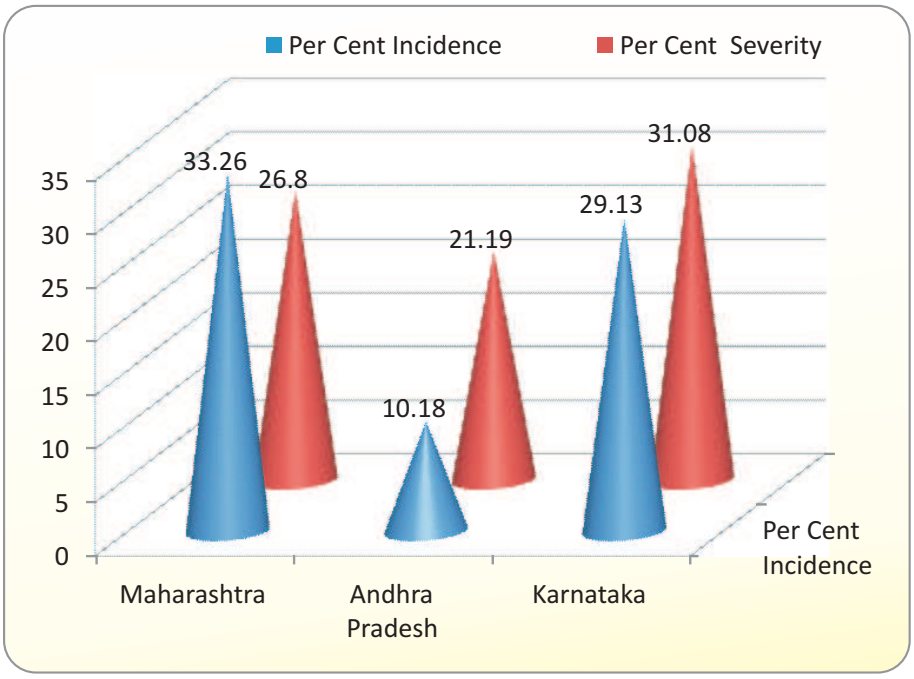



Fig 1. Differences in virulence of collected Isolates of *X. axonopodis punicae* from different states

Maharashtra Isolate

Karnataka Isolate Andhra Pradesh Isolate

Fig 2. Differences in Virulence of Collected Isolates of *X. axonopodis punicae* from different states

**Pathogenicity Tests of Isolates Sent by IARI**

In all eight isolates were received from Indian Agricultural Research Institute, New Delhi, two in May and six in June. These isolates along with two isolates from NRCP were tested under net house conditions for pathogenicity. Three plants per treatment of variety Bhagawa of 2 years age were used for challenge inoculation. All isolates except two isolates (57/L2/120 and IARI 56/119), sent by IARI, produced typical bacterial blight symptoms. In May symptoms appeared after 10 days of inoculation, however, in June symptoms appeared on the seventh day. Re-isolation from all plants showing bacterial blight symptoms produced typical *X.axonopodis* pv. *punicae* colonies with fuscan production. As per identity provided by IARI 4 isolates (IARI-5, IARI-80, IARI-81, IARI-82 ) were *X.axonopodis* pv. *punicae* and 4 (IARI 57/L2 /120, IARI 56/119, IARI 57, IARI 58) were *Pantoea agglomerans*, out of which two isolates (IARI 57, IARI 58) produced symptoms and two (IARI 57/L2 /120, IARI 56/119) did not produce any symptom. On reisolation from plants showing symptoms typical colonies of *X.axonopodis* pv. *punicae* with fuscan production were obtained. The original cultures sent by IARI of these two isolates also produced fuscan with further incubation, confirming that these were having *X. axonopodis punicae.* Hence, it can be concluded that the isolates IARI 57 and IARI 58 probably were mixed cultures having both the bacteria. The results also show that only *X.axonopodis* pv.*punicae* isolates were pathogenic and caused disease, where as *P. agglomerans* was not pathogenic hence, had no role in disease production as pure isolates of *P. agglumerans* failed to produce disease in pathogenicity tests (Table 5 and Fig 3).

Table 5. Incidence and severity of bacterial blight symptoms produced by different bacterial isolates sent by IARI

| S.No. | Isolates | Weeks after inoculation | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1wk | 2wk | 3wk | 1wk | 2wk | 3wk ** |
| IARI Isolates | | Av. Incidence (%) | | | Av severity (%) | | |
| 1. | *IARI 5 | 0.77 | 16.65 | 20.74 | 3.24 | 5.185 | 11.15 |
| 2. | IARI 80 | 5.52 | 26.79 | 28.94 | 14.16 | 23.03 | 20.33 |
| 3. | IARI 81 | 1.42 | 10.20 | 17.79 | 2.83 | 7.81 | 14.96 |
| 4. | IARI 82 | 0.41 | 3.95 | 9.50 | 1.78 | 13.67 | 16.13 |
| 5. | * IARI 57/L2 /120 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6. | IARI 56/119 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7. | IARI 57 | 2.09 | 19.75 | 20.95 | 1.81 | 13.29 | 15.10 |
| 8. | IARI 58 | 6.74 | 24.31 | 26.06 | 3.75 | 13.67 | 20.71 |
| Check NRCP Isolates | | | | | | | |
| 1 | *XAP 54 | 3.19 | 27.37553 | 36.12 | 2.00 | 24.10 | 16.50 |
| 2 | XAP 61 | 2.34 | 31.38972 | 38.10 | 5.58 | 14.35 | 24.51 |
| | Control | 0 | 0 | 0 | 0 | 0 | 0 |

* Isolate tested twice (Once in May 2011 and again in June 2011.
Inoculum sprayed on June 11, 2011.


Fig 3. Pathogenicity of bacterial blight isolates from IARI and Check isolate from NRCP Solapur

**Phenotypic tests**

*X. axonopodis* pv. *punicae* produced typical yellow mucoid raised colonies on nutrient glucose agar after 1 week though they start appearing after 3-4 days of incubation at 30°C and after further incubation fuscan production is seen after 2 weeks (Fig 4). Studies were conducted to see growth of selected isolates at different salt concentrations and Hydrogen ion concentration based on phenotypic tests outlined by IARI for confirming identity of *X. axonopodis punicae*. Studies were conducted with 8 isolates of *X. axonopodis punicae* (6 from Maharashtra and 2 from Andhara Pradesh) collected during the year on Luria Bertani (LB) broth. All isolates showed growth in absence of salt (NaCl), only 3 isolates, 2 from AP and 1 from Maharashtra XAP52 showed growth at 1% salt concentration, however, growth was less than that without salt (Fig 5). Fuscan production was observed in all the isolates where growth (turbidity) was observed. Hydrogen ion concentration pH 6-7.8 (Fig 6) favoured growth of *X. axonopodis* pv. *punicae, growth was absent at* pH below 6 and above 7.8. In all isolates growth was observed after 60 hrs at 30°C. Fuscan production was more in Luria Bertani media in comparison to nutrient glucose medium.

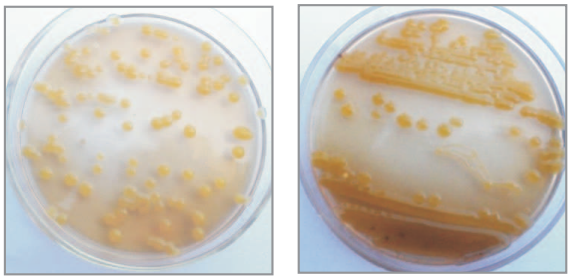
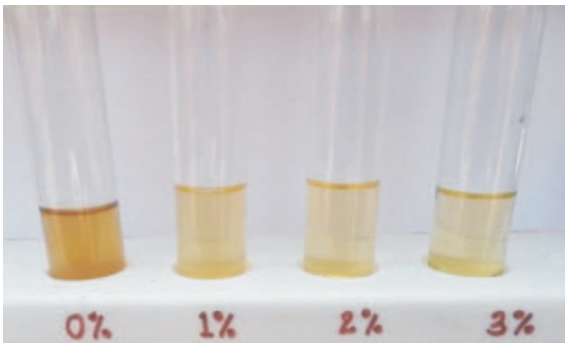
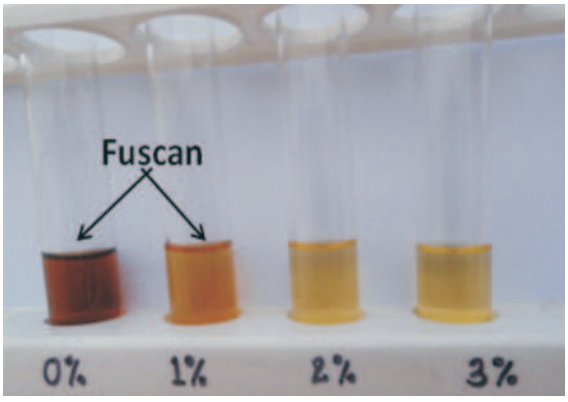


Fig 4: Growth of *X. axonopodis punicae on NGA* and fuscan production




After 10 days of inoculation




After 30 days of inoculation

Fig 5. Growth of *X. axonopodis* pv. *punicae* and fuscan production and fuscan production at different salt concentrations

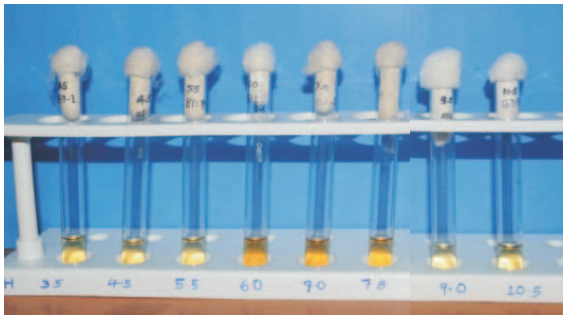


Fig 6. Growth of *X. axonopodis* pv.*punicae* and fuscan production at different pH and after one week

### Standardization of methodology for detecting *X. axonopodis* pv. *punicae* on asymptomatic plants and in air

Efforts were made to standardize media and methodology for detection of bacterial blight pathogen on asymptomatic leaves and studying movement of *X. axonopodis punicae* in air. Modified nutrient glucose agar medium was found most suitable to detect the pathogen on asymptomatic leaves near or at a distance below infected leaves. No pathogen could be detected in air at 3 time intervals (sunrise, afternoon and before sunset), at various distances and heights from heavily infected plant/orchard in Feb 2011. Study will be repeated in rainy season.

**Screening of germplasm for blight resistance under field conditions:** Germplasm at the field gene bank was screened for blight reaction during May 2011 and January 2012. In all 96 accessions having 299 replicated plants were screened . However, no blight was recorded on any of the accessions due to low disease pressure and also stringent blight mitigation measures. Some of the germplasm screened included:- Nayana, Bedana suri, Ruby, Kalisirin, Gul-e-Shah, Agah, Jodhpur collection, Kabul, Khog, Jallore Red, Saharanpur, Kayakianar, Achikdana, Jallore seedless, Surekhanar, Puna collection etc. Some of these accessions were susceptible to blight during the previous year when disesase pressure was high.

### Management of bacterial blight

**Evaluation of different schedules and formulations for the management of bacterial blight**

Fifteen different 'Orchard Health Management (OHM) Schedules including different bactericidal combinations and formulations were

evaluated in a replicated field trial at farmer's field The nutrient and pesticide applications were followed uniformaly for all the treatments. For the management of bacterial blight the bactericidal spray schedule in the normal OHM schedule(T1) was modified as per details given in Table 6. Total 12 sprays were given. In all 4 schedules (T7, T8, T9 and T11) were found significantly better and 2 treatments (T10 and T12) at par with the normal OHM schedule (T2) using streptocycline, COC and Bordeaux mixture. The schedule (T11) using combination of streptocycline (500ppm), copper oxychloride (0.25%) and Bronopol (500ppm) was most effective, though at par with T7, T8 and T9. The three formulations Telya killer, Vanshri Botanical and Revita Herbal Forte were ineffective and at par with untreated control (Fig.7).

Table 6: Treatment details for Evaluation of different schedules and formulations involving different bctericides for the management of bacterial blight

| |
|---|
| T1:Control (only w ater sprayed) |
| T2 [b]:Normal OHM* |
| T3:Normal OHM replaced COC with CHC |
| T4:Normal OHM replaced COC with CAC |
| T5:Normal OHM replaced Streptocycline with Rfp |
| T6:Normal OHM replaced Streptocycline with Rfp and COC with CHC |
| T7[a]:Normal OHM replaced Streptocycl ine with Rfp and COC with CAC |
| T8 [a]:Normal OHM replaced Streptocycline with Am |
| T9 [a]:Normal OHM replaced Streptocycline with Am and COC with CHC |
| T10 [b]:Normal OHM replaced Streptocycline with Am and COC with CAC |
| T11 [a]:Normal OHM in addition to Strep tocycline+ COC add Bactronol -100 |
| T12 [b] :Normal OHM and alternately use Stc, Rfp and Am and replaced COC with CHC, and replaced Bordeaux mixture with NSE (freshly prepared) spray . |
| T13: Telya Killer + Phosponic acid sprays and Three drenching with 10000 ppm azadirachtin at 60 days interval, in first spray azadirachtin was also used |
| T14: Vanshri Botanaical |
| T15: Revita herbal Forte |
| *The normal OHM consists of first spray of streptocycline (500ppm) +copper oxychloride (0.25%), second of Bordeaux mixture(0.5%), third of streptocycline (500ppm) +carbendazim(0.25%) and fourth again of Bordeaux mixture (0.5%). |

**Abbreviations used:** Streptocycline (Stc), Rifampicin (Rfp), Amoxycillin(Am), Copper oxy -chloride (COC), Copper hydroxide Carbonate (CHC), Copper Ammonium Carbonate (CAC), Neem seed (whole) Extract (NSE)

Concentrations used: Stc, RfP, Am and Bronopol @ 500ppm, COC, CHC and CAC @ 0.25%, NSE @7.5%.


Fig.7. Evaluation of different schedules and formulations involving different bactericides for the management of bacterial blight

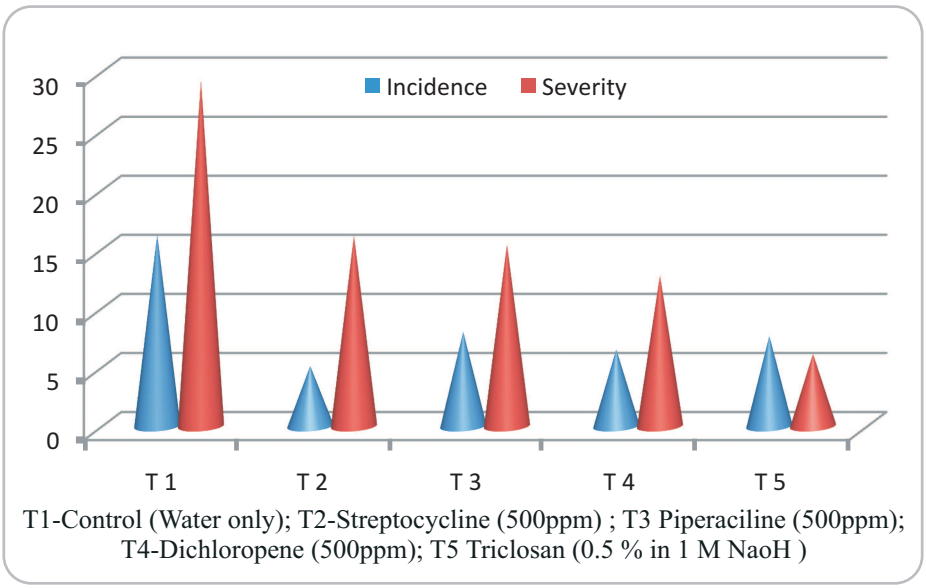



Fig 8. Evaluation of New bactericides against bacterial blight

**Evaluation of new bactericides against bacterial blight**

Three new bactericides (Piperaciline, Dichloropene and Triclosan) were compared with streptocycline in a replicated field trial for the control of bacterial blight. Among the three new bactericides tested, all the three effectively checked bacterial blight with maximum reduction in Triclosan, however were at par with streptocycline (Fig 8).

**Evaluation of different agents in improving efficacy of bactericide**

In order to improve efficacy of bactericides (streptocycline and Bronopol), 21 different treatments were evaluated, where bactericides were mixed with different agents to improve their efficacy under field conditions in a grower's orchard (Table 7). The use of non ionic spreader stickers, urea (0.2%) or salicylic acid (0.1%) with the bactericides significantly reduced bacterial blight severity (Fig 9).

Table7. Treatment details for evaluation of different agents in improving efficacy of bactericide

| T No. | TREATMENT | |
|---|---|---|
| S1 | Control | Use same quantity of water as for other treatments |
| S2 | Streptocycline | 500 ppm |
| S3 | Streptocycline | 200 ppm |
| S4 | Streptocycline | 100 ppm |
| S5 | Bactronol | 500 ppm |
| S6 | Streptocycline | 500 ppm + Leaf Mate 0.5 ml/L |
| S7 | Streptocycline | 200 ppm + Leaf Mate 0.5 ml/L |
| S8 | Streptocycline | 100 ppm + Leaf Mate 0.5 ml/L |
| S9 | Bactronol | 500 ppm + Leaf Mate 0.5 ml/L |
| S10 | Streptocycline | 500 ppm + urea 0.2% |
| S11 | Streptocycline | 200 ppm + urea 0.2% |
| S12 | Streptocycline | 100 ppm + urea 0. 2% |
| S13 | Bactronol | 500 ppm + urea 0.2% |
| S14 | Streptocycline | 500 ppm + Apsa 80 (0.3%) |
| S15 | Streptocycline | 200 ppm + Apsa 80 (0.3%) |
| S16 | Streptocycline | 100 ppm + Apsa 80 (0.3%) |
| S17 | Bactronol | 500 ppm + Apsa 80 (0.3%) |
| S18 | Streptocycline | 500 ppm + Salicyl ic acid1(ml/l) 4 sprays only |
| S19 | Streptocycline | 200 ppm + Salicylic acid (ml/l) 4 sprays only |
| S20 | Streptocycline | 100 ppm + Salicylic acid 4 (ml/l) sprays only |
| S21 | Bactronol | 500 ppm + Salicylic acid 4 (ml/l) sprays only |
| All sprays at 15 days interval; No. of Replications : 2; No. of plants/replication : 3 | | |

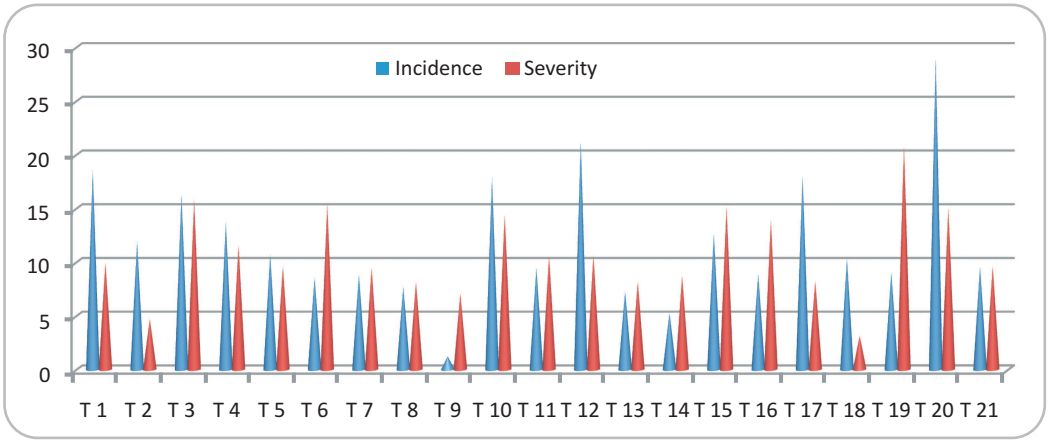



Fig. 9. Per cent incidence and severity of bacterial blight with different agents in improving

**Efficacy of bactronol on blight severity:** Study was carried out to observe the efficacy of bactronol on management of bacterial blight during the year. Experiment was conducted in potted plants and included 4 treatments having 5 replications each. Plants were sprayed twice with different concentrations of bactronol viz. 500, 750 and 1000 ppm on 12.09.11 and 27.09.11.

Disease severity was recorded at 15 days interval from the date of first spray. Statistical analysis was performed applying Completely randomized block design (CRBD). Results revealed that there was reduction in final disease severity (D2) under all the three concentrations of bactericide. Bactronol at 1000 ppm concentration provided the highest and significant reduction in blight severity (5.5% severity) over the unsprayed treatment and gave disease control of 71.54% (Table 8). Bactronol at 750 ppm also controlled disease significantly and gave 30.21% disease control. However, no significant disease control was observed under 500ppm concentration of bactronol. Study clearly revealed that bactronol at 1000 ppm concentration was most effective in managing bacterial blight as compared to lower concentrations of 500 and 750 concentrations.

## Organisms associated with bacterial blight cankers

It was often observed that bacterial blight lesions on stem, gradually formed big cankers, however, in isolations from old cankers *X. axonopodis* pv. *punicae* could rarely be isolated. Therefore isolations were made out of 35 stem cankers from different trees for different microflora and those found in high frequency were picked up and maintained in pure culture for further studies on pathogenicity. Pathogenicity was done on 3 year old potted plants in net house. Each isolate was inoculated on three plants and on each plant at three places. Five out of 10 fungi isolated frequently from bacterial blight cankers, produced cankers within 1 month, when inoculated individually on plant stems in controlled conditions, where as only blackening was observed in case of *X. axonopodis* pv. *punicae* (Table 9, Fig.10). Three fungal isolates CF7, CF8 and CF10 formed cankers on all 9 inoculations/treatment with disease index of 2.33-2.56 on a scale of 3. Based on these observations it can be said that secondary infections with these fungi in bacterial blight stem lesions, probably lead to formation of big cankers. Further studies are in progress.

Table 8: Efficacy of bactronol on bacterial blight control.

| Treatments | Blight severity on different dates | | % Blight control |
|---|---|---|---|
| | D1** | D2** | |
| T1:Control | 24.66 | 19.33 a | - |
| T2:Bactronol 500ppm | 17.66 | 14.66 ab | 24.15 |
| T3:Bactronol 750 ppm | 19.49 | 13.49 b | 30.21 |
| T4: Bactronol 1000ppm | 8.83 | 5.50 c | 71.54 |
| C.D (0.05) | 7.44 | 5.68 | - |

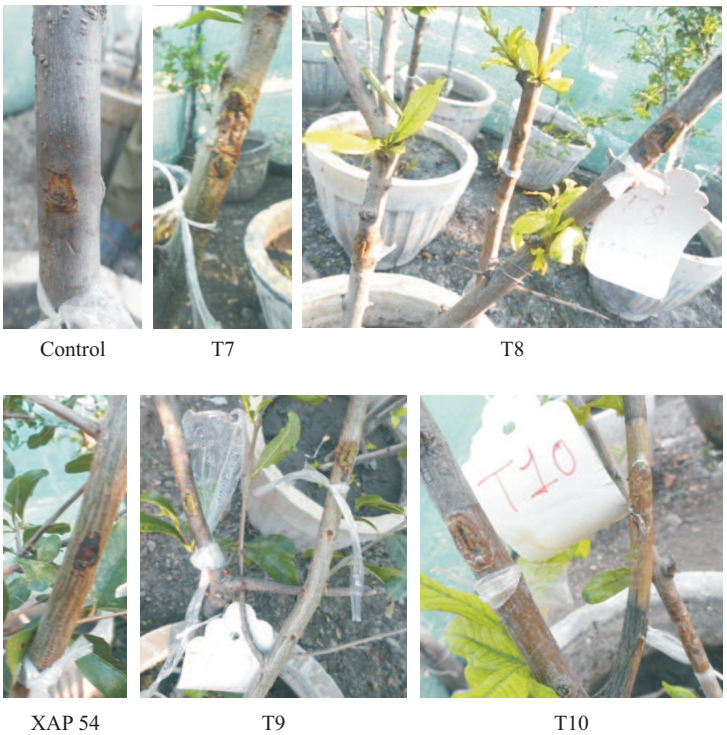
**: Significant at CD (0.01) also. D1: 27.09.11; D2: 12.10.11; Values with same alphabet do not differ significantly.

Table 9. Fungal flora associated with bacterial blight stem cankers

| Isolate | No canker Grade 0 | Canker grades | | | Cankers developed | |
|---|---|---|---|---|---|---|
| | | Grade 1 | Grade 2 | Grade 3 | Incidence % | Disease Index on scale of 3 |
| CF 1 | 6 | 2 | 1 | 0 | 33.33 | 0.66 |
| CF 2 | 8 | 1 | 0 | 0 | 0.11 | 0.11 |
| CF 3 | 8 | 0 | 1 | 0 | 0.11 | 0.22 |
| CF 4 | 4 | 3 | 2 | 0 | 55.56 | 0.77 |
| CF 5 | 7 | 1 | 1 | 0 | 22.22 | 0.33 |
| CF 6 | 6 | 0 | 3 | 0 | 33.33 | 0.67 |
| CF 7 | 0 | 0 | 6 | 3 | 100 | 2.33 |
| CF 8 | 0 | 0 | 4 | 5 | 100 | 2.56 |
| CF 9 | 2 | 1 | 0 | 3 | 66.67 | 1.67 |
| CF 10 | 0 | 1 | 2 | 6 | 100 | 2.56 |
| Control | 0 | 0 | 0 | 0 | 0 | 0 |

**Canker assessment scale:**

Grade 1: Slightly devel oped- brown to black layer with cracks, hypertrophied tissue not seen
Grade 2. Moderately developed - hypertrophied tissue formed to some extent
Grade 3. Well developed - hypertrophied tissue observed with well developed canker




Control T7 T8

XAP 54 T9 T10

Fig. 10. Cakers formed by fungal isolates (T7, T8, T9 and T10) associated with bacterial blight ' stem cankers in net house plants after 1 month of artificial inoculation in comparison to *X. axonopodis* pv. *punicae* isolate XAP54.

### Alternate host of bacterial blight

It has often been documented that Neem (*Azadirachta indica*) is an alternate host of bacterial blight of pomegranate. Hence 6 months old plants of neem grown from seeds in pots and pomegranate plants grown from air layers were inoculated with pure culture of *X. axonopodis* pv. *punicae* isolate XAP78 under net house. On pomegranate water soaked spots, appearing translucent yellow against light appeared on undersurface of leaves in 10 days, which turned necrotic and became more severe in 30 days after inoculation (Fig 11), however no symptoms were observed on neem plants even up to 3 months. Hence, neem is not an alternate host of *X. axonopodis* pv. *punicae*.

10 days after inoculation

1 month after inoculation

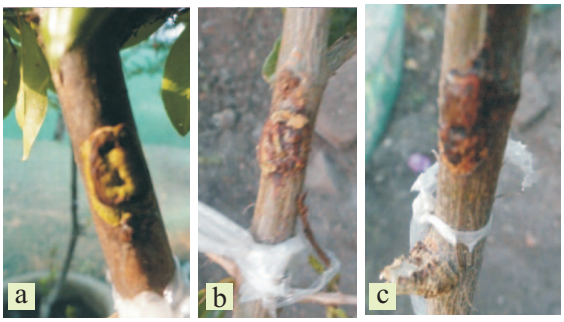
Fig. 11. Pathogenicity on pomegranate(left) and neem (right) with *X. axonopodis* pv. *punicae* isolate *XAP-78*

### Studies on Other Diseases

**Gummosis**

Gummosis-a new disease was observed for the first time in some orchards in Pandharpur. The infected stem showed lot of white/ cream coloured gum like exudate which flowed down and solidified on the stem. Although the point from where gum was exuding appeared to be due to insect damage, but no insect/or its stages were observed at or around the site of infection. Internal browning of wood from point of infection to some extent inside was also observed. Microflora found associated (3 bacterial isolates 1 fungal) with wood browning were isolated and pathogenicity conducted. Cankers were observed at 15 days in bacterial isolates (Fig 12), however, plants are being regularly monitored for further symptoms. The role of insects has not been ruled out, studies are in progress with entomologist.

Farmer's orchard




Pathogenicity test in net house

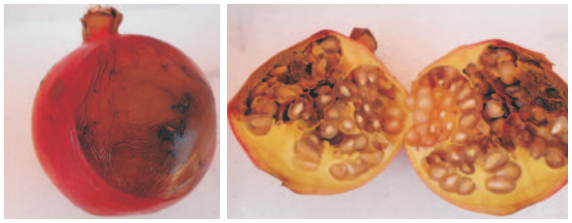
Fig 12: Symptoms of Gummosis in orchard and cankers produced in pathogenicity tests with bacteria isolated from internal brown wood of gummosis stems after (a) 15 days and (b-c) 30 days in net house

## Fungal fruit spots and rots

The combined incidence of all fungal leaf spots in an adopted orchard in Hiraj (S. solapur) in June was 21.83% and disease intensity was 15.09%. The isolates from various spots were species of *Cercospora punicae, Colletotrichum gloeosporioides* and *Alternaria alternata*. Among the fruit spots *Sphaceloma punicae* and *Cercospora punicae* were found with an incidence of 100% and 32.39% where as *Colletotrichum gloeosporioides* causing anthracnose was in traces with less than 5% incidence(Fig 13 ). Scab symptoms also showed lot of variability (Fig 14), hence species of *Sphaceloma punicae* cauing these symptoms need to be studied for variability if any. Among the rot symptoms *Aspergillus* sp. (Fig 15) and *Colletotrichum gloeosporioides* (Fig 16) were the main organism resulting in 28.84% rot. The rot organisms were isolated and pathogenicity proved. *Colletotrichum gloeosporioides* was the main cause of pre harvest rot and *Aspergillus* sp. and one unidentified fungus were found frequently in post harvest rot.

Fig 13. Anthracnose

Fig 14. Various symptoms of fruit scab



Field symptoms

Pathogenicity test

Fig 15. Aspergillus rot

## Management of fungal fruit spots.

In a replicated field trial for the management of fungal fruit spots and rot 5 chemicals were tested in a randomized block design with variety Bhagawa (Fig 17). Azoxystrobin and pyraclostrobin significantly reduced pomegranate scab, whereas pyraclostrobin was also effective in reducing incidence of *Cercospora* fruit spots.

Field symptoms

Pathogenicity test on Ganesh and Bhagawa

Fig 16. Colletotrichum rot

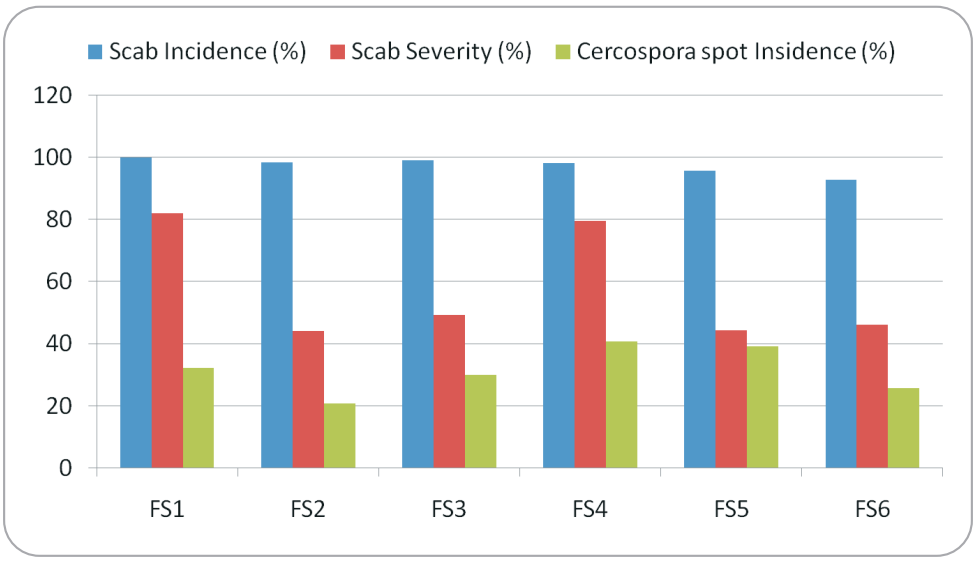



Fig 17: Effect of some fungicides on fruit spots FS1:Control :water only; FS2:Pyraclostrobin @ 0.5g/plant; FS3:Azoxystrobin @ 0.5g/plant; FS4: Benomyl/Benlate @ 0.1%; FS5: Captan/Captafol @ 0.3%; FS6: Alum (Hydrated potassium aluminium sulphate)@ 5%.

## Project 3.2: Etiology, Epidemiology and Management of Wilt of Pomegranate.

**Wilt prevalence and severity:** Wilt Surveys were conducted in Solapur, Beed and Nashik districts of the State during the year to ascertain the present status of wilt. Survey of pomegranate orchards in Solapur district revealed that wilt was prevalent in 63.6% of the orchards and its incidence varied between 0.26 - 11.0% with av. wilt incidence of 4.07% (Table 1). Wilt was prevalent in mild form in 54.5% of the orchards and in moderate form in 9.09% orchards of the district. In Beed district, wilt prevalence was only 20.0% with incidence of 3.0%. In Nashik district in all 21 orchards were surveyed in talukas of Satana, Deola and Malegaon. Wilt was prevalent in 33.3% of the orchards with disease incidence varying between 0.36 to 38% (av. incidence 15.78%). Out of 21 orchards surveyed 28.5% orchards each revealed wilt in mild and moderate proportions. In general, wilt prevalence in three districts of the State was 54.0% with av. wilt incidence of 7.61%. The wilt was prevalent in mild to moderate proportion in 35.1% and 18.9% orchards of the state.

**Etiology:** During the year, 22 samples collected from wilt affected orchards in Solapur, Beed and Nashik districts were examined for ascertaining the causal agent. Isolations of the pathogen from the wilt infected samples revealed presence of *Ceratocystis fimbriata* in 86.36% of the examined samples (Table 2). Other pathogens found associated included Shot hole borer (9%), *Fusarium* spp. (9%) and nematode infestation (9.0%).

Table 1: Wilt Prevalence and Incidence in Solapur, Beed and Nashik districts of the state during 2011-2.

| Sl.No | District | Orchards surveyed | Wilt prevalence (%) | Wilt incidence av.(range)% | Orchards with wilt severity | | |
|---|---|---|---|---|---|---|---|
| | | | | | Mild | Moderate | Severe |
| 1 | Solapur | 11 | 7 (63.63) | 4.07 (0.26-11.0) | 6 (54.54) | 1 (9.09) | 0 (0.0) |
| 2 | Beed | 5 | 1(20.00) | 3.0 | 1 (20.0) | 0 (0) | 0 (0.0) |
| 3 | Nashik | 21 | 12(57.14) | 15.78 (0.36-38.0) | 6 (28.57) | 6 (28.57) | 0 (0.0) |
| | Total | 37 | 20(54.05) | 7.61 (0.26-38.0) | 13(35.13) | 7 (18.9) | 0 (0.0) |

Table 2: Wilt affected samples revealing association of *C. fimbriata* and other pathogens.

| Sl.No | No. of samples examined | Samples collected from district/place | Samples revealing association of *C. fimbriata (%)* | Other pathogens found associated |
|---|---|---|---|---|
| 1 | 7 | Solapur | 6 (85.91) | *Fusarium* spp (1), Shot hole borer +nematode+ C.f(1). |
| 2 | 1 | Beed | 1 (100) | - |
| 3 | 14 | Nashik | 12 (85.71) | *Fusarium* spp (1), shot hole borer + C.f (1), nematode + C.f (1) |
| Total | 22 | | 19 (86.36) | *Fusarium* spp 2 (9%) shot hole borer 2 (9%) nematode 2 (9%.). |

**Biology of *Ceratocystis fimbriata***: All the 19 isolates collected during the year were observed to be homothallic as they revealed production of perithecial bodies, besides production of endoconidia and aleurioconidia.

**Screening of germplasm for wilt resistance**: **Five germplasm** were screened during the year 2011-12 against *C. fimbriata* and these included i) Alah (5 accessions),ii) EC-62182 (4),(iii) Tabesta (3), (iv) Bedana (2) and v) GR Pink (2). Screening of germplasm through artificial inoculation with *C.fimbriata* did reveal wilt symptoms in one germplasm viz. Alah till the period and experiment is still in progress

**Management of Wilt under field conditions:** Wilt affected orchard (2.16% incidence) was adopted for the management of wilt in Wadjegaon village of Solapur district. The basins of affected plants and adjacent plants were drenched with bavistin (0.2%) + chlorpyriphos (0.2%) at monthly intervals in December 2011 and January 2012. Soil drenching resulted in effective management of wilt as no new infections were observed after the treatments.

***Aspergillus* spp. as antagonist of *C. fimbriata***: One *Aspergillus* spp was observed to be antagonist of *C. fimbriata* as it completely inhibited the growth of wilt pathogen under *in vitro* conditions. The test pathogen, *C.fimbriata* was seeded at three to four equidistant points near the periphery of the culture plate and the antagonist(*Aspergillus* sp.) was seeded in the centre of the plate. After 6 days of inoculation both pathogen and antagonist revealed good growth side by side and colony diameter of the pathogen was more than that of the bioagent. After 18 days of incubation, antagonist had covered about 40.0% colony growth of *C. fimbriata* in some petriplates (Photograph). After about one month of incubation the antagonist had completely covered the growth of the pathogen in some of the petriplates as it was observed overgrowing on the colony of *C. fimbriata*. Antagonism between the two organisms was observed as the pathogen's growth was inhibited upon contact with the antagonist and the antagonist continued to grow over the colony of the test fungus.

## Project 3.3. Studies on borer pests of pomegranate with special emphasis on fruit borer *Deudorix isocrates* and their management.

### Identification of insect pests and natural enemies

Insect identification report is depicted in Table 1. Among the borer pests identified from National Pusa collection (NPC), IARI, PUSA, New Delhi, shot hole borer (*Xylosandrus compactus*) and hairy caterpillars (*Olene mendosa*, *Somena scintillans and Euproctis fraterna)* have been noticed for the first time on pomegranate. One hymenopteran parasitoid, *Brachymeria* sp. is also being reported for the first time from hairy caterpillar, *Olene mendosa.*

Table. 1: Identification of borer pests and natural enemies

| Sr. No. | RRS No. | Common Name | Scientific Name | Family |
|---|---|---|---|---|
| 1 | 639-646/11 | Shot hole borer | *Xylosandrus compactus* (Eichhoff) | Scolytidae |
| 2 | 647-655/11 | Shot hole borer | *Xyleborus forn icatus* Eichhoff | Scolytidae |
| 3 | 2597-2598/11 | Hairy caterpillar | *Olene mendosa* Hubner | Lymantriidae |
| 4 | 2600/11 | Hairy caterpillar | *Somena scintillans* Walker | Lymantriidae |
| 5 | 2601/11 | Hairy caterpillar | *Euproctis fraterna* Moore | Lymantriidae |
| 6 | 2576-2577/11 | Parasitoid of hairy caterpillar | *Brachymeria* sp. | Chalcidae |
| 7 | 2583-2586/11 | Parasitoid of hairy caterpillar | ---- | Sarcophagidae |

Table 2. Correlation coefficient between fruit borer, *Deudorix isocrates* and weather parameters.

| Sl. No | Fruit Borern Incidence o Variety | Correlation Coef. | | Rainfall |
|---|---|---|---|---|
| | | Mean of Min. & Max. Temperature | Mean of Min. & Max. Relative Humidity | |
| 1 | Ganesh | 0.03 | 0.26 | 0.02 |
| 2 | Bhagwa | -0.24 | 0.02 | 0.05 |

**Survey of borer insect pests in some of the district of Maharashtra**

Incidence of fruit borer (Deuodrix isocrates) in talukas of Solapur district i. e. North Solapur, South Solapur, Mohol, Pandharpur, Akkalkot and Sangola is found to be < 10%, < 10%, > 10%, < 10%, > 10% and > 10%, respectively. However, incidence of fruit borer (*Deuodrix isocrates*) is found < 10% in all the three surveyed talukas (Satana, Deola and Malegaon) of Nashik district.

**Population dynamics of borer pests on Pomegranate**

Coefficient of correlation for fruit borer on pomegranate is depicted in Table 2. Among the borer pests, fruit borer, Deudorix isocrates showed positive correlation on var. Ganesh and negative correlation on Bhagwa with temperature; relative humidity is found positively correlated on both the var. Ganesh and Bhagwa. However, rainfall is found positively correlated on both the var. Ganesh and Bhagwa.

**Toxicological studies**

**Ovicidal activity of chemicals:** Results of the ovicidal activity on fruit borer (*Deudorix isocrates*) eggs are depicted in Table. 3. Ovicidal activity of Methomyl 40 SP was tested in the laboratory against the fruit borer eggs collected from the field. Three concentration of Methomyl (0.02, 0.04 and 0.06%) were prepared in distilled water and for control only distilled water was used. Results about mean percent egg hatching revealed that none of the treatments are significantly different.

Table. 3. Ovicidal activity of Methomyl against the fruit borer eggs

| Treatments | Mean percent Hatching |
|---|---|
| Methomyl (0.02%) | 45 |
| Methomyl (0.04%) | 37.5 |
| Methomyl (0.06%) | 37.5 |
| Control | 42.5 |
| Treatments found to be Non Significant | |

**Repellent activities of chemicals:** Results of the repellent activity on fruit borer (*Deudorix isocrates*) are depicted in Table 4, Fig.1a,1b. Repellent activity of PPFM (Pink pigmented facultative methylotrophs) collected 48 hrs after incubation in glycerol peptone broth was studied against the fruit borer adults. Three concentration of PPFM (0.1%, 0.2% and Undiluted) were prepared in distilled water and for control only distilled water was used. Results revealed that PPFM (Undiluted) has attracted maximum percent oviposition (50 %) than control (5.74%). Hence, it is inferred that PPFM did not repel the adults of fruit borer from ovipositing on pomegranate.

Table 4: Repellent Activity of PPFM against the Fruit borer

| Treatments | Oviposition (%) |
|---|---|
| PPFM (0.1%) | 11.8 |
| PPFM (0.2%) | 28.6 |
| PPFM (Undiluted) | 50 |
| Control | 5.71 |
| Mean | 24.02 |
| SD | 19.83 |

Fig.1a: Spraying of PPFM in Pomegranate

Fig.1b: PPFM in glycerol peptone broth

**New problem in Pomegranate**

**Gummosis:** Few pomegranate orchards of Pandharpur of Solapur and the Kavathemahakal of Sangli showed symptoms of Gummosis (Fig.2a). All the affected orchards have been surveyed in February to March 2012 and samples were brought to the laboratory. Affected parts of twig from which gum was exuding were seen with small holes of same size as inflicted by the shot hole borer (Fig.2b). Old literature also supports insects like shot hole borer, bark beetle and stem borer leads to gummosis in horticultural plants. Infested twigs were cut open to see the presence of insects and few dead shot hole borer like adults were recovered. Conformity tests will be carried out this year to find exact cause leading to gummosis in pomegranate.

Fig.2a: Exuding gum and small hole on twig

Fig.2b: Split open twig showing hole inside

## Project 3.4:. Studies on Bionomics and Management of Sucking Pests of Pomegranate with Special Emphasis on Thrips.

### Identification of insect pests and natural enemies

Insect identification report is depicted in Table 1. Among the sucking pests identified from National Pusa collection (NPC), IARI, PUSA, New Delhi, thrips (*Rhipiphorothrips cruentatus*), mealybug (*Planococcus ficus),* cottony cushion scale *(Icerya aegyptiaca),* brown scale *(Coccus hesperidium)* and hopper *(Flata sp.)* have been noticed for the first time on pomegranate.

### Survey of sucking insect pests in some of the district of Maharashtra

**Survey of Solapur:**

Results pertaining to survey of Solapur district are depicted in Table 2. Highest (> 50%) fruit infestation by thrips (*Scrirtothrips dorsalis*) is noticed in South Solapur and Mohol taluks whereas; lowest (< 10%) in North Solapur and Sangola. However, Twig infestation by thrips is found > 50% in North Solapur, South Solapurr, Pandharpur and Sangola and < 50% in Mohol and Akkalkot taluks.

### Survey of Nashik:

Results pertaining to survey of Nashik district are depicted in Table 3. Satana and Malegaon showed > 50%, whereas Deola showed < 50% fruit infestation by thrips *(Scrirtothrips dorsalis).* Twig infestation by thrips is found > 75% in Satana and > 50% in Deola and Malegaon.

Table. 1: Identification of sucking pests and natural enemies

| Sr. No. | RRS No. | Common Name | Scientific Name | Family |
|---|---|---|---|---|
| 1 | 3083-3087/11 | Thrips | *Rhipiphorothrips cruentatus* Hood | Thripidae |
| 2 | 2527-2532/11 | Mite | *Tenuipalpus punicae* Pritchard & Baker | Tenuipalpidae |
| 3 | 2602-2607/10 | Mealybug | *Planococcus ficus* (signoret) | Pseudococcidae |
| 4 | 2608-2612/11 | Cottony cushion scale | *Icerya aegyptiaca* (Douglas) | Margarodidae |
| 5 | 2613-2617/11 | Brown scale | *Coccus hesperidium* L. | Coccidae |
| 6 | 2618/11 | Plant Hopper | *Flata* sp. | Flatidae |
| 7 | 2578-2582/11 | Parasitoid of mealybug | --- | Eulophidae |
| 8 | 2587-2596/11 | Predators of aphids | --- | Chaemaemyiidae |

Table 2: Incidence of thrips in Solapur

| Taluks of Solapur | Fruit infestation by thrips | Twig infested by thrips |
|---|---|---|
| N. Solapur | < 10 % | > 50 % |
| S. Solapur | > 50 % | > 50 % |
| Mohol | > 50 % | < 50 % |
| Pandharpur | < 50 % | > 50 % |
| Akkalkot | < 50 % | < 50 % |
| Sangola | < 10 % | > 50 % |

**Population dynamics of sucking pests o Pomegranate**

Coefficient of correlation for thrips and aphids on pomegranate is depicted in Table 4. Thrips showed negative correlation with temperature, humidity and rainfall on both the var. Ganesh and Bhagwa. However, aphids showed no correlation on Ganesh and found negatively correlated on Bhagwa with all the above said weather parameters.

Table 3: Incidence of thrips in Nashik

| Taluks of Nashik | Fruit infestation by thrips | Twigs infestation by thrips |
|---|---|---|
| Satana | > 50 % | > 75 % |
| Deola | < 50 % | > 50 % |
| Malegaon | > 50 % | > 50 % |

Table 4: Correlation coefficient between sucking pests and weather parameters.

| Sl. No | Incidence of sucking pests on leaves of variety | Correlation Coef. | | |
|---|---|---|---|---|
| | | Mean of Min. & Max. Temperature | Mean of Min. & Max. Relative Humidity | Rainfall |
| 1 | Thrips on Ganesh | -0.26 | -0.40 | -0.43 |
| 2 | Thrips on Bhagwa | -0.45 | -0.31 | -0.54 |
| 3 | Aphids on Ganesh | 0.0 | 0.0 | 0.0 |
| 4 | Aphids on Bhagwa | -0.37 | -0.19 | -0.24 |

## Proramme 4: Post Harvest Technology

### Project 4.1: Post Harvest Management of Pomegranate

**Effect lac formulations on physico-chemical characters of pomegranate var. Bhagwa:**

The effect of lac formulations developed at Indian Institute of Natural Resins and Gums, Ranchi on physiological loss in weight (PLW), shrinkage, glossiness, decay loss, shelf life & fruit quality of pomegranate fruits were determined through pre-harvest spray of lac formulations and post-harvest dip of lac formulations (Table1.).

Table 1. Physico-chemical characteristics on the day of storage:

| Physico-chemical traits | 0 days after storage (DAA) |
|---|---|
| PLW (%) | 0.0 |
| Shrinkage (%) | 0.0 |
| Rotting (%) | 0.0 |
| TSS (°B) | 15.4 |
| Acidity (%) | 0.51 |
| TSS/acid ratio | 30.20 |

**Pre-harvest spray of lac formulations:**

Three aqueous lac formulations (SH, SH2, SH3) were foliar sprayed at 2 different concentrations (50%, 100%) to pomegranate var. Bhagwa during fruit development stage and the fruits harvested after 3 weeks were observed for post harvest quality in January along with untreated control (Fig1).

**Physiological loss in weight (PLW) & shrinkage:**

The physiological loss in weight (PLW) and shrinkage was minimum in SH2-100% in all the period of storage (Table 2). On 32 days after storage (DAS), PLW was minimum in SH2-100% (36.00%) whereas it was highest in control (48.77%) The shrinkage of the fruits was lowest in SH2-100% (16.85%) followed by SH2-50% (17.10%) on 32 DAS, whereas it was highest in control (21.28%).


Lac formulation


50% & 100% lac formulation


Pre-harvest spray of lac


Control fruit (without lac spray)


Spraying lac on fruit


Lac sprayed fruit with enhanced glossiness

Fig.1 Preharvest spray of lac formulation to pomegranate variety Bhagwa

Glossiness of fruits showed a decreasing trend over the storage period (Table 3). The glossiness of the fruits was found to be highest in SH2-100% (5.3) followed by SH2-50% (5.0) on 8 days after storage. Similar trend was observed on 16 DAS also. Beyond 16 days, glossiness was almost lost as the fruits have reached their shelf life. The decay loss was found to vary from 20.00 to 26.67% on 32 days after storage. The decay loss was minimum in SH2-50% & SH2-100% (20.00%) whereas it was highest in untreated control (26.67 %). The shelf life was highest in SH2-100% (20.5 days) followed by SH2-50% (20.3 days) whereas it was lowest in control (16.0 days).

Table.2 Effect of preharvest spray of lac formulation on PLW & shrinkage of pomegranate fruits var. Bhagwa

| Treatment | Physiological Loss in Weight (%) | | | | Shrinkage (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Days after storage | | | | Days after storage | | | |
| | 8 | 16 | 24 | 32 | 8 | 16 | 24 | 32 |
| Control | 12.50 | 24.00 | 36.00 | 48.77 | 9.59 | 15.57 | 18.47 | 21.28 |
| SH1-50% | 11.33 | 22.50 | 32.33 | 42.00 | 9.25 | 13.50 | 16.91 | 18.80 |
| SH1-100% | 11.00 | 21.00 | 30.00 | 39.00 | 9.08 | 13.12 | 16.12 | 18.32 |
| SH2-50% | 10.66 | 20.50 | 31.33 | 37.50 | 8.25 | 12.40 | 15.65 | 17.10 |
| SH2-100% | 10.33 | 19.66 | 28.67 | 36.00 | 8.12 | 12.16 | 15.33 | 16.85 |
| SH3-50% | 10.33 | 21.00 | 30.00 | 36.60 | 8.77 | 13.00 | 16.33 | 17.60 |
| SH3-100% | 10.00 | 19.66 | 29.00 | 37.00 | 8.48 | 12.80 | 16.16 | 17.25 |
| CD (5%) | 0.92 | 1.36 | 1.96 | 2.21 | 0.80 | 0.84 | 0.86 | 0.97 |

Glossiness & Decay loss:

Table.3. Effect of preharvest spray of lac formulation on glossyness & decay loss of pomegranate fruits var. Bhagwa

| Treatment | Glossiness* | | | | | Decay loss (%) | | | | Shelf life (days) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Days after storage | | | | | Days after storage | | | | |
| | 0 | 8 | 16 | 24 | 32 | 8 | 16 | 24 | 32 | |
| Control | 6.00* | 3.0 | 0.5 | 0.0 | 0.0 | 0.00 | 6.67 | 16.67 | 26.67 | 16.0 |
| SH1-50% | 7.00 | 4.0 | 1.0 | 0.0 | 0.0 | 0.00 | 6.67 | 16.67 | 23.33 | 18.4 |
| SH1-100% | 7.00 | 4.3 | 1.3 | 0.0 | 0.0 | 0.00 | 10.00 | 20.00 | 26.67 | 18.5 |
| SH2-50% | 7.25 | 5.0 | 2.0 | 0.3 | 0.0 | 0.00 | 6.67 | 13.33 | 20.00 | 20.3 |
| SH2-100% | 7.50 | 5.3 | 2.3 | 0.5 | 0.0 | 0.00 | 6.67 | 16.67 | 20.00 | 20.5 |
| SH3-50% | 7.00 | 4.5 | 1.5 | 0.0 | 0.0 | 0.00 | 6.67 | 16.67 | 23.33 | 19.0 |
| SH3-100% | 7.25 | 4.8 | 1.8 | 0.3 | 0.0 | 0.00 | 10.00 | 20.00 | 23.33 | 19.7 |
| CD (5%) | 0.70 | 0.73 | 0.61 | 0.11 | - | - | NS | NS | NS | 0.95 |

*- score out of maximum value 10.

Quality traits:

The TSS, acidity and TSS/acid ratio were recorded (Table 4). On 16 days after storage, the TSS/acid ratio was found to be highest in SH2-100% (35.21) followed by SH2-50% (35.0) whereas it was lowest in control (32.70). The TSS/acid ratio increased slightly on 24 & 32days after storage.

Table.4. Effect of preharvest spray of lac formulation on quality of pomegranate

| Treatment | 8DAS | | | 16 DAS | | | 24DAS | | | 32DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TSS (°B) | Acid (%) | TSS / acid ratio | TSS (°B) | Acid (%) | TSS / acid ratio | TSS (°B) | Acid (%) | TSS / acid ratio | TSS (°B) | Acid (%) | TSS / acid ratio |
| Control | 15.5 | 0.5 | 31.0 | 15.7 | 0.48 | 32.70 | 15.9 | 0.46 | 34.56 | 16.0 | 0.44 | 36.36 |
| SH1-50% | 15.7 | 0.5 | 31.4 | 15.8 | 0.48 | 32.91 | 16.0 | 0.45 | 35.50 | 16.1 | 0.43 | 37.44 |
| SH1-100% | 15.8 | 0.5 | 31.6 | 15.9 | 0.48 | 33.12 | 16.1 | 0.45 | 35.77 | 16.2 | 0.43 | 37.67 |
| SH2-50% | 16.0 | 0.48 | 33.33 | 16.1 | 0.46 | 35.00 | 16.3 | 0.42 | 38.80 | 16.5 | 0.41 | 40.24 |
| SH2-100% | 16.1 | 0.48 | 33.54 | 16.2 | 0.46 | 35.21 | 16.4 | 0.42 | 39.04 | 16.6 | 0.40 | 41.50 |
| SH3-50% | 15.9 | 0.49 | 32.44 | 16.0 | 0.47 | 34.04 | 16.2 | 0.44 | 36.81 | 16.3 | 0.42 | 38.80 |
| SH3-100% | 15.9 | 0.48 | 33.12 | 16.0 | 0.47 | 34.04 | 16.2 | 0.43 | 37.67 | 16.4 | 0.42 | 39.04 |
| CD (5%) | 0.28 | NS | 0.84 | 0.30 | NS | 1.12 | 0.32 | NS | 1.24 | 0.36 | NS | 1.40 |

**Postharvest dip in lac formulations:**

Three aqueous lac formulations (SH1, SH2, SH3) were used to dip the farm fresh fruits of pomegranate var. Bhagwa at 2 different concentration and the air-dried fruits were observed for post harvest quality in January (Fig.2)

Dipping the fruits in lac

Air drying the lac coated fruits

Lac coated fruits in CFB

Glossiness on 0 DAS (Control)

Glossiness on 0 DAS (SH3-100% lac)

Glossiness on 0 DAS (SH2-100% lac)

Glossiness on 16 DAS (Control vs SH2-50% lac)

Glossiness on 16 DAS (Control vs SH3-100% lac)

Glossiness on 16 DAS (Control vs SH2-100% lac)

Fig.2 Post harvest dip of pomegranate variety Bhagwa in lac formulation

**Physiological Loss in Weight (PLW) & shrinkage:**

The PLW and shrinkage were lesser in fruits dipped in lac compared to control which recorded the highest PLW and shrinkage (Table 5.). The PLW was minimum in SH2-100% on 16 DAS (18.00%) & 24 DAS (29.00%) whereas it was highest in control on 16 DAS (22.33%) and 24 DAS (34.00%). The shrinkage of the fruits was lowest in SH2-100% on 16 DAS (9.07%) and 24 DAS (11.27%).

**Glossiness & Decay loss:**

The glossiness of the fruits was found to be highest in SH2-100% (6.00) followed by SH2-50% (5.75) on 8 days after storage (Table 6.). Similar trend was observed on 16 DAS also. Beyond 16 days, glossiness was almost lost as the fruits have reached their shelf life.

The decay loss was found vary from 26.67 to 36.67%. The decay loss was minimum in untreated control (26.67%) whereas it was highest in SH1-50% & SH3-50% (33.33%).

The shelf life was highest in SH2-100% (23.3 days) followed by SH1-2-50% (22.7 days) whereas it was lowest in control (16.7 days).

Table.5. Effect of postharvest dip in lac formulation on PLW of pomegranate fruits var. Bhagwa

| Treatment | Physiological Loss in Weight (%) | | | | Shrinkage (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Days after storage | | | | Days after storage | | | |
| | 8 | 16 | 24 | 32 | 8 | 16 | 24 | 32 |
| Control | 12.00 | 22.33 | 34.00 | 44.00 | 8.50 | 12.40 | 14.33 | 18.31 |
| SH1-50% | 11.33 | 20.00 | 32.33 | 41.66 | 6.01 | 11.30 | 13.61 | 16.49 |
| SH1-100% | 11.00 | 19.66 | 31.00 | 40.00 | 5.90 | 10.84 | 13.22 | 16.09 |
| SH2-50% | 10.67 | 19.00 | 29.33 | 37.50 | 4.93 | 9.40 | 11.78 | 14.81 |
| SH2-100% | 10.33 | 18.00 | 29.00 | 36.00 | 4.78 | 9.07 | 11.27 | 14.38 |
| SH3-50% | 10.67 | 19.66 | 30.00 | 38.00 | 5.54 | 10.14 | 12.34 | 15.34 |
| SH3-100% | 10.67 | 19.33 | 29.66 | 37.50 | 5.40 | 9.83 | 12.14 | 14.90 |
| CD (5%) | 0.90 | 1.30 | 1.90 | 2.12 | 0.76 | 0.84 | 0.88 | 0.96 |

Table.6. Effect of postharvest dip in lac formulation on glossiness & decay loss of pomegranate fruits var. Bhagwa

| Treatment | Glossiness* | | | | | Decay loss (%) | | | | Shelf life (days) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Days after storage | | | | | Days after storage | | | | |
| | 0 | 8 | 16 | 24 | 32 | 8 | 16 | 24 | 32 | |
| Control | 6.00 | 3* | 0.5 | 0 | 0 | 0.00 | 6.67 | 16.67 | 26.67 | 16.7 |
| SH1-50% | 9.00 | 4.75 | 1.25 | 0 | 0 | 3.33 | 10.00 | 16.67 | 26.67 | 19.3 |
| SH1-100% | 9.00 | 5 | 1.5 | 0 | 0 | 3.33 | 10.00 | 20.00 | 23.33 | 20.0 |
| SH2-50% | 9.00 | 5.75 | 2.25 | 0.5 | 0 | 0.00 | 10.00 | 16.67 | 26.67 | 22.7 |
| SH2-100% | 9.50 | 6 | 2.5 | 0.75 | 0 | 0.00 | 6.67 | 13.33 | 23.33 | 23.3 |
| SH3-50% | 9.00 | 5.25 | 1.75 | 0.25 | 0 | 0.00 | 6.67 | 16.67 | 26.67 | 21.0 |
| SH3-100% | 9.50 | 5.5 | 2 | 0.5 | 0 | 3.33 | 10.0 | 16.67 | 23.33 | 21.7 |
| CD (5%) | 0.62 | 0.75 | 0.63 | 0.12 | | NS | NS | NS | NS | 0.98 |

*- score out of maximum value 10.

**Quality traits:**

The TSS and TSS/acid ratio revealed slight increase with the advancement of storage period (Table 7). On 24 DAS, the TSS/acid ratio was found to be highest in SH2-100% (39.28) followed by SH2-50% (39.04) whereas it was lowest in control (34.56).

**Maturity indices for harvesting of pomegranate :**

To determine the maturity indices for harvesting of pomegranate, the flowers were tagged on the day of anthesis (DAA). The fruit samples were drawn after fruitset at an interval of 15 days from the day of anthesis to the fruit maturity. Once maturity is attained, the sampling was done at narrow interval of 2-4 days so as to fix up the appropriate maturity indices under Solapur conditions.

**Bhagwa:**

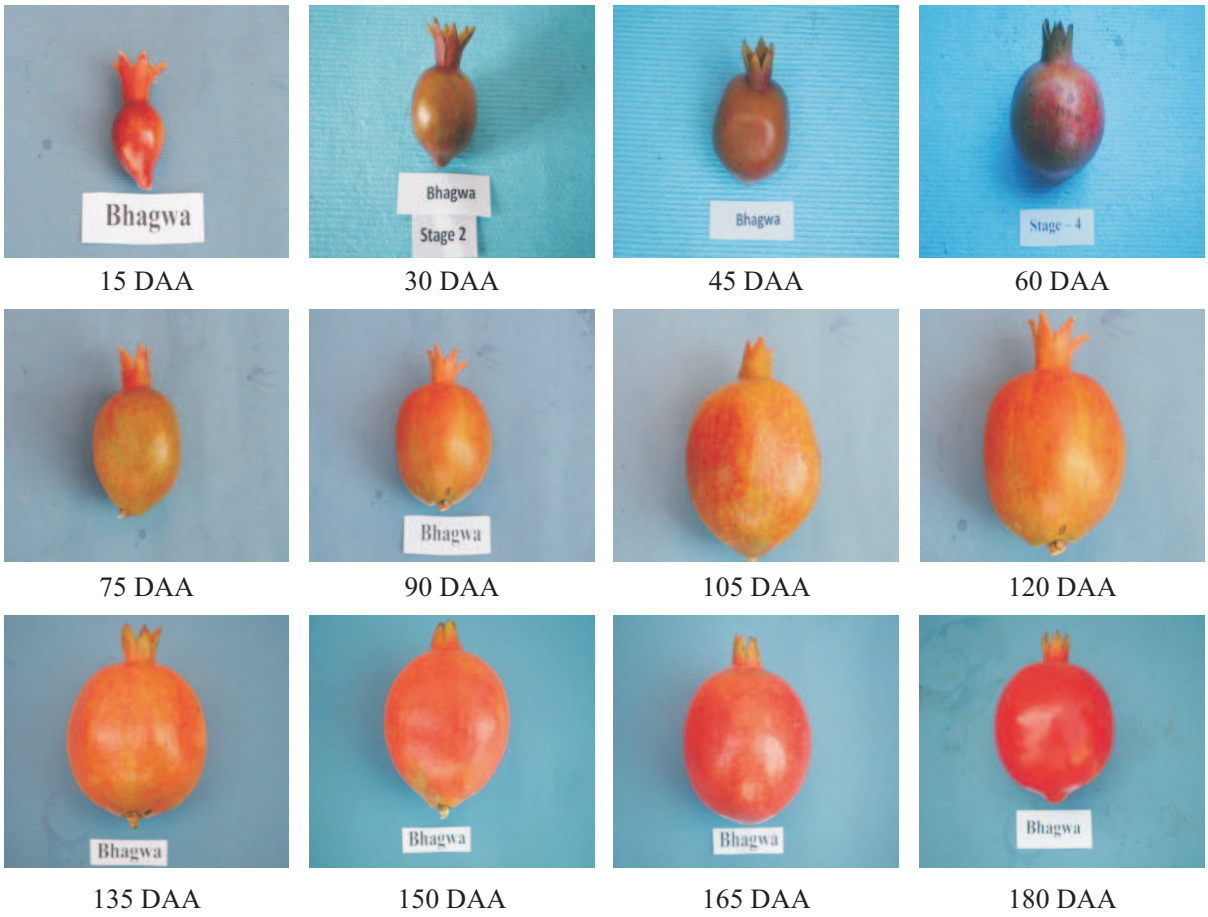
The fruits of pomegranate variety Bhagwa can be harvested around 180 days after anthesis (DAA) when the TSS/acid ratio reaches 32.31 (Table 8 & Fig.3).

Table.7. Effect of preharvest spray of lac formulation on the qualitative traits of pomegranate var. Bhagwa

| Treatment | 8DAS | | | 16DAS | | | 24DAS | | | 32DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TSS (°B) | Acid (%) | TSS/acid ratio | TSS (°B) | Acid (%) | TSS/acid ratio | TSS (°B) | Acid (%) | TSS/acid ratio | TSS (°B) | Acid (%) | TSS/acid ratio |
| Control | 15.5 | 0.5 | 31.0 | 15.7 | 0.48 | 32.70 | 15.9 | 0.46 | 34.56 | 16.0 | 0.44 | 36.36 |
| SH1-50% | 15.8 | 0.5 | 31.6 | 15.9 | 0.48 | 33.12 | 16.2 | 0.45 | 36.00 | 16.3 | 0.43 | 37.90 |
| SH1-100% | 15.8 | 0.5 | 31.6 | 15.9 | 0.48 | 33.12 | 16.2 | 0.45 | 36.00 | 16.4 | 0.43 | 38.13 |
| SH2-50% | 16.1 | 0.48 | 33.54 | 16.3 | 0.46 | 35.43 | 16.4 | 0.42 | 39.04 | 16.9 | 0.41 | 41.21 |
| SH2-100% | 16.2 | 0.48 | 33.75 | 16.4 | 0.46 | 35.65 | 16.5 | 0.42 | 39.28 | 17.0 | 0.40 | 42.50 |
| SH3-50% | 15.9 | 0.49 | 32.44 | 16.0 | 0.47 | 34.04 | 16.3 | 0.44 | 37.04 | 16.5 | 0.42 | 39.28 |
| SH3-100% | 16.0 | 0.48 | 33.33 | 16.1 | 0.47 | 34.25 | 16.4 | 0.43 | 38.13 | 16.6 | 0.42 | 39.52 |
| CD (5%) | 0.30 | NS | 0.96 | 0.32 | NS | 1.20 | 0.36 | NS | 1.32 | 0.40 | NS | 1.44 |

Table.8. Determination of maturity indices for pomegranate variety Bhagwa

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/ acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 24.87 | 34.89 | 33.52 | 3.99 | 1.30 | 6.11 | 3.17 | 8.22 | 0.64 | 12.84 |
| 30 DAA | 43.31 | 52.34 | 50.28 | 5.99 | 1.95 | 6.16 | 4.10 | 8.33 | 0.64 | 13.02 |
| 45 DAA | 76.81 | 56.57 | 52.66 | 10.56 | 3.67 | 7.52 | 4.76 | 8.74 | 0.64 | 13.66 |
| 60 DAA | 120.58 | 64.64 | 65.19 | 16.81 | 9.17 | 8.36 | 5.46 | 9.91 | 0.61 | 16.25 |
| 75 DAA | 156.48 | 68.11 | 67.04 | 18.52 | 12.00 | 8.79 | 5.79 | 10.73 | 0.61 | 17.59 |
| 90 DAA | 187.77 | 69.50 | 68.71 | 20.65 | 13.50 | 9.05 | 6.06 | 11.71 | 0.61 | 19.20 |
| 105 DAA | 213.05 | 71.72 | 70.90 | 22.12 | 15.00 | 9.52 | 6.18 | 12.50 | 0.58 | 21.55 |
| 120 DAA | 234.42 | 73.70 | 72.86 | 24.58 | 16.33 | 9.80 | 6.26 | 13.93 | 0.58 | 23.84 |
| 135 DAA | 260.70 | 75.12 | 74.86 | 28.42 | 18.83 | 10.01 | 6.38 | 15.23 | 0.58 | 26.26 |
| 150 DAA | 282.64 | 78.11 | 77.05 | 31.67 | 20.00 | 10.17 | 6.40 | 15.53 | 0.54 | 28.75 |
| 165 DAA | 300.06 | 80.08 | 80.75 | 32.83 | 21.60 | 10.25 | 6.42 | 16.20 | 0.54 | 30.00 |
| *180 DAA* | 313.33 | 82.56 | 83.59 | 34.03 | 23.00 | 10.29 | 6.48 | 16.48 | 0.51 | 32.31 |
| 185 DAA | 313.60 | 82.56 | 83.59 | 33.90 | 22.50 | 10.29 | 6.48 | 16.40 | 0.51 | 32.16 |
| CD(p=0.05) | 10.10 | 3.79 | 1.04 | 0.54 | 0.78 | 0.24 | 0.13 | 0.62 | 0.23 | 1.20 |




15 DAA | 30 DAA | 45 DAA | 60 DAA

75 DAA | 90 DAA | 105 DAA | 120 DAA

135 DAA | 150 DAA | 165 DAA | 180 DAA

Fig. 3 Maturity indices of pomegranate cv. Bhagwa at different stages of fruit development

Table.9 Determination of maturity indices for pomegranate variety Ganesh

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/ acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 25.45 | 28.16 | 26.92 | 3.30 | 1.85 | 5.2 | 2.3 | 7.6 | 0.77 | 9.87 |
| 30 DAA | 48.48 | 43.24 | 38.74 | 5.25 | 2.45 | 5.35 | 2.6 | 7.66 | 0.64 | 11.97 |
| 45 DAA | 91.84 | 61.17 | 57.95 | 8.40 | 3.2 | 7.11 | 3.53 | 8.03 | 0.64 | 12.55 |
| 60 DAA | 152.77 | 65.15 | 66.32 | 11.28 | 10.5 | 8.69 | 4.68 | 10.8 | 0.58 | 18.62 |
| 75 DAA | 195.70 | 68.44 | 67.58 | 13.40 | 12 | 8.8 | 5.19 | 11.38 | 0.58 | 19.62 |
| 90 DAA | 228.01 | 75.14 | 74.93 | 15.24 | 13.25 | 9.3 | 5.6 | 12.06 | 0.54 | 22.33 |
| 105 DAA | 259.24 | 77.06 | 78.20 | 17.12 | 16.2 | 9.92 | 6.08 | 13.5 | 0.54 | 25.00 |
| 120 DAA | 288.91 | 79.83 | 81.08 | 19.64 | 19.33 | 10.54 | 6.3 | 15 | 0.51 | 29.41 |
| 135 DAA | 310.76 | 81.02 | 83.45 | 21.40 | 21 | 10.94 | 6.48 | 15.61 | 0.51 | 30.61 |
| *150 DAA* | 325.61 | 84.61 | 86.70 | 25.84 | 24.5 | 10.92 | 6.98 | 16.7 | 0.45 | 37.11 |
| 155 DAA | 328.46 | 84.63 | 86·74 | 25.50 | 24.3 | 10.92 | 6.98 | 16.6 | 0.45 | 36.89 |
| CD(p=0.05) | 13.20 | 3.90 | 1.12 | 0.60 | 0.88 | 0.22 | 0.12 | 0.62 | 0.23 | 1.30 |

**Ganesh:**

The fruits of pomegranate variety Ganesh can be. harvested around 150 days after anthesis (DAA) when the TSS/acid ratio reaches 37.11 (Table 9)

**Ruby:**

The fruits of pomegranate variety Ruby can be harvested around 175 days after anthesis (DAA) when the TSS/acid ratio is around 33.61 (Table 10).

**Jalore Seedless:**

The fruits of pomegranate variety Jalore Seedless can be harvested on 145 days after anthesis (DAA) when the TSS/acid ratio reaches 35.82 (Table 11).

Table.10 Determination of maturity indices for pomegranate variety Ruby

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 18.61 | 24.11 | 21.89 | 3.80 | 1.50 | 5.30 | 3.00 | 8.20 | 0.77 | 10.65 |
| 30 DAA | 38.11 | 47.78 | 38.48 | 4.66 | 1.55 | 6.11 | 3.05 | 8.96 | 0.77 | 11.67 |
| 45 DAA | 80.58 | 52.26 | 50.49 | 10.62 | 4.50 | 7.06 | 3.31 | 8.79 | 0.71 | 12.42 |
| 60 DAA | 118.87 | 57.89 | 59.89 | 16.64 | 9.07 | 8.68 | 5.08 | 10.53 | 0.61 | 17.32 |
| 75 DAA | 150.03 | 63.90 | 63.06 | 21.16 | 13.09 | 9.00 | 5.32 | 12.10 | 0.58 | 20.78 |
| 90 DAA | 178.76 | 66.45 | 65.44 | 23.28 | 14.25 | 9.03 | 5.60 | 13.30 | 0.58 | 22.93 |
| 105 DAA | 202.10 | 68.10 | 67.40 | 25.75 | 18.20 | 9.12 | 5.84 | 14.00 | 0.58 | 24.48 |
| 120 DAA | 225.24 | 70.84 | 69.43 | 26.50 | 20.50 | 9.30 | 6.10 | 14.10 | 0.56 | 25.17 |
| 135 DAA | 245.20 | 72.52 | 71.52 | 28.64 | 20.50 | 9.60 | 6.32 | 14.30 | 0.55 | 26.48 |
| 150 DAA | 264.80 | 74.47 | 76.10 | 30.50 | 20.50 | 9.92 | 6.40 | 15.00 | 0.52 | 28.84 |
| 165DAA | 283.04 | 76.24 | 78.00 | 31.50 | 22.75 | 10.10 | 6.45 | 15.20 | 0.49 | 31.02 |
| *175 DAA* | 301.78 | 77.40 | 79.28 | 32.00 | 24.83 | 10.20 | 6.49 | 15.80 | 0.47 | 33.61 |
| 180 DAA | 303.65 | 77.50 | 79.30 | 31.90 | 24.75 | 10.24 | 6.48 | 15.65 | 0.47 | 33.29 |
| CD(p=0.05) | 10.20 | 3.76 | 1.12 | 0.58 | 0.80 | 0.24 | 0.13 | 0.62 | 0.23 | 1.22 |

Table.11 Determination of maturity indices for pomegranate variety Jalore Seedless

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 20.77 | 33.95 | 30.99 | 3.12 | 1.40 | 4.87 | 2.15 | 8.55 | 1.44 | 5.96 |
| 30 DAA | 39.59 | 47.56 | 39.46 | 5.23 | 3.00 | 6.16 | 3.43 | 8.76 | 0.78 | 11.22 |
| 45 DAA | 79.20 | 60.39 | 56.67 | 12.90 | 5.17 | 8.05 | 6.04 | 8.92 | 0.72 | 12.44 |
| 60 DAA | 128.36 | 64.02 | 63.31 | 16.52 | 8.83 | 8.37 | 4.86 | 11.37 | 0.64 | 17.65 |
| 75 DAA | 168.04 | 70.34 | 67.02 | 18.84 | 10.50 | 8.64 | 5.06 | 12.82 | 0.59 | 21.77 |
| 90 DAA | 205.38 | 72.60 | 71.26 | 20.40 | 12.80 | 9.06 | 5.29 | 13.43 | 0.59 | 22.76 |
| 105 DAA | 238.10 | 74.24 | 74.60 | 22.10 | 15.20 | 9.72 | 5.84 | 14.40 | 0.55 | 26.18 |
| 120 DAA | 270.21 | 76.83 | 79.98 | 24.12 | 17.30 | 10.12 | 6.24 | 15.00 | 0.58 | 27.27 |
| 135 DAA | 298.31 | 80.15 | 82.21 | 28.70 | 22.80 | 10.52 | 6.50 | 15.20 | 0.50 | 30.40 |
| *145* DAA | 320.10 | 83.16 | 84.32 | 28.80 | 23.00 | 10.62 | 6.76 | 16.12 | 0.45 | 35.82 |
| 150 *DAA* | 321.56 | 83.20 | 84.34 | 28.84 | 25.17 | 10.64 | 6.78 | 16.00 | 0.45 | 35.55 |
| CD(p=0.05) | 12.20 | 3.80 | 1.10 | 0.64 | 0.86 | 0.20 | 0.12 | 0.60 | 0.23 | 1.32 |

**G-137:**

The fruits of pomegranate variety G-137 can be harvested on 147 days after anthesis (DAA) when the TSS/acid ratio reaches 32.74 (Table 12).

**Arakta:**

The fruits of pomegranate variety Arakta can be harvested on 140 days after anthesis (DAA) when the TSS/acid ratio reaches 34.12 (Table 13).

Table. 12:Determination of maturity indices for pomegranate variety G-137

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 22.32 | 29.67 | 28.68 | 1.62 | 1.00 | 2.67 | 1.11 | 8.10 | 0.64 | 12.66 |
| 30 DAA | 41.24 | 44.31 | 42.41 | 7.12 | 2.35 | 6.06 | 3.70 | 8.35 | 0.61 | 13.73 |
| 45 DAA | 84.41 | 58.77 | 54.34 | 12.24 | 3.70 | 8.01 | 3.83 | 8.50 | 0.61 | 13.98 |
| 60 DAA | 132.35 | 64.38 | 63.20 | 14.50 | 7.00 | 8.28 | 4.28 | 9.49 | 0.59 | 16.12 |
| 75 DAA | 178.94 | 71.21 | 69.62 | 16.32 | 13.00 | 8.64 | 5.12 | 10.20 | 0.59 | 17.32 |
| 90 DAA | 215.00 | 72.63 | 72.08 | 18.50 | 15.20 | 8.80 | 5.41 | 11.60 | 0.57 | 20.44 |
| 105 DAA | 249.00 | 76.24 | 78.12 | 20.48 | 17.60 | 9.50 | 6.12 | 13.20 | 0.56 | 23.44 |
| 120 DAA | 280.00 | 79.30 | 80.82 | 23.73 | 19.40 | 10.04 | 6.43 | 14.45 | 0.55 | 26.15 |
| 135 DAA | 308.00 | 81.82 | 82.01 | 25.65 | 21.33 | 10.28 | 6.63 | 15.68 | 0.54 | 28.82 |
| *147*DAA | 332.17 | 85.24 | 86.48 | 28.84 | 25.83 | 10.61 | 6.84 | 16.70 | 0.51 | 32.74 |
| 155 *DAA* | 335.20 | 85.26 | 86.48 | 28.50 | 25.80 | 10.61 | 6.84 | 16.65 | 0.51 | 32.64 |
| CD(p=0.05) | 14.20 | 4.16 | 1.52 | 0.80 | 0.96 | 0.23 | 0.13 | 0.64 | 0.10 | 1.30 |

Table.13. Determination of maturity indices for pomegranate variety Arakta

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 18.12 | 32.12 | 30.33 | 1.35 | 1.60 | 3.95 | 1.97 | 8.06 | 0.83 | 9.69 |
| 30 DAA | 40.14 | 40.51 | 38.16 | 5.90 | 2.50 | 7.28 | 3.24 | 8.57 | 0.77 | 11.15 |
| 45 DAA | 72.36 | 50.60 | 49.06 | 8.69 | 4.30 | 8.02 | 3.68 | 8.23 | 0.72 | 11.48 |
| 60 DAA | 112.39 | 58.20 | 60.08 | 15.60 | 11.80 | 8.40 | 5.12 | 9.55 | 0.61 | 15.65 |
| 75 DAA | 140.13 | 66.51 | 66.35 | 18.84 | 12.33 | 8.84 | 5.40 | 10.92 | 0.55 | 19.76 |
| 90 DAA | 175.48 | 68.53 | 68.05 | 20.40 | 13.20 | 9.00 | 5.64 | 11.40 | 0.54 | 21.21 |
| 105 DAA | 208.30 | 70.20 | 72.84 | 23.12 | 14.82 | 9.16 | 5.82 | 13.24 | 0.52 | 25.23 |
| 120 DAA | 235.35 | 72.81 | 73.73 | 25.35 | 16.40 | 9.32 | 6.00 | 14.50 | 0.51 | 28.32 |
| 135 DAA | 260.24 | 74.00 | 75.38 | 28.50 | 19.10 | 9.50 | 6.24 | 15.30 | 0.49 | 31.32 |
| *140 DAA* | 282.10 | 76.19 | 78.86 | 30.25 | 20.60 | 9.68 | 6.42 | 15.36 | 0.45 | 34.12 |
| 145 DAA | 283.40 | 76.20 | 78.86 | 30.00 | 20.50 | 9.68 | 6.40 | 15.30 | 0.45 | 34.00 |
| CD(p=0.05) | 11.40 | 2.80 | 1.04 | 0.50 | 0.70 | 0.18 | 0.10 | 0.52 | 0.18 | 1.10 |

**Mridula:**

The fruits of pomegranate variety Mridula can be harvested around 140 days after anthesis (DAA) when the TSS/acid ratio is around 33.65 (Table 14).

Table.14. Determination of maturity indices for pomegranate variety Mridula

| Sampling period | Fruit weight (g) | Fruit length (mm) | Fruit dia (mm) | 100 aril weight (g) | 100 aril juice volume (ml) | Aril length (mm) | Aril width (mm) | TSS (°B) | Acidity (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAA | 18.58 | 29.09 | 27.69 | 1.20 | 0.90 | 2.65 | 1.12 | 8.20 | 0.70 | 11.65 |
| 30 DAA | 42.33 | 43.59 | 39.24 | 6.81 | 2.00 | 6.40 | 3.49 | 8.73 | 0.64 | 13.64 |
| 45 DAA | 74.08 | 50.75 | 48.56 | 12.61 | 6.67 | 7.70 | 4.10 | 9.77 | 0.61 | 16.07 |
| 60 DAA | 116.86 | 59.10 | 59.37 | 16.66 | 10.50 | 7.98 | 5.05 | 10.82 | 0.58 | 18.78 |
| 75 DAA | 145.30 | 65.40 | 64.80 | 19.49 | 12.02 | 8.52 | 5.36 | 11.33 | 0.54 | 20.83 |
| 90 DAA | 180.71 | 68.33 | 70.94 | 22.01 | 13.17 | 9.00 | 5.58 | 12.50 | 0.54 | 22.98 |
| 105 DAA | 214.00 | 70.20 | 72.64 | 24.20 | 16.50 | 9.24 | 5.80 | 13.20 | 0.51 | 25.78 |
| 120 DAA | 242.20 | 72.55 | 75.71 | 26.52 | 18.50 | 9.42 | 6.10 | 14.41 | 0.51 | 28.14 |
| 135 DAA | 268.10 | 74.38 | 77.54 | 29.40 | 20.00 | 9.60 | 6.36 | 15.30 | 0.47 | 32.31 |
| *140 DAA* | 290.55 | 75.20 | 79.10 | 30.60 | 20.67 | 9.68 | 6.42 | 15.48 | 0.46 | 33.65 |
| 145DAA | 292.25 | 75.28 | 79.14 | 30.16 | 20.60 | 9.68 | 6.42 | 15.45 | 0.46 | 33.58 |
| CD(p=0.05) | 11.80 | 2.40 | 1.62 | 0.70 | 0.80 | 0.18 | 0.12 | 0.56 | 0.18 | 1.16 |

# Transfer of Technology

| Sl No. | Title | Venue & Date | Participant(s) |
|---|---|---|---|
| 1 | Pomegranate growers' meeting. | Kuldharan, Ahmednagar August 18, 2011, | Dr V.T. Jadhav |
| 2 | Pomegranate Growers' Melawa and felicitation of award winning farmers. | Jalna October 1, 2011, | Dr V.T. Jadhav |
| 3 | Brain storming Session cum Training Programme on 'Good Agricultural Practices for Pomegranate' organized by Maharashtra Pomegranate Growers' Research Association. | Zonal Agriculture Research Centre of MPKV at Solap ur November 5 - 6, 2011 | Dr V.T.Jadhav Dr Jyotsana Sharma Dr R.A. Marathe |
| 4 | Meeting at "The Collector, Solapur District office" for discussing the role of NRCP, Solapur in planting seedlings of Pomegranate under EGS. | Collector's office, Solapur Novemb er 28, 2011. | Dr S.S Suroshe |
| 5 | 'Agro-one Krishi Exhibition' organized by Agro-one Sakal Papers Ltd. | Sangli, Solapur December 4, 2011 | Dr R.A. Marathe |
| 6 | Dalimb Utpadak Prasikshan Melawa organized by Godrej Agrovet Ltd | Satanaa, Nasik January 9, 2012 | Dr R.A. Marathe Dr S.S.Suroshe |
| 7 | Interactive meet with Chief Ex ecutive Officer and Director-Finance, Maharashtra Economic Development Council (MEDC), Mumbai and Technical committee of Maharashtra Pomegranate Growers Research Association, Pune. | NRCP S olapur Jan 19, 2012 | Dr VT Jadhav All NRCP Scientists and Technical staff |
| 8 | KVK Solapur Agricultural Technology Week. | KVK Solapur, Jan uary 25, 2012 | Dr Jyotsana Sharma |
| 9 | Workshop on Pomegranate Production organized by the Govt. of Maharashtra . | Beed, Maharashtra January 27, 2012 | Dr V.T. Jadhav |
| 10 | "Agrovision W orkshop" | Nagpur, Maharashtra January 29, 2012. | Dr S.S Suroshe |
| 11 | Interactive meeting with Technical committee of Maharashtra Pomegranate Growers Research Association, Pune and progressive growers and field visits to selected orchards . | Jat (Sangli), Sangola and Pandharpur (Solapur) Feb ruary 11 and 12, 2012. | Dr Jyotsana Sharma |
| 12 | Training programme on "Identification, Diagnostics and Management of Insect Pests of Pomegranate organized by Govt of Maharashtra for Maharashtra state agricultural officials, Pest Scouts, Pest Monitors and Data operators selected under CROPSAP project of Pomegranate. | KVK, Solapur, February 13, 2012 | Dr Jyotsana Sharma Dr S.S.suroshe |

| Sl No. | Title | Venue & Date | Participant(s) |
|---|---|---|---|
| 13 | Ttraining on sample base d identification of pomegranate insect s and other pests to the Pest Scouts, Pest Monitors and Data operators selected under CROPSAP project of Pomegranate | NRCP, Shelgi, February 14, 2012 . | Dr S.S Suroshe |
| 14 | Training on ' survey guidelines to the Pest Scouts, Pest Monitors and Data operators ' selected under CROPSAP project of Pomegranate at NRCP's farm at Hiraj on date 29/02/12. | NRCP farm at Hiraj February 29, 2012 . | Dr S.S Suroshe |
| 15 | Meeting called by Department of Agriculture, Maharashtra under the CRO PSAP project for the formulation of "pomegranate capsule" for issuing advisory to the pomegranate growers. 05/03/12 at RAMETI, Aurangabad | RAMETI, Aurangabad March 5, 2012 | Dr S.S Suroshe |
| 16 | Krishi Mela | Zuwari Agripark, Lamboti, Solapur on March 5, 2012 | Dr V.T.Jadhav<br>Dr R.A. Marathe |
| 17 | Lecture cum training programme at "Pik-Parisavvad" organized by Doordarshan, Pune and Agriculture D epartment, Maharashtra | Kasegaon, Pandharpur,<br>March 6, 20 12. | Dr VT Jadhav<br>Dr Jyotsana Sharma<br>Dr RA Marathe<br>Dr S.S Suroshe |
| 18 | "Training Programme - cum –Farmers fair" organized under 'Network Project on Mitigating bacterial blight disease of pomegranate in Maharashtra, Karnataka and Andhra Pradesh'. | NRCP, Solapur, March 18, 2012 | Dr VT Jadhav<br>All Scientist and Technical Staff |
| 19 | Radio Talk / Short Story programme on 'Rashtriya Dalimb Sansodhan Kendra – Activities and research programmes' | All India Radio, Solapur on March 24, 2012. | Dr R.A. Marathe |

# Institutional Activities

Meetings of the following committees concerned with Research and Development activities of the NRCP were held during the year.

**1. RAC Meeting**: The V$^{th}$ meeting of the RAC of the Centre was held on July 22 and 23, 2011 under the Chairmanship of Dr S.D. Shikhamany, Ex-VC, A.P. Horticulture University. The constitution of the Vth RAC of NRCP was as follows:

The meeting was attended by all the RAC members but Dr S.N. Pandey, Dr B.M.C. Reddy and Dr Srikant Kulkarni. Committee after examining the research achievements of the Centre presented by individual scientists, suggested the following recommendations.

- Technologies should be developed for the management of bacterial blight and wilt.
- Genetic base of pomegranate be broadened for locating the resistance source for bacterial blight and disease resistant varieties should be evolved.
- A diagnostic kit for identification of Bacterial blight should be developed.
- Insect distribution maps should be developed.
- In order to improve the water use efficiency in pomegranate, studies on sub-surface drip irrigation should be initiated and seasonal water requirement based on phenological stage of the crop should be developed.
- Extension activities to disseminate the pomegranate technology to growers should be expedited.

| Sl.No. | Name | Designation/Address |
|---|---|---|
| 1 | Dr S.D. Shikhamany - Chairman | Former VC, A.P. Horticulture University, A.P. |
| 2 | Dr S. Rajan - Member | ADG (Hort.), ICAR, New Delhi |
| 3 | Dr H. Shivan na –Member | Director of Research, University of Agricultural Sciences, Bangalore. |
| 4. | Dr V. Nachegowda -Member | Professor of Pomology, Special officer, College of Horticulture, Kolar, University of Hort icultural Sciences, Bagalkot, Karnataka. |
| 5 | Dr V.T. Jadhav - Member | Director, NRCP Solapur. |
| 6 | Dr S.N. Pandey -Member | Ex-ADG (Hort.), ICAR, New Delhi. |
| 7 | Dr Srikant Kulkarni - Member | Former Professor &Head, Plant Pathology, UAS Dharwad, Karnataka |
| 8 | Dr B.M.C. Reddy -Member | National Project Coordinator, UNAP -GEF-TFT Project & former Director, CISH, Lucknow |
| 9 | Shri Arun Nimba Deore -Member | Progessive farmer, Nashik |
| 10 | Shri Jaysingrao Manikrao Deshmukh –Member | Progressive farmer, Pandharpur, Solapur |
| 11 | Dr Ram Chandra - Member-Secretary | Principal Scientist (Horticulture) |

**2.IMC Meeting:** The VII[th] IMC meeting of NRCP was held on August 20, 2011 and was attended by the following members.

| Sl. No. | Name | Designation |
|---|---|---|
| 1 | Dr V.T. Jadhav -Chairman | Director, NRCP Solapur |
| 2 | Dr R.N.Prasad –Member | Principal Scientist, IIVR, Varanasi . |
| 3 | Dr B.R. Ulmek - Member | Associate Dea n and Principal College of Agriculture, Pune . |
| 4 | Shri A. A. Goswami - Member-Secretary | Administrative Officer, NRCP, Solapur. |

| Sl.No | Name | Designation |
|---|---|---|
| 1 | Dr V.T. Jadhav - Chairman | Director, NRCP |
| 2 | Dr S.D. Gorantiwar - Special Invitee | Head, Department of I rrigation and Draingae Engineering, MPKV, Rahuri. |
| 3 | All Scientists of NRCP - Members | Scientists , NRCP |
| 4 | Dr Ram Chandra -Member Secretary | Principal Scientist, NRCP. |

The following issues pertaining to development of the centre were discussed. i) HT electric commercial connection for main building at Kegaon, ii) Ratification of IMC for the purchase/replacement of new equipments iii) Establishment of pomegranate nursery for supply of quality planting material and iv) Appointment of one part time Medical officer for the welfare of NRCP's staff.

**3. IRC Meeting**: The VI[th] IRC meeting of the Centre was held on August 19, 2011 and was attended by the following members.

During the Meeting research achievements of 15 ongoing projects were presented by the scientists and one new research project proposal was presented and approved by the committee.

Other activities organized by the NRCP during the year are mentioned hereunder.

**Hindi Fortnight**: NRCP celebrated the 'Hindi Day' by organizing a Hindi Fortnight from September 14 to 29, 2011 during which different competitions were held to encourage hindi language as a official and day to day medium of communication. The function was attended by the Director NRCP and all the scientists and staff members of the Centre. The event culminated on 29[th] September with prize distribution to the winners by the Chief Guest Shri Himmat Rao Deshbhratar, Police Commissioner Solapur who during his brief speech emphasized the importance of hindi medium in Nation's building and reiterated that the language should be promoted by all so that it becomes a common language of the country. Dr VT Jadhav, Director NRCP also spoke on the occasion and highlighted the role of Hindi in bringing unity in diversity. The function was organized by Dr NV Singh, scientist and Hindi Officer with the cooperation of all the staff members of the Centre.


Chief Guest Shri Himmatrao Deshbhratar Police Commissioner Solapur addressing the NRCP staff on the occasion of Hindi Day on 29th September 2011.

**Interactive Meeting with MEDC Members**: The Centre organized one day meeting with the Director and CEO of MEDC (Mumbai Economic Development Council) on 19th January, 2011 which was attended by prominent farmers, State department officials and Scientists of the centre. The objective of calling the meeting was to listen to the views of the scientists, growers and State Agriculture Department officials on the management aspects of dreaded disease like bacterial blight, development of efficient drip irrigation and fertigation schedules and also on post harvest management of pomegranate so that the MEDC could take necessary steps to develop and finance programmes for sustainable pomegranate production. At the outset, Shri Anil Deshpande, CEO, MEDC highlighted the functioning of MEDC and subsequently, Dr V.T. Pai, Director, MEDC informed that when the problem of Bacterial blight was brought to his knowledge by Shri Prabhakar Chandane, President Pomegranate growers association, he wanted to develop certain programmes to overcome the problem in association with NRCP. Prior to this, Director NRCP informed the members about the achievements of the Centre in various fields of pomegranate production and protection. During the meeting, farmers, State Agriculture Department officials and scientists NRCP also expressed their views on important issues related to pomegranate production and utility.

Dr VT Pai, Director Finance (MEDC), Dr VT Jadhav Director NRCP and Mr AnilDeshpandey CEO (MEDC) Mumbai (left) and Members of Growers' Pomegranate Association Pune and scientists NRCP (right) during the interactive meeting on bacterial blight at NRCP on 19th January 2012.

**Republic Day Celebrations:** NRCP celebrated the 63rd Republic day of the Nation on 26th January 2012. On the occasion Dr VT Jadhav Director NRCP and Dr M.S. Raut Incharge, Centre on Rabi Sorghum addressed the staff of both the Centres highlighting the achievements of respective Centres.

Flag hoisting ceremony being performed by Dr VT Jadhav Director NRCP and Dr MS Raut Incharge CRS Solapur (left) and Staff of both the Centres during the 63rd Republic day celebrations on 26th January 2012.

**Training Programme cum - Farmers' fair**: The Centre organized a training programme - cum - Farmers' fair on 18th March, 2012 under the Network Project to disseminate pomegranate production technology to farmers. The fair was attended by about 300 farmers from various parts of the State. Mr Babanrao Shinde, President, Panchayat raj Samiti, Solapur and MLA Madha ,Solapur, was the chief guest on the occasion who in his address described the benefits extended to farmers based on research achievements and wanted that more work should be done to disseminate the latest technologies for enhancing production and utilization of pomegranate. Some of the progressive farmers like Mr. P. Chandane, President Pomegranate Growers' Association and Mr. Jaysingrao Deashmukh also expressed their views and highlighted the problems of pomegranate growers and wanted that necessary measures should be taken to provide amicable solutions to the farmers. At the end of the inaugural session, an interactive meet was organized during which farmers' queries were listened to by the scientists of the NRCP and appropriate replies were made.


Inauguration of Training Programme cum - Farmers' fair at NRCP on 18.03.2012. by Shri. Babanrao Shinde President, Panchayat Raj Samiti and MLA, Madha constituency (left) and Chief Guest alonwith Dr VT Jadhav Director NRCP and Shri P. Chandane President Pomegranate Growers'Association and other progressive farmers (right).


Scientists NRCP (left) replying to the queries of pomegranate farmers (right) on the occasion of Training programme cum-Farmers' fair on 18th March 2012.

# Human Resource Development

Participation of Scientists / Staff in Conferences /Courses /Meetings/ Symposia /Workshops/Trainings during 2011-12.

| Sl No. | Title | Venue & Date | Participant (s) |
|---|---|---|---|
| 1. | Research Review Committee Meeting (RRC) in Horticulture. | MPKV, Rahuri . April 2-3, 2011 | Dr Ram Chandra |
| 2. | Meeting on "Finalization of schedule of pesticides to be used on pomegranate for export to European Union (EU)". | APEDA, Vashi, Mumbai. April 20, 2011. | Dr S.S Suroshe. |
| 3. | Training programme o n 'Employer's perspective on labour related laws' at NAARM, Hyderabad during May 10 -12, 2011. | NAARM, Hyderabad. May 10 -12, 2011. | Dr R.A. Marathe |
| 4. | Indo -Israel meeting organized by the project steering committee o f Indo-Israel workplan project. | Mantralaya, Mumbai. July 6, 2011. | Dr. K. Dhinesh Babu |
| 5. | II$^{nd}$ Meeting of working sub group of Horticultural crops of working group in Agri - Research and Education for the XII $^{th}$ five year plan 2012-17. | New Delhi. July 26, 2011 | Dr Ram Chandra |
| 6. | Training cum Workshop on "Advances in phenomics, genomics and diagnostics of *Xanthomonas axonopodis* pv. *punicae* causing bacterial blight of pomegranate" . | IARI Regional Station, Pune July 28 -30, 2011 | Dr V.T. Jadhav Dr Jyotsana Sharma |
| 7. | One week training program on Tissue cul ture at IIHR. | IIHR, Bangalore. August 8-14, 2011 | Dr N.V.Singh |
| 8. | Entomologist s' Meet chaired by Hon'ble DG, ICAR. | NBAII, Bengaluru August 24-27, 2011. | Dr S.S Suroshe |
| 9. | Validation of PCR diagnostic kit developed by IARI, for the detection of bacterial blight pathogen in pomegranate . | Division of Plant Pathology, IARI, New Delhi. September 3, 2011 | Dr Jyotsana Sharma |
| 10. | "National consultation on pomegranate" organized by IIHR Bangalore. | IIHR Bangalore. September 7, 2011. | Dr K. K. Sharma Dr K. Dhinesh Babu |
| 11. | Meeting for formulation of CROPSAP Project, organized by Department of Agriculture, Maharashtra . | Sakhar Sankul , Pune September 23, 2011 . | Dr S.S Suroshe Dr Jyotsana Sharma |

| Sl No. | Title | Venue & Date | Participant (s) |
|---|---|---|---|
| 12. | Interactive meet of Scientists with the President ICAR, Hon'ble Union Agri. Minister Shri Sharad Pawar . | NASC, Complex, New Delhi. September 29, 2011 | Dr VT Jadhav<br>Dr Ram Chandra<br>Dr Jyotsana Sharma |
| 13. | Meeting of the task force pertaining to preparation of pomegranate DUS test guidelines. | PPV & FRA, New Delhi. November 28, 2011. | Dr Ram Chandra. |
| 14. | National Symposium on "Biology of Infection, Immunity and Disease control in Pathogen - Plant Interactions" organized by the Indian Phytopathological Society. | University of Hyderabad December 4-6, 2011. | Dr K.K.Sharma |
| 15. | Workshop - cum- Installatio n training programme on SAS (with new version of JMP, JMP genomics) for the Nodal Officers of the project – Strengthening Statistical computing for NARS. | CIFE, Mumbai. December 6, 2011. | Dr. K. Dhinesh Babu |
| 15. | Participated in Winter School on "Advances in Micropropagation of Horticulture Crops" organized by KAU Kerala. | KAU, Kerala. December 1 -21, 2011, | Dr N.V. Singh |
| 16. | National training course on "Fermentation Technology -Methods & scale -up strategies in fermentation" . | IARI, New Delhi December 9 –22, 2011. | Dr. K. Dhinesh Babu |
| 17. | AGROVISION Workshop, National Expo & Conference "Building sustainable livelihood & increasing farmers income". | Nagpur January 27-30, 2012 | Dr S.S Suroshe |
| 18. | Sensitization -cum- Training workshop for the Nodal officers of PME Cell of I CAR Institutes to implement HYPM. | CIFE, Mumbai February 2, 2012. | Dr K.K.Sharma |
| 19. | 14th Indian Agricultural Scientists and Farmer's Congress on Diversification in Agriculture and Agripreneurship . | Allahabad, Uttar Pradesh. February 18-19, 2012. | Dr N.V.Singh |
| 20. | Meeting of Nodal officers of RFD to prepare the RFD, Strategy Framework document and Citizens Charter of the NRCP under the chairmanship of ADG (Hort.). | NASC Complex, New Delhi. February 22, 2012 | Dr K.K.Sharma |

# Publications

## Research articles


1. Babu, K. D., Chandra, R., Jadhav, V.T., Sharma, J., 2011. Blossom biology of pomegranate cultivar 'Bhagwa' under semi-arid tropics of Western India. *Acta Horticulturae* 890 : 227-232.
2. Babu, K. D., Chandra, R., Sharma, J., Jadhav, V.T., 2011. Flower biology of pomegranate cultivar 'Ganesh' under Solapur conditions of Maharashtra a Preliminary Study. *Acta Horticulturae* 890 : 221-226.
3. Chandra R., Kumar, P., Babu, K. D., Marathe, R. A., Jadhav, V. T. 2009. Effect of gamma irradiation on seed germination and survival of seedlings of pomegranate (*Punica granatum* L.). *Indian Journal of Arid Horticulture* 4(1): 49-50
4. Chandra, R., Jadhav, V.T., Babu, K. D. and Maity, A., 2011. Influence of chemical defoliants on defoliation and twig bud sprouting in pomegranate (*Punica granatum* L.) 'Bhagwa'. *Acta Horticulturae* 890 : 359-361.
5. Chandra, R., Jadhav, V.T., Sharma, J. and Marathe, R. A. 2011. Effect of grafting methods and time on scion sprouting, graft success and subsequent growth of grafted plants of pomegranate *(Punica granatum* L.*)* 'Bhagawa'. *Acta Horticulturae* 890 : 83-86.
6. Gorantiwar, S. D., D. T. Meshram and Mittal, H.K. 2011. Water requirement of pomegranate (*Punica granatum* L.) for Ahmednagar district of Maharashtra State, India. *Journal of Agro-Meteorology* 13(2):123-127.
7. Gorantiwar, S. D., Meshram, D.T. and Mittal, H. K. 2011. Seasonal ARIMA model for generation and forecasting evapotranspiration of Solapur district of Maharashtra, India. *Journal of Agro-Meteorology* 13(2):119-122.
8. Marathe, R.A., Chandra, R., Maity, A., Sharma J. and Jadhav, V.T. 2011. Effect of different microbial inoculants on soil properties, nutrient acquisition and growth of pomegranate (*Punica granatum* L.). *Indian Journal of Agricultural Sciences* 81 (7): 622-7.
9. Marathe, R.A., Chandra, R.A., Maity A., Jadhav, V.T. and Sharma J. 2011. Effect of plant growth promoting microorganisms on nutrient acquisition and plant growth in pomegranate. *Indian Journal of Agricultural Science* 81 (7): 622-7.
10. Meshram D. T., Gorantiwar S. D., Jadhav, V. T. and Chandra R. 2011. Evaluation of ET models to study water requirement of *Pomegranate (Punica granatum L.)* for Satara district of Maharashtra. *Indian journal of Soil Conservation* 39, 142-148
11. Meshram, D. T., Mittal, H.K., Purohit, R.C. and Gorantiwar S.D. 2011. Water requirement of Pomegranate (*Punica granatum* L.) for Solapur district of Maharashtra state, India. *Acta Horticulturae (ISHS)* 890:311-322.
12. Sharma, K.K., Jadhav, V.T. and Sharma J. 2011. Present Status of Pomegranate Bacterial Blight caused by *Xanthomonas axonopodis* pv. *punicae* and its Management. *Acta Horticulture* 890:513-522.

13. Singh, N.V., Singh, S.K. and Patel, V.B. 2011. *In vitro* culture establishment studies in pomegranate. *Indian Journal of Horticulture* 68 (3): 307-11.
14. Singh, N.V., Singh, S.K., Singh, A.K., Meshram, D.T., Suroshe, S.S. and Mishra, D.C. 2012. Arbuscular mycorrhizal fungi (AMF) induced hardening of micro propagated pomegranate (*Punica granatum* L.) plantlets. *Scientia Horticulturae* 136:122-127.

## Papers presented in Symposia /Meetings

1. Chandra, R., Jadhav, V. T. and Meshram, D.T. 2012. Global scenario and prospect of pomegranate in India. *National seminar on new frontiers and future challenges in horticultural crops* held between 15th and 17th March, 2012 at PAU, Ludhiana (abstract). pp. 79-80.
2. Meshram, D.T., Jadhav, V.T., Gorantiwar, S., Singh, N.V. and Suroshe, S.S. 2011. Stochastic modeling of pomegranate (*Punica granatum* L.) evapotranspiration using class A pan for Ahmednagar Station of Maharashtra. *In: Agrometerological Research and Services to Combat Climate Change Challenges*. Dec 9-10, 2011 Kalyani, West Bengal, p 80 (Abstract).
3. Meshram, D.T., Jadhav, V.T., Jadhav, S. D. and Chandra R. 2012. Modeling of weather parameters using Stochastic methods. International conference on climate change, sustainable agriculture and public leadership held 7th and 9th February, 2012 at NASC, New Delhi (abstract). p. 127.
4. Mondal, K.K., Rajendran, T.P., Phaneendra, C., Mani, C, Sharma J., Verma G., Kumar R, Kumar, A., Singh, D., Saxena, A.K., Pooja, Sharma R. and Jain, R.K. 2011. Gyrase B gene-based specific detection of *Xanthomonas axonopodis* pv. *punicae* causing bacterial blight of pomegranate. *64th Indian Phytopathological Society Annual Meeting & National Symposium on Biology of infection, immunity and disease control in pathogen-plant interactions,* organized by Indian Phytopathological Society at Department of Plant Sciences School of Life Sciences, University of Hyderabad at Hyderabad. Dec. 2-4, 2011: p180
5. Sharma, K.K. and Sharma Jyotsana. 2011. Diseases of Pomegranate and their Management. *64th Indian Phytopathological Society Annual Meeting & National Symposium on Biology of infection, immunity and disease control in pathogen-plant interactions,* organized by Indian Phytopathological Society at Department of Plant Sciences School of Life Sciences, University of Hyderabad at Hyderabad, December 2-4, 2011. Brain Storming Session on "*Plant Pathology in India: Vision 2030*, pp 74-81.
6. Singh, N.V., Singh, S.K. and Patel, V.B. 2011. Improving performance of pomegranate cuttings using Arbuscular Mycorrhizal Fungi. In: *14th Indian Agricultural Scientists and Farmer's Congress on Diversification in Agriculture and Agripreneurship*, Feb. 18-19, 2012, Allahabad, Uttar Pradesh, p 2.

## Review Article

1. Singh, S.K., Singh, A., Singh, N.V. and Ramajayam, D. 2010. Pomegranate tissue culture and biotechnology. *Fruit, Vegetable, Cereal Science and biotechnology*. 4 (2): 35-44.

## Technical/Popular articles

1. Meshram, D. T., Jadhav, V.T. and Gorantiwar, S.D. *Hasta bahar* Madhe Dalimb Bagela Panyachi Garaj. *Agro One.* (31st August, 2011). pp. 8.(Marathi).
2. Meshram, D.T., Jadhav, V.T. and Gorantiwar, S.D. *Hasta bahar* Madhe Dalimb Bagela Panyachi Garaj. *Agro One.* pp. 8. 18 September, 2011.
3. Meshram, D.T., Jadhav, V.T. and Gorantiwar, S.D. 2011. *Ambe bahar* Madhe Dalimb Bagela Panyachi Garaj. *Agro One*. (May, 2011), pp. 8. (Marathi).
4. Meshram, D.T., Jadhav, V.T. and Gorantiwar, S.D. 2011. *Hasta bahar* Madhe Dalimb Bagela dya Mojun Pani. *Agro One.* (30th August, 2011), pp. 8. (Marathi).
5. Singh, N. V., Chandra R., Sharma, J., Singh, A. and Meshram, D. T. 2012. *Anar men prawardhan ki pramukh vidhiyan evam paudh utpadan ka dhang (Hindi)*. *Vindhya Krishi* : 6 (1-2) : 30-33.

## Technical Bulletins/Manuals

1. Chandra, R., Suroshe, S., Sharma, J., Marathe, R. A. and Meshram, D. T. 2011. *Pomegranate Growing Manual* (NRCP), 56p.
2. Maity, A., Marathe, R.A., Babu, K.D. and Singh, N.V. 2012. *Bio-fertilizers in Pomegranate Production*. *Extension Bulletin 6* (NRCP), 26 p.
3. Marathe, R. A., Jadhav, V.T. and Shinde, Y.R. 2011. *Dalimb Hasta Bahar Vayastapan*, *Extension Bulletin 3*, (NRCP) , Solapur. 8 p.
4. Sharma J., Suroshe, S.S. and Shinde Y.R. 2012. *Dalimbavaril Rog va Kid Nidan aani Vyavsthapan*. *Extension Bulletin* 7. (NRCP), 5 p.
5. Sharma, J., Sharma, K.K. Marathe, R.A., Suroshe, S. Babu, K.D., Singh N.V. 2011. *Integrated Disease and Insect Pest Management in Pomegranate*, *Extension Bulletin 4* (English). (NRCP) , 33p.
6. Sharma, J., Sharma, K.K., Marathe, R.A., Suroshe, S., Babu, K.D., Singh N.V. 2011. *Dalimbvaril rog va kidinche ekathmic vyasthapan kruthi arakada* (Marathi), *Extension Bulletin 5* (NRCP), 34p.
7. Sharma, J., Sharma, K.K., Marathe, R.A., Suroshe, S., Babu, K.D., Singh, N.V. 2011. *Anar ke rog kit eva pedko ka samanvi prabandhan (*Hindi) *Extension Bulletin* 6, (NRCP), 36p.

## Books/Chapter in books

1. Fand, B.B., Gautam, R D., Suroshe, S.S. 2012. *Bio-intensive Management of Mealybug Phenacoccus solenopsis: Methods and Approaches*. Lambert Academic Publishing, Germany. p 124.
2. Meshram, D.T., Gorantiwar, S. D. and Mittal, H.K. 2012. *Seasonal ARIMA model for Pomegranate Evapotranspiration*. Published by LAMBERT Academic Publishing, Germany, 171p.
3. Meshram, D.T., Gorantiwar, S.D. and Singh, N.V. 2012. *Probability Distribution Function for Pomegranate Evapotranspiration*. Published by LAMBERT Academic Publishing, Germany, 141p.

4. Sharma, K.K. and Sharma Jyotsana. 2011. Diseases of Pomegranate and their Management. In: *Plant Pathology in India: Vision 2030*. Indian Phytopathological Society, New Delhi, pp 74-81.
5. Singh, N.V., Singh, S.K. and Meshram, D.T. 2012. *Pomegranate: In vitro propagation and biohardening*. Lap Lambert Academic Publishing, Saarbrucken, Germany. 145 p.

## Compilations

| Title | Compiled by |
|---|---|
| Annual Report 2010 -11, NRCP, 83p. | Dr. K.K. Sharma<br>Dr. R.A Marathe<br>Dr. K. Dhinesh Babu<br>Dr. V. T. Jadhav |
| Vision 2030, NRCP, 29p. | Dr. K.K. Sharma<br>Dr. V.T. Jadhav |

# Distinguished Visitors during 2011-12

| Name | Designation /Address | Date of visit |
|---|---|---|
| Dr. S.K.Sharma | Director, C entral Institute of Arid Horticulture, Bikaner | April 20, 2011 |
| Prof. Laxman rao Dhoba le | Guardian Minister Solapur and State Cabinet Minister for Water Supply and Environment safety , Maharashtra. | June 30, 2011 |
| Dr. V.J. Shivankar | Director, NRC on Citrus, Nagpur | August 10, 2011. |
| Mr. Himmat rao Deshbhratar | Police Commissioner Solapur, Maharashtra. | September 29, 20 11 |
| Dr. V.T. Pai | Director Finance, Maharashtra Economic Development Council (MEDC), Mumbai. | January 19, 2012 |
| Shri Anil Deshpande | CEO, MEDC, Mumbai. | |
| Dr. C.D. Mayee | Former Chairman, ASRB | January 25, 2012 |
| Shri Babanrao Shinde | President, Panchayat raj Samiti, MLA Madha, Solapur. | March 18, 2012 |

Prof. Laxmanrao Dhobale Guardian Ministaer Solapur and Cabinet Water supply Minister Maharashtra) during his visit to NRCP Soalpur on June 30,2011 being received by the Scientists of NRCP (left) and Minister discussing activities of the Centre with NRCP Scientists (right).

Dr. V. J. Shivankar, Director, NRC for Citrus, Nagpur (right) along with other Scientists of the Centre during his visit to NRCP farm on August 10, 2011. Dr. V. T. Jadhav, Director NRCP (left) accompanying the Director NRCC.


Dr. V. J. Shivankar, Director, NRC for Citrus, Nagpur (right) along with other Scientists of the Centre during his visit to NRCP farm on August 10, 2011. Dr. V. T. Jadhav, Director NRCP (left) accompanying the Director NRCC.

Shri Babanrao Shinde, President Panchayati raj Samiti Solapur and MLA Madha, Solapur being received by the Director NRCP during his visit to NRCP Solapur on 18.3.2012. Shri P. Chandane, President Pomegranate Growers Association was also present on the occasion.

# Recruitments/Promotions/Relievings/Recognitions

## Recruitments

### Administration

- Shri A.A.Goswami joined as Administrative Officer w.e.f 5.0 4.2011
- Shri Kiran Bhaskar Khatmode recruited as L.D.C w.e.f 18.07.2011
- Ms Smita Dadarao Karale recruited as L.D. C w.e.f. 30.11.2011

## Promotions

Mr M.S.Gogaon Technical T1 promoted to Technical T2 w.e.f 12.10.2011

## Recognitions

Dr N.V Singh, Scientist Horticulture, received the young scientist award on 19th February, 2012 in the field of Tissue Culture from Bioved Research Institute of Agriculture and Technology, Allahabad during 14th Indian Agricultural Scientists and Farmers on diversification in Agriculture and Agripreneurship.

# Personnel

## List of Staff

| 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 | Principal Scientist (Pathology) |
| Dr. R.A. Marathe | Sr. Scientist (Soil Science) |
| Dr. K. Dhinesh Babu | Sr. Scientist (Horticulture-Fruit Science) |
| Dr. D.T. Meshram | Scientist Sr. Scale (Soil and Water Conservation Engineering) |
| Mr. Sachin S. Suroshe | Scientist (Entomology) |
| Dr. Ashis Maity | Scientist (Soil Science) |
| Dr. N. V. Singh | Scientist (Horticulture - Fruit Science ) |
| **Technical Staff** | |
| Shri. Dinkar T. Chaudhari | T-3 Field Technician |
| Shri Yuvraj Shinde | T-3 Field Technician |
| Shri. Mahadev S.Gogaon | T-2 Field Technician |
| Shri. Govind Anirudh S alunke | T-1 Field Technician |
| Shri Vijay U.Lokhande | T-1 Field Technician |
| **Administrative Staff** | |
| Shri A.A. Goswami | Administrative Officer |
| Shri. K.S. Sharma | Assistant Administrative Officer |
| Shri. R.B. Rai | Assistant |
| Shri Kiran Bhaskar Khatmode | LDC |
| Ms. Smita D adarao Karale | LDC |
| **Supporting Staff** | |
| Shri. Shilendrasing Shivpalsing Bayas | Skilled Support Staff |
| Shri. Vishal Shankar Gangane | Skilled Support Staff |

# Research Programmes and Projects

| Programmes and Projects | Title | Principal Investigators (PI) | Co-Investigator |
|---|---|---|---|
| Programme 1 :Pomegranate Improvement | | | |
| Project 1.1. | Survey, collection, evaluation, characterization and conservation of pomegranate | Dr.Ram Chan dra | Dr Jyotsana Sharma<br>Dr K.Dhinesh Babu<br>Dr D.T. Meshram |
| Project 1.2 | Improvement of pomegranate | Dr. K. Dhinesh Babu | Dr V.T.Jadhav<br>Dr Ram Chandra<br>Dr Jyotsana Sharma<br>Dr N.V.Singh |
| Programme 2: Pomegranate Production | | | |
| Project 2.1 | Propagation of pomegr anate through conventional and non - conventional methods | Dr. NV Singh | Dr.Ram Chandra<br>Dr. V.T. Jadhav<br>Dr K.Dhinesh Babu<br>Dr. K.K. Sharma<br>Dr. Ashish Maity |
| Project 2.2 | Exploitation of bioagents in pomegranate productivity | Dr. V.T. Jadhav | Dr. Ashish Maity<br>Dr.Ram Chandra<br>Dr. Jyotsana Sharma<br>Dr R.A.Marathe |
| Project 2.3 | Identification of Suitable soils for Sustained productivity of pomegranate | Dr. R.A. Marathe | Dr. V.T. Jadhav |
| Project 2.4 | Nutrient Management in pomegranate | Dr. R.A. Marathe | Dr. V.T. Jadhav |
| Project 2.5 | Micronutrient management for sustainable growth, yield and quality of pomegranate | Dr. Ashish Maity | Dr R.A.Marathe<br>Dr Ram Chandra<br>Dr V.T.Jadhav |
| Project 2.6 | Water Management in pomegranate orchards under different soil types. | Dr. R.A. Mara the | Dr. V.T. Jadhav |
| Project 2.7 | Effect of mulches and irrigation level on yield, quality and WUE of pomegranate ( *Punica granatum* L.) | Dr. D.T. Meshram | Dr. Ashish Maity<br>Dr.Ram Chandra |

| Programmes and Projects | Title | Principal Investigators (PI) | Co-Investigator |
|---|---|---|---|
| Project 2.8 | Comparison of various irrigation methods with sub -surface drip irrigation system for pomegranate ( *Punica granatum* L.) production. (Approved this year) | Dr. D.T. Meshram | Dr N.V.Singh |
| Programme3:.Pomegranate Protection (Management of Diseases and Insect-Pests of Pomegranate) | | | |
| Project 3.1. | Studies on Economica lly Important Diseases of pomegranate with special emphasis on bacterial blight and their Control. | Dr. Jyotsana Sharma | Dr. K.K. Sharma<br>Dr V.T. Jadhav |
| Project 3.2. | Etiology, Epidemiology and Management of wilt of pomegranate | Dr. K.K. Sharma | Dr. Jyotsan a Sharma<br>Dr V.T.Jadhav |
| Project 3.3 | Studies on Borer Pests of Pomegranate with special emphasis on *Deudorix isocrates,* and their management. | Dr. S.S. Suroshe | Dr. K.K. Sharma<br>Dr V.T.Jadhav |
| Project 3.4 | Studies on Bionomics and Management of Sucking P est of Pomegranate with Special emphasis on thrips. | Dr. S.S.Suroshe | Dr Jyotsana Sharma<br>Dr V.T.Jadhav |
| Programme 4: Post Harvest Technology | | | |
| Project 4.1 | Post Harvest Management of Pomegranate ( *Punica granatum* L.) | Dr. K. Dhinesh Babu | Dr N.V.Singh<br>Dr.Ram Chandra |
| Externally Funded Projects | | | |
| 1.NETWORK PROJECT | Network Project on 'Mitigating Bacterial Blight of pomegranate' in Maharashtra, Karnataka and Andhra Pradesh (NHM) | Dr. V.T. Jadhav (Project Director) | Dr Jyotsana Sharma (Project Coordinator )<br>Dr K.K. Sharma<br>Dr K.Dhinesh Babu<br>Dr Ashis Maity<br>Dr N.V.Singh<br>Dr S.S.Suroshe |

| Programmes and Projects | Title | Principal Investigators (PI) | Co-Investigator |
|---|---|---|---|
| 2. Contract Research Project | Evaluating bioefficacy of formulations Avtar and Merger in the management of fungal leaf/fruit spots and rots of pomegranate. (Indofil chemicals Company) . | Dr V.T. Jadhav Director | Dr. Jyotsana Sharma |
| 3.Project under RKVY | Crop pest surveillance, advisory and management Project (CROPSAP) for Mango, Pomegranate and Banana. | Dr V.T. Jadhav Director | Dr Jyotsana Sharma<br>Dr S.S.Suroshe |
| 4.Intellectual Property Right | Intellectual Property Management and Transfer/commercialization of Agricultural Technology Scheme . | Dr V.T. Jadhav Director | Dr K.K.Sharma<br>Dr Ram Chandra<br>Dr S.S.Suroshe |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