# Annual Report 2016-2017

**ICAR - Directorate of Onion and Garlic Research**
Rajgurunagar–410 505, Pune, Maharashtra, India

# Annual Report 2016-2017

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# Preface

Onion and garlic are two important vegetable commodities used mostly for culinary purpose. Beside culinary uses, these also have several medicinal values. India is the second largest producer of both onion and garlic in the world after China. In past 20 years, production of onion in India has increased more than four times and that of garlic more than two times. In 2015-16, onion crop occupied 13.20 lakh ha area with total production of 209.31 lakh tones, while garlic occupied 2.81 lakh ha with the production of 16.17 lakh tones. Maharashtra, Karnataka, Madhya Pradesh, Bihar, Gujarat, Rajasthan, Haryana, Andhra Pradesh, Uttar Pradesh and Odisha are the major onion producing states, whereas garlic is mainly produced in Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan, Assam, Punjab, Maharashtra, West Bengal, Haryana and Odisha.

I feel privileged to present Annual Report of ICAR-Directorate of Onion and Garlic Research for 2016-17. As per mandate, ICAR-DOGR continued different research and development activities. We also undertook production and distribution of onion seed and garlic plant material, contract research projects and farmers oriented extension activities.

During the year, onion variety 'Bhima Light Red' was identified for release at national level by All India Network Research Project of Onion and Garlic (AINRPOG) and multiplier onion genotype 'DOGR-1549-Agg' has been registered with ICAR-NBPGR. Two onion varieties *viz.,* Bhima Super and Bhima Shakti were notified by Central Varietal Release Committee. Also, two onion extant varieties *viz.,* Bhima Kiran and Bhima Red were registered with PPV&FRA.

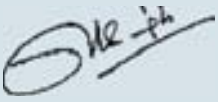
ICAR-DOGR is also National Active Germplasm Site for Onion and Garlic. Presently 30 different *Allium* species collected from within the country (17 species) and abroad (13 species) are being maintained as field gene bank at ICAR-DOGR. Foliage from nine of *Allium* species were evaluated for their palatability and possible use as vegetable. *A. tuberosum* line All-1587 and *A. tuberosum* Rott. Kuichai line CGN-16373 produced uniform yield in all seasons and thus are suitable for year round cultivation and will be substitute of onion and garlic with added nutrition. In total, 18 garlic ecotypes have been added in gene bank.

Incidences of three lepidopteran pests *viz.,* Green looper *Chrysodeixis* sp., Cutworm *Agrotis ipsilon* and Army worm *Spodoptera exigua* were recorded in onion during 2016-17. Though considered as minor pest, their recent infestation levels were found to be high, posing serious threat to onion production. IPM compatible seed treatment can be achieved by imposing polymer film coating along with seed treatment chemicals. Initial standardization of optimum dose of polymer was done with three different concentrations *i.e.,* 5 ml, 8ml and 12ml per kg seed. Seeds treated with polymer @ 12 ml per kg of seed showed better coverage without affecting the seed germination and also had higher vigour index.

In order to disseminate the technologies developed, seven front-line demonstrations and 30 trainings were organized and ICAR-DOGR participated in seven exhibitions. A number of lectures and visits were arranged for the farmers from different parts of the country. ICAR-DOGR Mobile App was also launched for transfer of information from the Directorate to the farmers and other beneficiaries. The Directorate organized Annual group meeting of

AINRPOG, RAC, IMC, Hindi Saptah, Vigilance week and Swachh Bharat Abhiyan activities and celebrated Foundation Day, International Yoga Day, Independence Day, Republic Day, National Unity Day, Communal Harmony Week, Constitution Day, Agricultural Education Day, World Soil Day, etc. ICAR-DOGR supplied onion seed and garlic planting material to 1639 farmers, 40 KVKs, and 95 government and private seed producing organization and companies. ICAR-DOGR also generated the record revenue of 99.36 lakhs during the year.

I take this opportunity to place my sincere thanks and gratitude to Dr. T. Mohapatra, Honourable Director General (ICAR), Dr. A. K. Singh, Deputy Director General (Horticulture Science) and Dr. T. Jankiram, Assistant Director General (Horticulture Science) for their continued guidance, encouragement and support in executing the mandate of ICAR-DOGR. In the end, I express my sincere thanks to all the staff of the Directorate for their team work, efficiency and dedication.



**Major Singh**
Director

# Executive Summary

The R & D activities undertaken by ICAR-DOGR spread over six research programmes and twelve adhoc/externally funded projects. Most of the projects are inter-disciplinary and aimed at taking studies on all aspects to achieve the targets as per objectives. In addition, production and distribution of onion seed and garlic planting material, contract research projects and farmer oriented extension activities including demonstrations, training, exhibitions etc. were also conducted by the Directorate. The salient achievements in the ongoing R&D programmes during the year 2016-17 are summarized below briefly.

## Crop Improvement

Onion variety 'Bhima Light Red' was identified for release at national level by All India Network Research Project of Onion and Garlic (AINRPOG). Multiplier onion genotype 'DOGR-1549-Agg' has been registered with ICAR-NBPGR. Two onion varieties *viz.,* Bhima Super and Bhima Shakti were notified by Central Varietal Release Committee. Also, two onion extant varieties *viz.,* Bhima Kiran and Bhima Red were registered with PPV&FRA.

Bhima Light Red is recommended for cultivation in *rabi* season in Karnataka and Tamil Nadu. It has light red globe bulbs of about 70 g with thin neck, total soluble solids of 13% and average yield of 38.5 t/ha, total weight loss after four months of storage was less than 25 % and almost free of doubles and bolters. DOGR-1549 is the first multiplier onion genotype registered with ICAR-NBPGR as a unique genetic stock which has six uniform pink bulbets per bulb, suitable for both *kharif* and *rabi* and about one week earlier than popular variety CO-5. Bhima Super is recommended for *kharif* in Chhattisgarh, Delhi, Gujarat, Haryana, Jammu, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan and Tamil Nadu. It has attractive red bulbs, maturity 100-105 days after transplanting, average yield 22-26 t/ha, potential yield 48 t/ha and 30-45 days bulbs storability. Bhima Shakti is recommended for *rabi* in Andhra Pradesh, Chhattisgarh, Karnataka, Madhya Pradesh, Maharashtra and Odisha. It has attractive red bulbs, maturity 125-135 days after transplanting, average yield 32-36 t/ha with potential yields up to 52 t/ha, very good bulbs storability up to five months, its bulb attains immediate attractive red colour after harvest with uniform neck-fall. It is also suitable for late *kharif* in Maharashtra.

ICAR-DOGR is also National Active Germplasm Site for Onion and Garlic. Presently 30 different *Allium* species collected from within the country (17 species) and abroad (13 species) are being maintained as field gene bank at ICAR-DOGR. All species were characterized for flowering, number of tillers/plant, foliage characters, shape, presence of wax etc. Among 139 different accessions studied, 27 lines of eight species flowered in short day plains. Ten non flowering accessions were forced to induce flowering. Response to flowering was found highest in long day photoperiod exposed accessions supplemented with 200 ppm of $GA_3$ spray. The seeds were produced and maintained in these accessions. Foliage from nine of *Allium* species were evaluated for their palatability and possible use as vegetable. *A. tuberosum* line All-1587 and *A. tuberosum* Rott. kuichai line CGN-16373 produced uniform yield in all seasons and thus are suitable for year round cultivation and will be substitute of onion and garlic with added nutrition. In total, 18 garlic ecotypes have been added in gene bank.

Three onion accessions W 397, Arka Pitamber and

Acc. 1656 were reported as drought tolerant lines and five entries KHM2, RGP5, RGP2, Acc.1626 and W208 WL1 identified as a tolerant for water logging. Ten onion entries identified as moderately resistance to disease *Stemphyllium* Blight with 11-25 % disease severity. Similarly fifteen onion accessions and sixteen garlic accessions reported moderate disease reaction (11 to 25 % disease incidence) against *fusarium* basal rot. Garlic accession no. 56 identified as a resistant to *fusarium* basal rot with less than 10% disease incidence. Further 20 garlic accessions reported resistant to *allexivirus* group, LYSV and GarCLV viruses. Total 46 core garlic accessions conserved in standardized medium for a year had slow growth.

Few breeding lines along with some promising entries were identified on the basis of higher marketable yield, longer storage life, less number of doubles and bolters, high TSS etc. Two advance *kharif* breeding lines KH-M-3 and KH-M-4 were introduced in AINRPOG based on continuous significant performance. KH-M-3 bulbs are medium red in color, flat globe shape and almost free of bolters with 2.33% doubles. Its average marketable yield was 29.44 t/ha. However, KH-M-4 has dark red bulb with globe shape and had 30 t/ha average marketable yield in last two years. Both breeding lines were early in maturity (ready for harvest within 95 days after transplanting). Five multiplier onion lines were also introduced in AINRPOG *viz.,* DOGR-1523-Agg, DOGR-1544-Agg, DOGR-1546-Agg, DOGR-1549-Agg and DOGR-1550-Agg from which DOGR-1523-Agg and DOGR-1549-Agg were suitable for *kharif* and *rabi*, DOGR-1544-Agg and DOGR-1550-Agg for *rabi* and DOGR-1546-Agg was suitable for *kharif* season. All these lines had 15-22 % increased marketable yield over best check CO-1.

Looking importance of export in onion, efforts were made to breed export suitable variety by introgression of short day and yellow long day type onion. DOGR Hy-8 F1 hybrid suitable for late *kharif* was introduced in AINRPOG. In last two years, this hybrid produced 54.45 t/ha average marketable yield which is 23.57% higher than best check. After screening of 5000 plantlets to search natural male sterile lines, two lines one from RGP-4-Sel and another from Arka Kalyan found male sterile.

Using biotechnical approaches, gynogenic haploid plantlets were developed and confirmed by cytology and flow cytometry. Further in same plantlets, dihapliody has been induced using colchicine treatment. Creation of somaclonal variation in garlic attempted using root tips as an explant in regeneration of plantlets through callus. Total 245 plantlets have been generated in three garlic varieties *viz.,* Bhima Omkar, Bhima Purple and G-41.

## Crop production

Weed control efficiency of different pre-emergence and post-emergence herbicides were evaluated during *kharif,* 2015-16. All treatments showed significant reduction in total weed population as compared to untreated control. However, pre-emergence application of pendimethalin 30% EC before planting and one hand weeding at 45 days after transplanting showed 340% more yield than control and 127% more yield than ICAR-ICAR-DOGR recommended practice (Oxyflurofen 23.5% EC application before planting + one hand weeding at 40-60 days after transplanting). Hence, this treatment could be incorporated while revising the package of practice in onion.

Mechanization in garlic planting helps to dispense individual garlic cloves at specified distance during which the clove may drop either vertically, reverse or inclined position. In order to study the effect of garlic positioning in soil on its growth and yield, manual planting and direct planting by garlic planting machine were compared. Plant height was found to be significantly low in plants planted in reverse direction. Germination percentage was high in plants that were planted vertically. However, higher yield was recorded with inclined position.

Effect of permanent manurial trails on onion production and soil fertility status and soil health in different cropping systems were evaluated. The results showed that inclusion of maize as preceding crop and application of inorganic fertilizers along

with vermicompost gave significantly higher bulb yield than inorganic fertilizers alone. Similarly in soybean–onion system, integrated use of vermicompost and inorganic fertilizer (75% RDF), and 75% RDF alone produced significantly higher bulb yield over remaining fertilizer treatments. In general, inclusion of maize as preceding crop and application of inorganic fertilizers along with vermicompost increased nutrient uptake compared to soybean-onion system. Application of vermicompost along with inorganic fertilizers showed higher soil organic carbon soil available N, P and S compared to inorganic fertilizer alone applied treatments.

## Crop Protection

Two botanicals namely Karanj (*Pongamia pinnata*) and Eucalyptus (*Eucalyptus globulus*) were evaluated for antifungal activity against *Stemphylium* blight in onion. *Stemphylium* blight severity was reduced with increasing concentration of the extracts. Lowest disease severity (18.3%) was observed in foliar application of 15% leaf extract *P. pinnata.* The morphological diversity among the *Colletotrichum* cultures collected from different cultivated and wild onions were evaluated based on mycelial growth and sporulation. After 5 days of incubation, maximum mycelial growth of 79.3mm was recorded in isolate no. 12, while least (41mm) in isolate no. 17. Meanwhile, maximum sporulation (234 spores/microscopic field at 40X) was observed in isolate no. 16 and least (4 spores/ microscopic field at 40X) in isolate no. 3. The present study confirmed no relation between mycelia growth and spore formation. The genetic diversity of 23 *Colletotrichum* cultures was characterized based on ITS sequences. The phylogenetic analysis with K2+G with 500 boostrap resulted in phylogenetic tree with two distinct clusters i.e., *C. anthracnose* and *C. capsici*.

In general, endosymbionts associated with insects are known to affect certain traits having vital physiological functions. Therefore, the present study aimed at bacterial diversity analysis associated with Thrips tabaci through next generation sequencing. Based on the 16S rRNA sequence information, abundant bacterial phyla such as Actinobacteria, Proteobacteria, Firmicutes, Cyanobacteria, Bacteroidetes were identified from *T. tabaci* samples. A thorough knowledge of these endosymbionts and its impact on *T. tabaci* may help in formulating better management strategy.

Three novel insecticides *viz.*, Emammectin benzoate, Cyantraniliprole and tolfenpyrad were tested against onion thrips under field condition. The positive control profenophos @ 160 g a.i/ ha was found superior over all tested insecticides with 91 and 92% mortality at 1$^{st}$ and 2$^{nd}$ spray respectively. However, plots treated with cyantraniliprole recorded highest marketable yield (22.26 tonnes/ha) compared to profenophos treated plots (24.09 tonnes/ha). The present study revealed that cyantraniliprole was found to be effective against both adults and nymphs of onion thrips.

Regular monitoring and onion pest surveillance by ICAR-DOGR found lepidopterans as emerging pests in onion. Incidences of three lepidopteran pest *viz.,* Green looper *Chrysodeixis* sp, Cutworm *Agrotis ipsilon* and Army worm *Spodoptera exigua* were recorded in onion during 2016-17. Though considered as minor pest, their recent infestation levels were found to be high, posing serious threat to onion production. IPM compatible seed treatment can be achieved by imposing polymer film coating along with seed treatment chemicals. Initial standardization of optimum dose of polymer was done with three different concentrations *i.e.*, 5ml, 8ml and 12ml per kg seed. Seeds treated with polymer @ 12 ml per kg of seed showed better coverage without affecting the seed germination and also had higher vigour index.

Weather based forecast models were developed for each date of planting (01-Nov, 15-Nov, 01-Dec, 15-Dec, 01-Jan and 15-Jan) for *rabi* from 2000 to 2015. Models were developed using weather indices as independent variables, while character under study such as crop age at first appearance of thrips (Y1), crop age at peak population of thrips (Y2) and maximum thrips population (Y3) was used as

dependent variable for onion crop. Stepwise regression technique has been used for selecting significant variables in all the models. The forecasts for different character in various date of planting were at par with the observed one. The models fitted well with all the coefficients of determination. Therefore these models, based on weekly weather data starting from week of planting up to six weeks of crop growth, can be used for reliable forewarning of thrips.

## Post-Harvest Technology

Pre-harvest sprays of $CaCl_2$ and $NaCl_2$ were tried separately at different concentrations to reduce storage losses in onion. However, these sprays alone or in interaction with storage had no significant clear effect on sprouting, rotting and total weight loss. Two botanicals namely *Pongammia pinnata* and *Ecalyptus globules* each @ 5%, 10% and 15% were evaluated against black mould in storage onion. Among the different treatments, *P. pinnata* leaf extract @15% showed minimum black mould incidence after four month of storage.

In order to verify if any biochemical and nutritional change occur with varying bulb size, eight *kharif* onion varieties were taken and grouped into three different grades based on their size. In red varieties, grade and their interaction had significant effect on the biochemical constituents, exception being pyruvic acid content where only variety had significant effect. In general, white varieties had significantly less total flavonoids, total phenol, total antioxidant activity and total protein. However, white varieties had significantly higher pyruvic acid content compared to red varieties with exception from Bhima Dark Red. Mixed trend was observed in case of total soluble solids.

Biochemical constituents were analyzed from dried skin of eight onion varieties. The study revealed that variety had significant effect on biochemical content of onion skin. White varieties had significantly lower biochemical constituents compared to red. The total phenol content ranged from 37.17 to 43.19 mg GAE /g in red varieties while 2.42 to 2.54 mg GAE/g in white varieties. Similarly, total antioxidant activity ranged from 60.35 to 70.11 mg AAE/g in red varieties, where as in white varieties it was 18.91 to 19.21 mg AAE/g. However, pyruvic acid content was significantly more in white varieties (0.023 to 0.024 µmoles pyruvate/g) compared to red varieties (0.020-0.021 µmoles pyruvate/g).

Differences in dehydration characteristics of three white onion varieties and High TSS lines were evaluated. No significant difference was observed for browning of onion flakes during drying at 60°C. Rehydration ratio was significantly less in high TSS lines compared to varieties dried at similar temperature and time. Moreover, with the increasing demand for the ready to prepare foods, instant pakoda mix recipes using dehydrated white onion was optimized. Water ratio, time and their interaction had significant effect on the rehydration of dehydrated onion. Based on the sensory score, instant pakoda mix with dehydrated onion, chilli, ginger, ajvoin, salt and basin (100g) was optimised. The optimised mix was then rehydrated for different time periods (5, 10, 15 and 20 min) and used for pakoda preparation. The instant mix rehydrated at 20 minutes got the maximum sensory score making it more preferable over others.

Effect of drought stress at different growth stage on post-harvest attributes of onion crop was studied during *rabi,* 2015-16. Significant difference in post harvest loss in storage was recorded in bulbs obtained from normal irrigated and drought stress plots at different growth stage. Bulbs from normally irrigated plots recorded low total soluble solids (11.4%) as compared to bulbs from drought stress subjected plots, which emphasized that the drought stress at any growth stage increases the percentage of total soluble solids in onion bulbs. This result thus revealed that water management in onion crop is extremely important at all the stages of plant development. Effect of pre-harvest spray of Carbosulfan 2ml/l @ 15 days before harvest on garlic storage pest *viz*., almond moth, *Ephestia cautella* and cigarette beetle *Lasioderama serricorne*

was studied. Pre-harvest sprays had delayed the *E. cautella* and *L. serricorne* infestation in garlic at storage. Infestations of both the pests were noticed at 30 days after storage in untreated garlic, while 45 days after storage in pre-harvest spray treated garlic sample. Contact/fumigant toxicity of essential oils *viz*., Eucalyptus, Lemongrass and Peppermint oil were evaluated for survival of *L. serricorne*. All three oils were effective at higher dose @ 5-10% resulting high mortality after 48 hrs of release. Similarly, effect of essential oil on ovipositional preference of *E. cautella* was also studied. The number of eggs laid by *E. cautella* was found to be low at higher doses *i.e*., 5-10% of all three essential oils, which suggests that these oils at high doses have oviposition deterrent effect.

## Extension

Seven front-line demonstrations were conducted in three states *viz.,* Punjab, Karnataka and Gujarat during *rabi, kharif* and late *kharif* seasons, respectively. The seeds of onion varieties developed by the Directorate were provided to the selected progressive farmers of these states. Seeds of local varieties were arranged by the farmers. ICAR-DOGR varieties were performed better than local varieties in all demonstrations.

An impact study was conducted on gain in knowledge and skill of onion and garlic farmers due to training interventions. Ten farmers' training programmes were analyzed on the basis of five methods (Lecture, Lecture + Discussion, Lecture + Demonstration, Discussion + Demonstration, and Lecture + Discussion + Demonstration). Average Learning Index was least (3.87) when applied the lecture method. It was highest (7.95) for Lecture + Discussion + Demonstration method. Findings indicated that when lecture followed by discussion and demonstration, the training was more successful than the training programmes in which other methods were applied.

During the year, thirty trainings were organized for the farmers under *Mera Gaon Mera Gaurav*, Tribal Sub-Plan and ATMA scheme which were attended by 1794 farmers. ICAR-DOGR participated in seven exhibitions to showcase onion and garlic technologies. ICAR-DOGR Mobile App was also launched for transfer of information from the Directorate to the farmers and other beneficiaries.

## Miscellaneous

The Directorate celebrated its Foundation Day on 16$^{th}$ June 2016. It also celebrated International Yoga Day, Independence Day, Republic Day, National Unity Day, Communal Harmony Week, Constitution Day, Agricultural Education Day, World Soil Day, etc. The Directorate organized all mandatory meetings including Annual group meeting of AINRPOG, RAC, IMC, etc as per schedule. ICAR-DOGR also organized Hindi Saptah, Vigilance week and Swachh Bharat Abhiyan activities and other official events time to time. Monthly advisory for onion and garlic crop for the farmers' benefit uploaded on website of the Directorate regularly. ICAR-DOGR also generated the record revenue of 99.36 lakhs during the year. ICAR-DOGR supplied onion seed and garlic planting material to 1639 farmers, 40 KVKs, and 95 government and private seed producing organizations and companies.

# Introduction

## The Directorate

Realizing the importance of onion and garlic in the country, Indian Council of Agricultural Research (ICAR) established National Research Centre for Onion and Garlic in VIII Plan at Nasik in 1994. Later, the Centre was shifted to Rajgurunagar on 16th June 1998. Due to expansion of R&D activities of onion and garlic, the centre was rechristened and upgraded to Directorate of Onion and Garlic Research (DOGR) in December 2008. Besides the R&D at main Institute, ICAR-DOGR also has All India Network Project on Onion and Garlic with 12 participating centres and 14 voluntary centres across the country.

## Location and weather

The Head Quarter of Directorate located at Rajgurunagar, is about 45 km from Pune, Maharashtra on Pune -Nashik Highway. It is 18.32 °N and 73.51°E at 553.8m above m.s.l. with a temperature range of 5.5 °C to 42.0 °C and having annual average rainfall of 669 mm.

## Infrastructure

The centre has 55 acres of research farm with perennial irrigation facilities at Rajgurunagar, 56 acres at Kalus and 10 acres at Manjari. The centre has research laboratories for biotechnology, soil science, plant protection, seed technology and post-harvest technology with modern state of the art equipments. The library at the centre has extensive collection of books, journals, e-sources on Alliums. The internet and e-mail connectivity has been strengthened for easy literature access. The centre has its own website: http://dogr.res.in, which provides rapid updates and all relevant information on onion and garlic and administrative matters of ICAR-DOGR.

## Vision

To improve production, productivity, export and add on value of onion and garlic.

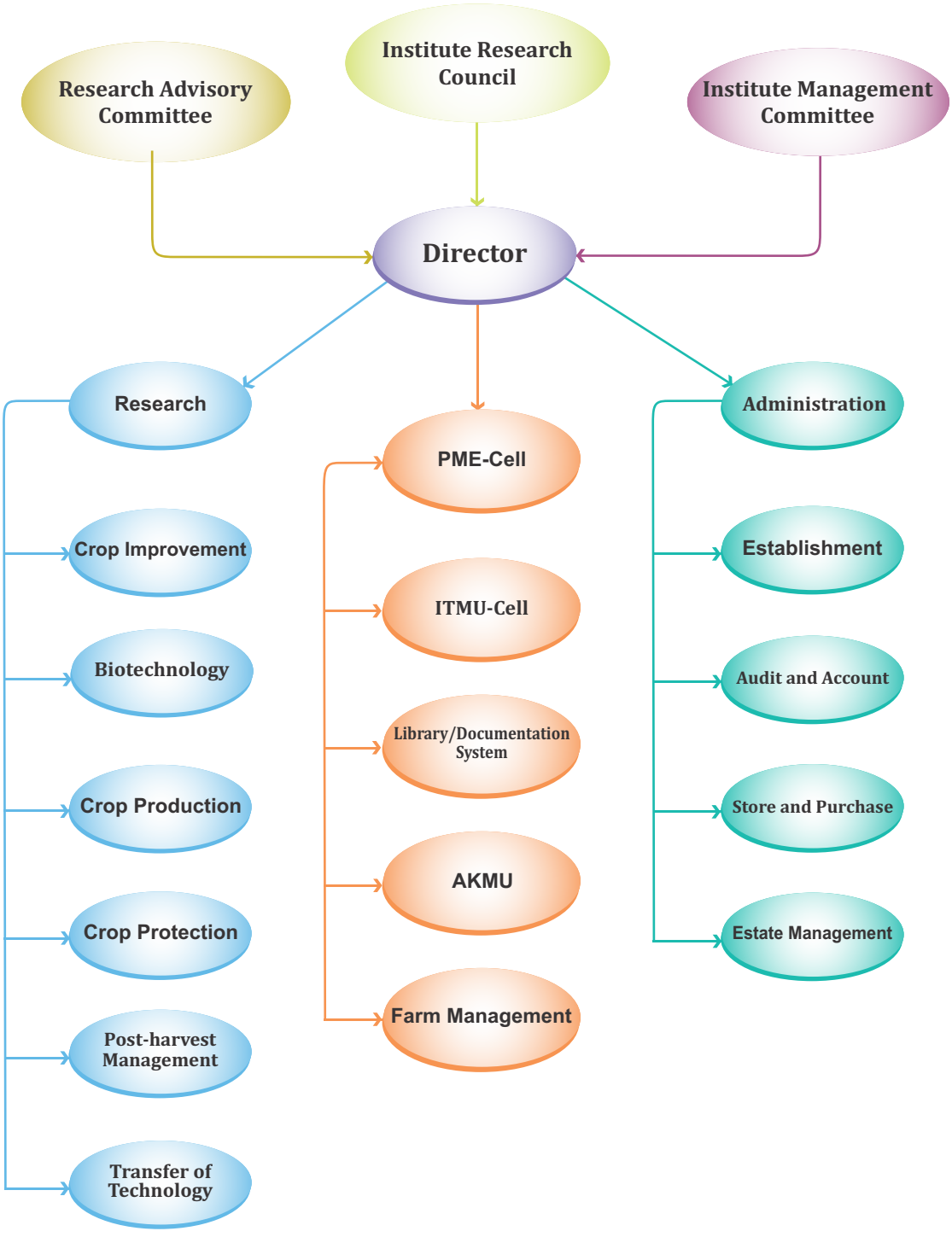
## Mission

To promote overall growth of onion and garlic in terms of enhancement of quality production, export and processing.

## Mandate

- Basic, strategic and applied research on genetic resource management, crop improvement and production technologies for enhancing and sustaining production of onion and garlic
- Transfer of Technology and capacity building of stakeholders for enhancing productivity of onion and garlic
- Coordinate research and validation of technologies through AINRP on onion and garlic

# Organogram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Institute Research Council
Institute Management Committee
Director
Research
Crop Improvement
Biotechnology
Crop Production
Crop Protection
Post-harvest Management
Transfer of Technology
PME-Cell
ITMU-Cell
Library/Documentation System
AKMU
Farm Management
Administration
Establishment
Audit and Account
Store and Purchase
Estate Management

# Crop Improvement

## Project 1. Conservation, characterizat -ion and utilization of genetic resources of *Allium* species

Due to climatic change, urbanization, road construction, landslides, etc., many landraces and *Allium* species are on the verge of extinction. Thus for their safe conservation and utilization, there is need to collect and evaluate them systematically for various important characters. Wider genetic base is desirable for a breeding programme so as to develop varieties suitable for various agro-climatic conditions and seasons. With these aims, wild as well as cultivated Alliums were collected, conserved, characterized and evaluated under this project.

### Collection, evaluation, conservation and documentation of onion and garlic germplasm

#### Collection, conservation and documentation of wild *Alliums* at ICAR-DOGR

Presently, ICAR-DOGR field gene bank hold 30 different *Allium* species collected from India (17 species) and abroad (13 species). All species were characterized for flowering, number of tillers/plant, foliage characters, shape, presence of wax etc. and comprised total 139 accessions. Among 139 different germplasm lines, 27 lines of eight species were flowered under short day plains. Ten non flowering type accessions were forced to induce flowering. Results indicated that the response to flowering was highest in long day photoperiod accessions supplemented with spray of 200 ppm of $GA_3$. The seeds were produced and being maintained in these accessions. Nine *Allium* species were evaluated for foliage palatability for possible use as vegetable. *A. tuberosum* line All-1587 and *A. tuberosum* Rott. kuichai line CGN-16373 recorded uniform yield in all seasons and thus are suitable for year round cultivation and could be substitute to onion and garlic with added nutrition. Further, few more species are being multiplied for exploiting their uses in consumption and for utilization in breeding programme.

#### Collection of garlic germplasm at ICAR-DOGR

Total eighteen garlic ecotypes have been added in gene bank. Five germplasm lines were collected from Uttar Pradesh, four from south costal area, one from Nepal, four from northern state, one from Jammu and three from Gujarat.

#### Pollen conservation in *Allium* spp.

Pollen cryopreservation can act as adjunct to conventional storage of seeds. The method aims at preserving nuclear variability of a species. Though haploid chromosomes are conserved, the total genetic variability within strain is maintained. The present study was carried out with three *Allium* sp. namely, *Allium cepa*, *A. tuberosum* and *A. clarkii* at -80oC. Pollen will be conserved for next year and the germination will be tested every three months. Initial germination percentages recorded in *A. clarkii, A. cepa* and *A. tuberosum* were 80, 99 and 90 respectively.

#### Maintenance of garlic germplasm *in vivo*

Total 625 garlic germplasm accessions were grown for maintenance in augmented design during *rabi* 2015-16. The following trait specific lines have been identified using two years pooled data.

#### Maintenance of garlic germplasm *in vitro*

A total of 46 germplasm lines representing core set were maintained under slow growth condition (4% sucrose+2% sorbitol) for a year with two subcultures. The plants derived from meristem culture were subcultured on slow growth media.

**Table 1.1: Identified trait specific garlic genotypes**

| Specific Trait | Genotypes | Range |
|---|---|---|
| High marketable yield (q/ha) | 18, 19, 318, 493, 761 | 65-75 |
| Early maturity (days) | 40, 201, 266,278, 338, 587 | 99-100 |
| High TSS (brix) | 28, 288, 618, 708, 743, 757 | 45-47 |
| Highest average bulb weight (gm) | 7, 360, 456, 555 | 18-26 |
| Highest number of cloves per bulb | 4, 61, 255, 401, 424, 510, 588 | 20-30 |

Ten plantlets were maintained for each accession. Mortality was higher in DOGR-32 at 50% and lowest in DOGR-561 at 5%.

After one year of slow growth conservation, data on rooting status, shooting behavior and overall status of garlic plantlets were grouped in three clusters as follows.

Figure 1.1: Garlic core set accession behavior under slow growth conservatio

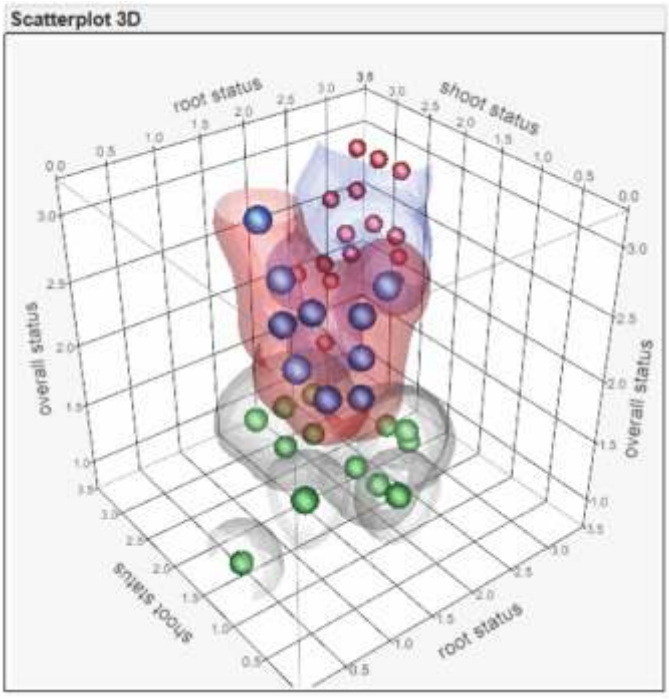


Figure 1.2: 3D scatter plot showing three clusters (red, blue and green bubbles) on basis of three morphological traits *viz.*, shoot status, rooting behavior and overall plant condition

First group (red colour) comprises 19 accessions (104, 161, 176, 220, 266, 267, 291, 318, 339, 357, 365, 367, 374, 488, 543, 561, 570, 583 and 595) has good rooting, shooting and overall status with no mortality. Second group ( blue colour) comprises 15 accessions (18, 20, 34, 110, 148, 258, 294, 319, 366, 432, 436, 437, 448, 486 and 534) has average status for all recorded traits. Third group comprises (green colour) comprises 12 genotypes (28, 32, 123, 200, 214, 355, 456, 536, 502, 540, 542 and 571) has poor status for one or two of recorded traits with 20 to 40% mortality. Accessions mentioned in the first cluster had good ability for conservation.

Further, experiments were conducted for prolonging conservation period using four (0.1M, 0.2M, 0.3M and 0.4M) combinations of each sorbitol and sucrose. The development of shoot and root growth was monthly observed. Media supplemented with 0.1M, 0.2M, 0.3M, 0.4M sucrose, 0.1M, 0.2M, 0.3M, 0.4M sorbitol, 0.1M, 0.3M, 0.4M sorbitol and sucrose were not effective for conservation. But 0.2M sucrose and sorbitol provided moderate growth of shoot and root with the ability to conserve garlic for 8-9 months (Figure1.3).

## Collection and maintenance of *Allium* germplasm at ICAR-CITH, Srinagar

Two long day onion and four garlic genotypes were collected from the different parts of Kashmir valley on the basis of morphological attributes and evaluated for some valuable traits. After multiplication, these selections will be evaluated in the next year.

## Evaluation of red onion germplasm

Onion germplasm lines were evaluated during late *kharif* (145 accessions), *rabi*(201 accessions including 36 multiplier onion) and *kharif* (238 accessions including 36 multiplier onion) along with checks. During late *kharif*, accessions Acc.1652, 1646, 595, 1256 and 1660 (61.2-70.8 t/ha) yielded superior marketable yield over best check Bhima Shakti (38.02 t/ha) and were free from bolters except Acc. 1256 which recorded 10.65% bolters (Table 1.2). These accessions also recorded more than 55% 'A' grade bulbs, 80% marketable yield and 100 g average bulb weight. Minimum storage loss after four months of storage was recorded in Acc. 1244 (12.54%) followed by 1667 (12.75%), 571 (12.95%), 1207 (14.24%) and 1663 (15.17%).

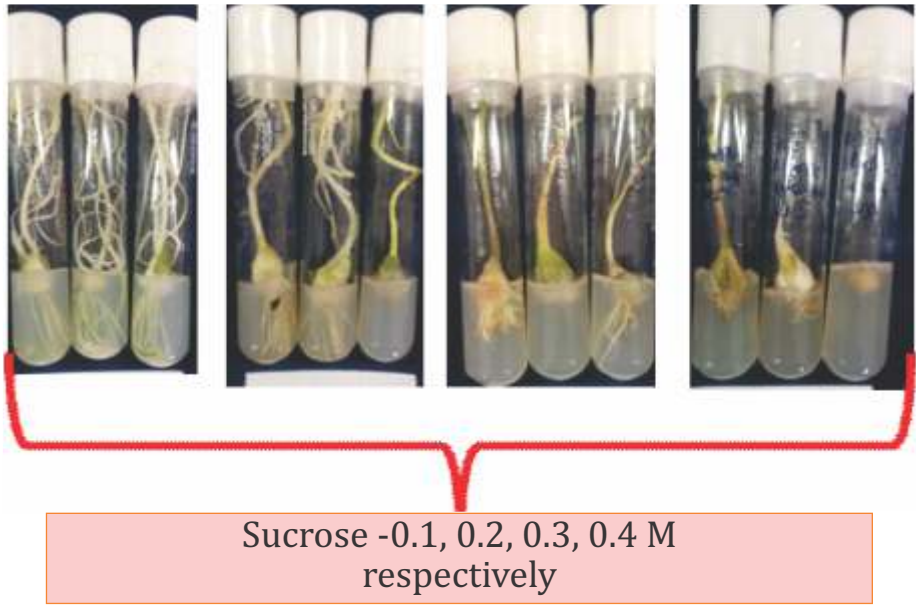


Figure1.3: Response of garlic tissue culture plant in various concentrations of sucrose

**Table 1.2: Five best performing accessions in late *kharif* 2015-16**

| Accessions | MY(t/ha) | TY(t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH | E:P |
|---|---|---|---|---|---|---|---|---|
| 1652 | 70.80 | 74.80 | 118.00 | 5.35 | 0.00 | 11.60 | 103.00 | 0.95 |
| 1646 | 69.20 | 69.20 | 148.29 | 0.00 | 0.00 | 10.20 | 115.00 | 1.03 |
| 595 | 69.20 | 69.20 | 115.33 | 0.00 | 0.00 | 11.53 | 122.00 | 1.11 |
| 1256 | 61.53 | 68.87 | 102.56 | 0.00 | 10.65 | 11.60 | 115.00 | 1.04 |
| 1660 | 61.20 | 73.73 | 102.00 | 17.00 | 0.00 | 11.00 | 109.00 | 1.08 |
| Bhima Shakti (C) | 38.02 | 45.06 | 68.80 | 10.18 | 2.92 | 11.17 | 116.33 | 1.01 |
| Bhima Super (C) | 34.64 | 41.07 | 61.16 | 2.66 | 12.16 | 11.48 | 108.67 | 1.09 |
| C.D. (5%) | 6.03 | 5.78 | 19.10 | 12.60 | 10.58 | 0.91 | 10.27 | - |

During *rabi,* Acc. 1605, 1061, 1606, 595 and 1653 produced more than 25 t/ha marketable yield and found superior over best check Bhima Shakti (24.05 t/ha) (Table 1.3). These accessions showed early in maturity (100-101 days after transplanting), medium sized bulbs (49-89 g), more than 85% marketable yield and were free from doubles and bolters except Acc. 1653 (7.46% doubles). Minimum storage loss after four months of storage was recorded in Acc. 1605 (33.42%) followed by 1657 (34.38%) and 1049 (36.57%).

**Table 1.3: Five best performing accessions in *rabi* 2015-16**

| Accessions | MY(t/ha) | TY(t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH | E:P |
|---|---|---|---|---|---|---|---|---|
| 1605 | 59.33 | 59.33 | 89.00 | 0.00 | 0.00 | 12.10 | 100.00 | 1.09 |
| 1061 | 45.33 | 45.33 | 68.00 | 0.00 | 0.00 | 11.24 | 100.00 | 1.17 |
| 1606 | 41.33 | 41.33 | 62.00 | 0.00 | 0.00 | 11.20 | 101.00 | 1.17 |
| 595 | 26.20 | 29.57 | 51.76 | 0.00 | 0.00 | 11.56 | 106.00 | 1.16 |
| 1653 | 25.02 | 27.41 | 49.07 | 7.46 | 0.00 | 11.59 | 100.67 | 1.11 |
| Bhima Shakti (C) | 24.05 | 25.99 | 49.25 | 0.40 | 0.00 | 11.19 | 116.00 | 1.06 |
| Bhima Kiran (C) | 19.91 | 22.15 | 46.72 | 0.00 | 0.00 | 11.25 | 113.33 | 1.07 |
| C.D. (5%) | 4.55 | 3.89 | 13.18 | 6.53 | 0.45 | 0.34 | 3.23 | - |

MY-Marketable Yield, TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio

In multiplier onion, Acc. 1546-Agg, 1519-Agg, 1516-Agg and 1523-Agg produced more than 21 t/ha bulb yield and found superior over best check CO-5 (17.86 t/ha). These accessions also recorded early maturity (87-93 days after planting), TSS (14-15%) and 32-41 g average compound bulb weight (Table 1.4).

**Table 1.4: Five best performing multiplier onion in *rabi* 2015-16**

| Accessions | TY(t/ha) | ABW(g) | TSS(%) | Bulblets/Bulb | DTH | E:P |
|---|---|---|---|---|---|---|
| 1546-Agg | 27.82 | 41.73 | 14.84 | 7.27 | 91.33 | 1.66 |
| 1519-Agg | 23.03 | 34.55 | 14.92 | 6.27 | 86.67 | 1.46 |
| 1516-Agg | 22.57 | 33.86 | 14.05 | 7.13 | 91.33 | 1.56 |
| 1523-Agg | 21.51 | 32.26 | 14.03 | 7.27 | 89.00 | 1.56 |
| 1539-Agg | 20.68 | 31.02 | 15.01 | 6.27 | 92.67 | 1.61 |
| CO-4 (C) | 16.75 | 29.62 | 14.88 | 5.40 | 86.67 | 1.58 |
| CO-5 (C) | 17.86 | 26.79 | 14.45 | 6.87 | 86.67 | 1.56 |
| C.D. (5%) | 3.10 | 6.15 | 1.37 | 0.78 | 4.15 | - |

TY-Total Yield, ABW-Average Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio

During *kharif*, Acc. 936, 1054, 1306, 1631, 1048, 923 and 1662 produced more than 70 t/ha marketable yield and found superior over best check Bhima Super (40.57 t/ha). These accessions showed more than 100 g average bulb weight and free from doubles and bolters (Table 1.4).

**Table 1.5: Ten best performing accessions in *kharif* 2016**

| Accessions | MY(t/ha) | TY(t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH | E:P |
|---|---|---|---|---|---|---|---|---|
| 936 | 76.93 | 76.93 | 115.40 | 0.00 | 0.00 | 11.80 | 122.00 | 1.09 |
| 1054 | 76.20 | 79.07 | 127.00 | 0.00 | 0.00 | 12.12 | 110.00 | 1.12 |
| 1306 | 75.20 | 75.20 | 112.80 | 0.00 | 0.00 | 12.00 | 113.00 | 1.14 |
| 1631 | 73.87 | 73.87 | 110.80 | 0.00 | 0.00 | 11.80 | 125.00 | 1.10 |
| 1048 | 72.00 | 72.00 | 108.00 | 0.00 | 0.00 | 12.60 | 118.00 | 1.17 |
| 923 | 71.77 | 71.77 | 107.65 | 0.00 | 0.00 | 11.96 | 122.00 | 1.10 |
| 48 | 71.73 | 77.67 | 119.56 | 7.64 | 0.00 | 12.20 | 110.00 | 1.12 |
| 1662 | 70.47 | 71.90 | 111.26 | 0.00 | 0.00 | 11.64 | 122.00 | 1.08 |
| 1428 | 69.47 | 69.47 | 104.20 | 0.00 | 0.00 | 11.56 | 121.00 | 1.12 |
| 546 | 64.58 | 64.58 | 96.87 | 0.00 | 0.00 | 12.04 | 122.00 | 1.13 |
| Bhima Super (C) | 40.57 | 42.81 | 74.14 | 3.36 | 0.82 | 11.51 | 117.67 | 1.02 |
| Bhima Dark Red (C) | 39.66 | 44.23 | 75.10 | 5.39 | 3.29 | 11.45 | 121.33 | 0.99 |
| C.D. (5%) | 6.93 | 6.43 | 11.49 | 5.80 | 0.80 | 0.53 | 7.05 | |

MY-Marketable Yield, TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio

In multiplier onion, highest bulb yield recorded in accession 1546-Agg (26.00 t/ha) followed by 1549-Agg (24.01 t/ha), 1525-Agg (23.80 t/ha), 1541-Agg (22.42 t/ha) and 1550-Agg (21.41 t/ha). These accessions also recorded early maturity (83-89 days after planting), TSS (13-14%) and 32-39 g average compound bulb weight (Table 1.5).

**Table 1.6: Ten best performing multiplier onion in *kharif* 2016**

| Accessions | TY (t/ha) | MBW (g) | TSS (%) | Bulblets/Bulb | DTH | E:P |
|---|---|---|---|---|---|---|
| 1546-Agg | 26.00 | 39.00 | 14.17 | 6.33 | 89.67 | 1.27 |
| 1549-Agg | 24.01 | 36.01 | 13.64 | 5.87 | 86.67 | 1.27 |
| 1525-Agg | 23.80 | 35.71 | 13.39 | 6.40 | 86.33 | 1.44 |
| 1541-Agg | 22.42 | 33.63 | 13.99 | 7.20 | 83.00 | 1.33 |
| 1550-Agg | 21.41 | 32.12 | 13.93 | 6.27 | 83.33 | 1.29 |
| 1531-Agg | 20.78 | 31.18 | 13.27 | 6.73 | 85.67 | 1.35 |
| 1545-Agg | 19.94 | 29.91 | 13.97 | 7.00 | 93.00 | 1.39 |
| 1532-Agg | 19.75 | 29.62 | 14.03 | 6.27 | 80.33 | 1.29 |
| 1522-Agg | 19.28 | 28.92 | 13.71 | 5.47 | 84.67 | 1.47 |
| 1544-Agg | 19.07 | 28.61 | 13.93 | 6.07 | 86.33 | 1.32 |
| CO-4 (C) | 13.55 | 20.33 | 13.44 | 5.47 | 86.00 | 1.41 |
| CO-5 (C) | 13.31 | 19.97 | 14.05 | 6.40 | 89.67 | 1.31 |
| C.D. (5%) | 4.79 | 7.18 | 0.79 | 0.96 | 7.46 | - |

TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P- Equatorial and Polar ratio


Figure 1.4: DOGR-1549-Agg

### Evaluation of white onion germplasm

During *rabi*, out of 69 germplasm lines, 40 lines were statistically at par with check Bhima Shweta (24.54 t/ha) and reported marketable yield in range of 18.14-32.23 t/ha. Germplasm lines W-208 and W-087 were significantly superior for marketable yield with 32.23 and 31.31 t/ha, respectively. Highest marketable weight of 92.20 g was observed in W-087. In storage, line W-498 reported 6.63% weight loss after 3 months of storage followed by W-443 (9.96 %), whereas, check Bhima Shweta reported 11.85% weight loss. All the accessions were bolter free (Table 1.7).

**Table 1.7: Five high yielding accessions of white onion during *rabi* season**

| Accessions | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Gross loss in weight after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| W-208 | 33.51 | 32.23 | 58.80 | 0.00 | 0.00 | 12.62 | 122.75 | 17.31 |
| W-087 | 32.39 | 31.31 | 92.20 | 2.77 | 0.00 | 10.74 | 122.00 | 46.27 |
| W-172 | 30.49 | 29.18 | 61.49 | 0.00 | 0.00 | 12.00 | 122.50 | 32.79 |
| W-364 | 30.44 | 28.71 | 59.28 | 0.00 | 0.00 | 11.06 | 122.50 | 23.29 |
| W-205 | 28.98 | 27.30 | 63.28 | 0.00 | 0.00 | 12.30 | 123.00 | 29.75 |
| Bhima Shweta (C) | 26.27 | 24.54 | 49.01 | 0.00 | 0.00 | 10.77 | 122.00 | 11.85 |
| C.D. (5%) | 6.32 | 6.43 | 10.62 | 2.02 | 0.00 | 1.04 | 000.78 | 16.05 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Evaluation of onion germplasm received from NBPGR

Total 450 onion accessions received from NBPGR were evaluated in augmented block design with three blocks and three check varieties *viz.,* Bhima Kiran, Bhima Shakti and Bhima Shweta, in one sq/m plot during *rabi* season. Total 33 germplasm lines (Table 1.8) yielded significantly superior marketable yield (26-44.17 t/ha) against check Bhima Shweta (25.58 t/ha).Among these, 16 germplasm lines also reported significantly superior yield in range of 32.50-44.17 t/ha against check Bhima Shakti (30.94 t/ha) and Bhima Kiran (31.41 t/ha). Highest marketable yield was recorded in IC-49105 (44.17 t/ha) followed by IC-33591(42.89 t/ha).Most of the lines were bolter free.Total 20 lines reported less than 6% weight loss after 3 months of storage, lowest loss reported by line IC-505768 with 0.25% weight loss followed by IC-588224 (0.71% weight loss).

**Table 1.8: Five high yielding accessions of NBPGR germplasm during *rabi* season**

| Entries | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Gross loss in weight after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| IC-49105 | 44.17 | 44.17 | 75.71 | 0.00 | 0.00 | 11.20 | 114.00 | 66.98 |
| IC-33591 | 44.22 | 42.89 | 68.93 | 3.02 | 0.00 | 11.20 | 115.00 | 54.77 |

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| Entries | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Gross loss in weight after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| IC-505809 | 39.26 | 39.26 | 66.25 | 0.00 | 0.00 | 11.20 | 114.00 | 09.43 |
| IC-35832-1 | 37.56 | 37.56 | 62.59 | 0.00 | 0.00 | 11.20 | 115.00 | 30.65 |
| IC-505713 | 37.56 | 36.22 | 58.21 | 3.55 | 0.00 | 10.60 | 114.00 | 53.79 |
| Bhima Kiran | 31.94 | 31.41 | 55.41 | 0.00 | 0.00 | 11.29 | 114.33 | 11.24 |
| Bhima Shakti | 31.81 | 30.94 | 52.96 | 0.00 | 0.00 | 11.19 | 115.00 | 13.22 |
| Bhima Shweta | 26.23 | 25.59 | 43.69 | 0.00 | 0.00 | 11.52 | 114.33 | 29.28 |
| C.D. (5%) | 2.84 | 1.80 | 11.67 | 0.23 | 0.01 | 0.11 | 2.05 | 61.37 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Evaluation of white onion germplasm during *kharif* season

Total 33 germplasm were evaluated during *kharif* season. Line W-302 was significantly superior with 43.51 t/ha marketable yield, whereas, W-344 and W-009 were statistically at par with 33.33 and 30.70 t/ha against check Bhima Shubhra (35.96 t/ha). Highest total yield was reported by W-302 (48.97 t/ha) followed by W-344 (38.15 t/ha) and W-172 (36.25 t/ha), while check Bhima Shubhra reported 41.62 t/ha. The highest average bulb weight of onion (86.10 g) reported in W-08. Accessions W-009, W-356, W-337, W-440 and W-282 were free from doubles (Table 1.9). All the accessions were bolter free.

**Table 1.9: Five high yielding accessions of white onion during *kharif* 2016**

| Accessions | TY (t/ha) | MY (t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH |
|---|---|---|---|---|---|---|---|
| W- 302 | 48.97 | 43.51 | 82.86 | 09.12 | 0.00 | 13.69 | 109.00 |
| W- 344 | 38.15 | 33.33 | 74.28 | 07.79 | 0.00 | 12.88 | 109.00 |
| W- 009 | 30.97 | 30.70 | 67.47 | 00.00 | 0.00 | 11.96 | 109.33 |
| W- 321 | 34.43 | 29.43 | 67.45 | 06.96 | 0.00 | 12.13 | 109.50 |
| W- 087 | 34.61 | 28.15 | 86.10 | 15.29 | 0.00 | 12.35 | 108.50 |
| W- 361 | 34.84 | 27.45 | 70.92 | 16.60 | 0.00 | 14.08 | 109.33 |
| W- 078 | 27.16 | 24.93 | 74.80 | 07.16 | 0.00 | 12.33 | 109.50 |
| W- 172 | 36.25 | 22.75 | 71.21 | 30.05 | 0.00 | 08.72 | 108.33 |
| BhimaShubhra (C) | 41.62 | 35.96 | 74.18 | 11.73 | 0.00 | 12.31 | 109.00 |
| C.D. (5%) | 06.65 | 05.72 | 12.82 | 13.11 | 0.00 | 01.84 | 001.03 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Screening of onion germplasm for drought stress

A field screening of 19 red and 39 white onion accessions against drought stress was undertaken during *rabi* 2015-16. Water deficit stress was imposed on 45 days old onion seedling by withholding irrigation for continuous 50 days, while in control plants, normal routine irrigation schedule were practiced throughout the growth period. The major indicators of drought susceptibility are the reduction in relative water content (RWC %), leaf greenness and yield. Significant reduction in RWC (65-70%) was recorded in stressed plants in comparison to controlled plants (75-85%). All the studied accessions were screened for drought tolerance on the basis of their leaf senescence rate and bulb yield and finally categorized as tolerant, intermediate and susceptible lines depending on the percentage change in bulb yield. The white onion accessions; Arka Pitamber, Bhima Shubhra and W 344, while red accessions; Acc. 1656, Bhima Red, Bhima Shakti were recorded with less leaf senescence rate. The minimum percent reduction in bulb weight was recorded in W 397 (12%), Arka Pitamber (20%), W 441 (30%), Acc. 1656 (30%) and W 151 (32%). The white onion accessions, W 397 and Arka Pitamber, and red accession Acc. 1656 were reported as drought tolerant lines (Table 1.10, Figure 1.5).

**Table 1.10: Categorization of onion entries against drought stress**

| Categories | Percent change in bulb weight | No. of Entries | Onion entries |
|---|---|---|---|
| Susceptible | More than 50% | Red: 15<br>White: 17 | **Red:** DOGR Hybrid 1, DOGR Hybrid 2, DOGR Hybrid 5, DOGR Hybrid 6, DOGR Hybrid 7, DOGR Hybrid 8, DOGR Hybrid 50, Hybrid Orient, Hybrid 441, Bhima Kiran, Bhima Raj, Bhima Shakti, Bhima Red, Acc. 1627, RGP 4<br>**White:** W 597 X Reforma, F6 M12 W, I9 X EL5, B2 K11 Y3, W 344, HTGR-2B-M66, W 306 AD3, MS 100 X W 172, W 279, W 189 AD3, Phule Safed, Y 003, W 302P, W 355 AD3, W 401 M2, W 417 AD3, W 146 |
| Moderately Susceptible | 30-50% | Red: 3<br>White: 19 | **Red:** Acc. 1630, Acc. 1663, RGP2<br>**White:** HTGR-1A-M6(SC), W 151, W 009 X 222, MS 100 X W 361, W 149, HTGR-3C-M6, MS100 X Bhima Shubhra, W 282, W 009 AD3, W 440, AFW X AFR F4, W 394 EL5, W 402 AD3, MS 100 X Phule Safed, W 448 P, W 439, W 422, Bhima Shubhra, MS 100 X W 448 |
| Tolerant | Less than 30% | Red: 1<br>White: 3 | **Red:** Acc.1656<br>**White:** W 397, Arka Pitamber, W 441 |


**Figure 1.5: Comparison of different drought tolerant lines**

### Screening of onion germplasm entries for water logging

Screening of red (31) and white onion (57) entries against water logging stress was carried out in controlled condition during *kharif* 2016. Artificial water logging condition was created in pit. The 45 days old seedlings were planted in plastic pots containing water to a level of 3 cm above the soil surface. Plants were monitored daily for evaluating its growth and number of survival days under water logging condition. The entries were categorized on the basis of number of days survived. Out of 88 entries screened, 4 red entries *viz.,* KHM2 (96% survival), RGP5 (80% survival), RGP2 (76% survival), Acc.1626 (40% survival) and one white line W208 WL1 (60% survival) were survived for 55-60 days under water logged condition and hence identified as tolerant onion entries for water logging stress (Table 1.11, Figure 1.6).

**Table 1.11: Categorization of onion entries against water logging**

| Categories | No. of days survived under water logging | No. of Entries | Onion entries |
|---|---|---|---|
| Highly Susceptible | Less than 10 days | Red: 4<br>White: 1 | **Red:** Acc.1667, DOGR Hybrid1, Acc.1629, RGP3<br>**White:** W395 GP |
| Susceptible | 11-25 days | Red: 4<br>White: 7 | **Red:** Bhima Red, Bhima Raj, RGP1, Acc.1664,<br>**White:**W423GP, W340GP, W420AD3, W043, MS100 X W043, W398AD3, HTGR 4B M6 SMC |
| | 30-40 days | Red: 4<br>White: 7 | **Red:** Acc.1628, Acc.1604, Acc.1609, 571LR BLR<br>**White:** W442, W085, W043AD3, WHT23D, W011EL6, W453M8, W189 |
| Moderately Tolerant | 40-50 days | Red: 5<br>White: 32 | **Red:** Acc.1605, Acc.1622, Acc.1608, 1172DR, 546DR<br>**White:** W119GP, W396, W302WL1, MS100 X Bhima ShubhraWL1, WHT23C, MS100 X W448, W408EL9, W122AD3, W355, W439, MS100 X W306, W197, W507GP, W407GP, W172 AD3, W197AD5, MS100 X W043, MS100 X W189,MS100 X W504F1, W344, W028M6, W517M2, HTGR3BM6 SMC, BhimaShubhra Wl1, WHT23BTSS12-14, W340EL6, Bhima Shubhra, W011EL7WL1, HYBSS255WL, MS100 X Phule SafedWL1, HTGR53M6SMC, W028 M7 |
| Tolerant | 50-55 days | Red: 10<br>White: 9 | **Red:** DOGR Hybrid 56, DOGR Hybrid 50, Acc.1617, KHM1, ADR, Acc.1613, Acc.1606, Acc.1623, Acc.1624, DOGR Hybrid7<br>**White:** W396, W306AD3, W174GP, MS100 X Phule Safed, Palampur, Bhima Shweta, MS100 X W172WL1, MS100 X Bhima Shweta WL1, W361 |
| Highly Tolerant | 55-60 days | Red: 4<br>White: 1 | **Red:** KHM2 (96%), RGP5 (80%), RGP2 (76%), Acc.1626 (40%)<br>**White:** W208 WL1 (60%) |


Figure 1.6: Changes in bulb weight and size in onion germplasm under artificial water logging condition

### Evaluation of onion germplasm at ICAR-CITH, Srinagar (2015-2016)

Sixty nine long day onion germplasm lines were evaluated for 24 characters. The highest marketable and average total yield of 148.44 and 151.52 t/ha, respectively were recorded in CITH-O-40. All germplasm lines were harvested at 235 days after transplanting.

**Table1.12: Five high yielding onion germplasms collected by CITH, Srinagar**

| Entries | Doubles (%) | Bolters (%) | MY (t/ha) | TY (t/ha) | TSS (%) |
|---|---|---|---|---|---|
| CITH-O-40 | 2.71 | 7.3 | 148.44 | 151.52 | 13.10 |
| CITH-O-34 | 7.89 | 10.91 | 147.90 | 150.90 | 11.76 |
| CITH-O-27 | 2.54 | 8.18 | 141.80 | 146.16 | 10.24 |
| CITH-O-3 | 2.24 | 17.29 | 141.78 | 145.29 | 15.02 |
| CITH-O-66 | 2.98 | 2.98 | 139.64 | 142.71 | 12.90 |
| C.D. (5%) | 1.96 | 4.76 | 7.84 | 7.57 | 1.02 |

MY-Marketable Yield, TY-Total Yield, TSS-Total Soluble Solids

### Field screening of onion accessions against *stemphylium* blight

Field screening of white (93) and red (19) onion accessions was carried out for source of resistance against *Stemphylium* blight during *rabi*. *Stemphylium* blight severities showed by various entries were ranged between 14 to 34%. Among them, 10 entries were found moderately resistant while remaining found susceptible to *Stemphylium* blight.

**Table 1.13: Reaction of onion accessions against basal rot *stemphylium* blight**

| Reaction | Disease incidence (%) | No of accessions | Name of accessions |
|---|---|---|---|
| Highly resistance (HR) | 0 | - | - |
| Resistant (R) | 1-10 | - | - |
| Moderately resistant (MR) | 11-25 | 08<br>02 | **White entries:** W-009x111NRCxW009 (14%), W-332, MS-100xW-172, MS-100xW-482, MS-100xB. Shubhra, W-23xT-10(W), 597xReform F4, F-6xM-12(W),<br>**Red entries:** B. Shakti, HY-441 |
| Susceptible (S) | 26-50 | 85<br>17 | **White entries:** W-045, W-063, W-092, W-104, W-125, W-138, W-143, W-146, W-149, W-151, W-157, W-172, W-177, W-224, W-246, W-279, W-282, W-302, W-328, W-329, W-331, W-344, W-358, W-361, W-395, W-397, W-422, W-423, W-430, W-439, W-441, W-448, W-459, W-511, W-543, W-534, W-567, W-009/AD-3, W-043/AD-3, W-078/AD-3, W-085/AD-3, W-172/AD-3, W-189/AD-3, W-306/AD-3, W-355/AD-3, W-396/AD-3, W-398/AD-3, W-402/AD-3, W-411/AD-3, W-417/AD-3, W-419/AD-3, W-353/M-2, W-401/M-2, W-437/M-2, W-440/M-2, W-477/M-2, W-504/M-2, W-523/M-3, W-306/M-6, W-340/M-6, W-453/M-7, W-408/EL-9, MS-100xW-361, MS-100xW-419, MS-100xW-453, MS-100xPhule Safed, W-009x222NRC-8-3, W-448xWM-570/NRC(A-3), W-526xW-448, AFWxAFR-11, F-6xM-13(LR), I-9xE-5(W), HT-GR-4B-M6-SMC, HT-GR-5A-M6-SC, HT-GR-2B-M6-SMC, HT-GR-4A-M6-SC, HT-GR-3D-M6-T-55, HT-GR-1A-M6-SC-T-85, HT-GR-3B-M6-SMC, Phule Safed, White composite 3, WHT-A/M, W-394/EL-4, W-444/EL-6, B. Shubhra,<br>**Red entries:**1627, 1630, 1656, 1663, DOGR HY-1, DOGR HY-2, DOGR HY-5, DOGR HY-6, DOGR HY-7, DOGR HY-8 , DOGR HY-50, HY Orient, RGP-2, RGP-4 B. Kiran, B. Red, B. Raj |
| Highly Susceptible (HS) | >50 | - | - |

### Evaluation of exotic genotypes of onion at ICAR-CITH, Srinagar

Out of seven exotic collections characterised, accession EC-862433 reported maximum plant height (65.25 cm). Highest average bulb weight (156 g) was recorded in EC-862428 with marketable yield of 78.82 t/ha.

**Table 1.14: Performance of exotic genotypes of onion evaluated at CITH**

| Entries | PH(cm) | NOL | P (cm) | E (cm) | N (cm) | MY (t/ha) | TY(t/ha) | ABW (g) |
|---|---|---|---|---|---|---|---|---|
| EC-862422 | 42.28 | 6.60 | 6.40 | 6.69 | 14.29 | 61.23 | 63.41 | 100.00 |
| EC-862428 | 63.11 | 5.40 | 6.50 | 5.84 | 11.22 | 78.82 | 81.21 | 156.32 |
| EC-862429 | 44.12 | 4.40 | 7.60 | 6.45 | 09.15 | 57.82 | 58.23 | 115.25 |
| EC-862430 | 55.36 | 7.40 | 7.80 | 6.12 | 17.89 | 52.91 | 54.03 | 105.23 |
| EC-862431 | 53.82 | 6.60 | 6.20 | 5.26 | 10.49 | 51.23 | 52.31 | 099.64 |
| EC-862432 | 49.11 | 6.90 | 6.60 | 5.10 | 12.66 | 49.52 | 51.66 | 106.32 |
| EC-862433 | 65.25 | 4.40 | 7.10 | 6.25 | 13.40 | 57.81 | 62.25 | 112.36 |
| C.D. (5%) | 02.25 | 0.71 | 0.72 | 0.51 | 00.62 | 01.63 | 01.23 | 004.42 |

PH-Plant Height, NOL- No. of Leaves per plant, P-Polar diameter, E-Equatorial diameter, N- Neck thickness, MY-Marketable Yield; TY-Total Yield; ABW-Average Bulb Weight

### Molecular characterization of wild *Allium* species

Total 35 *Allium* accessions were evaluated with 15 SRAP and 8 SCAR markers. SCAR markers were designed based on sequence from flanking region of *copiatransposan* obtained from TRAP polymorphic bands. Amplification was carried with *copia* LTR sequence based primer and plant sequence from junction. Diversity ranged from 0.09 to 0.96 percent.

### Evaluation of garlic germplasm at ICAR-DOGR

New garlic accessions (126) including high yielding old genotypes and check varieties were evaluated during *rabi*. Data has been recorded on marketable yield (q/ha), polar diameter (mm), equatorial diameter (mm) and average bulb weight (g).Four garlic genotypes namely 756, 743, 752 and 746 (Table 1.15) yielded significantly superior marketable yield than existing old collection (accessions 701, 726) and check as mentioned in Table 1.15.

**Table 1.15: Evaluation of new garlic genotypes for marketable yield and its contributing traits**

| Genotype | MY(q/ha) | PD (mm) | ED (mm) | ABW (g) |
|---|---|---|---|---|
| 756 | 65.7 | 25.19 | 32.846 | 10.6 |
| 743 | 65.4 | 29.526 | 40.894 | 20.2 |
| 752 | 61.9 | 32.22 | 39.48 | 17.4 |
| 746 | 60.5 | 26.25 | 36.208 | 16.2 |
| 701 | 46.9 | 27.792 | 38.846 | 18.4 |
| 726 | 41.6 | 24.998 | 35.898 | 13.6 |
| Bhima Purple (C) | 35.6 | 22.34 | 29.54 | 10.11 |
| C. D. (5%) | 11.12 | 3.45 | 4.02 | 2.11 |

MY-Marketable Yield, PD-Polar Diameter, ED-Equatorial Diameter, ABW-Average Bulb Weight

Total 625 garlic accessions were evaluated in last year during *kharif* season for nine quantitative and five qualitative traits. In pooled analysis only 68 bulb forming accessions were selected for further diversity studies. Average values of different traits were taken for secondary analysis as non-significant difference found between years to accession interaction. The highest genetic distance was reported between accession 202 and DOGR-499 (14.44), however, accessions 695 and 14 found to be most similar with minimum genetic distance i.e. 0.95. In cluster analysis (Ward 1963 method) five groups were identified with cluster 1 (11 accessions), cluster 2 (7 accessions), cluster 3 (3 accessions), cluster 4 (33 accessions) and cluster 5 (14 accessions). Top five garlic accessions performed significantly better in marketable yield over existing varieties with other related traits were as follows.

**Table 1.16: Evaluation of *kharif* garlic for yield, traits and qualitative characters**

| Genotype | MY (q/Ha) | ABW (g) | NC/B | TSS (%) | W50C (g) | COB | COC |
|---|---|---|---|---|---|---|---|
| 784 | 3.92 | 10.11 | 11.2 | 42.14 | 42.35 | White | White |
| 266 | 3.90 | 08.15 | 14.4 | 43.36 | 47.54 | Purple | Purple |
| 493 | 3.68 | 08.48 | 15.0 | 43.98 | 46.78 | Purple | Purple |
| 282 | 2.78 | 07.66 | 10.3 | 45.20 | 65.12 | Purple | Purple |
| 438 | 2.72 | 07.51 | 10.1 | 42.96 | 56.32 | White | White |
| Bhima Omkar (C) | 2.22 | 06.66 | 11.2 | 42.52 | 33.89 | White | White |
| Bhima Purple (C) | 2.05 | 06.56 | 07.8 | 41.24 | 29.65 | Purple | Purple |
| C.D. (5%) | 0.93 | 3.72 | 1.04 | 1.47 | 2.09 | - | - |


Figure 1.7: *Kharif* garlic genotypes showing adequate bulb size

### Screening of garlic germplasm for Fusarium basal rot during *kharif* 2015

Field screening of 87 accessions along with two garlic varieties were carried out for source of resistance for *Fusarium* basal rot during *kharif* 2015. The disease incidences showed by various entries were ranged between 9.8 to 49.7 percentages. Accession-360 recorded resistant reaction with lowest disease incidence of 9.8%, however, 15 entries found moderately resistant and remaining 73 entries were susceptible to basal rot.

**Table 1.17: Reaction of garlic accessions against basal rot (*Fusarium* spp.) during *kharif* 2015**

| Reaction | Disease incidence (%) | No of accessions | Name of accessions |
|---|---|---|---|
| Highly resistance (HR) | 0 | - | - |
| Resistant (R) | 1-10 | 01 | 360 |
| Moderately resistant (MR) | 11-25 | 15 | 72, 210, 282, 284, 352, 365, 414, 460, 467, 504, 546, 558, 598, 617, 751. |
| Susceptible (S) | 26-50 | 73 | 13, 18, 22, 23, 30, 34, 36, 38, 40, 52, 57, 73, 77, 94, 95, 103, 111, 113, 161, 178, 179, 190, 196, 212, 226, 251, 261, 264, 266, 305, 311, 322, 348, 350, 393, 427, 444, 453, 464, 478, 481, 489, 490, 496, 501, 502, 503, 508, 521, 524, 527, 528, 530, 531, 534, 552, 555, 556, 569, 570, 572, 576, 593, 608, 609, 614, 618, 621, 641, 697, 714, Godavari, Bhima Purple. |
| Highly susceptible (HS) | >50 | - | - |

### Screening of garlic germplasm for *Fusarium* basal rot during *rabi* 2015

Field screening of total 30 garlic accessions were carried out for source of resistance against *Fusarium* rot during *rabi* 2015. The disease incidence noticed in various accessions ranged between 10 to 53.2 percentages. Among screened entries, accession-56 recorded resistant reaction with lowest disease incidence of 10%. Sixteen entries found moderately resistant while 12 entries were susceptible and one entry was highly susceptible to basal rot.

**Table 1.18: Reaction of garlic accessions against basal rot (*Fusarium* spp.) during *rabi* 2015**

| Reaction | Disease incidence (%) | No. of accessions | Name of accessions |
|---|---|---|---|
| Highly resistance (HR) | 0 | - | - |
| Resistant (R) | 1-10 | 01 | 56 |
| Moderately resistant (MR) | 11-25 | 16 | 48, 52, 100, 119, 123, 141, 166, 211, 228, 271, 389, 458, 500, 513, 519, 573 |
| Susceptible (S) | 26-50 | 12 | 44, 72, 96, 197, 281, 392, 419, 420, 438, 505, 568, 598 |
| Highly susceptible (HS) | >50 | 01 | 192 |

### Screening of garlic germplasm against viruses

Total 60 accessions of garlic were tested for resistance to the *allexivirus* group, LYSV and GarCLV, 20 accessions found resistant to these viruses and will be further tested for confirmation during second year.

### Evaluation of long day garlic germplasm at ICAR-CITH, Srinagar

Seventy two garlic germplasm lines were characterised for 25 agro-morphological characters. It was observed that CITH-G-37 recorded maximum plant height (86.40 cm), CITH-G-32 recorded maximum average bulb weight (105.80 g) with marketable yield of 23.11t/ha. However, the highest marketable yield was recorded in CITH-G-20 (44.15 t/ha) with an average bulb weight of 89.80 g.

**Table 1.19: Performance of top five long day garlic germplasm at ICAR-CITH**

| Entries | PH (cm) | No. of Cloves | ABW(g) | MY(t/ha) | TY(t/ha) | DTH | AW50C (g) |
|---|---|---|---|---|---|---|---|
| CITH-G-20 | 80.80 | 10.60 | 89.80 | 44.15 | 44.96 | 239 | 380.20 |
| CITH-G-24 | 80.40 | 12.00 | 75.00 | 42.23 | 42.40 | 239 | 247.00 |
| Mukhteshwar | 57.00 | 07.60 | 20.60 | 39.44 | 39.82 | 239 | 131.20 |
| CITH-G-26 | 81.80 | 13.00 | 74.80 | 39.43 | 40.70 | 239 | 379.60 |
| CITH-G-17 | 74.00 | 08.20 | 66.40 | 38.51 | 40.32 | 239 | 358.00 |
| C.D. (5%) | 3.39 | 1.35 | 3.42 | 7.35 | 8.47 | - | 19.03 |

PH-Plant Height, ABW-Average Bulb Weight, MY-Marketable Yield, TY-Total Yield, DTH-Days to Harvest, AW50C -Average weight of 50 clove.

### Evaluation of short day garlic germplasm at ICAR-CITH, Srinagar

Out of 22 short day garlic germplasm received during 2015-16 from ICAR-DOGR were evaluated under long day conditions at ICAR-CITH, Srinagar. Among all the genotypes, DOGR-677 recorded maximum plant height of 78.96 cm. DOGR-676 recorded maximum total and marketable yield of 42.67 and 42.33 t/ha respectively, with an average bulb weight of 63.80g. DOGR-676, DOGR-674, DOGR-671, DOGR-665, DOGR-666 were significantly superior for marketable yield.

**Table 1.20: Five high yielding garlic germplasm evaluated at ICAR-CITH**

| Entries | PH (cm) | No. of cloves | ABW (g) | MY (t/ha) | TY (t/ha) | DTH | AW50C (g) |
|---|---|---|---|---|---|---|---|
| DOGR-676 | 77.40 | 3.20 | 63.80 | 42.33 | 42.67 | 239 | 106.40 |
| DOGR-674 | 55.90 | 5.20 | 52.60 | 34.00 | 34.33 | 239 | 090.00 |
| DOGR-671 | 61.80 | 9.40 | 48.00 | 33.33 | 33.69 | 239 | 173.00 |
| DOGR-665 | 56.96 | 11.4 | 48.80 | 31.33 | 31.71 | 239 | 206.00 |
| DOGR-666 | 65.36 | 12.6 | 39.00 | 31.00 | 31.66 | 239 | 175.00 |
| CITH-M-1(C) | 70.12 | 9.20 | 38.23 | 25.48 | 29.65 | 239 | 222.32 |
| C.D. (5%) | 2.90 | 0.90 | 3.47 | 24.09 | 32.15 | - | 032.22 |

PH-Plant Height, ABW-Average Bulb Weight, MY-Marketable Yield, TY-Total Yield, DTH-Days to Harvest, AW50C -Average Weight of 50 Cloves

### Evaluation of long day garlic germplasm at ICAR-CITH received from ICAR-DOGR

Total 53 long day garlic germplasm lines were evaluated in which DOGR-FB-8 recorded maximum plant height of 52 cm. Maximum average bulb of 51 g was observed in DOGR-FB-6 with highest total and marketable yield of 35.05 t/ha and 34.33 t/ha, respectively. DOGR-FB-6 and DOGR-FB-4 were significantly superior with 34.33 and 29 t/ha marketable yield, respectively.

**Table 1.21: Performance of top five high yielding long day garlic germplasm**

| Entries | PH (cm) | NOL | ABW (g) | MY (t/ha) | TY (t/ha) | DTH |
|---|---|---|---|---|---|---|
| DOGR- FB -6 | 36.74 | 3.80 | 51.60 | 34.33 | 35.05 | 239 |
| DOGR- FB 4 | 42.60 | 9.20 | 43.80 | 29.00 | 29.52 | 239 |
| DOGR- FB -5 | 35.42 | 9.00 | 36.80 | 25.33 | 25.66 | 239 |
| DOGR- FB -7 | 39.12 | 1.60 | 33.80 | 22.33 | 22.75 | 239 |
| Kodaikanal -S-2 | 72.15 | 8.80 | 32.32 | 21.33 | 22.96 | 239 |
| CITH-M-1 (C) | 64.22 | 8.40 | 38.23 | 25.48 | 26.54 | 239 |
| C.D. (5%) | 04.43 | 0.92 | 01.13 | 10.12 | 19.19 | - |

PH-Plant Height, NOL-No. of Leaves per plant, ABW-Average Bulb Weight, MY-Marketable Yield, TY-Total Yield, DTH-Days to Harvest, AW50C -Average Weight of 50 Cloves

## Project 2: Devising efficient breeding techniques and genetic improvement of onion and garlic through conventional breeding and biotechnological approaches

Since its inception, ICAR-DOGR has developed 10 onion and 2 garlic varieties suitable for growing in different parts of the country in different seasons. Under this project, breeding activities are being continued to yield even better results with emphasis on developing onion hybrids and improved garlic clones using conventional and non-conventional approaches.

### Breeding of onion for table varieties

In order to breed onion varieties suitable for table purpose with high yield and quality, the breeding material was evaluated under three categories i.e. pre-breeding, initial breeding and advance breeding lines.

### Evaluation of red onion advance breeding lines

Advance breeding lines were evaluated during late *kharif* (23 lines), *rabi* (22 lines) and *kharif* (26 lines) along with checks. During late *kharif*, three lines DOGR-1172-DR (53.87 t/ha), DOGR-1047-Sel (52.44 t/ha) and RGP-3 (47.98 t/ha) yielded higher than check Bhima Shakti (41.05 t/ha) with dark red, oval and big sized bulbs (76-101 g). These lines also recorded more than 85% marketable yield and less than 5% doubles and bolters. Less than 14% storage loss was recorded in DOGR-1607 (10.20%) followed by DOGR-1605 (13.28%) and DOGR-1606 (13.37%). During *rabi*, three lines DOGR-1414 (38.17 t/ha), DOGR-1604 (32.67 t/ha) and DOGR-1607 (25.18 t/ha) had higher marketable yield compare to check Bhima Shakti (24.05 t/ha) with dark red, oval and medium sized bulbs. These breeding lines also recorded more than 80% marketable yield and were free from bolters. However, less than 20% storage loss was noted in DOGR-1048-Sel (24.06%) followed by DOGR-1605 (28.72%) and DOGR-1172-DR (28.90%). During *kharif,* more than 45 t/ha marketable yield was recorded in five breeding lines namely DOGR-1610, DOGR-1607, DOGR-1043-DR, DOGR-1611, and

RGP-1 and found superior over check Bhima Super (40.57 t/ha). These lines also recorded free of doubles and bolter except RGP-1 (8.51% doubles). Storage loss after two months of storage was minimum in Acc. 1608 (15.57%) followed by Acc. 1612 (16.91%) and DOGR-546-DR (17.56%) as compare to check Bhima Super (26.70%).


Figure 2.1: Red onion advance breeding lines (a) RGP-3 and (b) DOGR-1414

### Evaluation of red onion initial breeding lines

Forty-four breeding lines were evaluated along with checks during late *kharif*, 47 lines during *rabi* and 49 lines during *kharif*. During late *kharif*, three lines including LK-07-C3-LR-1 (58.00 t/ha), DOGR-654-Sel (51.90 t/ha) and LK-07-C3-DR-1 (46.32 t/ha) yielded higher than the best check Bhima Shakti (43.43 t/ha). These lines recorded more than 55% A grade bulbs, 85% marketable yield and 80 g average bulb weight, less than 9% doubles and less than 5% bolters. Minimum loss after four months of storage was recorded in Red Genepool-3 (18.07%) followed by RGP-2-Rb-Sel (22.47%) and RGP-2-LK-Sel (24.76%). During *rabi*, five breeding lines LK-07-C3-LR-2 (41.50 t/ha), RGP-1-LK-Sel (33.58 t/ha), RGP-2-LK-Sel (33.50 t/ha), Red Genepool-4 (33.00 t/ha) and R-Rb-M-II (31.14 t/ha) had higher marketable yield than best check Bhima Shakti (24.05 t/ha). These lines also recorded more than 85% marketable yield, 55 g average bulb weight and free from bolters. Breeding line DOGR-REL-Sel (22.12%) and DOGR-1603 (25.0%) recorded minimum loss after four month of storage. During *kharif*, five lines (Table 2.1) had higher marketable yield compare to check Bhima Dark Red (43.97 t/ha). Minimum storage loss after two months of storage was recorded in Acc.1630 (11.85%), RGP-5 (20.74%) and C7-KM-2 (24.50%) compare to check Bhima Super (26.70%).

**Table 2.1: Five best performing initial breeding lines in *kharif* 2016**

| Accessions | MY(t/ha) | TY(t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH | E:P |
|---|---|---|---|---|---|---|---|---|
| DOGR-1043-GLR | 53.07 | 61.47 | 99.50 | 10.41 | 0.00 | 11.84 | 110.00 | 0.97 |
| LK-07-C3/LR-3 | 49.72 | 53.16 | 81.04 | 4.11 | 0.00 | 11.80 | 112.33 | 0.97 |
| R-Rb-M-III | 49.20 | 55.33 | 82.00 | 11.08 | 0.00 | 11.72 | 118.00 | 0.97 |

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| Accessions | MY(t/ha) | TY(t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH | E:P |
|---|---|---|---|---|---|---|---|---|
| R-Kh-M-I | 46.68 | 48.81 | 83.12 | 3.14 | 0.00 | 11.60 | 118.00 | 0.99 |
| R-LK-M-I | 46.51 | 48.19 | 79.48 | 3.23 | 0.00 | 11.49 | 116.33 | 0.98 |
| Bhima Dark Red (C) | 43.97 | 45.47 | 75.50 | 2.70 | 0.00 | 11.63 | 118.00 | 1.00 |
| Bhima Super (C) | 43.56 | 45.26 | 77.92 | 2.29 | 0.00 | 11.68 | 119.67 | 1.00 |
| C.D. (5%) | 4.82 | 4.48 | 9.51 | 8.92 | 0.93 | 0.35 | 6.38 | - |

MY-Marketable yield, TY-Total yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E: P-Equatorial and Polar ratio

## KH-M-3 and KH-M-4 introduced in AINRPOG trials

Two advance *kharif* breeding lines KH-M-3 and KH-M-4 have been introduced in All India Network Research Project on Onion and Garlic (AINRPOG) for multi location trials. Average marketable yield of line KH-M-was 29.44 t/ha over last two years. Its bulbs are medium red in color, flat globe shape and almost free of bolters with 2.33% doubles. Breeding line KH-M-4 has dark red bulb with globe shape. On the basis of two year data, this line produced 30.09 t/ha marketable yield which was 41.70% higher than the best check Bhima Dark Red (21.23 t/ha). It is free from double bulbs and bolters (Table 2.2, Figure 2.1). Both breeding lines were early in maturity (ready for harvest within 95 days after transplanting).

### Table 2.2a: Marketable yield and total yield of KH-M-3 and KH-M-4

| Entries | Marketable yield (t/ha) | | | | Total yield (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | % Increase over best Check(Mean) | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | % Increase over best Check (Mean) |
| KH-M-3 | 30.04 | 28.84 | 29.44 | 38.67 | 32.29 | 33.42 | 32.86 | 28.22 |
| KH-M-4 | 28.33 | 31.84 | 30.09 | 41.70 | 29.42 | 35.36 | 32.39 | 26.39 |
| ADR (C) | 17.50 | 12.15 | 14.82 | - | 26.40 | 18.46 | 22.43 | - |
| Bhima Dark Red (C) | 22.39 | 20.07 | 21.23 | - | 25.07 | 24.48 | 24.78 | - |
| Bhima Super (C) | 16.82 | 24.08 | 20.45 | - | 19.41 | 31.83 | 25.62 | - |
| C.D. (5%) | 4.19 | 3.41 | 3.80 | - | 4.38 | 4.43 | 4.40 | - |

### Table 2.2b: Doubles, bolters and days to maturity of KH-M-3 and KH-M-4

| Entries | Doubles (%) | | | Bolters (%) | | | Days to maturity | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean |
| KH-M-3 | 02.26 | 02.40 | 02.33 | 0.00 | 0.00 | 0.00 | 105.67 | 85.00 | 95.33 |
| KH-M-4 | 00.00 | 00.88 | 00.44 | 0.00 | 0.00 | 0.00 | 105.00 | 88.67 | 96.83 |

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| Entries | Doubles (%) | | | Bolters (%) | | | Days to maturity | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean | *Kharif* 2014-15 | *Kharif* 2015-16 | Mean |
| ADR (C) | 10.00 | 10.43 | 10.21 | 0.00 | 0.00 | 0.00 | 105.33 | 87.33 | 96.33 |
| Bhima Dark Red (C) | 01.95 | 04.74 | 03.34 | 0.00 | 0.00 | 0.00 | 106.67 | 91.67 | 99.17 |
| Bhima Super (C) | 02.00 | 10.99 | 06.49 | 0.00 | 0.00 | 0.00 | 107.33 | 93.00 | 100.17 |
| C.D. (5%) | 6.04 | 8.92 | 7.48 | 0.00 | 0.00 | 0.00 | 4.31 | 7.06 | 5.68 |


Figure 2.2: Onion lines introduced in AINRPOG

### Five multiplier onion lines introduced in AINRPOG trial

**DOGR-1523-Agg** is a multiplier onion suitable for both *kharif* and *rabi* season. Its bulblet colour is dark red with elliptic shape. In last two years, it produced 22.81 t/ha total yield during *rabi* season, which was 27.22% higher than best check CO-5 (17.93 t/ha). It is early in maturity (75 days in *kharif* and 85 days in *rabi* after planting).

**DOGR-1544-Agg** is a multiplier onion suitable for *rabi* season. It has ovate bulblets of medium red colour. It produced 20.54 t/ha average total yield in last two years which was 14.58% higher than best check CO-5 (17.93 t/ha). It produces six bulblets per bulb.

**DOGR-1546-Agg** is a multiplier type onion suitable for *kharif* season. Its bulblets are light red with elliptic shape tapering upward. On the basis of two year data, it produced 17.64 t/ha total yield which was 11.97% higher than best check CO-4 (15.76 t/ha). It has 13.67% total soluble solids.

**DOGR-1549-Agg** is a multiplier onion suitable for both *kharif* and *rabi* season. Its bulblets are pink in colour with ovate shape tapering towards neck. On the basis of two year data, it produced 22.36 t/ha total yield during *rabi* season, which was 24.73% higher than best check CO-5 (17.93 t/ha). It matures in 88 days and produces 6 bulblets per bulb.

**DOGR-1550-Agg** is a multiplier onion suitable for *rabi* season. Its bulblets are ovate with light red in colour. On the basis of two year data, this line produced 22.05 t/ha total yield which was 23.02% higher than best check CO-5 (17.93 t/ha). It has 14.63% total soluble solids.

### Table 2.3a: Qualitative traits of five AINRPOG introduced multiplier onion lines

| Entries | Suitable Season | Foliage Colour | Foliage Attitude | Bulblet Colour | Bulblet Shape |
|---|---|---|---|---|---|
| DOGR-1523-Agg | *Rabi & Kharif* | Dark Green | Semi-Erect | Dark Red | Elliptic |
| DOGR-1544-Agg | *Rabi* | Light Green | Erect | Medium Red | Ovate |
| DOGR-1546-Agg | *Kharif* | Med Green | Semi-Erect | Light Red | Elliptic |
| DOGR-1549-Agg | *Rabi & Kharif* | Dark Green | Erect | Pink | Ovate |
| DOGR-1550-Agg | *Rabi* | Med Green | Semi-Erect | Light Red | Ovate |

### Table 2.3b: Marketable yield and days to maturity of multiplier onion during *rabi*

| Entries | Marketable yield (t/ha) | | | | Days to maturity | | | |
|---|---|---|---|---|---|---|---|---|
| | *Rabi* 2013-14 | *Rabi* 2014-15 | Mean | % Increase Over best Check (Mean) | *Rabi* 2013-14 | *Rabi* 2014-15 | Mean | % Increase over best Check (Mean) |
| 1523-Agg | 26.37 | 19.24 | 22.81 | 27.22 | 91.33 | 79.33 | 85.33 | -6.07 |
| 1544-Agg | 26.13 | 14.95 | 20.54 | 14.58 | 91.67 | 82.67 | 87.17 | -4.04 |
| 1546-Agg | 20.78 | 18.62 | 19.70 | 09.90 | 96.00 | 86.00 | 91.00 | 0.18 |
| 1549-Agg | 25.33 | 19.39 | 22.36 | 24.73 | 89.67 | 85.33 | 87.50 | -3.68 |
| 1550-Agg | 25.05 | 19.05 | 22.05 | 23.02 | 90.00 | 80.67 | 85.34 | -6.06 |
| CO-4 (c) | 18.08 | 13.00 | 15.54 | - | 90.00 | 91.67 | 90.84 | - |
| CO-5 (c) | 23.75 | 12.10 | 17.93 | - | 95.00 | 92.00 | 93.50 | - |
| C.D. (5%) | 1.12 | 2.07 | 1.59 | - | 4.76 | 4.38 | 4.57 | - |

### Table 2.3c: Marketable yield and days to maturity of multiplier onion during *kharif*

| Entries | Marketable yield (t/ha) | | | | Days to maturity | | | |
|---|---|---|---|---|---|---|---|---|
| | *Kharif* 2013 | *Kharif* 2014 | Mean | %Increaseover bestCheck (Mean) | *Kharif* 2013 | *Kharif* 2014 | Mean | % Increase over best Check (Mean) |
| 1523-Agg | 22.42 | 15.48 | 18.95 | 20.25 | 69.33 | 80.67 | 75.00 | -7.41 |
| 1544-Agg | 17.18 | 13.92 | 15.55 | -1.32 | 68.67 | 84.00 | 76.34 | -5.76 |
| 1546-Agg | 21.51 | 13.78 | 17.64 | 11.97 | 71.00 | 86.00 | 78.50 | -3.09 |
| 1549-Agg | 24.02 | 14.30 | 19.16 | 21.61 | 68.33 | 84.33 | 76.33 | -5.77 |
| 1550-Agg | 21.90 | 13.64 | 17.77 | 12.77 | 69.00 | 84.33 | 76.67 | -5.35 |
| CO-4 (C) | 18.56 | 12.95 | 15.76 | - | 77.00 | 85.00 | 81.00 | - |
| CO-5 (C) | 17.71 | 11.40 | 14.55 | - | 78.00 | 87.00 | 82.50 | - |
| C.D. (5%) | 3.88 | 2.38 | 3.13 | - | 2.92 | 3.73 | 3.33 | - |

### Breeding of onion for processing and export varieties

In onion, processing industries are interested in high yielding, high TSS with white skin colour varieties while for export purpose, high yielding yellow coloured varieties are more preferable. These should be early maturing, bolters free and suitable for year round cultivation in various seasons.

### Evaluation of white onion advance/initial breeding lines during *Rabi*

During *rabi*, out of 105 advance and initial breeding lines, six lines recorded higher marketable yield than check Bhima Shweta (27.11 t/ha) where W-104 M-5 recorded highest marketable yield (32.11 t/ha) followed by W-353 M-2 (30.05 t/ha). Lowest storage loss (8.18%) after three month of storage was reported in line W -225 M -2 (Table 2.4a).

**Table 2.4a: Five high yielding white onion advance/initial breeding lines in *rabi***

| Lines | TY(t/ha) | MY(t/ha) | MBW(g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Storage loss after 3 months ofstorage (%) |
|---|---|---|---|---|---|---|---|---|
| W -104 M -5 | 34.67 | 32.11 | 88.57 | 3.52 | 0.00 | 12.34 | 122.50 | 47.77 |
| W -353 M - 2 | 30.24 | 30.05 | 55.62 | 0.50 | 0.00 | 10.47 | 124.00 | 43.71 |
| W -339 M - 6 | 29.33 | 28.89 | 48.15 | 0.00 | 0.00 | 11.48 | 120.00 | 19.23 |
| W -225 M -2 | 28.00 | 27.78 | 44.79 | 0.00 | 0.00 | 12.06 | 122.50 | 08.18 |
| W- 488 M -2 | 28.09 | 27.61 | 48.96 | 1.01 | 0.00 | 11.12 | 120.00 | 20.32 |
| W- 171 M -2 | 28.22 | 27.56 | 45.07 | 0.00 | 0.00 | 12.52 | 122.00 | 20.04 |
| Bhima Shweta ( C ) | 27.76 | 27.11 | 53.75 | 0.43 | 0.62 | 11.76 | 151.67 | 23.64 |
| C.D. (5%) | 05.48 | 05.41 | 09.95 | 3.20 | 0.35 | 01.00 | 2.12 | 18.71 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Evaluation of white onion advance/initial breeding lines during *kharif*

A total of 77 advance and initial breeding lines were evaluated during *kharif*. Two lines W-523 M2 and W.E Composite found significantly superior with 53.13 and 52.39 t/ha marketable yield over check Bhima Shubhra (44.72 t/ha). Fourteen breeding lines were statistically at par with check (Table 2.4b).

**Table 2.4b: Five high yielding white onion advance/initial breeding lines in *kharif***

| Lines | TY (t/ha) | MY (t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH |
|---|---|---|---|---|---|---|---|
| W-523 M-2 | 68.40 | 53.13 | 113.86 | 21.35 | 0.00 | 12.00 | 109.00 |
| W.E.Composite | 56.56 | 52.39 | 092.01 | 06.57 | 0.00 | 13.20 | 109.00 |
| W-009 EL-6 | 52.82 | 49.64 | 093.43 | 04.86 | 0.00 | 12.58 | 109.00 |
| W-448 BR-8 | 50.37 | 47.33 | 091.56 | 04.61 | 0.00 | 12.47 | 106.00 |
| W-408 EL-10 | 53.17 | 47.24 | 085.21 | 09.50 | 0.00 | 13.11 | 109.00 |

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| Lines | TY (t/ha) | MY (t/ha) | MBW(g) | Doubles(%) | Bolters(%) | TSS(%) | DTH |
|---|---|---|---|---|---|---|---|
| W-408 AD-3 | 47.35 | 45.83 | 076.94 | 03.13 | 0.00 | 12.36 | 107.00 |
| B. Shubhra ( C ) | 45.94 | 44.72 | 082.44 | 02.05 | 0.00 | 13.16 | 108.33 |
| C.D. (5%) | 07.70 | 07.52 | 012.19 | 11.14 | 2.32 | 00.90 | 000.69 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Evaluation of white onion advance/initial breeding lines in late *kharif*

Out of 22 evaluated advance and initial breeding lines, 15 lines yielded at par marketable yield compare to check Bhima Shubhra (24.35 t/ha). The highest yield reported by W-441M-3(28.88 t/ha) with 12.18% loss after storage followed by W-453 M-6 (27.39t/ha) with 14.01% loss. Minimum storage loss after two months storage was recorded in W-453M-7 (3.62%) with 24.18 t/ha marketable yield followed by W-504M-2 (4.17%) with 24.04 t/ha marketable yield (Table 2.4c).

**Table 2.4c: Five high yielding white onion advance/initial breeding lines in late *kharif***

| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Storage loss after 2 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| W-441 M-3 | 32.91 | 28.88 | 69.89 | 01.53 | 01.51 | 11.96 | 127 | 12.18 |
| W-453 M-6 | 33.71 | 27.39 | 66.75 | 04.83 | 05.63 | 12.76 | 127 | 14.01 |
| W-009 AD-3 | 31.78 | 25.10 | 54.52 | 02.21 | 00.42 | 13.15 | 127 | 05.56 |
| W-043 AD-3 | 32.58 | 24.97 | 60.92 | 01.35 | 21.71 | 12.13 | 127 | 08.65 |
| W-306 AD-3 | 32.63 | 24.53 | 56.19 | 11.48 | 10.26 | 12.28 | 127 | 07.92 |
| Bhima Shubhra ( C ) | 32.86 | 24.35 | 57.48 | 00.63 | 22.39 | 12.98 | 127 | 06.58 |
| C.D. (5%) | 11.76 | 8.48 | 13.48 | 14.44 | 17.31 | 00.96 | 00 | 14.47 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH=Days to Harvest

### Performance of LG lines during late *kharif*

Five lines obtained from late *kharif* were evaluated to develop bolter free varieties. Three lines viz., White Elite Comp. LG-209-4, White Genepool LG-107-4 and W-448 LG-107-4 were statistically at par with check Bhima Shubhra (29.36 t/ha) with 28.19 t/ha, 26.38 t/ha and 24.08 t/ha marketable yield, respectively (Table 2.5). Line White GP Comp. LG-107-4 reported lowest total loss in weight of 4.37% after 2 months of storage with 13.94 t/ha marketable yield, followed by W-448 LG-107-4 with 11.66% total loss in weight after 2 months of storage with 24.66 t/ha yield. Bolting was less than 7% as compared to respective checks (up to 20%).

### Table 2.5: Performance of LG lines during late *kharif*

| Genotypes | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS(%) | DTH | Storage loss after 2 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| White Elite Comp. LG-209-4 | 34.95 | 28.19 | 70.27 | 2.18 | 06.95 | 12.50 | 127 | 13.66 |
| White Genepool LG-107-4 | 29.66 | 26.38 | 64.08 | 0.00 | 05.74 | 12.53 | 127 | 12.33 |
| W-448LG-107-4 | 29.24 | 24.08 | 53.91 | 3.08 | 03.80 | 11.83 | 127 | 11.66 |
| Bhima Shweta LG-107-4 | 22.35 | 17.09 | 42.38 | 2.91 | 05.28 | 12.00 | 127 | 18.25 |
| White GP Comp. LG-107-4 | 18.10 | 13.94 | 59.48 | 0.25 | 20.55 | 12.73 | 127 | 04.37 |
| Bhima Shubhra ( C ) | 41.44 | 29.36 | 74.66 | 0.00 | 25.66 | 13.43 | 127 | 16.56 |
| C.D. (5%) | 07.63 | 06.45 | 10.90 | 7.21 | 09.23 | 00.83 | 00 | 08.04 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Performance of lines developed from the crosses between short day and exotic onions

Nine white onion and 10 yellow onion exotic crosses were evaluated during *rabi*. Among ten yellow onion exotic crosses, eight yielded significantly superior marketable yield over check Phule Suvarna (17.78 t/ha), however, remaining crosses were statistically at par with check. Cross K-11 X C-3 (Y) F3M2 (39.64 t/ha) reported highest marketable yield followed by A-1 X N-14 (Y) F3M2 (39.32 t/ha). All 9 white onion exotic crosses were statistically at par with check and 5 crosses reported marketable yield higher than the check Bhima Shweta (27.31 t/ha). Highest marketable yield reported by cross F-6 X L-12 (W) F3M2 (32.96 t/ha) followed by W-23 X J-10 (W) OLD SNGOP F3M2 (32.38 t/ha). Less than 18% storage loss was recorded by cross F-6 X M-13 (LR) F3M2 (Y) (42.59%) followed by W-23 X J-10 (W) F3M2 (17.71%) after 3 months of storage (Table 2.6).

### Table 2.6: Performance of short day x exotic onion crosses

| Exotic crosses | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS(%) | DTH | Storage loss after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| F-6 X L-12 (W)F3M2 | 34.15 | 32.96 | 79.68 | 2.66 | 0.00 | 11.94 | 123.67 | 42.59 |
| W-23 X J-10 (W) Old F3M2 | 33.09 | 32.38 | 62.73 | 1.10 | 0.00 | 11.88 | 123.67 | 46.12 |
| I-9 X E-5 (Y) F4M3 SNGOP | 32.06 | 32.06 | 58.05 | 0.00 | 0.00 | 10.46 | 121.67 | 54.33 |
| F-6 X L-12 (W)F3M2 | 32.56 | 28.61 | 68.44 | 9.64 | 0.00 | 11.36 | 123.67 | 41.76 |
| W-23 X J-10 (W) F3M2 | 28.73 | 28.34 | 51.94 | 0.00 | 0.00 | 10.96 | 123.33 | 17.71 |
| Bhima Shweta ( C ) | 28.52 | 27.31 | 50.54 | 0.00 | 2.28 | 10.73 | 121.67 | 17.43 |
| C.D. 5% | 09.36 | 08.55 | 16.01 | 6.40 | 1.27 | 01.15 | 12.20 | 25.96 |

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| Exotic crosses | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS(%) | DTH | Storage loss after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| K-11 X C-3 (Y) F3M2 | 41.94 | 39.64 | 76.80 | 3.33 | 0.00 | 11.35 | 129.50 | 19.73 |
| A-1 X N-14 (Y) F3M2 | 41.15 | 39.32 | 70.97 | 4.26 | 0.00 | 10.73 | 124.00 | 27.77 |
| J-10 X F-6 (Y) F4M3 | 38.77 | 36.92 | 71.35 | 4.07 | 0.00 | 10.60 | 124.00 | 43.95 |
| F-6 X J-10 (Y) F3M2 | 38.70 | 35.79 | 60.85 | 0.00 | 0.00 | 11.57 | 124.00 | 33.00 |
| C-3 X H-8 (Y) F4M3 | 32.66 | 32.43 | 78.73 | 0.00 | 0.00 | 11.35 | 129.50 | 26.10 |
| I-9 X E-5 (Y) F4M3 | 32.06 | 32.06 | 58.05 | 0.00 | 0.00 | 10.46 | 123.33 | 54.33 |
| C-3 X K-11 (Y) F3M2 | 36.63 | 30.31 | 64.64 | 15.5 | 0.00 | 10.85 | 129.50 | 34.01 |
| F-6 X M-13 (Y) F4M3 | 29.02 | 28.19 | 55.37 | 0.00 | 0.00 | 13.93 | 135.00 | 31.23 |
| Phule Suvarna (C) | 20.10 | 17.78 | 43.19 | 3.34 | 0.00 | 11.20 | 124.00 | 34.62 |
| C.D. (5%) | 09.36 | 08.55 | 16.01 | 6.40 | 1.27 | 01.15 | 12.20 | 25.96 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Performance of lines developed from the MS and NRC crosses

Seventeen NRC crosses were made during *rabi* season with the aim to transfer desirable traits and to widen genetic base. Total 13 NRC crosses were statistically at par with check Bhima Shweta (27.31 t/ha), six crosses yielded higher than the check variety. Highest yield reported by WM-526 X W-448 NRC with 31.87 t/ha followed by 597 X Basic F2 M4 with 31.72 t/ha (Table 2.7). Cross (W-009 x 111NRC F3) X W-009 BC-2 was reported lowest weight loss of 28.05% followed by 597 X BASIC F2 F4 (28.30%) after 3 months of storage.

### Table 2.7: Performance of lines in fourth generation

| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles(%) | Bolters (%) | TSS (%) | DTH | Storage loss after 3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| WM-526 X W-448 NRC | 32.25 | 31.87 | 59.33 | 0.35 | 0.00 | 10.60 | 119.67 | 37.23 |
| 597 X BASIC F2 F4 | 32.04 | 31.72 | 54.36 | 0.00 | 0.00 | 10.60 | 119.67 | 28.30 |
| MS-100 X W-361NRC F3 | 30.53 | 30.53 | 60.63 | 0.00 | 0.00 | 10.50 | 119.50 | 36.39 |
| AFW X AFR F4 | 30.14 | 30.14 | 53.42 | 0.00 | 0.00 | 10.50 | 120.00 | 32.43 |
| (W-009 x 111NRC F3) X W-009 BC-2 | 30.82 | 29.63 | 55.90 | 0.00 | 0.00 | 10.57 | 120.00 | 28.05 |
| W-009 X W-222 NRC F3 | 33.46 | 29.59 | 60.86 | 0.00 | 0.00 | 10.80 | 120.00 | 30.46 |
| Bhima Shweta ( C ) | 28.52 | 27.31 | 50.54 | 0.00 | 2.28 | 10.73 | 121.67 | 17.43 |
| C.D. (5%) | 7.05 | 7.34 | 14.88 | 4.69 | 1.32 | 0.35 | 1.32 | 22.66 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Evaluation of white onion high TSS lines

During *rabi*, a total of 25 lines were evaluated for high TSS. The highest TSS (18.24%) recorded by line HT-GR-2C M-5-1 (yield 8.52 t/ha) followed by line WHT-5B (TSS 17.92%, yield 16.33 t/ha) compare to check Bhima Shweta (TSS 11.76%, yield 27.11 t/ha) (Table 2.8a). Among 25 lines, line HT-GR-4A-M-6 reported lowest storage loss (10.32%) followed by HT-GR-5B M-6 (12.93%) after 3 months of storage.

**Table 2.8a: Evaluation of white onion high TSS lines in *rabi***

| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Storage loss after3 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| HT-GR-2C M-5-1 | 11.10 | 8.52 | 31.12 | 0.00 | 0.00 | 18.24 | 120.33 | 25.47 |
| WHT-5B | 17.78 | 16.33 | 39.49 | 0.00 | 0.00 | 17.92 | 121.50 | 38.95 |
| HT-GR-1A M-6 | 14.17 | 12.69 | 29.11 | 0.00 | 0.00 | 17.84 | 120.00 | 25.18 |
| HT-GR-1B-M-6 SMC | 11.00 | 9.82 | 31.64 | 0.13 | 0.00 | 17.49 | 122.00 | 25.49 |
| HT-GR-2B-M-6 SMC | 15.96 | 14.78 | 31.70 | 3.45 | 0.00 | 17.37 | 122.00 | 26.38 |
| HT-GR-1A-M-6 SC (14-14.8 ) | 13.54 | 13.08 | 36.10 | 0.07 | 0.00 | 17.20 | 122.00 | 46.34 |
| HT-GR-6E M-5-1 SELF-I | 13.00 | 13.00 | 35.49 | 0.00 | 0.00 | 17.02 | 120.00 | 42.12 |
| Bhima Shweta ( C ) | 27.76 | 27.11 | 53.75 | 0.43 | 0.62 | 11.76 | 151.67 | 23.64 |
| C.D. (5%) | 03.40 | 03.50 | 11.43 | 2.76 | 0.36 | 01.55 | 000.76 | 22.81 |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

During *kharif* eleven highTSS breeding line were evaluated and all found significantly superior for TSS over check Bhima Shubhra (12.81%) with maximum value 17.06% in HT-GR-2A-M-6 with marketable yield of 4.38 t/ha followed by 16.56% in HT-GR-2B-M-6 SMC with marketable yield of 12.56 t/ha. However, check Bhima Shubhra reported highest marketable yield of 32.76 t/ha (Table 2.8b).

**Table 2.8b: Evaluation of white onion high TSS lines in *kharif***

| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH |
|---|---|---|---|---|---|---|---|
| HT-GR-2A-M-6 | 10.40 | 04.38 | 49.88 | 10.15 | 0.00 | 17.06 | 106.00 |
| HT-GR-2B-M-6 SMC | 15.17 | 12.31 | 48.94 | 06.38 | 0.00 | 16.56 | 109.00 |
| WHT-23A | 09.38 | 04.57 | 40.78 | 20.14 | 0.00 | 16.52 | 109.00 |
| WHT-23B | 09.75 | 06.06 | 50.73 | 09.07 | 0.00 | 16.36 | 109.00 |
| HT-GR-3B-M-6-SMC | 17.43 | 05.03 | 39.91 | 45.73 | 0.00 | 16.34 | 106.00 |

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| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH |
|---|---|---|---|---|---|---|---|
| HT-GR-2B-M-6 | 15.98 | 09.39 | 52.80 | 13.92 | 0.00 | 16.30 | 106.25 |
| WHT-23C | 15.67 | 10.11 | 56.88 | 02.72 | 0.00 | 15.96 | 109.00 |
| HT-GR-5B-M-6 SMC | 13.54 | 05.00 | 49.25 | 29.53 | 0.00 | 15.91 | 106.00 |
| HT-GR-4B-M-6 SMC | 10.21 | 03.75 | 52.33 | 31.30 | 0.00 | 15.80 | 106.00 |
| WHT-6A-M-2-2-DC | 17.09 | 15.82 | 52.91 | 04.42 | 0.00 | 15.73 | 109.00 |
| WHT-23D | 19.00 | 12.67 | 47.48 | 33.64 | 0.00 | 15.52 | 109.00 |
| Bhima Shubhra ( C ) | 40.25 | 32.76 | 67.42 | 16.00 | 0.00 | 12.81 | 106.00 |
| C.D. (5%) | 5.71 | 4.76 | 9.49 | 15.71 | 0.00 | 0.53 | 0.25 |

TY-Total Yield, MY-Marketable Yield; MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

During *late kharif* 4 lines of high TSS were evaluated against check Bhima Shubhra (13.43$^0$brix). Line HT-GR-2A-M-6 SC reported highest TSS (17.81%) with 10.54 t/ha marketable yield followed by HT-GR-3B-M-5 SMC 16.52% with 9 t/ha marketable yield compare to check Bhima Shubhra (TSS 13.43%, marketable yield 29.36 t/ha). Less than 9% storage loss reported by Line HT-GR-5B-M-6 SMC followed by HT-GR-3B-M-5 SMC with 8.78% after 2 months of storage.

**Table 2.8c: Evaluation of white onion high TSS lines in late *kharif***

| Lines | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Storage loss after 2 months of storage (%) |
|---|---|---|---|---|---|---|---|---|
| HT-GR-2A-M-6 SC ( 18-19.8 ) | 22.65 | 10.54 | 52.60 | 17.87 | 25.03 | 17.81 | 127 | 24.82 |
| HT-GR-3B-M-5 SMC ( 15-17.8 ) | 19.24 | 09.00 | 40.88 | 21.91 | 20.04 | 16.52 | 127 | 08.78 |
| HT-GR-4B-M-6 SMC ( 14-14.8 ) | 19.26 | 09.17 | 35.13 | 26.19 | 16.96 | 15.08 | 127 | 10.88 |
| HT-GR-5B-M-6 SMC ( 12-13.8 ) | 25.12 | 12.07 | 41.77 | 19.82 | 15.82 | 14.92 | 127 | 06.57 |
| Bhima Shubhra ( C ) | 41.44 | 29.36 | 74.66 | 00.00 | 25.66 | 13.43 | 127 | 16.56 |
| C.D. (5%) | 07.63 | 06.45 | 10.90 | 07.21 | 09.23 | 00.83 | 0.00 | 08.04 |

TY-Total Yield, MY-Marketable Yield; MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

### Dehydration characteristics of different white varieties and high TSS lines

During the last few years the demand for the dehydrated onion flakes is increasing as they offer convenience for use, store and transport. As high TSS is prerequisite trait for getting promising

dehydrated product. Present experiment was planned to see the differences in the dehydration characteristics of three white onion varieties (Bhima Shweta, Bhima Shubhra and Bhima Safed) and three high TSS onion lines. In preparation, out of 20 bulbs half sample was used for biochemical analysis while half kept for dehydration. Drying was done at 60°C in a food grade drier that has a provision to provide equal temperature and air to each tray. Weight loss was noted after each one hour and a drying curve was prepared.

In biochemical properties, no significant difference was observed for total phenol content in onion varieties and High TSS lines. However, high TSS lines had significantly high pyruvic acid content compared to varieties. No significant difference was observed for browning of onion flakes during drying at 60°C. Rehydration ratio was significantly less in high TSS lines compared to varieties.

## Breeding for improved garlic varieties

### Evaluation of elite lines

For off season cultivation of garlic during *kharif,* sixty elite lines were evaluated along with check Bhima Purple. Line PB-5.0-GY-MUT EL (3.21 t/ha) and ten line yielded significantly higher than the check (0.83 t/ha).

Seventy elite lines of garlic developed through selection or mutations were evaluated during *Rabi* season and line COL-PB-05 EL gave significantly higher total yield 5.52 t/ha as compared to 3.96 t/ha in check Bhima Omkar. Total soluble solids percentage was highest (41.37%) in line ACC-12 EL and in eleven lines it was at par with the check (40.73%). Storage loss was below 10% in two lines SCS-5-M-5 EL (5.27%) & PB-6-KR EL (8.39%) after four months of storage as compared with check (14.67). Weight of bulb was highest in Godavari-5.6-GY-MUT (9.99 g). 50 cloves weight was highest in SG-1 (39.95 g) (Table 2.9).

**Table 2.9: Top five high yielding garlic elite lines during *rabi***

| Lines | MY(t/ha) | AWB(g) | TSS(%) | Average Weight of 50 Cloves | Storage loss after 4 months of storage(%) |
|---|---|---|---|---|---|
| COL-PB-05 | 5.52 | 8.83 | 40.37 | 38.18 | 4.45 |
| Godavari-1-GY-MUT | 4.53 | 7.63 | 40.69 | 36.07 | 3.55 |
| PB-EMS-5 | 4.10 | 7.85 | 40.53 | 33.25 | 3.29 |
| CDT-14.6-KR | 4.08 | 7.91 | 40.08 | 33.39 | 3.32 |
| SG-1 | 4.00 | 7.27 | 39.84 | 39.95 | 3.37 |
| Bhima Omkar ( C ) | 3.96 | 8.25 | 40.73 | 34.59 | 3.38 |
| C.D. (5%) | 1.35 | 1.86 | 01.53 | 07.35 | 1.17 |

MY-Marketable Yield, ABW-Average Bulb Weight, TSS-Total Soluble Solids

## Development of $F_1$ hybrids in onion through conventional method

### Evaluation of red onion $F_1$ hybrids developed through male sterile lines

Fifty-seven $F_1$ hybrids along with their parents and checks were evaluated during late *kharif* season. Standard heterosis for marketable yield was 33.10% in MS65A x Bhima Kiran. Four $F_1$ hybrids *viz*; MS65A x Bhima Kiran, MS48A x 595, MS1600A x 595 and MS111A x 1133 recorded more than 15% heterosis for marketable yield over best check Bhima Super (39.77 t/ha) with uniformity in bulb size and shape and early in maturity (Table 2.10). Minimum storage loss after four months of storage was recorded in MS1600A x 595 (14.59%) followed by MS1600A x 1133 (15.64%) and MS222A x N-2-4-1 (23.86%).

### Table 2.10: Five best performing $F_1$ hybrids during late *kharif* 2015-16

| Accessions | MY (t/ha) | TY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | E:P | Heterosis over check BS (%) |
|---|---|---|---|---|---|---|---|---|---|
| MS65A X Bhima Kiran | 52.93 | 60.47 | 132.33 | 7.94 | 0.00 | 11.60 | 103.00 | 1.04 | 33.10 |
| MS48A X 595 | 46.89 | 56.67 | 93.78 | 11.76 | 5.49 | 11.53 | 109.00 | 0.92 | 17.90 |
| MS1600A X 595 | 46.20 | 54.93 | 92.40 | 10.92 | 4.98 | 9.53 | 109.00 | 1.02 | 16.17 |
| MS111A X 1133 | 45.82 | 62.65 | 99.38 | 11.28 | 14.80 | 11.38 | 118.50 | 0.99 | 15.21 |
| MS48A X Bhima Shakti | 39.83 | 58.60 | 104.84 | 21.07 | 9.62 | 10.93 | 120.00 | 0.97 | 0.16 |
| Bhima Super (C) | 39.77 | 45.84 | 74.59 | 5.05 | 6.53 | 11.25 | 113.00 | 0.98 | - |
| HY-441 (C) | 25.88 | 38.87 | 60.65 | 19.36 | 12.58 | 11.59 | 113.33 | 1.09 | - |
| HY-Orient (C) | 26.67 | 47.71 | 77.94 | 22.91 | 7.39 | 10.86 | 117.67 | 1.17 | - |
| C.D. (5%) | 5.51 | 6.42 | 12.01 | 13.25 | 13.11 | 0.73 | 8.03 | - | - |

MY-Marketable Yield, TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio, BS-Bhima Super

During *rabi*, 58 $F_1$ hybrids were evaluated along with their parental lines and checks. Standard heterosis was recorded up to 50.54% in MS48A x 595 on marketable yield. Four $F_1$ hybrids *viz.* MS48A x 595, MS48A x 592, MS1600A x 595 and MS48A x Bhima Shakti showed more than 19% heterosis on marketable yield over best check Bhima Shakti (24.05 t/ha). These hybrids showed more than 90% marketable yield, free from bolters and less than 2% doubles (Table 2.11). Minimum storage loss after four months of storage was recorded in hybrid MS65A x DOGR-1203 (10.11%) followed by MS65A x 1133 (15.85%) and MS1600A x N-2-4-1 (18.50%).

### Table 2.11: Five best performing $F_1$ hybrids during *rabi* 2015-16

| Accessions | MY (t/ha) | TY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | E:P | Heterosis over check |
|---|---|---|---|---|---|---|---|---|---|
| MS48A X 595 | 36.21 | 36.21 | 61.39 | 0.00 | 0.00 | 11.47 | 111.00 | 1.15 | 50.54 |
| MS48A X 592 | 31.23 | 31.88 | 50.39 | 1.55 | 0.00 | 11.39 | 116.33 | 1.08 | 29.84 |
| MS1600A X 595 | 30.42 | 31.67 | 52.65 | 0.00 | 0.00 | 12.13 | 119.00 | 1.10 | 26.50 |
| MS48A X Bhima Shakti | 28.80 | 29.95 | 53.33 | 1.81 | 0.00 | 11.88 | 112.33 | 1.15 | 19.74 |
| MS65A X Bhima Red | 27.18 | 29.08 | 53.84 | 1.29 | 0.00 | 11.53 | 111.00 | 1.02 | 13.01 |
| Bhima Shakti (C) | 24.05 | 25.99 | 49.25 | 0.40 | 0.00 | 11.19 | 116.00 | 1.06 | - |
| HY-441 (C) | 16.90 | 18.55 | 39.73 | 0.00 | 0.00 | 11.61 | 113.67 | 1.04 | - |
| HY-Orient (C) | 15.43 | 17.76 | 44.51 | 0.00 | 0.00 | 11.60 | 115.00 | 0.97 | - |
| C.D. (5%) | 4.65 | 4.41 | 10.72 | 2.35 | 0.00 | 0.38 | 7.16 | - | - |

MY-Marketable Yield, TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio, BSh-Bhima Shakti

During *kharif*, 110 $F_1$ hybrids along with their parents and checks were evaluated. Standard heterosis was recorded up to 30.81% (MS1600A x 546) on marketable yield. Five $F_1$ hybrids *viz;* MS1600A x 546, MS1600A x RGP-4, MS222A x 1629, MS222A x 1605 and MS1600A x 1612 performed better during *kharif* and showed more than 15% heterosis on marketable yield over best check Bhima Dark Red (58.71 t/ha) with uniform sized bulbs (Table 2.12).

**Table 2.12: Five best performing $F^1$ hybrids during *kharif* 2016**

| Accessions | MY (t/ha) | TY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | E:P | Heterosis over check BDR (%) |
|---|---|---|---|---|---|---|---|---|---|
| MS1600A x 546 | 76.80 | 80.27 | 121.26 | 4.32 | 0.00 | 12.08 | 113.00 | 1.11 | 30.81 |
| MS1600A x RGP-4 | 75.10 | 75.10 | 112.65 | 0.00 | 0.00 | 10.96 | 110.00 | 1.02 | 27.92 |
| MS222A x 1629 | 72.73 | 89.28 | 151.53 | 18.53 | 0.00 | 11.48 | 108.00 | 1.12 | 23.89 |
| MS222A x 1605 | 68.40 | 68.40 | 106.88 | 0.00 | 0.00 | 11.64 | 110.00 | 1.09 | 16.50 |
| MS 1600A x 1612 | 67.93 | 73.87 | 119.88 | 8.03 | 0.00 | 11.88 | 115.00 | 1.09 | 15.71 |
| Bhima Dark Red (C) | 58.71 | 62.27 | 97.99 | 5.74 | 0.00 | 11.83 | 120.33 | 0.98 | - |
| Bhima Super (C) | 57.68 | 62.23 | 100.11 | 6.65 | 0.00 | 11.61 | 120.00 | 1.03 | - |
| C.D. (5%) | 6.38 | 7.00 | 13.10 | 13.05 | 8.57 | 0.48 | 8.66 | - | - |

MY-Marketable Yield, TY-Total Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest, E:P-Equatorial and Polar ratio, BDR-Bhima Dark Red

### Hybrids in early generations of evaluation

Eighteen crosses made between early maturing advance line DOGR-1203 and selected 18 elite lines were evaluated in $F_3$ stage during *rabi* season. Crosses with DOGR-595, DOGR-571 and Bhima Super were found promising for achieving uniform neck-fall and earliness (80-81days after transplanting). Out of 68 $F_4$ population from crossing between short day lines with exotic lines, four population found promising and early maturity (81-82 days after transplanting). Out of 60 $F_2$ populations developed through male sterile lines, two found promising with dark red uniform bulbs and also free from doubles and bolters with early maturity (80-82 days after transplanting). Further, 110 $F_1$ hybrids of red onion were developed by crossing between five MS lines (MS 48A, MS 65A, MS 111A, MS 222A and MS 1600A) with selected 22 elite lines as pollinators (546-DR, 571-LR, KH-M-1, KH-M-2, RGP-1, RGP-2, RGP-3, RGP-4, RGP-5, 1604, 1605, 1606, 1607, 1608, 1609, 1612, 1613, 1629, 1630, 1657, 1663 and 1666). Their evaluation during *rabi* 2016-17 is in progress. Another evaluation of 15 synthetic crosses made between selected six elite lines and their evaluation is in progress. Advancement of 18 combinations between selected elite lines with DOGR-1203-DR to enhance earliness and bulb storability is also in progress.

### DOGR Hy-8 introduced in AINRPOG trial

DOGR Hy-8 is $F_1$ hybrid suitable for late *kharif* season and its bulbs are flat-globe with medium red. It produced uniform bulbs and free from doubles and bolters. In last two years, this hybrid produced 54.45 t/ha average marketable yield which is 23.57% higher than best check Bhima Shakti (44.06 t/ha). The average bulb weight was 83.33 g with thin neck. These bulbs can be harvested 118 days after transplant and good in storage (Table 2.13).

### Table 2.13a: Marketable yield and total yield of DOGR Hy-8

| Entries | Marketable yield (t/ha) | | | | Total yield (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | Late *kharif* 2012-13 | Late *kharif* 2013-14 | Mean | % Increase over best Check (Mean) | Late *kharif* 2012-13 | Late *kharif* 2013-14 | Mean | % Increase over best Check of Mean |
| DOGR Hy-8 | 53.33 | 55.56 | 54.45 | 23.57 | 60.00 | 55.56 | 57.78 | 18.62 |
| Bhima Shakti (C) | 45.08 | 43.04 | 44.06 | - | 51.11 | 46.31 | 48.71 | - |
| Bhima Super (C) | 42.70 | 38.30 | 40.50 | - | 47.94 | 42.59 | 45.27 | - |
| Arka Kirtiman (C) | 18.72 | 37.06 | 27.89 | - | 30.95 | 46.13 | 38.54 | - |
| Arka Lalima (C) | 27.94 | 29.52 | 28.73 | - | 41.33 | 40.29 | 40.81 | - |
| C.D. (5%) | 6.50 | 4.24 | 5.37 | - | 8.68 | 3.96 | 6.32 | - |

### Table 2.13b: Double bulbs, bolters and days to maturity of DOGR Hy-8

| Entries | Double bulbs (%) | | | Bolter bulbs (%) | | | Days to maturity | | |
|---|---|---|---|---|---|---|---|---|---|
| | Late *kharif* 2012-13 | Late *kharif* 2013-14 | Mean | Late *kharif* 2012-13 | Late *kharif* 2013-14 | Mean | Late *kharif* 2012-13 | Late *kharif* 2013-14 | Mean |
| DOGR Hy-8 | 0.00 | 0.00 | 0.00 | 7.78 | 0.00 | 3.89 | 120.00 | 115.00 | 117.50 |
| Bhima Shakti (C) | 0.65 | 1.32 | 0.99 | 8.70 | 4.98 | 6.84 | 125.00 | 122.00 | 123.50 |
| Bhima Super (C) | 3.20 | 0.00 | 1.60 | 6.18 | 9.82 | 8.00 | 124.33 | 112.67 | 118.50 |
| Arka Kirtiman (C) | 3.63 | 5.42 | 4.53 | 30.59 | 12.55 | 21.57 | 126.00 | 118.00 | 122.00 |
| Arka Lalima (C) | 4.02 | 0.84 | 2.43 | 28.00 | 25.42 | 26.71 | 126.67 | 114.00 | 120.34 |
| C.D. (5%) | 6.07 | 2.69 | 4.38 | 13.70 | 15.94 | 14.82 | 1.25 | 1.82 | 1.54 |


Figure 2.3: DOGR Hy-8

### Development of male sterile lines and inbreds in onion

Purification and multiplication of five red onion male sterile lines were continued with the selected bulbs. Two combinations are in $BC_2$ stage and three combinations in $BC_3$ stage for transfer of male sterility in different varietal background of DOGR released varieties. Development of inbred lines from single bulb of selected parents (127 inbreds in $I_1$ and 16 inbreds in $I_2$ stage) are in progress.

During *rabi* 2015-16, about 5000 individual umbels of different varieties/ lines were observed to search

naturally occurred male sterile plant. This activity was undertaken in the onion breeding/ improvement block of ICAR-DOGR, Rajgurunagar which includes germplasm, advance breeding lines, varieties planted for maintenance under DUS project and commercial seed production plot. Out of 5000 screened plantlets, two red onion lines one from 'RGP-4-Sel' and another from 'Arka Kalyan' (Fig. 2.4) showed male sterility. Pollens of these two new naturally occurred male sterile lines were also confirmed through acetocarmine test. Multiplication/ development of maintainer lines as well as confirmation through DNA are under progress.

Male sterile flowers in RGP-4-Sel

Male fertile flowers in RGP-4-Sel

Male sterile flowers in Arka Kalyan

Male fertile flowers in Arka Kalyan

Male sterile pollens in RGP-4-Sel

Male fertile pollens in RGP-4-Sel

Figure 2.4: New male sterile lines in *Allium* cepa L.

## Evaluation of white onion F1 hybrids

Sixteen $F_1$ hybrids using MS lines were evaluated in *rabi*. Five $F_1$'s reported positive heterosis of more than 20% over parents and check. Cross MS-100 x W-085 recorded 54.46% heterosis over parent and 24.86 % heterosis over check Bhima Shweta, followed by cross MS-100 x W-147 (38.14% and 54.19% heterosis) MS-100 X W-396 (35.65 and 39.16%) and MS-100 X W-507(30.71 and 53.01%) over parent and check Bhima Shweta. Among these superior crosses, MS-100 x W-085 recorded lowest weight loss of 16.47% followed by MS-100 X W-507(21.17%), (Table 2.14).

**Table 2.14: Evaluation of white onion $F_1$ hybrids during *rabi***

| Hybrids | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Storage loss after 3 months of storage (%) | Heterosis over respective check(%) | Superiority overBhima Shweta(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Hy-W-1-16Rb | 25.70 | 23.39 | 50.67 | 0.07 | 0.00 | 10.91 | 120.67 | 29.33 | 14.56 | 06.43 |
| Hy-W-2-16Rb | 28.39 | 28.39 | 53.23 | 0.00 | 0.00 | 10.80 | 121.00 | 16.47 | 54.46 | 24.86 |
| Hy-W-3-16Rb | 37.80 | 36.34 | 68.81 | 0.00 | 0.00 | 10.85 | 137.50 | 32.61 | 38.14 | 54.19 |
| Hy-W-4-16Rb | 31.84 | 31.84 | 51.07 | 0.00 | 0.00 | 10.47 | 122.67 | 40.18 | 23.02 | 37.58 |
| Hy-W-5-16Rb | 36.80 | 36.22 | 59.45 | 0.00 | 0.00 | 10.90 | 139.50 | 15.25 | 02.61 | 53.76 |
| Hy-W-6-16Rb | 27.79 | 26.68 | 43.59 | 2.81 | 0.00 | 10.70 | 122.00 | 22.10 | 09.98 | 18.55 |
| Hy-W-7-16Rb | 36.47 | 36.02 | 56.88 | 1.22 | 0.00 | 10.50 | 122.00 | 21.17 | 30.71 | 53.01 |
| Hy-W-8-16Rb | 43.11 | 43.11 | 71.85 | 0.00 | 0.00 | 10.80 | 120.00 | 39.69 | 35.65 | 79.16 |
| Bhima Shweta (C) | 27.76 | 27.11 | 53.75 | 0.43 | 0.62 | 11.76 | 121.67 | 23.64 | - | - |
| C.D. (5%) | 05.16 | 05.29 | 08.47 | 1.01 | 0.35 | 01.13 | 14.61 | 22.26 | - | - |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

During *kharif,* 14 crosses evaluated in 1x1 sq. m plot and 5 in 1x6 sq. m plot. In 1x1 sq.m plot six crosses reported higher than 40% heterosis over parent *viz.,* Cross MS-100 x W-197 (77.37%), MS-100 x W-396 (72.02%) , MS-100 X W-361 (54.88%), MS-100 X W-344 (50.94%),MS-100 X W-523 (43.55%) and MS-100 X W-085 (40.48%).Highest marketable bulb weight of MS-100 XW- 344 (106.40g) followed by MS-100 X W-197 (90.66g).Most of the crosses were matured in 107 days. In 1x6 sq. m plot two crosses MS-100 x Phule Safed and MS-100 x Bhima Shweta reported 15.34 and 20.39% heterosis over check. Ms-100 X Bhima Shweta reported 40.13% superiority over Bhima Shubhra (Table 2.15a&b).

**Table 2.15a: Evaluation of white onion $F_1$ hybrids during kharif in 1x1 sq.m plot**

| Hybrid | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Heterosis over respective check(%) | Superiority over Bhima Shubhra(%) |
|---|---|---|---|---|---|---|---|---|---|
| Hy-W-2-16Kh | 46.04 | 25.16 | 87.08 | 44.40 | 0.00 | 13.04 | 109.0 | 40.48 | -46.74 |
| Hy-W-4-16Kh | 42.90 | 39.17 | 75.60 | 11.44 | 0.00 | 12.72 | 109.7 | 16.39 | -17.08 |

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| Hybrid | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Heterosis over respective check(%) | Superiority over Bhima Shubhra(%) |
|---|---|---|---|---|---|---|---|---|---|
| Hy-W-8-16Kh | 52.46 | 34.55 | 79.51 | 32.46 | 0.00 | 12.60 | 109.5 | 72.02 | -26.87 |
| Hy-W-9-16Kh | 56.30 | 44.15 | 90.66 | 21.16 | 0.00 | 12.28 | 110.0 | 77.37 | -06.55 |
| Hy-W-10-16Kh | 49.47 | 47.29 | 106.4 | 02.61 | 0.00 | 12.60 | 110.0 | 50.94 | 00.11 |
| Hy-W-11-16Kh | 49.09 | 48.45 | 79.48 | 00.88 | 0.00 | 13.62 | 109.5 | 54.88 | 02.55 |
| Hy-W-12-16Kh | 47.53 | 42.44 | 78.77 | 06.51 | 0.00 | 13.16 | 109.7 | 15.79 | -10.17 |
| Hy-W-13-16Kh | 42.70 | 36.03 | 78.81 | 13.83 | 0.00 | 14.28 | 109.0 | 43.55 | -23.73 |
| Bhima Shubhra ( C ) | 48.83 | 47.24 | 79.18 | 02.14 | 0.00 | 12.72 | 109.7 | -- | -- |
| C.D. (5%) | 8.19 | 8.60 | 8.34 | 10.11 | 0.00 | 0.81 | 0.5 | -- | -- |

**Table 2.15b: Evaluation of white onion $F_1$ hybrids during kharif in 1x 6 sq.m plot**

| Hybrid | TY (t/ha) | MY (t/ha) | MBW (g) | Doubles (%) | Bolters (%) | TSS (%) | DTH | Heterosis over respective check (%) | % Superiority over B. Shubhra |
|---|---|---|---|---|---|---|---|---|---|
| Hy-W-1-16Kh | 40.49 | 35.27 | 69.30 | 9.23 | 0.00 | 12.80 | 107 | 15.34 | 07.66 |
| Hy-W-14-16Kh | 49.31 | 45.91 | 78.94 | 5.51 | 0.00 | 13.26 | 107 | 20.39 | 40.13 |
| Hy-W-15-16Kh | 41.12 | 40.07 | 69.06 | 1.89 | 0.00 | 13.22 | 107 | 02.33 | 22.29 |
| Bhima Shubhra (C ) | 40.25 | 32.76 | 67.42 | 16.0 | 0.00 | 12.81 | 106 | -- | -- |
| C.D. (5%) | 06.23 | 05.06 | 10.93 | 8.68 | 0.00 | 1.16 | 0.22 | -- | -- |

TY-Total Yield, MY-Marketable Yield, MBW-Marketable Bulb Weight, TSS-Total Soluble Solids, DTH-Days to Harvest

Two white onion hybrids were introduced under initial evaluation trial in All India Network Research Project on Onion and Garlic at 27 locations.

## Biotechnological approaches for improvement of onion and garlic

### Haploid induction in onion

A total of 14000 flower buds were cultured for six varieties of onion of which 703 gynogenic shoots were induced (Table 2.15). The ploidy status was assessed through cytology for 190 gynogenic plantlets and 171 were confirmed as haploids. 246 No. of gynogenic shoots (from 10 varieties) of last season were maintained. Out that 157 are tested on flow cytometry for ploidy level, 90 were found haploid while 37 were diploid. Haploid plant was treated with colchicine 2.5mM for 24 hrs and was transplanted in field for hardening. To refine the doubling protocol, an experiment was conducted with two concentrations (2.5 and 5mM) of colchicine tried for two different durations (24 and 36 hours). The Plants are yet to be tested for doubling.

**Table 2.15: Haploid induction in onion**

| Name of the variety | No. of Onion flower inoculated | No. of shoots induced | No. of Plants tested by cytology | No. of Haploid plants |
|---|---|---|---|---|
| Bhima Kiran | 3689 | 89 | 15 | 17 |
| Bhima Dark Red | 2387 | 113 | 32 | 29 |
| Bhima Raj | 2376 | 90 | 22 | 18 |
| ADR | 2145 | 133 | 20 | 19 |
| Bhima Super | 2310 | 203 | 67 | 60 |
| Bhima Shubhra | 1296 | 75 | 34 | 31 |
| Total | 14203 | 703 | 190 | 171 |

## Breeding for Anthracnose resistance in onion

Being an annual crop, onion encounters wide range of abiotic and biotic stresses during its life span. Among the biotic stresses, fungal pathogens are most prevalent, causing severe crop loss annually. Anthracnose caused by *Colletotrichum gloeosporioides*, is currently one of the most destructive disease that significantly affects the production of onion. Management of this disease is difficult as it has short and multiple disease cycles with several generations within a single crop season. Therefore, it requires repeated applications of fungicides. Although, the applications of protectant and eradicant fungicides have shown encouraging results, it leaves certain side effects like phytotoxicity and fungicide residues on crop. Available bio-controls derived from antagonists were not found to be very effective. Furthermore, genetic improvement of resistance against anthracnose has suffered due to rare availability of resistant accession, highly heterozygous nature, self-incompatibility. In this context mutagen breeding for onion improvement was followed where the onion seeds were treated with various concentrations of sodium azide a chemical mutagen and generated M1 lines. Further M2 lines will be developed for selection of anthracnose resistant/tolerant lines (Figure 2.5).

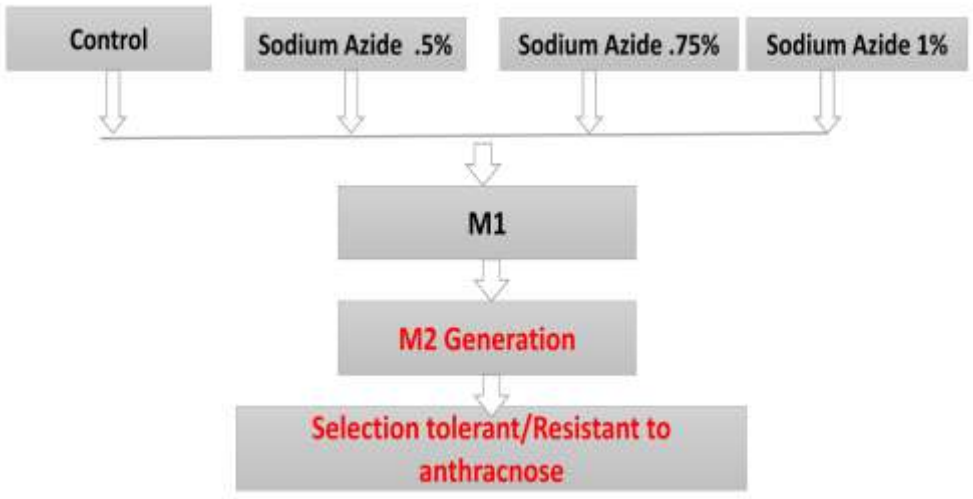



Figure 2.5: A generalised scheme for mutation breeding for an anthracnose resistant/tolerant trait of onion

### Standardization of DNA isolation protocol in onion

Secondary metabolites are reported to interfere with the isolation of DNA. So a rapid and less cumbersome system for isolation of DNA was essential to facilitate any study related to genetic improvement of onion. Onion tissues have phenolic compounds, which get oxidized and bind to DNA and hinder DNA isolation and/or downstream applications. The present study involved standardization of CTAB method for isolation of genomic DNA. So in this context various combinations of Tris HCL, NaCl, EDTA, CTAB, BME, PVP were used, of which, 1M Tris HCL, 5MNacl, 0.5M EDTA, PVP,15% CTAB, 4% BME provide higher yield of genomic DNA (Figure 2.6a). Further DNA quality was confirmed by amplification with SSR marker (Figure 2.6b). This method of DNA isolation can be used for further onion genotypic improvement.

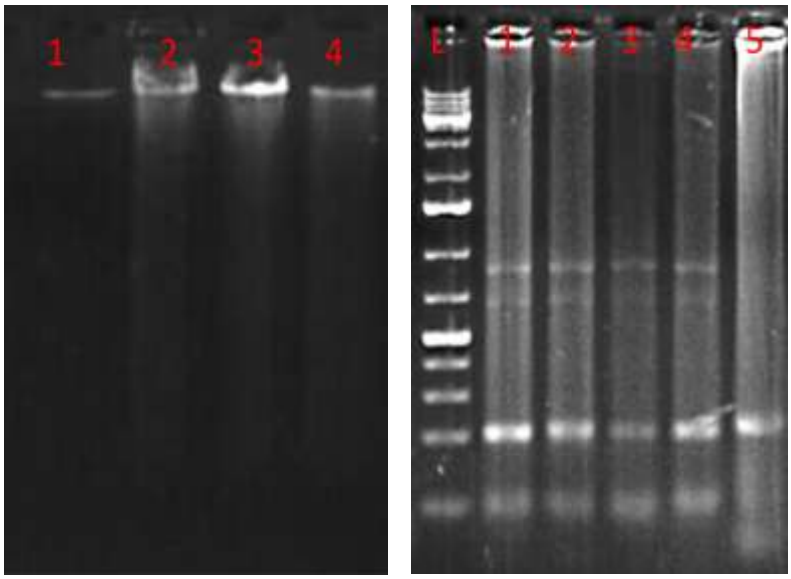



Figure 2.6 (a) DNA isolation (1:5%PVP, 2:10% PVP, 3:15% PVP, 4:20% PVP), (b) DNA amplification with DNA isolated from 15% PVP CTAB extraction buffer (1-5 onion leaf from different variety, L- Ladder)

### Creation of somaclonal variation in garlic

Using standard protocol of *in vitro* generation of plantlets through root tip callusing, 245 plantlets were developed (excluding contaminated and dead plants) in three garlic varieties namely Bhima Purple, Bhima Omkar and G-41. In regenerated plantlets, morphological observations were made in three replicates with ten plants per each replication. Furthermore, these tested plantlets were ranked in ascending order of 1, 2, and 3 for their respective traits. Plant age ranges from 0.9 to 1.5 year, shooting 0.5 to 2.5, rooting 0.5 to 2.5 and bulbing status 1 to 3. Morphological analysis of *in vitro* plantlets revealed no visible and remarkable somaclonal variations among tested varieties (Table 2.16).

**Table 2.16 General status of *in vitro* regenerated plantlets through callus**

| Variety | Shooting | Rooting | Plant status |
|---|---|---|---|
| Bhima Purple | Leaves become dried and yellowish in color | No new root emergence | Bulb has formed |
| G-41 | Leaves are dried and yellowish | No new rooting | Bulb formation observed |
| Bhima Omkar | Leaves become yellowish but not necrotic | Three to four roots per plant | Bulb formation initiated |

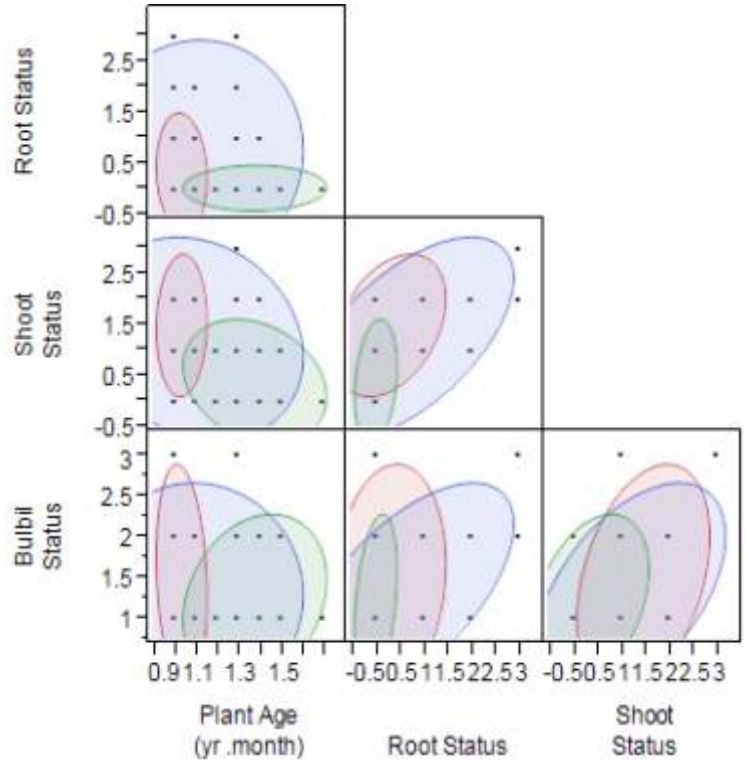



Figure 2.7: Scatter plot metrics showing overall combine multivariate effect. Blue effect is of Bhima Omkar, Green is of Bhima Purple and Red is of G-41

## Effect of harmones on flower induction in garlic

Flower induction in garlic is highly limited to photoperiod and temperature in which it is been cultivated. During *rabi*, three garlic cultivars namely, Gadag Local, CITH-5 and local garlic cultivar were planted in field. On 30$^{th}$ day after planting, 30 plants in two replications were subjected to long day photoperiod (9 hours day light followed by 10 hours supplemented light of 4 µmol $m^{-2}$ $s^{-1}$ PAR using LED Lamps of 400W), Gibberillic acid (GA3) and 6-Benzyl amino purine (BAP) treatments. The treatment details are as follows; T1: long day photoperiod, T2: long day photoperiod + GA3 200ppm, T3: long day photoperiod + BAP 200ppm, T4: long day photoperiod + GA3 200ppm + BAP 200ppm, T5: GA3 200ppm, T6: BAP 200ppm and T7: GA3 200ppm + BAP 200ppm and T8: Control. No significant difference was observed for morphological traits in the studied cultivars for different treatments. However, treatments failed to induce the flowering in the studied genotypes and this might be due to some environmental factors.

## Registration of Lines/ Varieties

### Bhima Kiran and Bhima Red

Two red onion extant varieties i.e. Bhima Kiran (Application No. of E1 AC8 15 2014 dated 19 Nov, 2015 and Registration No. 341 of 2016 dated 22 October, 2016) and Bhima Red (Application No. of E2 AC9 15 2015 dated 26 Nov, 2015 and Registration No. 342 of 2016 dated 22 October, 2016) have been registered with PPV&FRA, New Delhi for its protection. Registration of five onion varieties *viz.*, Bhima Dark Red, Bhima Shubhra, Bhima Shweta, Bhima Shakti and Bhima Super, and one garlic variety Bhima Omkar is in progress.

### DOGR-1549-Agg

DOGR-1549-Agg has been registered with ICAR-NBPGR, New Delhi. It has been provided the national identity, IC-0616539 and Registration No. INGR16006 vide approval of the Plant Germplasm Registration Committee (PGRC) of ICAR. 'DOGR-1549-Agg' is the first multiplier onion genotype registered with ICAR-NBPGR as a unique genetic stock. It is about one week earlier than popular variety CO-5 and is suitable for both *rabi* and *kharif.* It has six uniform pink bulblets per bulb.


Figure 2.8: Bhima Light Red

## Varieties identified at National Level

### Bhima Light Red

Onion variety DOGR-571-LR developed by ICAR-DOGR has been recommended for release in Annual Group Meeting of All India Network Research Project on Onion and Garlic (AINRPOG) held at Kanpur, Uttar Pradesh on 4-5 April, 2016. It has been christened as 'Bhima Light Red'. It is recommended for cultivation in *rabi* season in Karnataka and Tamil Nadu. It is a medium maturing (115 days after transplanting) variety having light red globe bulbs of about 70 g with thin neck and total soluble solids of 13%. Its average yield in multi location trials in the recommended zone was 385 q/ha. Total weight losses after four months of storage were less than 25%. It is almost free of doubles and bolters.

### Bhima Super

Red onion variety Bhima Super has been recommended for notification vide Minutes of the 24th Meeting of Central Sub-Committee on Crop Standards, Notifications and Release of Varieties for Horticultural Crops held under the Chairmanship of Dr. A. K. Singh, DDG (Hort.), ICAR, Krishi Bhavan, New Delhi on 22.9.2016 (No. 3-50/2016-SD.IV dated 02.11.2016). It is recommended for *kharif* in Chhattisgarh, Delhi, Gujarat, Haryana, Jammu, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan and Tamil Nadu. It has attractive red bulbs, maturity 100-105 days after transplanting, average yield 22-26 t/ha, potential yield 48 t/ha and 30-45 days bulbs storability. It has very less frequency of doubles and bolters. It contains maximum number of single centred bulbs and is suitable for making dehydrated rings as well as salad.

Figure 2.9: Bhima Super

Figure 2.10: Bhima Shakti

### Bhima Shakti

Onion variety Bhima Super has also been recommended for notification vide Minutes of the 24th Meeting of Central Sub-Committee on Crop Standards, Notifications and Release of Varieties for Horticultural Crops held under the Chairmanship of Dr. A. K. Singh, DDG (Hort.), ICAR, Krishi Bhavan, New Delhi on 22.9.2016 (No. 3-50/2016-SD.IV dated 02.11.2016). It is recommended for *rabi* in Andhra Pradesh, Chhattisgarh, Karnataka, Madhya Pradesh, Maharashtra and Odisha. It has attractive red bulbs, maturity 125-135 days after transplanting, average yield 32-36 t/ha with potential yields up to 52 t/ha, very good bulbs storability up to five months. Its bulb attains immediate attractive red colour after harvest with uniform neck-fall. It is also suitable for late *kharif* in Maharashtra.

# Crop Production

## Project 3: Integrated water and nutrient management and physiological manipulation for improving productivity of onion and garlic

The production and productivity of onion and garlic could be enhanced if genetic improvement is supplemented with improved production practices. This project aims in developing sustainable production technology through production of healthy and virus free garlic propagules, improved onion seed quality, fertilizers scheduling, mechanization in garlic planting, direct seeding in onion and various physiological response in onion under drought stressed condition. The results obtained are presented here.

### Virus free garlic production and their mass multiplication

Virus diseases are significantly affecting (up to 80% crop loss) commercial production of garlic. Using meristem culture, 200 mericlones were generated and tested for virus among which 27 were found virus free. Further, mass multiplication media standardized using various concentrations of BAP and NAA (Figure 3.1a). Additionally 100 micro-bulbils were developed from multiplied garlic plantlets (Figure 3.1b). Moreover, 400 mericlones were produced using heat therapy in combination of meristem tip culture (Figure 3.1c).

### Weed management in onion

A field experiment was conducted to evaluate the effect of different herbicides on weed control efficiency of onion cv. Bhima Super with ten treatments during *kharif* 2015-16. The results showed that pre-emergence application of pendimethalin 30% EC application before planting and one hand weeding at 45 days after transplanting found better for marketable yield and weed control efficiency followed by pre-emergence application of pendimethalin 30% EC application before planting and post-emergence application of fluazifop-p-butyl 12.5% EC at 30 days after transplanting, and combination of pre-emergence application of Pendimethalin 30% EC application before planting, Fluazifop-p-butyl 12.5 EC application at 30 days after transplanting and

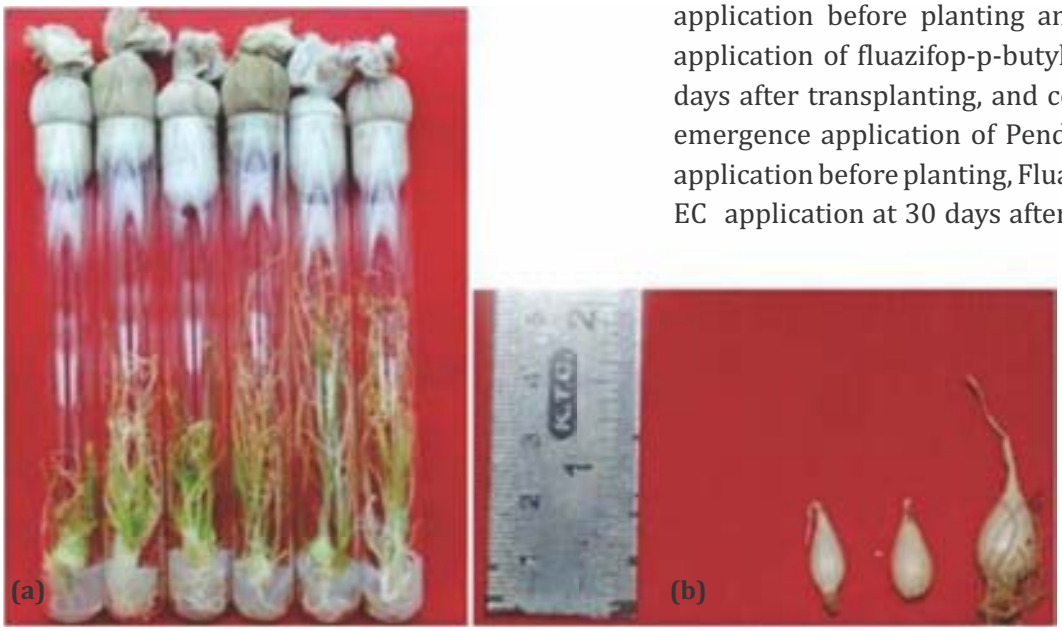



Figure 3.1 a & b: Mass multiplication and micro-bulbils development

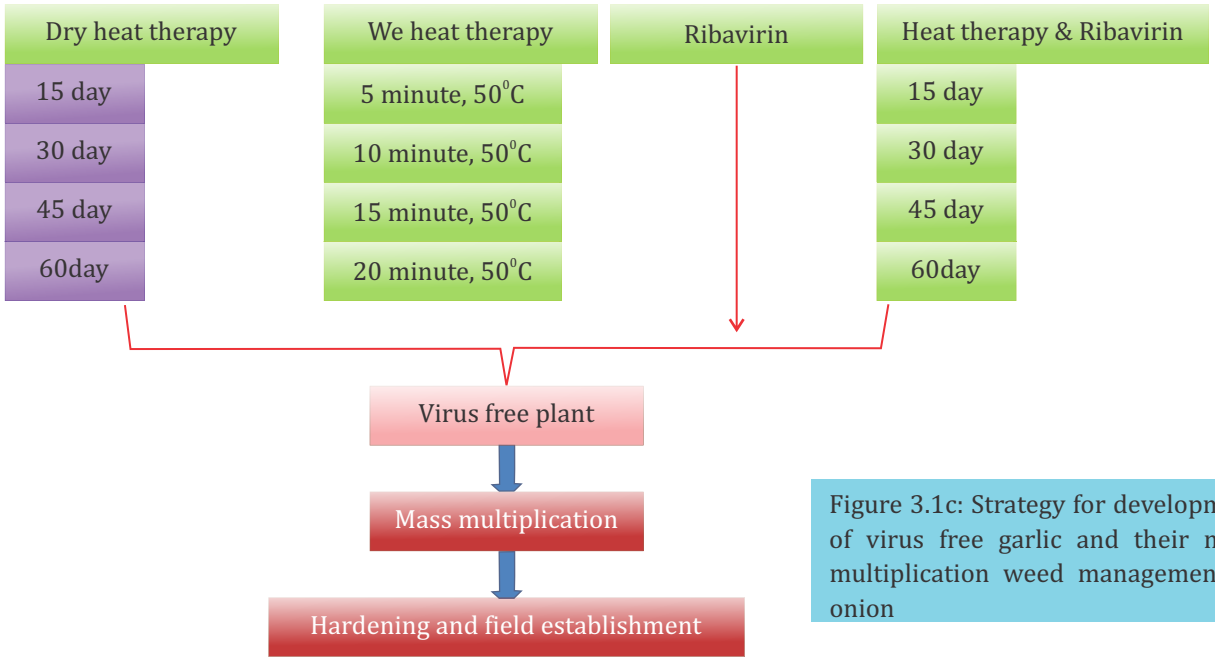



Figure 3.1c: Strategy for development of virus free garlic and their mass multiplication weed management in onion

one hand weeding (HW) at 60 days after transplanting (Fig. 3.2 and 3.3). Pre-emergence application of pendimethalin 30% EC application before planting and one hand weeding at 45 days after transplanting showed 340% more yield than control and 127% more yield than ICAR-DOGR recommended practice (Oxyflurofen 23.5% EC application before planting + one hand weeding at 40-60 days after transplanting (DAT)). All treatments showed significant reduction in total weed population as compared to untreated control during the *kharif* season.

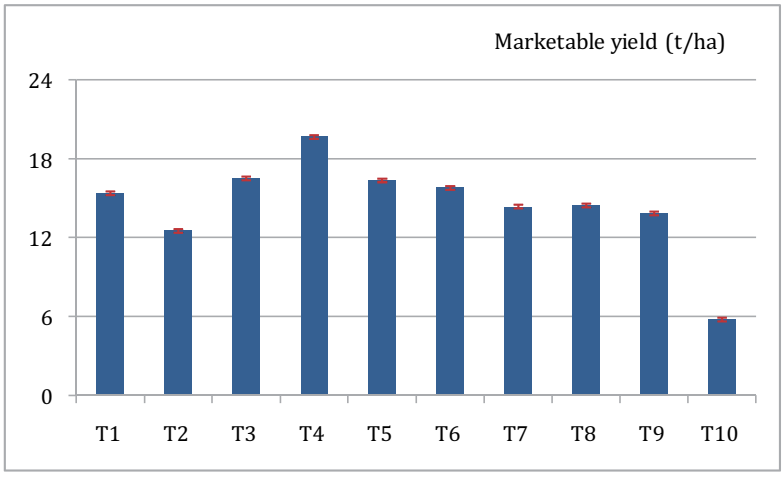



Figure 3.2: Effect of weed management on Marketable yield (t/ha) of onion during *kharif*

Treatments: T1- Oxyflurofen before planting + one HW at 40-60 DAT, T2- Oxyflurofen before planting + Fluazifop-p-butyl 30 DAT, T3- Oxyflurofen before planting + Fluazifop-p-butyl 30 DAT + one HW at 40-60 DAT, T4- Pendimethalin before planting + one HW at 40-60 DAT, T5- Pendimethalin before planting + Fluazifop-p-butyl 30 DAT, T6- Pendimethalin before planting + Fluazifop-p-butyl 30 DAT + one HW at 40-60 DAT, T7- Oxyflurofen before planting + Quizalofop Ethyl 30 DAT, T8- Oxyflurofen before planting + Quizalofop Ethyl 30 DAT + one HW at 40-60 DAT, T9- Weed free (four hand weeding at 15, 30, 45 and 60 DAT, T10- Weedy check, Error bar of mean indicates the difference of significance at p=0.05.

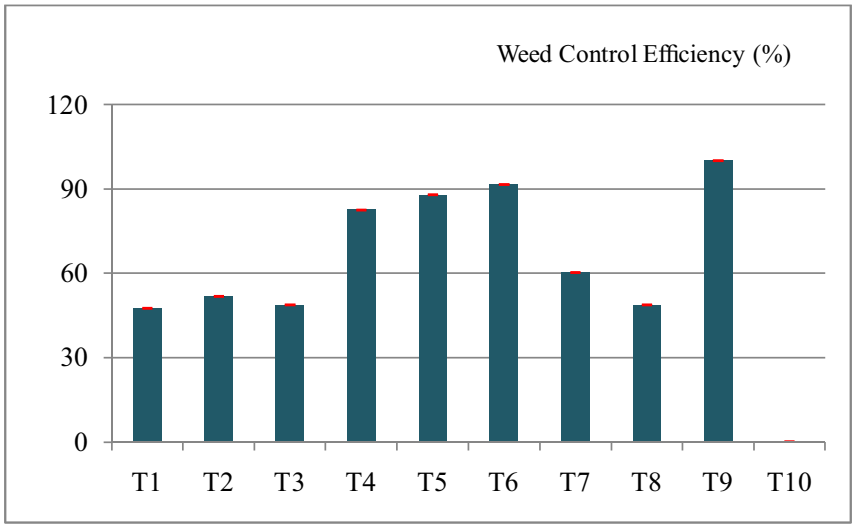



Figure 3.3: Effect of weed management on Weed Control Efficiency (WCE) during kharif

Treatments: T1- Oxyflurofen before planting + one HW at 40-60 DAT, T2- Oxyflurofen before planting + Fluazifop-p-butyl 30 DAT, T3- Oxyflurofen before planting + Fluazifop-p-butyl 30 DAT + one HW at 40-60 DAT, T4- Pendimethalin before planting + one HW at 40-60 DAT, T5- Pendimethalin before planting + Fluazifop-p-butyl 30 DAT, T6- Pendimethalin before planting + Fluazifop-p-butyl 30 DAT + one HW at 40-60 DAT, T7- Oxyflurofen before planting + Quizalofop Ethyl 30 DAT, T8- Oxyflurofen before planting + Quizalofop Ethyl 30 DAT + one HW at 40-60 DAT, T9- Weed free (four hand weeding at 15, 30, 45 and 60 DAT, T10- Weedy check, Error bar of mean indicates the difference of significance at p=0.05.

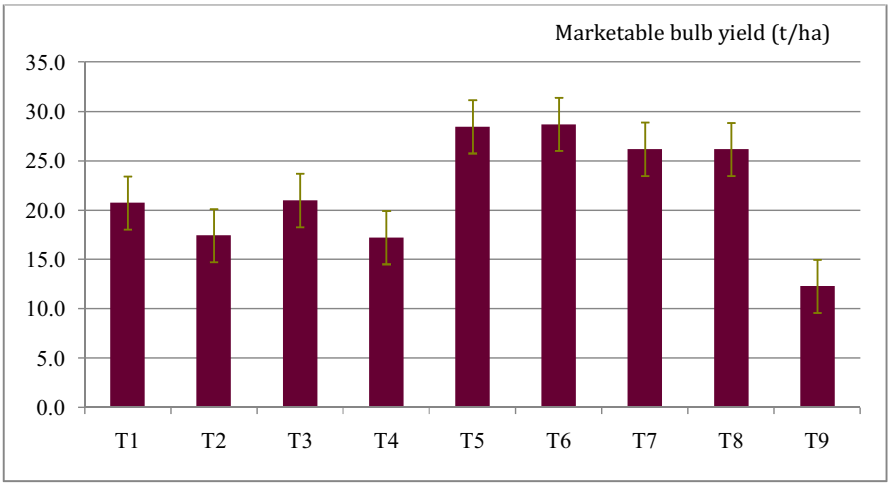
## Effect of planting methods on growth and yield of garlic

Mechanization in garlic cultivation is gaining importance due to labour scarcity. The main idea behind having garlic planter is to drop individual garlic cloves at specified distance. When garlic cloves are being dispensed from the hopper into the soil, it is not certain that the clove is placed in vertical direction as of planted manually. The clove is either dropped vertically, reverse or in inclined position. To see whether the position of placing the clove affects the plant germination, growth and yield of garlic, an experiment was conducted using variety Bhima Purple during *rabi* 2016-17 with treatments-1: manually planted in vertical position, 2: manually planted in reverse direction, 3: manually planted in inclined position 4: machine planted. Data on plant height, mortality and total yield were noted. Plant height was found to be significantly different with least height being recorded in plants planted in reverse direction as compared to all other. However, no significant difference was observed regarding number of leaves in different planting methods. Germination percentage was more in vertical position (95.29%) followed by reverse (86.65%) and then inclined position (73.37%). While, the total yield obtained was found to be high (39.37q/ha) in inclined planting followed by vertical (35.21q/ha) and then reverse direction (24.96 q/ha). Due to poor crop stand, the yield received through machine planting was very low (2.54 q/ha).

## Permanent manurial experiment: Effect of continuous of inorganic fertilizers and manures on onion production and soil quality

Permanent manurial experiment was initiated during *rabi* 2013-14 with eight treatments. Each block was assigned for specific fertilizer treatment and care was taken to avoid mixing of soil from one block to another. Vermicompost (VC) @ 10 t/ha was included as ninth treatment during 2015-16. Field experiment was carried out to monitor the effect of soybean and maize (*kharif*) - onion (*rabi*) cropping system and four fertilizer treatments on onion production, soil fertility status and soil health. The results showed that inclusion of maize as preceding crop and application of inorganic fertilizers along with VC produced significantly higher bulb yield compared to treatments that received inorganic fertilizers alone. In case of soybean - onion cropping system, integrated use of VC with

inorganic fertilizer *i.e.* 75% Recommended dose of fertilizers (RDF), and 75% RDF alone produced significantly higher bulb yield over rest of the fertilizer treatments (Figure 3.4). Application of 10 t VC/ha showed 12.3 t yield which was significantly lesser than other fertilizer treatments. Inclusion of maize as preceding crop and application of inorganic fertilizers along with Vermicompost increased nutrient uptake than in soybean-onion system (Table 3.1). The soil available nutrient content observed during *rabi* 2015-16 are presented in Table 3.2. Application of Vermicompost along with inorganic fertilizers showed higher soil organic carbon (SOC), soil available N, P and S as compared to inorganic fertilizer alone applied treatments.




Treatments: T1- Soybean:75% RDF+7.5 t VC/ha, T2- Soybean: 100% RDF+10 t VC/ha, T3- Soybean:75% RDF, T4- Soybean:100% RDF, T5- Maize:75% RDF+7.5 t VC/ha, T6- Maize: 100% RDF+10 t VC/ha, T7- Maize: 75% RDF, T8- Maize:100% RDF, T9- 10 t VC/ha. Error bar of mean indicates the difference of significance at p=0.05.

Figure 3.4: Effect of different levels of fertilizers and preceding crops on bulb yield (t/ha) in onion

**Table 3.1: Effect of different levels of fertilizers and preceding crops on plant nutrient uptake**

| | Major nutrient (kg/ha) | | | | Micronutrients (g/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | **N** | **P** | **K** | **S** | **Fe** | **Mn** | **Zn** | **Cu** |
| T1 | 89.4ab | 15.7a | 81.5a | 16.4a | 1694.7a | 147.1a | 83.3ab | 64.7a |
| T2 | 87.5ab | 14.7a | 81.8a | 19.0ab | 1344.5a | 159.0ab | 76.5a | 66.0a |
| T3 | 87.6ab | 16.7a | 91.4ab | 21.8b | 1607.8a | 182.7ab | 88.6ab | 70.9a |
| T4 | 86.4a | 15.7a | 82.3a | 20.0ab | 1406.3a | 176.4ab | 79.8ab | 67.4a |
| T5 | 92.1ab | 16.9a | 89.8ab | 19.0ab | 1860.0a | 226.5cd | 108.0bc | 69.3a |
| T6 | 91.2ab | 19.1a | 96.7b | 23.6b | 2013.0a | 240.4d | 131.1c | 73.0a |
| T7 | 92.3ab | 16.3a | 90.6ab | 20.7ab | 1663.8a | 224.1cd | 92.6ab | 63.6a |
| T8 | 94.3b | 16.0a | 83.0a | 20.2ab | 1735.5a | 196.7bc | 102.9 | 57.7a |

Treatments: T1- Soybean: 75% RDF+7.5 t VC/ha, T2- Soybean:100% RDF+10 t VC/ha, T3- Soybean:75% RDF, T4- Soybean:100% RDF, T5- Maize:75% RDF+7.5 t VC/ha, T6- Maize: 100% RDF+10 t VC/ha, T7- Maize: 75% RDF, T8- Maize:100% RDF, T9- 10 t VC/ha. Values in the same column followed by the same letters are not significantly different at P =0.05.

**Table 3.2: Effect of continuous use of inorganic fertilizers and manures on SOC and soil fertility status**

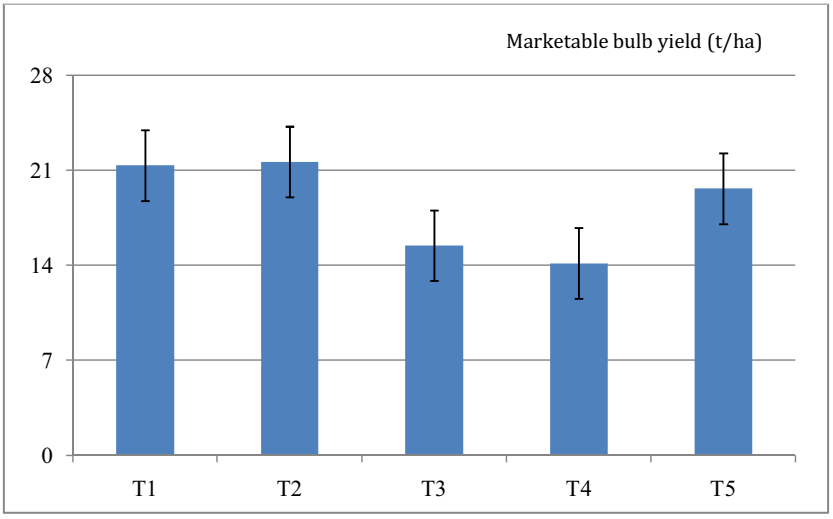
| Treatments | pH | EC | SOC | N | P | K | S |
|---|---|---|---|---|---|---|---|
| T1 | 7.82a | 0.20a | 0.65b | 156.8bcd | 40.6 | 455.3de | 18.1a |
| T2 | 7.85a | 0.21a | 0.62b | 167.3d | 42.5d | 401.3cd | 30.0bc |
| T3 | 8.01a | 0.18a | 0.52a | 150.5abc | 24.5a | 346.1bc | 20.8ab |
| T4 | 7.90a | 0.20a | 0.59ab | 159.9cd | 28.5ab | 515.2e | 21.1ab |
| T5 | 7.50b | 0.20a | 0.65b | 141.1abc | 36.2bc | 245.6a | 26.2abc |
| T6 | 7.41b | 0.21a | 0.68b | 138.0abc | 34.0abc | 259.6ab | 33.4d |
| T7 | 7.54b | 0.18a | 0.60ab | 128.6a | 31.7abc | 408.8cd | 28.9bc |
| T8 | 7.60b | 0.19a | 0.57ab | 134.8ab | 28.1ab | 377.4cd | 26.1abc |

Treatments: T1- Soybean-75% RDF+7.5 t VC/ha, T2- Soybean-100% RDF+10 t VC/ha, T3-Soybean-75% RDF, T4- Soybean:100% RDF, T5- Maize:75% RDF+7.5 t VC/ha, T6- Maize : 100% RDF+10 t VC/ha, T7- Maize: 75% RDF, T8- Maize: 100% RDF, T9- 10 t VC/ha, Values in the same column followed by the same letters are not significantly different at P =0.05.

## Fertilizer scheduling through drip irrigation

### Onion bulb crop- *rabi* season

Field experiment was carried out to study the effect of fertilizer application through drip irrigation system on bulb yield and nutrient uptake with five treatments and four replications each in randomized block design (RBD). The results revealed that application of irrigation water through drip system at 10 days interval showed significantly higher bulb yield compared to application of irrigation water through drip at 12 days interval. No significant difference was observed between fertilizer treatments for bulb yield and nutrient uptake during *rabi* season (Figure 3.5).




Treatments: TI- 110:40:60 NPK/ha at 10 days interval, T2- 100:36:54 NPK/ha at 10 days interval, T3- 110:40:60 NPK/ha at 12 days interval, T4- 100:36:54 NPK/ha at 12 days interval, T5- 100 N/ha at 10 days interval up to 50 DAT, P, K and S as basal, Error bar of mean indicates the difference of significance at p=0.05.

Figure 3.5: Effect of fertigation on marketable bulb yield (t/ha)

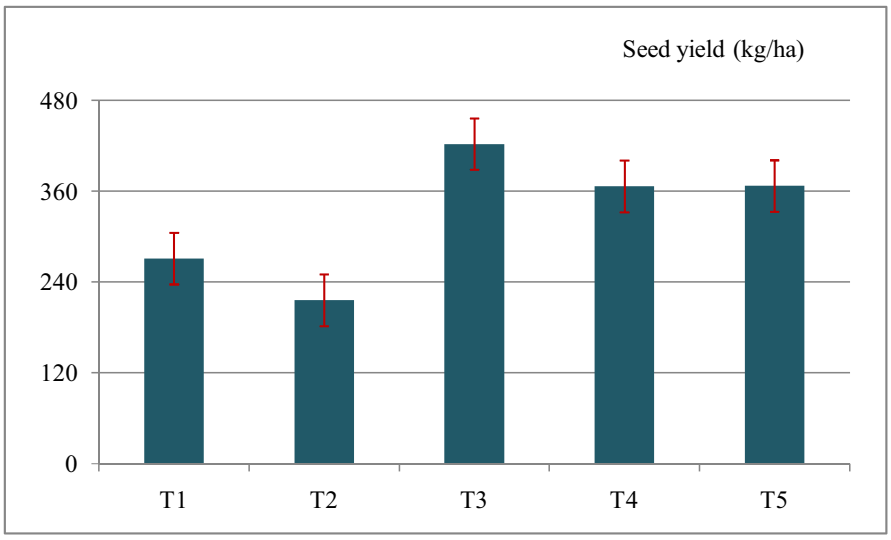
### Table 3.3: Effect of fertigation on nutrient uptake

| | Major nutrient (kg/ha) | | | | Micronutrients (g/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | N | P | K | S | Fe | Mn | Zn | Cu |
| T1 | 98.4a | 16.7a | 71.5a | 13.4a | 1082a | 159.6a | 109.9a | 44.7a |
| T2 | 99.7a | 16.7a | 71.7a | 13.5a | 1076a | 171.5a | 117.4a | 49.1a |
| T3 | 87.4b | 20.0a | 78.3a | 13.3a | 1191a | 179.0a | 117.4a | 47.0a |
| T4 | 83.2b | 18.9a | 77.9a | 13.8a | 1246a | 177.5a | 126.0a | 46.1a |
| T5 | 84.3b | 16.0a | 75.6a | 11.9a | 1267a | 168.4a | 112.6a | 43.5a |

Treatments: TI-110:40:60 NPK/ha at 10 days interval, T2-100:36:54 NPK/ha at 10 days interval, T3- 110:40:60 NPK/ha at 12 days interval, T4-100:36:54 NPK/ha at 12 days interval, T5- 100 N/ha at 10 days interval up to 50 DAT, P, K and S as basal. Values in the same column followed by the same letters are not significantly different at P =0.05.

## Onion seed crop - *rabi* season

A field experiment was conducted to study the effect of fertilizer application (two levels of fertilizers: 80:40:40 kg NPK/ha and 100:50:50 kg NPK/ha and two irrigation intervals: 10 and 12 days interval) with five treatments and four replication each during *rabi* season. NPK Fertilizers were applied at 10 and 12 days interval and observed the effect of these fertilizer and irrigation intervals on onion seed yield. Application of NPK fertilizer @ 80:40:40 kg NPK/ha after 12 days of interval from planting to 48 days produced significantly higher onion seed yield compared to remaining treatments (Figure 3.6).




Treatments: TI- 80:40:40 NPK/ha at 10 days interval, T2- 100:40:40 NPK/ha at 12 days interval, T3- 80:40:40 NPK/ha at 12 days interval, T4- 100:50:50 NPK/ha at 12 days interval, T5- 100 N/ha at 10 days interval up to 50 DAT, P, K and S as basal, Error bar of mean indicates the difference of significance at p=0.05.

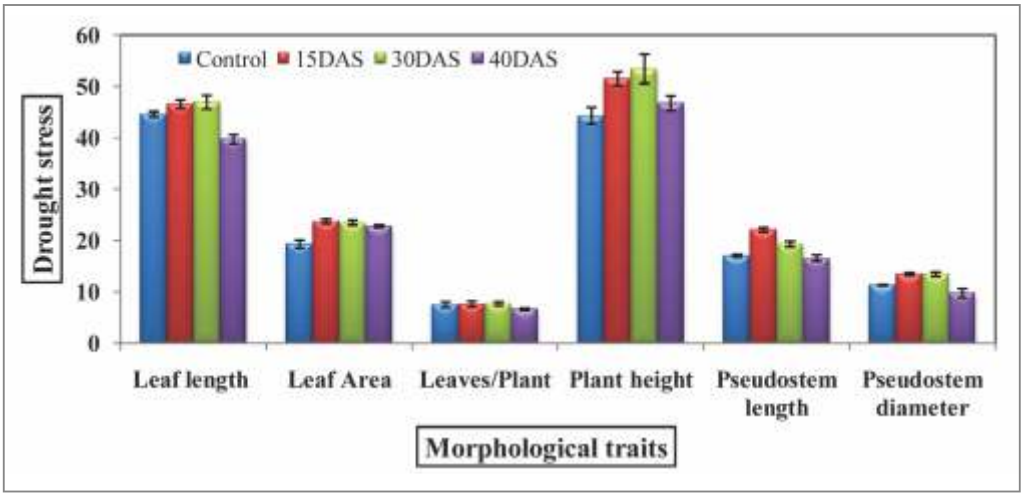
Figure 3.6: Effect of fertigation on onion seed yield (kg/ha)

## Morpho-physiological characterization of onion cultivar Bhima Kiran under drought stress

A field experiment was conducted with onion variety Bhima Kiran during *rabi* to observe the effect of drought stress on various morphological, physiological and biochemical parameters. Water deficit stress was imposed on seedlings at 45 days after transplanting by with-holding irrigation continuous for 40 days and thereafter normal routine irrigation was followed. The control plot was maintained with recommended irrigation schedule throughout the growth period. Observation was taken before drought treatment and after every 10 days to 40 days continuously from both control and drought stressed plots for various traits. Soil moisture status and sampling for various biochemical traits were also done simultaneously. Plants were monitored 45 days after transplanting, 15 days, 30 days and 40 days after drought stress for various morphological observations like plant height, no. of leaves per plant, leaf length, pseudostem diameter and pseudostem length. For physiological and biochemical traits sampling ($4^{th}$ leaf) was done during morphological observations from both control and drought stress affected plots. Physiological and biochemical traits namely, relative water content, chlorophyll content, lipid peroxidation, proline content, peroxidise activity, phenol, protein and antioxidant activity was estimated from leaf sample whereas, biochemical traits like flavanoids, pyruvic acid and TSS were evaluated from the bulb sample. Significant difference were observed in the RWC% in drought stress affected leaf (70-73%) and from control leaf (80-85%). Soil moisture content of 80-82% was recorded from normally irrigated plots whereas 65-70% moisture content was found in drought affected plots. Significant difference was observed in leaf length and leaf area from control and 40 days after drought stress affected plots (Table 3.4, Figure 3.7). Parameters like number of leaves per plant, plant height, pseudostem length and diameter recorded non-significant difference from control and 40 days after drought stress affected plot. No significant reduction in the above mentioned traits were recorded 15 days after drought stress and progressed only after 30 days of stress. In the present study antioxidant activity, lipid peroxidation and proline content were found to be significantly higher in response to drought stress in comparison to control. Significant reduction in protein and phenol content recorded from leaf and bulb tissues respectively (Table 3.5 and Figure 3.8a, 3.8b). Reduction in other essential constituents namely, flavanoids, peroxidase activity, pyruvic acid and chlorophyll content were

**Table 3.4: Morphological parameters recorded in response to drought stress imposed after transplanting in onion cultivar Bhima Kiran**

| Drought stress | Leaf length (cm) | Leaf Area cm-2 | Leaves Plant-1 | Plant height (cm) | Pseudostem length (cm) | Pseudostem diameter (mm) |
|---|---|---|---|---|---|---|
| T1 | 44.6 | 19.3 | 7.5 | 44.4 | 17.0 | 11.3 |
| T2 | 46.6 | 23.7 | 7.7 | 51.5 | 22.1 | 13.5 |
| T3 | 47.0 | 23.5 | 7.7 | 53.5 | 19.3 | 13.4 |
| T4 | 39.7 | 22.8 | 6.7 | 46.8 | 16.6 | 9.8 |
| LSD (P=0.05) | 3.5 | 1.9 | 1.1 | 3.4 | 1.2 | 1.9 |




Treatments: T1- Control, T2- 15 days of drought stress (55 DAT), T3- 30 days of drought stress (70 DAT), T4- 40 days of drought stress (80 DAT)

Figure 3.7: Morphological parameters recorded in response to drought stress imposed after transplanting in onion cultivar Bhima Kiran

observed but the decrease was not significant under drought stress (Table 3.5 and Figures 3.8a, 3.8c). Non-significant but higher chlorophyll content in leaf tissue of onion cultivar Bhima Kiran revealed that it maintained the stay-green trait during drought stress condition which is prerequisite for drought tolerance. Non-significant higher total soluble solids (TSS) content were recorded in bulbs from drought stressed plots than controlled plots (Table 3.5 and Figure 3.8b). Significant reduction in yield was recorded in onion cultivar Bhima Kiran, subjected to 40 days of drought stress in comparison to controlled plots. About 65% bulb yield reduction was observed with more number of 'C' grade bulbs. Moreover, significant reduction in both equatorial and polar bulb size was recorded in the present study providing confirmation that drought stress not only hampered the overall yield but also the marketable size and quality of bulb produced (Table 3.5). In conclusion, the onion cultivar Bhima Kiran responds to water deficit stress by altering its biochemical pathway and maintaining yield potential.

**Table 3.5: Biochemical traits in response to 40 days of drought stress in onion cultivar Bhima Kiran**

| Biochemical and Yield traits | Control | Drought stress | LSD (P=0.05) |
|---|---|---|---|
| Antioxidant activity | 243 | 236 | 4.12 |
| Phenol content | 109 | 74 | 5.64 |
| Lipid peroxidation | 43 | 53 | 4.30 |
| Flavanoids | 148 | 143 | 9.99 |
| Protein content | 11 | 8 | 1.33 |
| Proline content | 5 | 7 | 2.13 |
| TSS | 12 | 13 | 3.79 |
| Peroxidase activity | 2 | 1.5 | 0.71 |

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| Biochemical and Yield traits | Control | Drought stress | LSD (P=0.05) |
|---|---|---|---|
| Chlorophyll content | 0.28 | 0.25 | 0.09 |
| Pyruvic acid | 3.3 | 2.1 | 1.30 |
| Bulb yield (ton/ha) | 47.6 | 16.6 | 8.20 |
| Polar bulb size (mm) | 54.7 | 45.4 | 4.33 |
| Equator bulb size (mm) | 43.0 | 31.2 | 11.9 |

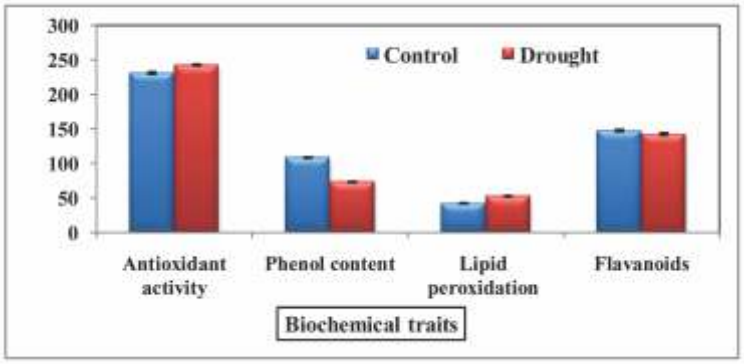
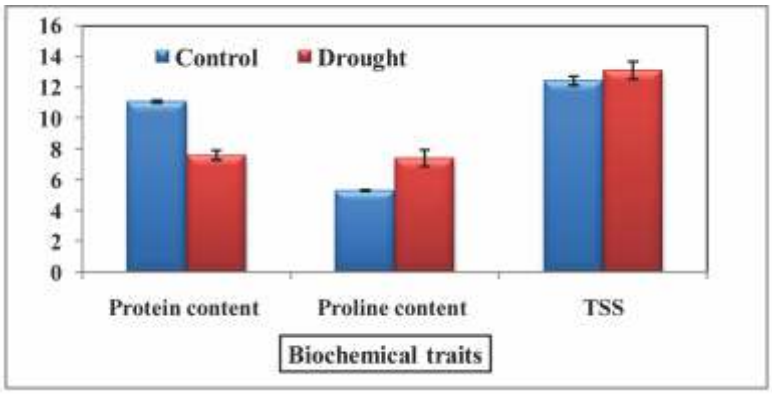



Figure 3.8a: Effect of drought stress on Peroxidase activity (leaf tissue), Chlorophyll content (leaf tissue) and Pyruvic acid content (bulb)

Figure 3.8b: Effect of drought stress on Protein content (leaf tissue), Proline content (leaf tissue) and Total soluble solids (TSS in bulb)



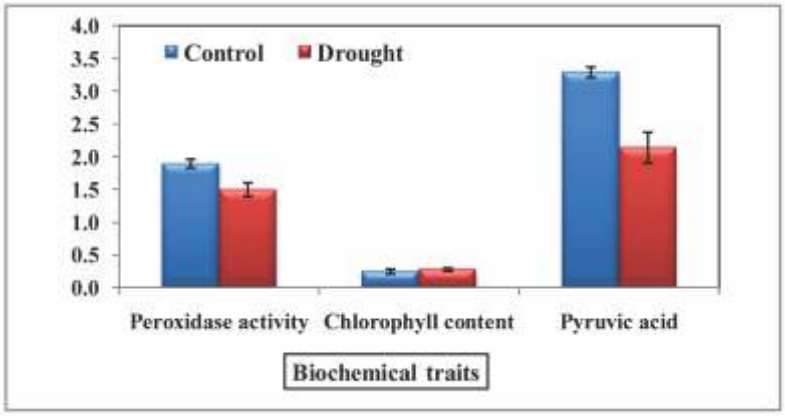




Figure 3.8c: Effect of drought stress on Antioxidant activity (leaf tissue), Phenol content (leaf tissue), Lipid peroxidation (leaf tissue) and Flavanoids content (bulb)

Figure 3.8 Biochemical traits in response to drought stress in onion cultivar Bhima Kiran

## Abundance and diversity of insect pollinators of onion

Abundance and diversity of insect pollinators in onion seed crop was studied during *Rabi* 2015-16. Eleven insect species namely, Little bee *Apis florea* Fab., Indian bee *Apis cerana* Fab., Rock bee *Apis dorsata* Fab., Western bee *Apis mellifera,* Stingless bee *Trigona* sp., Carpenter bee *Xylocopa* sp., Yellow banded wasp *Vespa orientalis* L., Sulphur butterfly *Pieris rapae* L., Danais butterfly *Danais chrysippus* L., Syrphid, *Syrphid* sp., and House fly *Musca domestica* L. were recorded (Table 3.6, Figure 3.9). These pollinator species belonged to different insect orders, of which eight pollinators fit in Hymenoptera, whilst two in Lepidoptera and one in Diptera. Among these, bee species *viz.*, *Apis dorsata* (51%), *A. mellifera* (24%), *A. cerana* (22%) and *Trigona* sp. (2%) (Figure 3.7) were most predominant insect pollinators. Regardless of the bee species, frequency of visits was found to be low during early morning hours and maximum number

**Table 3.6: Major insect pollinator species of onion**

| Pollinator Species | Family | Order |
|---|---|---|
| Little bee, *Apis florae* Fab. | Apidae | Hymenoptera |
| Indian bee, *Apis cerena* Fab. | Apidae | Hymenoptera |
| Rock bee, *Apis dorsata* Fab. | Apidae | Hymenoptera |
| Western bee, *Apis mellifera* L. | Apidae | Hymenoptera |
| Stingless bee, *Trigona* sp. | Apidae | Hymenoptera |
| Carpenter bee, *Xylocopa* sp. | Apidae | Hymenoptera |
| Wasp, *Vespa orientalis* L. | Vespidae | Hymenoptera |
| Pierid butterfly, *Pieris rapae* L. | Pieridae | Lepidoptera |
| Monarch butterfly, *Danais chrysippus* L. | Danaidae | Lepidoptera |
| Syrphid, *Syrphid* sp. | Syrphidae | Hymenoptera |
| House fly, *Musca domestica* L. | Muscidae | Diptera |

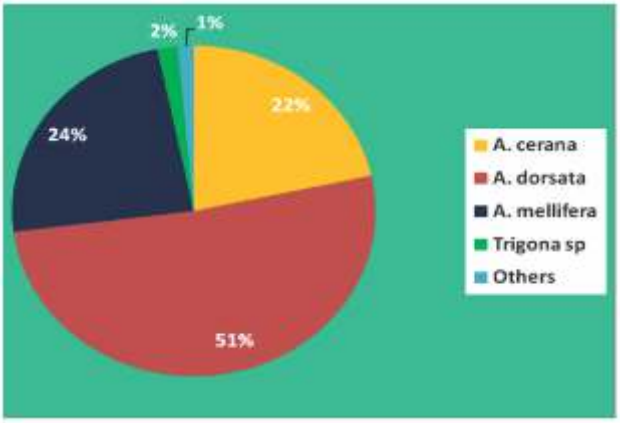



Figure 3.9: Abundance of different insect pollinators in onion

of visit was noticed during noon hours 12.30 PM to 1.30 PM. The index for diversity (Shannon-Weiner) and abundance (Berger-Parker) analysis revealed that, diversity of pollinator species was stable in onion ecosystem with the diversity index value of 1.595, where rock bee, *Apis dorsata* was found to be the predominant species with the index value of 0.333.

## Foraging behavior of major insect pollinators of Onion

Forage frequency/number of forage visits in a unit of time and time spent per flower has been studied among the major pollinators *viz*., Indian bee (*Apis cerana*), Little bee (*Apis florae*), Stingless bee (*Trigona* sp.) and Rock bee (*Apis dorsata*) of onion. Of these, *Apis cerana* was the most frequent visitor at ICAR-DOGR, Rajgurunagar followed by *Apis dorsata*. *Trigona* sp. was the least moving species between the flower and it spent more time per flower as compared to other species (Table 3.7).

## Influence of bee attractant crop on forage activity of pollinators

A set of experiment with onion + mustard combination and sole onion was conducted to enhance the pollinators' activity in the onion seed crop through planting mustard as a border and intercrop between the onion. The mustard was planted fifteen days after onion planting. The data of pollinators forage visit has been observed periodically. The data revealed that onion planted with mustard recorded more number of forage visits as compared to sole onion crop. The major species visited onion + mustard combination was *A. florea* followed by *Trigonella* and *A. cerana*. (Figure 3.8 a-f) Other side, the major species visited in sole onion was *A. cerana* followed by *A. florea* and *Trigona* sp. (Table 3.8).

**Table 3.7: Foraging behavior of major insect pollinators in onion**

| Name of insect pollinators | No. of flower visited/min | Forage time spent/flower (Sec.) |
|---|---|---|
| *Apis cerana* | 3.17±0.31a | 13.50±0.67$^{b}$ |
| *Apis florea* | 2.0±0.26b | 18.83±1.35$^{b}$ |
| *Trigona* sp. | 2.06±0.16b | 27.50±2.53$^{a}$ |
| *Apis dorsata* | 3.0±0.25ab | 17.83±1.19$^{b}$ |

Values in the same column followed by the same letters are not significantly different at P =0.05.

**Table 3.8 Forage visits of insect pollinators in onion and mustard combination**

| Name of insect pollinators | With (Mustard) | Without mustard |
|---|---|---|
| *Apis dorsata* | 2.33$^{b}$ | 0.88$^{c}$ |
| *Apis cerana indica* | 21.83$^{a}$ | 18.67$^{a}$ |
| *Apis florae* | 24.00$^{a}$ | 11.83$^{b}$ |
| *Trigona* sp. | 24.33$^{a}$ | 11.17$^{b}$ |
| Carpenter bee | 1.17$^{b}$ | 0.67$^{c}$ |
| Butterfly | 1.00$^{b}$ | 0.50$^{c}$ |
| Mean | 12.44 | 7.27 |

Values in the same column followed by the same letters are not significantly different at P =0.05.

(a)Rock bee

(b)Little bee

(c) Carpenter bee

(d) Stingless bee

(e) Wasp

(f) Monarch butterfly

Figure 3.10 a - f: Pollinators foraging in onion

# Crop Protection

## Project 4: Integrated pest and disease management for minimization of losses and improving productivity of onion and garlic

Biotic stresses caused by a number of diseases and insect pests not only hamper the yield but also deteriorate the quality of onion and garlic. Considering the current pest and disease scenario, ICAR-DOGR has focused its research on characterization of pathogens and insects. This projects aims in reducing losses in onion and garlic by developing integrated pest and disease management practices. The studies conducted in this direction in the year under report are presented.

### Field evaluation of botanicals for management of *Stemphylium* blight in onion

Antifungal effect of two botanicals *viz., Pongamia pinnata* and *Ecalyptus globulus* each at three different concentrations, *i.e.*, 5%, 10%, 15% were evaluated against *Stemphylium* blight of onion during *rabi*, 2015. Sprays were done at 30, 45 and 60 days after transplanting. *Stemphylium* blight severity was reduced with increasing concentration of the extracts. Lowest disease severity (37.32% disease reduction over control) was observed in foliar application of 15% leaf extract of *P. pinnata* (Table 4.1).

### Morphological diversity among the *Colletotrichum* cultures

Mycelial growth and sporulation variability of *Colletotrichum gloeosporiodes* isolates collected from different cultivated and wild onion accessions were studied on Oat Meal Agar medium (Table 4.2). Isolates significantly differed in their growth rate and sporulation. Among 18 cultures studied,

**Table 4.1: Effect of foliar application of leaf extracts of botanicals on *Stemphylium* blight severity under field condition**

| Treatment | Concentration (%) | Stemphylium blight severity (%) | % Disease control |
|---|---|---|---|
| Untreated (control) | - | 29.2 | - |
| Mancozeb | 0.25% | 20.4 | 30.14 |
| *Pongamia pinnata* | 5% | 21.1 | 27.74 |
| *Ecalyptus globulus* | 5% | 21.7 | 25.68 |
| *Pongamia pinnata* | 10% | 20.8 | 28.76 |
| *Ecalyptus globulus* | 10% | 20.4 | 30.14 |
| *Pongamia pinnata* | 15% | 18.3 | 37.32 |
| *Ecalyptus globulus* | 15% | 20.4 | 30.14 |
| Prefenophos | 1ml/lit | 19.7 | 32.53 |
| CD (5%) | - | 3.28 | - |
| C.V. | - | 8.8 | - |

maximum mycelial growth (79.3mm) was recorded with isolate no. 12 (*A. fistulosum* CGN-14770, Rajgurunagar) whereas lowest (41mm) with isolate no. 17 (Fursungi, Rajur) after 5 days of incubation. Meanwhile, maximum sporulation of 234 spores/microscopic field at 40X was observed in isolate no. 16 (B. Super, Peth) and least spore formation (4 spores/ microscopic field at 40X) was noticed in isolate no. 3 (B. Raj, Rajgurunagar). From the present study it was confirmed that no relation exist between mycelial growth and spore formation.

**Table 4.2: Mycelial growth and sporulation of isolates at different time interval**

| Isolate No | Host plant (Source) | Location | Mycelia growth (mm) DAI | | | | Mean (isolate) | Sporulation* (5DAI) |
|---|---|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 | | |
| 1 | B. Super | Rajgurunagar | 27.0 | 38.3 | 46.0 | 56.0 | 41.8 | 7.3 |
| 2 | B. Shakti | Rajgurunagar | 26.8 | 39.3 | 54.3 | 78.5 | 49.7 | 58.3 |
| 3 | B. Raj | Rajgurunagar | 26.5 | 37.8 | 52.5 | 75.3 | 48.0 | 4.3 |
| 4 | B. Kiran | Rajgurunagar | 26.3 | 37.5 | 49.3 | 63.0 | 44.0 | 8.1 |
| 5 | B. Red | Rajgurunagar | 25.3 | 36.5 | 46.5 | 57.8 | 41.5 | 96.8 |
| 6 | B. Shweta | Rajgurunagar | 24.8 | 38.0 | 51.3 | 64.0 | 44.5 | 203.8 |
| 7 | B. dark red | Rajgurunagar | 26.5 | 39.5 | 55.3 | 78.3 | 49.9 | 20.3 |
| 8 | B. Shubhra | Rajgurunagar | 25.5 | 37.5 | 46.5 | 57.0 | 41.6 | 36.7 |
| 9 | B. Shweta (onion smudge) | Rajgurunagar | 24.8 | 36.8 | 49.8 | 61.3 | 43.1 | 119.8 |
| 10 | A. *ledeboranum* (EC-328491) | Rajgurunagar | 23.5 | 34.8 | 46.0 | 58.5 | 40.7 | 226.6 |
| 11 | *A. fistulosum* (NGB-14619) | Rajgurunagar | 24.8 | 38.3 | 52.5 | 66.0 | 45.4 | 67.6 |
| 12 | *A. fistulosum* (CGN-14770) | Rajgurunagar | 27.3 | 40.8 | 56.0 | 79.3 | 50.8 | 191.1 |
| 13 | *A. fistulosum* (CGN-20779) | Rajgurunagar | 26.8 | 38.0 | 50.3 | 62.3 | 44.3 | 179.4 |
| 14 | *A. tuberosum* (NMK-14749) | Rajgurunagar | 26.3 | 39.0 | 52.0 | 74.5 | 47.9 | 35.7 |
| 15 | Local | Peth | 27.3 | 41.8 | 57.3 | 78.5 | 51.2 | 60.3 |
| 16 | B. Super | Peth | 28.3 | 42.5 | 59.3 | 78.5 | 52.1 | 234.3 |
| 17 | Fursungi | Rajur | 20.3 | 31.8 | 39.3 | 41.0 | 33.1 | 46.2 |
| 18 | Fursungi | Kolwadi | 21.3 | 31.8 | 39.8 | 43.3 | 34.0 | 14.6 |
| | **Mean (time interval)** | | **25.5** | **37.8** | **50.2** | **65.2** | | |

| Factors | C.D. | SE(d) | SE(m) |
|---|---|---|---|
| **Factor (A)** | 2.888 | 1.446 | 1.022 |
| **Factor (B)** | 1.361 | 0.682 | 0.482 |
| **Factor (A X B)** | 5.776 | 2.892 | 2.045 |

## Molecular diversity of Anthracnose affecting *Allium* species

Twenty three *Colletotrichum* cultures were characterised based on ITS sequences. The sequence were amplified from DNA isolated from cultured fungal mycelium. Around 550 bp sequence were amplified and sequenced using sanger dideoxy sequencing. Blast analysis identified 17 cultures as *C. gloeosporiodes* and 6 cultures as *C. capsici* (Fig. 4.1). Best model fit analysis for phygentic studies identified K-2 model with gamma distribution. The phylogenetic analysis with K2+G with 500 boostrap resulted in phylogenetic tree with two clusters *ie., C. gloeosporiodes* and *C. capsici.*

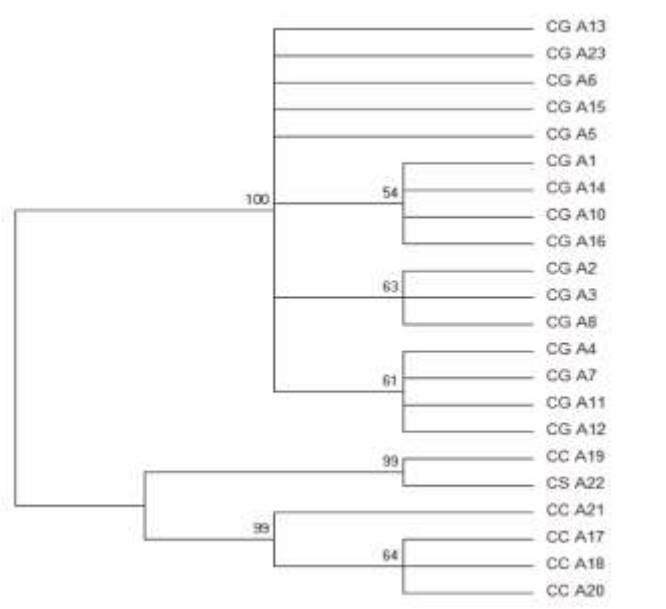



Figure 4.1: Phylogenetic analysis of *Colletotrichum* ITS sequences

mericlones tested, 27 were found to be virus free.

## Assessment of bacterial diversity in onion infesting *Thrips tabaci* L. through Next Generation Sequencing

Bacterial community associated with vertebrates and invertebrates are known to affect their important traits *vis-à-vis* vital physiological functions. The knowledge of bacterial communities associated with economically important pests such as *Thrips tabaci* Lindemann, is limited. Hence in the present investigation, diversity of bacterial communities associated with *T. tabaci* samples collected from 10 geographically distinct onion cultivating regions of India were studied. A

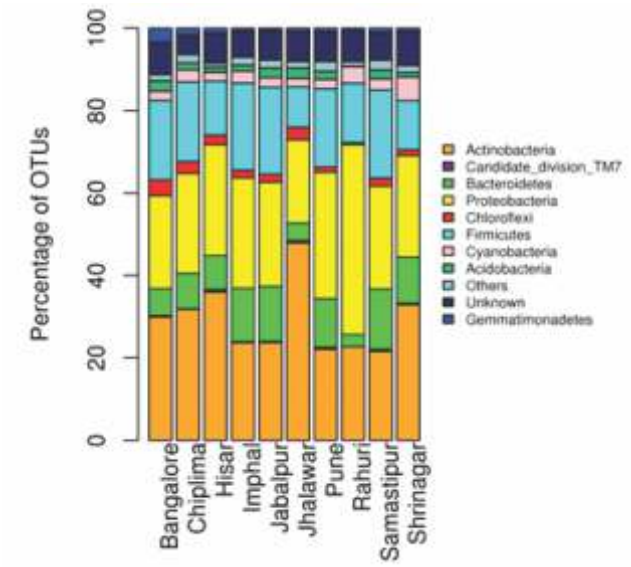



Figure 4.2: Taxonomic classification of OTUs at phylum level for the sample

## Screening of garlic mericlones for virus free propagules

Total 185 garlic mericlones were tested for freedom from viruses belonging to Allexiviruses (Garlic virus A, Garlic virus D, Shallot latent virus, Garlic virus C), Potyviruses (Onion yellow dwarf virus and Leek yellow stripe virus) and Carlaviruses through RT-PCR. Of the 185 garlic

propriety wet-lab approach used to sequence 16S rRNA V3 region of bacteria on Illumina Miseq platform. A pre-processing step was done before the acutal analysis. Chimeras were also removed using the de-novo chimera removal method UCHIME implemented in the tool USEARCH. A total of 30,306 OTUs were identified from 962,166 reads. Then, taxonomic classification was

performed using RDP classifier and SILVA OTUs database. Bacterial colonies such as, actinobacteria, proteobacteria, firmicutes, cyanobacteria, bacteroidetes were identified and found as abundant phyla in *T. tabaci* (Fig. 4.2). Further studies are required to understand the the nature of associations and its impact on important traits of *T. tabaci* .

## Evaluation of new molecules as insecticide for onion thrips

Three newer chemistry insecticides *viz*., emammectin benzoate, cyantraniliprole and tolfenpyrad were tested against onion thrips. Of these, cyantraniliprole 10 OD @ 120 g a.i/ha were found to be effective in reducing thrips population by 77.43 % and 72.15 % at 1st and 2nd spray respectively, followed by cyantraniliprole 10 OD @ 90 g a.i/ha and emamectin benzoate 5SG @ 22 g a.i/ha. The positive control profenophos @ 160 g a.i/ha was found superior over all tested chemicals with 91and 92% mortality at 1st and 2nd spray, respectively. Plots treated with cyantraniliprole recorded highest marketable yield of 22.26 t/ha followed by emamectin treated plots. Meanwhile, the positive check (profenophos treated plots) recorded 24.09 t/ha marketable yield. All three molecules evaluated were found effective over untreated control (water spray). Leaf curl index of emamectin benzoate and cyantraniliprole were low and moderate in tolfenpyrad treated plots. The present study revealed that cyantraniliprole was found to be effective against both adults and nymphs of onion thrips, while tolefenpyrad 15% EC was least effective (Table 4.3 a & b).

**Table 4.3 a: Bio-efficacy of new molecules against onion thrips**

| Treatment | Thrips mortality (%) | | Marketable Yield (t/ha) | Total Yield (t/ha) | Leaf curl index |
|---|---|---|---|---|---|
| | 1st Spray | 2nd Spray | | | |
| Emamectin benzoate 5SG @ 11 g a.i/ha | 67.18 (8.19)$^{ab}$ | 65.31 (8.07)$^{b}$ | 21.10 | 24.61 | Low |
| Cyantraniliprole 10% OD @ 90 g a.i/ha | 71.93 (8.46)$^{a}$ | 67.04 (8.18)$^{b}$ | 22.26 | 25.84 | Low |
| Tolfenpyrad 15EC @ 125 a.i/ha | 45.96 (6.71)$^{c}$ | 65.22 (8.07)$^{b}$ | 19.37 | 22.82 | Moderate |
| Emamectin benzoate 5SG @ 22 g a.i/ha | 67.07 (8.18)$^{ab}$ | 68.18 (8.24)$^{ab}$ | 19.35 | 21.63 | Low |
| Cyantraniliprole 10% OD @ 120 g a.i/ha | 77.43 (8.78)$^{a}$ | 72.15 (8.49)$^{ab}$ | 21.10 | 23.84 | Low |
| **Control** | | | | | |
| Profenophos | 91.14 (9.55)$^{a}$ | 92.10 (9.59)$^{a}$ | 24.09 | 27.14 | Low |
| Water Spray | 3.03 (1.73)$^{d}$ | 4.87 (3.25)$^{c}$ | 11.30 | 13.86 | High |

**Table 4.3 b: Effectiveness of new molecules for nymphs and adults of onion thrips**

| Treatment | Thrips mortality (%) | |
|---|---|---|
| | Nymph | Adult |
| Emamectin benzoate 5SG @ 11 g a.i/ha | 64.60 (8.03)$^{ab}$ | 69.80 (8.35)$^{ab}$ |
| Cyantraniliprole 10% OD @ 90 g a.i/ha | 67.66 (8.21)$^{ab}$ | 74.12 (8.59)$^{a}$ |
| Tolfenpyrad 15EC @ 125 a.i/ha | 47.39 (6.60)$^{b}$ | 44.53 (6.57)$^{c}$ |
| Emamectin benzoate 5SG @ 22 g a.i/ha | 74.93 (8.65)$^{ab}$ | 59.21 (7.68)$^{ab}$ |
| Cyantraniliprole 10% OD @ 120 g a.i/ha | 78.26 (8.77)$^{ab}$ | 76.61 (8.74)$^{a}$ |
| **Control** | | |
| Profenophos | 90.32 (9.50)$^{a}$ | 91.98 (9.58)$^{a}$ |
| Water Spray | 3.98 (1.27)$^{c}$ | 2.12 (1.27)$^{d}$ |

Values in the parenthesis are *sqrt* transformed; values in the same column followed by the same letters are not significantly different at P =0.05.

## Onion pest surveillance

### Lepidopterans as emerging pests in onion

Incidence of three lepidopteran pests *viz*., Green looper (*Chrysodeixis* sp.), Cutworm (*Agrotis ipsilon*) and Army worm (*Spodoptera exigua*) were recorded in onion during 2016-17. Although, considered as minor pests in onion, their incidence was found more severe during 2016-17. Green looper, *Chrysodeixis* sp. (Lepidoptera: Noctuidae) has been recorded in *kharif* onion. It is a defoliater pest, early larval instars would scrap the leaf tissuses while later instars make large feeding bore holes. The larvae is glossy green in colour with three pair of prolegs (Fig 4.3 a-c). Its occurrence was recorded during September to October, wherein the peak infestation coincided with 41$^{st}$ SMW at DOGR, Rajgurunagar.

Black cutworm, *Agrotis ipsilon* (Lepidoptera: Noctuidae) as a pest in direct seeded *rabi* onion. Severe incidence has been recorded during late *kharif* and *rabi*. The infestation was mainly noticed in 50 days old direct sown onion fields at Daund

(a) Damage symptoms

(b) Larva

(c) Adult

Figure 4.3(a-c): Green looper *Chrysodeixis* sp. damage symptoms and life stages

(Pune) and also at ICAR-DOGR, Kalus farm. Mainly damage was observed at 3-5 leaf stage. Caterpillars of mixed larval instars damaged tender foliage of young seedlings. Later instars of larvae completely cut through the stalks, and causes wilting and death of the crop (Fig 4.4 a-d). Damage was seen in patches mainly in drip irrigated onion fields, where moist loosen soil exists.

Army worm, *Spodoptera exigua* is a tropical pest that originates from southern Asia and has spread throughout most temperate and tropic zones. Severe infestation was observed on both onion bulb and seed crop during *rabi*. Early instars most frequently damage the young terminals while, older instars feed gregariously through boring into tubular leaves, flower stalks and buds (Figure 4.5 a-d). In heavily infested fields, total yield losses can amount up to 70 % and visible as white papery patches from a distance (Figure 4.6).

(a) Egg

(b) Larva

(c) Pupa (soil puparium)

(d) Adult moth

Figure 4.4 (a-d): Life stages of cutworm *Agrotis ipsilon*

(a) Egg

(b) Larva

(c) Pupa

(d) Adult

Figure 4.5 (a-d): Life stages of armyworm *spodoptera exigua*

Figure 4.6:
Field infested with armyworm

## Standardization of polymer seed film coating

Seed deterioration is inevitable and irreversible process but the rate of seed deterioration could be slowed down by imposing polymer film coating along with seed treatment chemicals to maintain the seed quality. By encasing the seed within a thin film of biodegradable polymer, the adherence of seed treatment to the seed can be improved, ensures accurate and even dosage of chemicals and reduces the chemical wastage. Initially an experiment was conducted to standardize the optimum dose for seed coating with a polymer namely Little's polykote (Silver colour). Seeds of Bhima Super and Bhima Kiran were coated with three different doses of polymer *i.e.*, 5ml, 8ml and 12ml per kg seed (Figure 4.7). Later its effect on germination was recorded. Seeds treated with polymer @ 12 ml per kg of seed showed better coverage without affecting the seed germination and also higher vigour index when compared to untreated control and other treatments with lower doses of polymer film coating (Table 4.4).

**Table 4.4: Effect of Little's polymer film coating on germination percentage, shoot and root length (cm) and vigour index in onion seeds**

| Variety | Treatment | Germination (%) | Shoot length (cm) | Root length (cm) | Vigour Index |
|---|---|---|---|---|---|
| Bhima Kiran | T1 = 5ml per kg seed | 90.7 (72.20 ± 0.67) | 7.1 ± 0.788 | 2.1 ± 0.6 | 835.93 |
| | T2 = 8ml per kg seed | 91.0 (74.01 ± 5.21) | 7.8 ± 0.907 | 1.3 ± 0.333 | 839.87 |
| | T3 =12ml per kg seed | 93.3 (75.04 ± 0.75) | 8.7 ± 0.361 | 1.8 ± 0.702 | 980.87 |
| | T4 = Untreated Check | 91.7 (73.38 ± 1.91) | 7.7 ± 1.073 | 2.5 ± 0.321 | 942.23 |
| | SE(m) | 2.818 | 0.825 | 1.236 | - |

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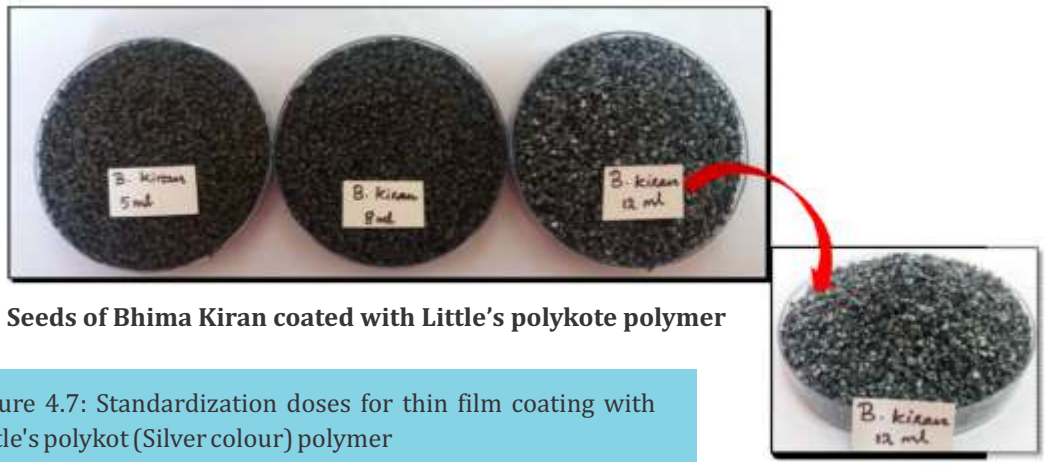
| Variety | Treatment | Germination (%) | Shoot length (cm) | Root length (cm) | Vigour Index |
|---|---|---|---|---|---|
| Bhima Shakti | T1 = 5ml per kg seed | 70.3 (57.02 ± 1.64) | 7.9 ± 1.946 | 1.83 ± 0.726 | 678.50 |
| | T2 = 8ml per kg seed | 71.0 (57.41 ± 1.90) | 8.2 ± 0.769 | 2.83 ± 0.939 | 785.20 |
| | T3 =12ml per kg seed | 72.0 (58.03 ± 0.37) | 7.3 ± 0.657 | 2.03 ± 0.203 | 669.70 |
| | T4 = Untreated Check | 72.3 (58.25 ± 0. 57) | 6.6 ± 1.141 | 2.1 ± 0.473 | 630.53 |
| | SE(m) | 1.04 | 0.517 | 0.647 | - |

All values represent mean of three replications, Values represent Mean ± Standard Error. Data in parenthesis are Angular transformed values.



**Seeds of Bhima Kiran coated with Little's polykote polymer**

Figure 4.7: Standardization doses for thin film coating with Little's polykot (Silver colour) polymer

## Weather based forecast models for onion thrips in *rabi*

Weather is an important factor, which affects the onion production as well as infestation of various crop pests and diseases. There is considerable loss in the yield of onion as well as quality of produce due to pest and disease infestation. Such losses can be reduced to a considerable extent if their occurrence is known in advance so that timely remedial measures may be taken up. To this end, one must have prior knowledge of the time and severity of the outbreak of these pests and diseases. Hence, Weather indices based regression models were developed for each date of planting of crops. The field trials were planting on different dates at fortnightly intervals (01-Nov., 15-Nov., 01-Dec., 15-Dec., 01-Jan. and 15-Jan.) in *rabi* at Pune during 2000 to 2015 was used. Models were developed using weather indices as independent variables, while character under study such as crop age at first appearance of thrips ($Y_1$), crop age at peak population of thrips ($Y_2$) and maximum thrips population ($Y_3$) was used as dependent variable for onion crop. Stepwise regression technique has been used for selecting significant variables in all the models. The forecasts for different character in various date of planting were at par with the observed one. The percentage deviation of forecast

for different character in various date of planting based on weather indices based regression models was low for crop age at first appearance of thrips ($Y_1$) and crop age at peak population of thrips ($Y_2$) while deviation is higher for maximum population of thrips ($Y_3$) (Table 4.5). This may be due to the sampling fluctuations. In general, the models fitted well with all the coefficients of determination. Forecasts from the models were very close to the observed values in subsequent years. Therefore these models based on weekly weather data starting from week of planting up to six weeks of crop growth can be used for reliable forewarning of thrips.

**Table 4.5: Weather Indices based models along with coefficient of determination**

| Date of sowing | Model | $R^2$ |
|---|---|---|
| 1 November | $Y_1= 12.5446 + 1.973\ Z_{11} + 0.018\ Z_{451} + 0.168\ Z_{31}$ | 0.96 |
| | $Y_2= -41.005 + 0.0176\ Z_{131} + 3.889\ Z_{11} - 0.006\ Z_{230}$ | 0.92 |
| | $Y_3= 3.508 + 0.0118\ Z_{251} + 0.0001\ Z_{341}$ | 0.89 |
| 15 November | $Y_1= -76.184 + 4.649\ Z_{11} + 0.395\ Z_{451}$ | 0.85 |
| | $Y_2= 243.604 + 0.0072\ Z_{31} + 0.0203\ Z21$ | 0.86 |
| | $Y_3= 1.703 + 0.0009\ Z_{131} + 0.0002\ Z_{350} - 0.0054\ Z_{10}$ | 0.99 |
| 1 December | $Y_1= 17.992 + 0.021\ Z_{121} + 0.032\ Z_{151}$ | 0.91 |
| | $Y_2= -152.722 + 3.455\ Z_{11}$ | 0.84 |
| | $Y_3= -1.712 + 0.0005\ Z_{131} + 0.002\ Z_{151}$ | 0.98 |
| 15 December | $Y_1= 15.401 + 0.0010\ Z_{11} + 0.0044\ Z_{151}$ | 0.89 |
| | $Y_2= 42.11+ 0.0434\ Z_{241} + 0.0616\ Z_{131}$ | 0.73 |
| | $Y_3= -13.793 + 0.043\ Z_{10} + 0.067\ Z_{31}$ | 0.89 |
| 1 January | $Y_1= 9.797 + 0.555\ Z_{251} - 0.008\ Z_{231}+ 0.005\ Z_{341}$ | 0.99 |
| | $Y_2= 37.804 + 4.146\ Z_{11} + 0.032\ Z_{231} + 0.066\ Z_{141}$ | 0.96 |
| | $Y_3= -0.886 + 0.1367\ Z_{11} + 0.0007\ Z_{231}$ | 0.94 |
| 15 January | $Y_1= 22.478 + 0.0001\ Z_{230} + 0.0194\ Z_{351}$ | 1.00 |
| | $Y_2= 113.305 + 0.011\ Z_{141} - 0.003\ Z_{131}$ | 1.00 |
| | $Y_3= 1.778 + 0.0028\ Z_{451}$ | 1.00 |

# Post - Harvest Technology

## Project 5: Development and refinement of post harvest handling, storage and processing techniques for minimization of losses and improving productivity of onion and garlic

Being perishable, post harvest handling, storage and processing of onion and garlic is inevitable as its demand is increasing day by day. Earlier studies have minimized the post harvest losses, yet damage of 40-50% in onion and 20-25% in garlic is still witnessed in 4-5 months storage. Further, the glut produced in the market may lead to price fluctuations that ultimately hinder framers from fetching premium price. In order to prevent this, product diversification through value addition has huge potential in reducing the losses. The work conducted during the year on storability including pre-harvest interventions to reduce losses, and on other related aspects is reported here.

### Effect of $CaCl_2$ pre-harvest treatment on storage of onion

Pre-harvest treatment of $CaCl_2$ was tried as a spray at different concentrations (1% after 90 Days after transplanting (DAT); 1% at 100 DAT, 1% at 90 and 100 DAT; 1.5% after 90 DAT; 1.5% at 100 DAT, 1.5% at 90 and 100 DAT; 2% after 90 DAT; 2% at 100 DAT, 2% at 90 and 100 DAT; Control (without any treatment)) to see the effect on storage losses in onion during Rabi 2015-16 (Figure 5.1). Treatment individually and in interaction with storage had no significant effect on sprouting, rotting and total weight loss.

### Effect of $NaCl_2$ pre-harvest treatment on storage of onion

$NaCl_2$ at different concentrations (1% after 90 DAT; 1% at 100 DAT, 1% at 90 and 100 DAT; 1.5% after 90 DAT; 1.5% at 100 DAT, 1.5% at 90 and 100 DAT; 2% after 90 DAT; 2% at 100 DAT, 2% at 90 and 100 DAT; Control (without any treatment))was sprayed before harvest to see the effect of spray on storage losses during *rabi* 2015-16 (Figure 5.2). $NaCl_2$ treatment individually and in interaction with storage had no significant effect on storage losses of onion.

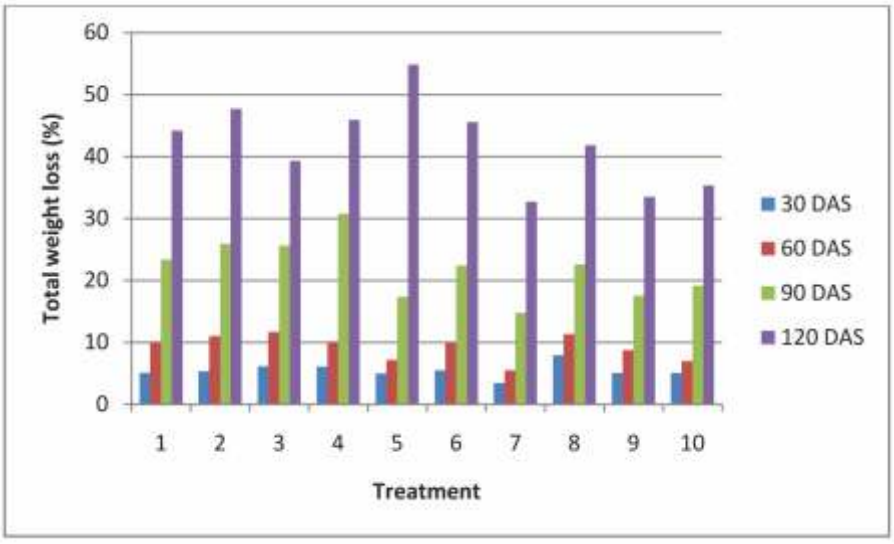



Figure 5.1: Effect of $CaCl_2$ Treatment on total weight loss during storage

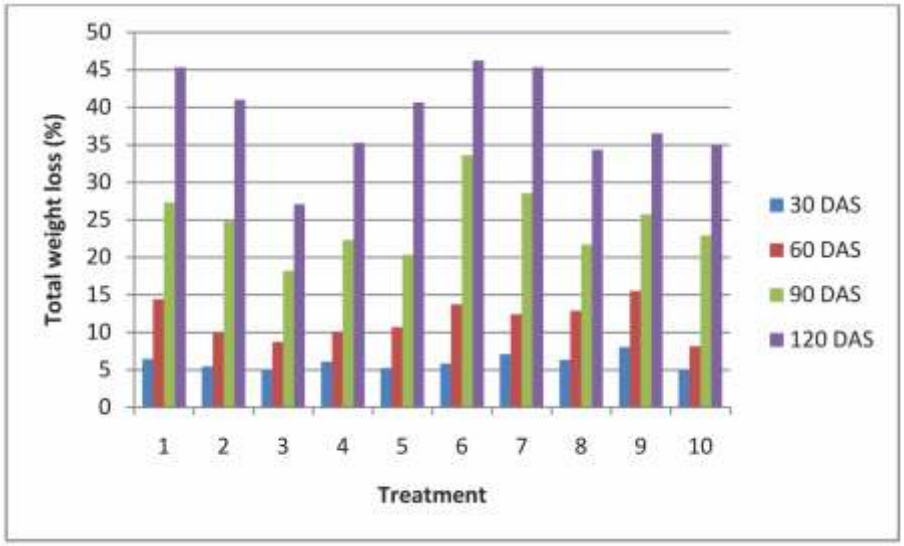



Figure 5.2: Effect of $NaCl_2$ treatment on total weight loss during storage

## Effect of pre-harvest sprays of botanicals on black mould disease

Pre-harvest sprays of aqueous leaf extracts of *Pongamia pinnata* and *Ecalyptus globules* each @ 5%, 10% and 15% were evaluated for black mould management in storage onion. Sprays were done 15 days before harvesting of the crop. Observations were started after one month of storage and recorded regularly every 15 days interval. Among the treatments *P. pinnata* leaf extract @15% showed minimum black mould incidence after four month of storage (Figure 5.3).

## Effect of size of onion on biochemical constituents

After harvest onion is available in different sizes. Based on the size, onions are graded in to different grades and then sold in the markets. Farmers get different prices for different grade of onion in market. An experiment was planned to check

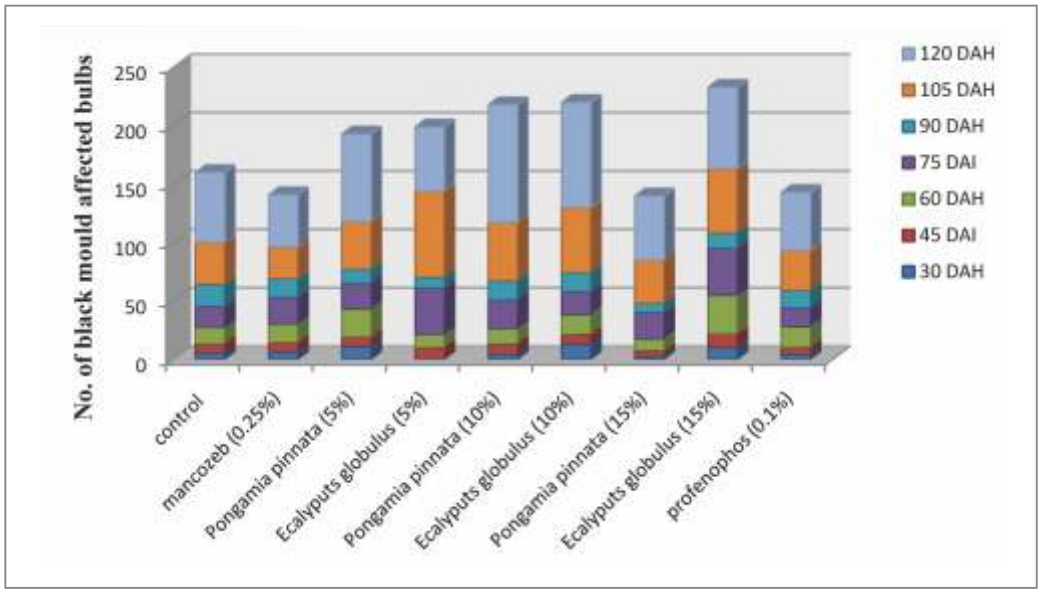



Figure 5.3: Effect of pre-harvest sprays of botanicals on black mould

whether the biochemical and nutritional quality vary among different sizes of onion. Eight onion varieties (B. Kiran, B. Raj, B. Red, B. Dark red, B. Super, B. Shakti, B. Shweta and B. Shubhra) were planted during *kharif* season and were grown under similar conditions. After harvesting, cured onion bulbs were taken and grouped in to different grades (A grade with size > 60 mm, B grade with size between 40-60mm and C grade with size < 40 mm). From each grade 20 bulbs were taken, peeled and cut into two pieces. One half of the bulb was further cut into small pieces, dried and used for mineral analysis. Remaining half was ground using mixer and was used for biochemical analysis.

In general, variety, grade and their interaction had significant effect on the biochemical constituents except in case of pyruvic acid content where only variety and interaction of variety and grade had significant effect. The white varieties had significantly less total flavonoids, total phenol, total antioxidant activity and total protein. However, these had significantly higher pyruvic acid content compared to red varieties with Bhima Dark Red as exception. Mixed trend was observed in case of total soluble solids (Table 5.1).

## Biochemical constituents in onion waste (skin)

Increasing awareness regarding the health promoting attributes of onions, had lead to the increase of its consumption day by day. However, pungency and lacrymation effect makes this vegetable inconvenient for daily preparations. Due to this, different ready to use value added products from onion *i.e.*, minimally processed ready to use or ready to cook fresh onions, onion paste, dehydrated onion flakes, onion powder, pickled onion *etc.*, are gaining importance. During processing, the dry outer skin goes waste from the industry. This waste skin contains very promising sources of value-added substances. Onion skin is a rich a source of phenols, quercetin and anthocyanins. Eight onion varieties were grown under similar conditions during kharif season of 2016-17 and the skin of onion was removed, dried and powdered. It was analysed for total phenol, total flavonoid, total antioxidant activity and pyruvic acid content.

Variety had significant effect on the biochemical constituents of onion skin. In general, total phenol content, total flavonoids and total antioxidant activity was significantly lower in white varieties as compared to red. The total phenol content ranged from 37.17 to 43.19 mg GAE /g in red varieties in contrast to white varieties with 2.42 to 2.54 mg GAE/g Total flavonoid content in red varieties ranged from 70.41 to 88.38 mg QE/g Total antioxidant activity ranged from 60.35 to 70.11 mg AAE/g in red varieties, where as in white varieties it was 18.91 to 19.21 mg AAE/g Pyruvic acid content was significantly more in white varieties (0.023 to 0.024 µmoles pyruvate/g) than red varieties (0.020-0.021 µmoles pyruvate/g).

**Table 5.1: Effect of size (grade) on Biochemical constituents**

| Grades | Total Flavonoids (mg QE/100 g) | Total phenol(mg GAE /100 g) | Total antioxidant activity (mg AAE/100 g) | Total protein (%) | Total Soluble Solids (TSS) |
|---|---|---|---|---|---|
| A grade (> 60 mm) | 55.09b | 37.05c | 188.78b | 0.35a | 13.75a |
| B grade (40-60mm) | 57.32ba | 40.92b | 189.10ba | 0.29b | 13.09b |
| C grade (<40mm) | 59.70a | 49.31a | 191.56a | 0.21c | 12.90c |
| LSD (5%) | 2.60 | 2.81 | 2.65 | 0.03 | 0.06 |

## Dehydration characteristics of different white varieties and High TSS lines

During the last few years, demand for dehydrated onion flakes is increasing as they offer convenience for use, storage and transport. Industry is focusing on the varieties that offer better quality onion dehydrated products. Research is going on to develop onion varieties with high Total Soluble Solid (TSS) content. An experiment was planned to see the differences in the dehydration characteristics of onion varieties and high TSS onion lines. Three white onion varieties (Bhima Shweta, Bhima Shubra and Bhima Safed) and three white high TSS lines (WHT-23A-1, WHT-23A-2 and WHT-23A-3) were chosen for the experiment. 20 bulbs from each variety and high TSS lines were cut in to small vertical pieces. Some portion of the cut onion from the mixed sample was taken out and used for biochemical analysis. Remaining cut onion was equally spread on trays and dried in a food grade dried that has a provision to provide equal temperature and air to each tray. Different trays were used for different variety/lines. Drying was done at 60ºC. Weight loss was noted after each one hour and a drying curve was prepared (Figure 5.4).

No significant difference was observed for browning of onion flakes during drying at 60ºC (Table 5.2). Rehydration ratio was significantly less in high TSS lines as compared to varieties dried at similar temperature and time.

### Table 5.2 Effect drying on browning and rehydration ratio in variety and High TSS lines

| Variety/Line | Browning | Rehydration |
|---|---|---|
| Bhima Shweta | 0.26ba | 15.17a |
| BhimaShubhra | 0.24b | 13.45b |
| Bhima Safed | 0.27a | 13.51b |
| WHT-23A-1 | 0.23b | 12.79cb |
| WHT-23A-2 | 0.26ba | 12.76cb |
| WHT-23A-3 | 0.25ba | 12.52c |
| LSD (5%) | 0.0289 | 0.7669 |

## Optimization of ready to prepare pakoda mix with dehydrated onion

As the demand for the ready to prepare foods is increasing, instant pakoda mix was optimized using dehydrated white onion. Onions were cut and dried in a food grade drier until constant weight was achieved. Later a drying curve was plotted using the moisture loss data (Figure 5.5). Rehydration capacity of dehydrated onions was tested at different sample to water ratio for different time intervals. Water ratio, time and their interaction had significant effect on the rehydration of dehydrated onion. Based on the sensory score, a mix of dehydrated onion, chilli, ginger, ajwain, salt for use with 100g of basin was

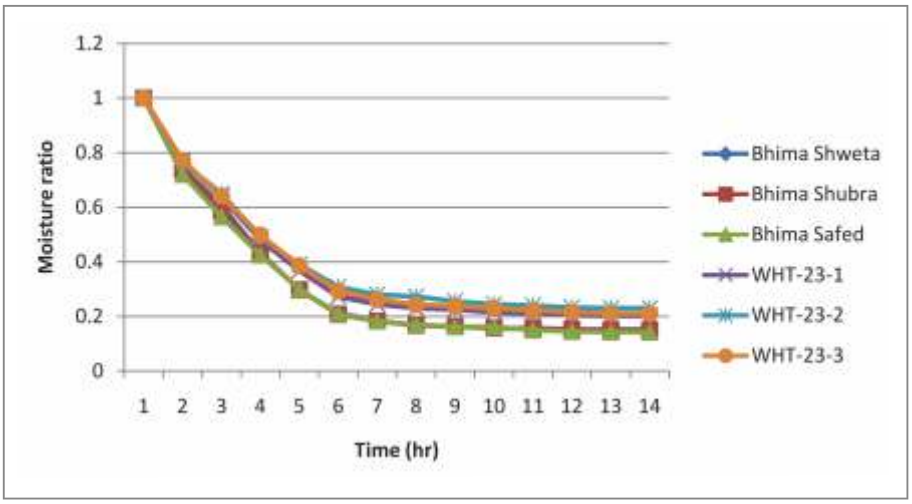



Figure 5.4: Drying curve of different varieties and high TSS lines

optimized. The optimized mix was later rehydrated for different time periods (5, 10, 15 and 20 min) and used for the preparation of pakoda (Figure 5.6). For comparison purpose, pakoda was prepared using fresh onion and other ingredients in the same ratio. The sensory scores were noted using 9 point hedonic scale. Ready to use mix rehydrated at 20 minutes got the maximum score (Figure 5.7).

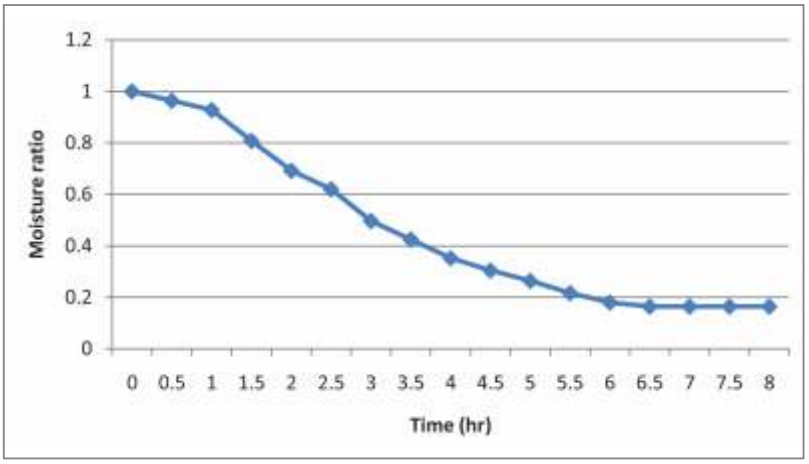



Figure 5.5: Drying curve of white onion variety Bhima Shubra

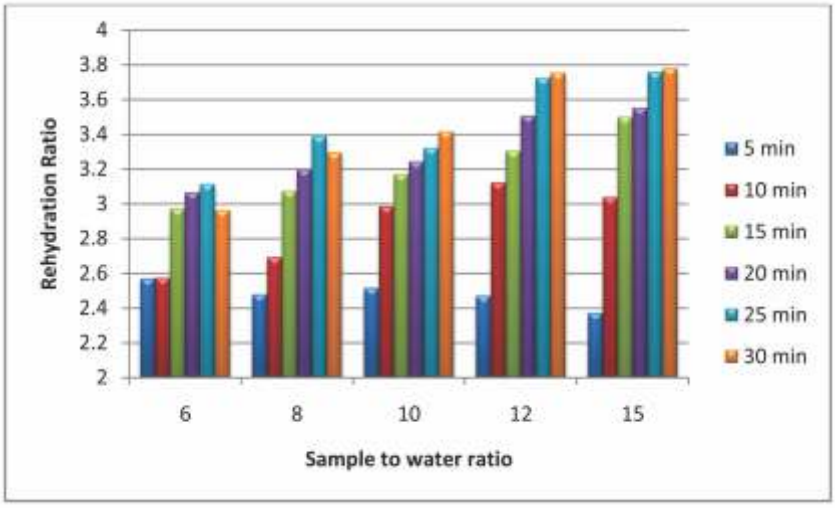



Figure 5.6: Rehydration ratio of white onion variety Bhima Shubra flakes

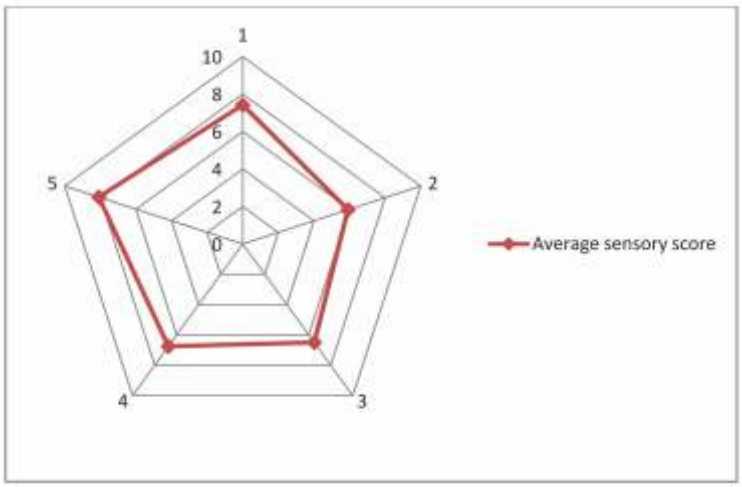



Figure 5.7: Sensory score of the ready to use pakoda mix

1: Control (prepared with fresh onion); 2: 5 minutes rehydrated; 3: 10 minutes rehydrated; 4: 15 minutes rehydrated; 5: 20 minutes rehydrated

## Effect of drought stress at different growth stages on post-harvest attributes of onion crop

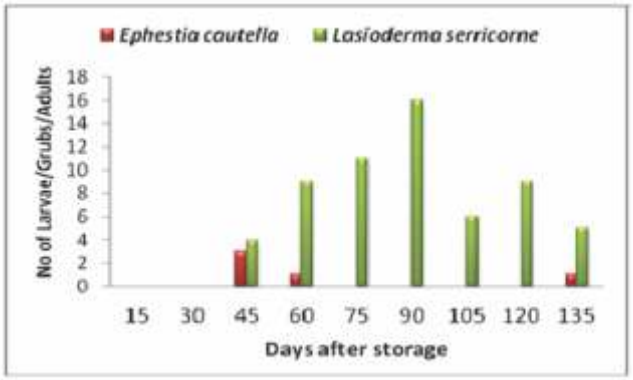
During *Rabi* 2015-16, a field experiment was conducted with onion variety Bhima Shakti to observe the effect of drought stress at different growth stages on post-harvest losses (Sprouting + Rotting + Physiological weight loss). Water deficit stress was imposed by withholding irrigation for 25 days at a particular growth stage *viz*., bulb initiation (15-40 DAT), bulb development (40 - 65 DAT), bulb enlargement (61-86 DAT) and bulb maturity (81-120 DAT) and after that normal routine irrigation schedule was practiced. Significant difference was recorded for post harvest losses in stored bulbs obtained from normal irrigated plots and drought stress at different growth stages. However, drought stress at bulb enlargement stage resulted significantly higher post harvest loss in storage as compared to control and drought stress at other growth stages. Similarly, TSS was affected significantly by drought stress. High TSS value of 15.5 % was found from drought treatment at bulb enlargement stage. Bulbs from normally irrigated plots recorded low TSS value of 11.4% as compared to bulbs from drought stress subjected plots, which emphasize that the drought stress at any growth stage increases the percentage of total soluble solids in onion bulbs. This result thus revealed that water management in onion crop is extremely important at all the stages of plant development (Table 5.3).

## Effect of pre-harvest spray on garlic storage pest infestation

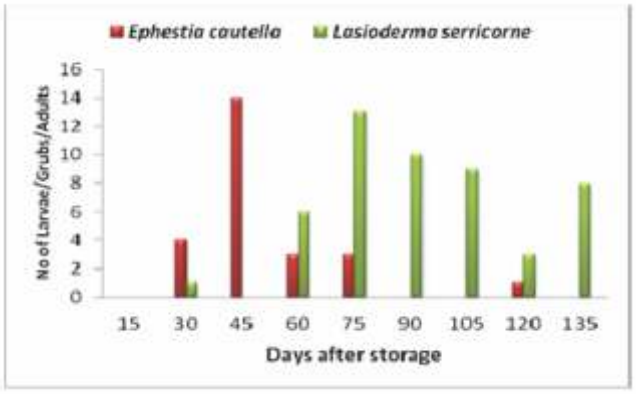
Peak time for almond moth, *Ephestia cautella* and cigarette beetle, *Lasioderma serricorne* infestation in stored garlic was recorded during the month of July-August, respectively. Pre-harvest (15 days before harvest) spray with carbosulfan @ 2ml/L delayed *Ephestia* and *Lasioderma* infestation in garlic at storage. The infestation of both the pests were noticed at 30 days after storage in untreated (pre-harvest) garlic samples, while at 45 days after storage at pre-harvest sprayed samples. Throughout the observations period, the number of larvae/grub (life stages) population was high in control. *Ephestia* infestation was further low in pre-harvest sprayed garlic but the trend in *Lasioderma* was similar for both treated and control Figure 5.8 (a-b).

**Table 5.3: Effect of drought stress at different growth stages on post-harvest attributes of onion crop**

| Drought stress at growth stages | Post-harvest losses (Sprouting + Rotting + Physiological weight losses) in onion variety Bhima Shakti | | | | TSS (%) |
|---|---|---|---|---|---|
| | 30 days storage | 60 days storage | 90 days storage | 120 days storage | After Harvest |
| Bulb initiation stage | 9.28 | 12.97 | 15.81 | 19.30 | 12.7 |
| Bulb formation stage | 9.57 | 13.70 | 18.84 | 25.15 | 14.2 |
| Bulb enlargement stage | 12.79 | 17.88 | 22.64 | 29.87 | 15.5 |
| Bulb maturation stage | 9.15 | 13.67 | 17.43 | 29.25 | 14.2 |
| Control | 9.09 | 13.56 | 16.77 | 20.08 | 11.4 |
| CD @ 5% | 1.16 | 2.51 | 3.41 | 3.80 | 0.745 |




(a) Pre-harvest spray

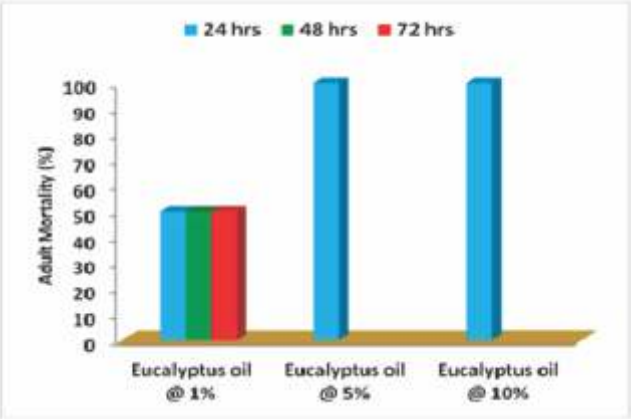



(a)Control

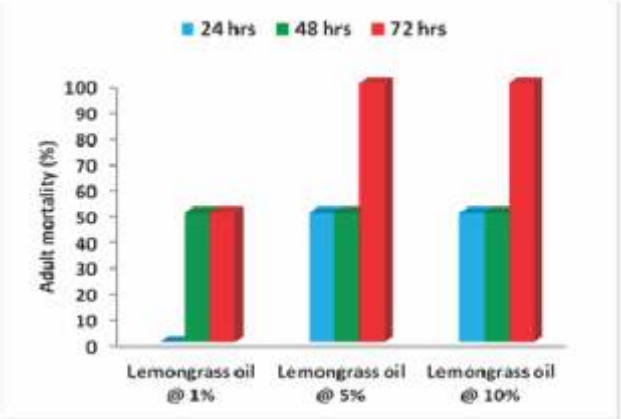
Figure 5.8 (a-b). Effect of pre-harvest spray on infestation of garlic storage pests

## Effect of essential oils on survival of *Lasioderma*:

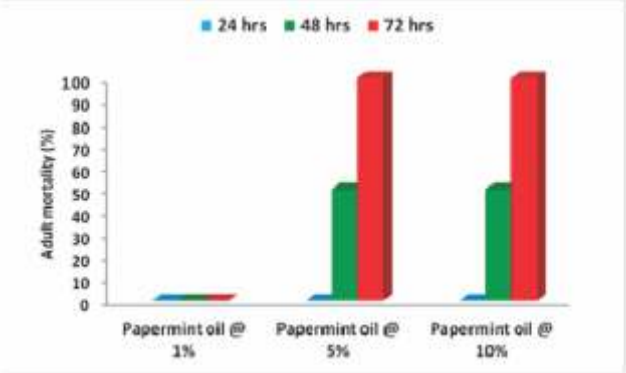
Contact/fumigant toxicity of essential oils *viz.,* eucalyptus, lemongrass and peppermint were evaluated for survival of *Lasioderma*. The adults of *Lasioderma* were released in a plastic container containing essential oil treated bulbs. Initially three broad range of doses *i.e.,* 1, 5 and 10 per cent were taken. Observation was made at 24, 48, 72 hrs after release. Study revealed that all three oils were effective at the higher doses @ 5-10% by giving high mortality after 48 hrs of release (Figure 5.9 a-c).




(a) Eucalyptus oil




(b) Lemongrass oil

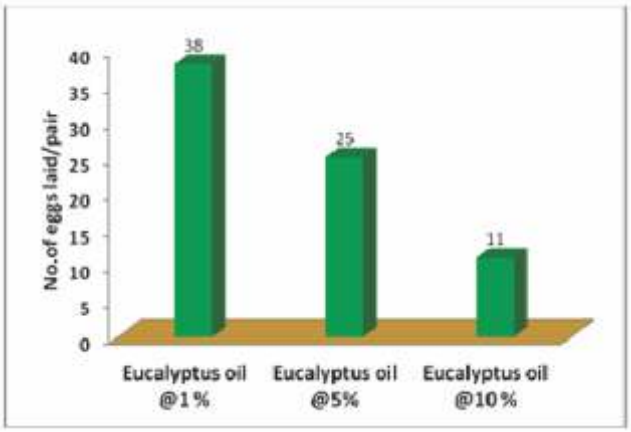



(c)Peppermint oil

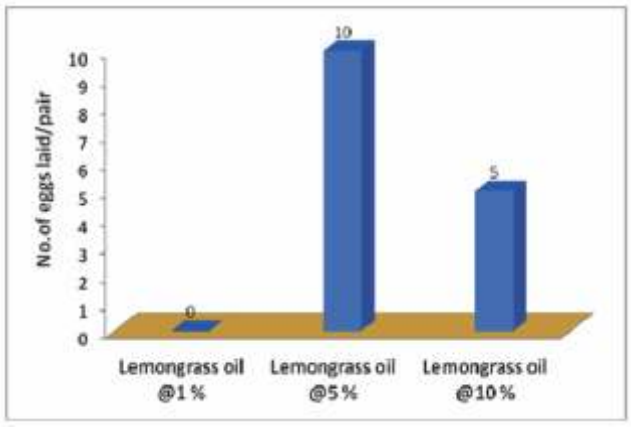
Figure 5.9 (a-c): Effect of essential oil on survival of *Lasioderma*

## Effect of essential oil on ovipositional rate of *Ephestia cautella*

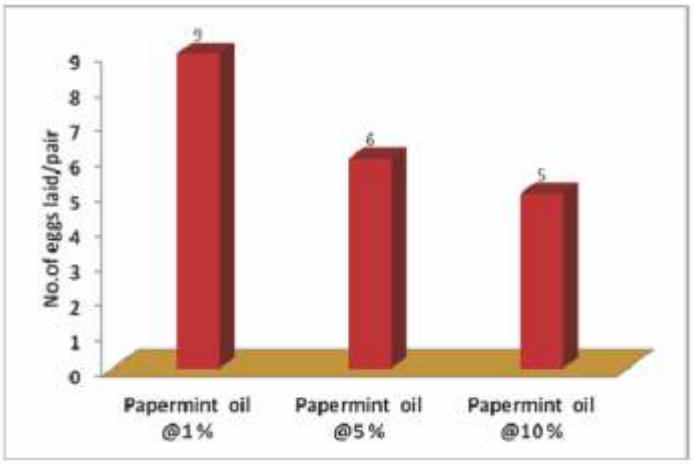
Effect of essential oil on ovipositional preference of *Ephestia* was studied. Pair of adult moths was released in a plastic container containing essential oil treated bulbs with doses of 1, 5 and 10 per cent. Observation was made at 24, 48, 72 hrs after release. Study revealed that number of eggs laid by *Ephestia* was low in bulbs treated with higher dose *i.e.,* 5-10% of essential oil and a similar trend was observed in all three treatments. Ovipostional preference was more in eucalyptus oil treatments with 11-38 eggs/pair while less in peppermint (5-9 eggs/pair) and lemongrass (5-10 eggs/pair) oil treated bulbs (Figure 5.10 a-c).




(a) Eucalyptus oil




(b) Lemongrass oil




(c) Peppermint oil

Figure 5.10 (a-c) Effect of essential oil on ovipositional rate of Ephestia cautella

# Extension

## Project 6: Improving knowledge and skill of stakeholders for improving production of onion and garlic

Extension activities not only help to disseminate the technology but evaluate its impact and help to further refine it. This project aims at improving knowledge and skill of the farmers, extension workers and all other stakeholders with regard to onion and garlic production. Besides, impact of training programmes was also analyzed.

### Performance of frontline demonstrations

Frontline demonstrations were carried out at the farmers' fields under different agro-climatic regions and farming situations. Seven demonstrations were conducted in three states *viz.*, Punjab, Karnataka and Gujarat during *rabi, kharif* and late *kharif* seasons, respectively. The seeds of onion varieties developed by the Directorate were provided to the selected progressive farmers of these states. Seeds of local varieties were arranged by the farmers.

**Demonstrations in Punjab:** Onion varieties, Bhima Shakti, Bhima Kiran and Bhima Shweta were selected for *rabi* demonstrations in Ludhiana and Moga districts of Punjab. For the purpose, 1800 gm onion seed (600 gm of each variety) was provided by the Directorate. Demonstrations were conducted at the fields of two progressive farmers (one from each district). Seed was equally distributed among the farmers for demonstration purpose.

**Demonstrations in Karnataka:** Onion varieties, Bhima Raj, Bhima Super, Bhima Red, Bhima Dark Red, Bhima Shubhra and Bhima Shweta were selected for *kharif* demonstrations in Bagalkot, Bijapur and Dharwad districts of Karnataka. For this purpose, 5400 g onion seed (900 g of each variety) was provided. Three progressive farmers (one from each district) were selected for carrying out the demonstrations and each farmer was given 300 g seed of each variety.

**Demonstrations in Gujarat:** Onion varieties, Bhima Super, Bhima Raj, Bhima Shakti and Bhima Red were selected for late *kharif* demonstrations in Bhavnagar and Amreli district of Gujarat. Two progressive farmers (one from each district) were selected for carrying out the demonstrations. For this purpose, 2400 g onion seed (600 g of each variety) was provided by the Directorate and distributed in such a way that everybody got 300 g seed of each variety.

Recommendations made by the Directorate were followed in all trials. The schedule of various operations followed in different trials is given in Table 6.1.

**Table 6.1: Schedule of various operations followed in frontline demonstration trials**

| Work | Date of operation in different states and seasons | | |
|---|---|---|---|
| State | Punjab | Karnataka | Gujarat |
| Season | *Rabi* | *Kharif* | Late *Kharif* |
| Sowing in nursery | 26/10/2015 | 21/06/2016 | 18/08/2016 |
| Transplanting | 20/12/2015 | 05/08/2016 | 07/10/2016 |

| Work | Date of operation in different states and seasons | | |
|---|---|---|---|
| Basal dose | FYM 15 t/ha<br>40:40:60:30 kg NPKS/ha<br>19/12/2015 | FYM 15 t/ha<br>25:40:40:30 kg NPKS/ha<br>04/08/2016 | FYM 15 t/ha<br>40:40:60:30 kg NPKS/ha<br>06/10/2016 |
| 1st top dress dose | 35 kg N/ha<br>19/01/2016 | 25 kg N/ha<br>04/09/2016 | 35 kg N/ha<br>06/11/2016 |
| 2nd top dress dose | 35 kg N/ha<br>03/02/2016 | 25 kg N/ha<br>19/09/2016 | 35 kg N/ha<br>21/11/2016 |
| Micronutrient spray | 5 g/L<br>05/02/2016<br>20/02/2016<br>07/03/2016 | 5 g/L<br>21/09/2016<br>06/10/2016<br>21/10/2016 | 5 g/L<br>22/12/2016<br>07/01/2017<br>22/01/2017 |
| Harvesting | 24/04/2016 | 18/11/2016 | 11/03/2017 |

The cultural practices which were common to all trials are described below.

**Nursery raising:** The debris of previous crops, weeds and stones were removed before bed preparation. Raised beds (size: 1.5 m width x 4 m length x 15 cm height) were prepared. Seeds were treated with thiram @ 2 g/kg seed before sowing to avoid damage from damping off disease. At the time of bed preparation, 50 kg of FYM and 10 kg vermicompost were added. Before sowing, the beds were moistened and sprayed with weedicide pendimethalin @ 2ml/L. Seeds were treated with carbendazim @ 3 g/kg of seeds. The seeds (35 g/bed) were mixed with sand and vermicompost, and sown in line on bed. Distance between two lines was 8 cm and depth of sowing was 1-1.5 cm. Seeds were covered with fine soil followed by light watering.

**Land preparation and transplanting:** Prior to transplanting, field was ploughed and disked properly to eliminate debris and soil clods. At the time of land preparation, 15 t FYM/ha was added. Seedlings were transplanted on broad bed furrows of 1.2 m width, 15 cm height and 60 m length with drip irrigation. Before transplanting, the bed was wetted by drip irrigation and weedicide pendimethalin (2 ml/L) was sprayed. After uprooting of seedlings, 1/3rd part of leaves was cut and the roots were washed with clean water and seedlings were kept for an hour in 10 L water having 15 g carbendazim.

**Pest and disease management:** Foliar sprays of carbosulfan (2 ml/L) with tricyclazole (1 g/L) and profenophos (1 ml/L) with hexaconazole (1 g/L) were given 30 and 45 DAT respectively, to control diseases and pests.

**Irrigation:** Inline dripper of 16 mm lateral with 40 cm distance between two drippers was used and water was discharged @ of 4 L/hour. Drip irrigation was given for half an hour twice a day on daily basis. Irrigation was stopped 20 days before harvesting.

**Harvesting:** It was done at 50-60% neck fall stage.

The performance of trials at different locations is given in Table 6.2.

**Table 6.2: Performance of frontline demonstration trials at different locations**

| District | Season | Variety | Germination Percentage | Av. bulb weight (g) | Marketable yield (q/ha) |
|---|---|---|---|---|---|
| Punjab | *Rabi* | Bhima Shakti<br>Bhima Kiran<br>Bhima Shweta<br>Local | 96<br>94<br>95<br>80 | 90<br>84<br>82<br>72 | 410<br>360<br>340<br>250 |
| Karnataka | *Kharif* | Bhima Super<br>Bhima Raj<br>Bhima Dark Red<br>Bhima Shubhra<br>Bhima Shweta<br>Local | 98<br>95<br>97<br>94<br>93<br>75 | 80<br>78<br>76<br>75<br>72<br>70 | 350<br>340<br>325<br>310<br>300<br>275 |
| Gujarat | Late *Kharif* | Bhima Raj<br>Bhima Super<br>Bhima Red<br>Bhima Shakti<br>Local | 98<br>97<br>96<br>92<br>85 | 87<br>83<br>80<br>78<br>76 | 460<br>430<br>420<br>410<br>320 |

In *rabi* demonstrations, the germination percentage (96), average bulb weight (90 g) and yield (410 q/ha) of Bhima Shakti were the highest. Bhima Kiran (360 q/ha) and Bhima Shweta (340 q/ha) yielded more than the local variety (250 q/ha). In *kharif* demonstrations, the germination percentage (98), average bulb weight (80g) and yield (350 q/ha) of Bhima Super were the highest. Bhima Raj (340 q/ha), Bhima Dark Red (325 q/ha),Bhima Shubhra (310 q/ha) and Bhima Shweta (300 q/ha) also yielded more than local variety (275 q/ha). The yield of Bhima Red (460 q/ha) was the highest in Late *kharif* demonstrations. Bhima Super (430 q/ha) and Bhima Raj (420 q/ha) and Bhima Shakti (410 q/ha) also yielded more than the local variety (320 q/ha) in Late *kharif* demonstrations. ICAR-DOGR varieties were performed better than local varieties in all demonstrations.


Figure 6.1: ICAR-DOGR varieties used in demonstrations

### Impact analysis of training programmes

A farmers' training programme is a specific learning process meant to improve the ability of the farmers to enable them to adopt modern agricultural technologies. The study was focused on gain in knowledge and skill of onion and garlic farmers due to training interventions. Thirty trainings were organized in the year 2016-17. From these, ten trainings were analyzed on the basis of five methods (1. Lecture, 2. Lecture + Discussion, 3. Lecture + Demonstration, 4. Discussion + Demonstration, and 5. Lecture + Discussion + Demonstration). The evaluation of training programmes is given in Table 6.3. Training method wise average of learning indices are given in Table 6.4.

**Table 6.3: Evaluation of training programmes**

| Training Date | Training Place | Training Method | Pre-training score | Post training score | Learning Index |
|---|---|---|---|---|---|
| 04/07/2016 | Pabal | Lec+Dem | 3.60 | 9.36 | 5.97 |
| 03/08/2016 | Khairewadi | Lec+Dis | 3.24 | 7.52 | 4.29 |
| 23/08/2016 | Bandharpada | Lec | 4.20 | 7.92 | 3.88 |
| 24/08/2016 | Raingan | Dis+Dem | 3.44 | 7.64 | 4.35 |
| 06/09/2016 | Gosasi | Lec+Dis+Dem | 2.96 | 10.40 | 7.66 |
| 08/11/2016 | Wafgaon | Lec+Dis | 2.72 | 6.76 | 4.15 |
| 16/11/2016 | Mitgudwadi | Lec+Dem | 3.44 | 9.12 | 5.88 |
| 05/12/2016 | Rajgurunagar | Lec+Dis+Dem | 2.96 | 10.96 | 8.24 |
| 19/12/2016 | Khandbara | Dis+Dem | 2.80 | 6.92 | 4.24 |
| 22/12/2016 | Gulani | Lec | 4.72 | 8.40 | 3.86 |

(Lec = Lecture, Dem = Demonstration and Dis = Discussion)

**Table 6.4: Training method wise average of learning indices**

| Training Methods | Average Learning Index |
|---|---|
| Lecture | 5.92 |
| Lecture + Discussion | 4.22 |
| Lecture | 3.87 |
| Discussion + Demonstration | 4.29 |
| Lecture + Discussion + Demonstration | 7.95 |

Average Learning Index was least (3.87) when applied lecture method. It was highest (7.95) for Lecture + Discussion + Demonstration method. Findings indicated that when lecture followed by discussion and demonstration, the training was more successful than the other methods of trainings.

(a)

(b)

Figure 6.2: Farmers Training at (a) Pabal and (b) Gosasi under MGMG

(a)

(b)

Figure 6.3: Farmers Training at (a) Raingan and (b) Bandharpada under TSP

Figure 6.4: Farmers Training at ICAR-DOGR under ATMA

(a)

(b)

Figure 6.5: (a) Pre and (b) Post test of trainee participants

# Transfer of Technology

## Trainings organized

| Topic of Training | Sponsored by | Date and Venue | No. of participants |
|---|---|---|---|
| Post-harvest management and storage of onion | KVK, Narayangaon | 11 April, 2016 ICAR-DOGR | 250 farmers from Maharashtra |
| Construction of low cost onion storage structure to improve bulb storability | TSP, ICAR-DOGR, Rajgurunagar, Pune | 19-20 May, 2016 Shravani and Palsun | 145 farmers from District Nandurbar |
| *Kharif* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 14 June, 2016 Rase | 23 farmers from District Pune |
| Onion and Garlic Technologies developed by ICAR-DOGR | ICAR-DOGR, Rajgurunagar, Pune | 16 June, 2016 ICAR-DOGR | 55 farmers from different states of India |
| *Kharif* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 4 July, 2016 Pabal | 25 farmers from District Pune |
| Late *kharif* nursery management | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 3 August, 2016 Khairewadi | 25 farmers from District Pune |
| Late *kharif* nursery preparation | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 6 August, 2016 Dattawadi | 28 farmers from District Pune |
| Advance onion and garlic cultivation technology for farmers of Godhra (Gujarat) | AGRI, New Delhi | 11 August, 2016 ICAR-DOGR | 50 farmers from Godhra (Gujarat) |
| Construction of low cost onion storage structure to improve bulb storability | TSP, ICAR-DOGR, Rajgurunagar, Pune | 23 August, 2016 Bandharpada | 50 farmers from District Nandurbar |
| *Rabi* onion production technology | TSP, ICAR-DOGR, Rajgurunagar, Pune | 24 August, 2016 Raingan | 70 farmers from District Nandurbar |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 6 September, 2016 Varude | 25 farmers from District Pune |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 8 September, 2016 Gosasi | 28 farmers from District Pune |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 15 September, 2016 Khairewadi | 32 farmers from District Pune |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 17 September, 2016 Daundkarwadi | 26 farmers from District Pune |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 19 September, 2016 Wafgaon | 30 farmers from District Pune |
| Insect, Pest and Disease Management in onion crop | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 27 September, 2016 Khairenagar | 25 farmers from District Pune |

| Topic of Training | Sponsored by | Date and Venue | No. of participants |
|---|---|---|---|
| Commercial cultivation of onion and garlic | TSP, ICAR-DOGR, Rajgurunagar, Pune | 4-6 October, 2016 Savrat, Khairve and Khandbara | 250 farmers from District Nandurbar |
| *Rabi* onion production technology | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 8 November, 2016 Wafgaon | 30 farmers from District Pune |
| Disease and pest management in onion crop | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 16 November, 2016 Mitgudwadi | 25 farmers from District Pune |
| Onion: pest and disease management | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 25 November, 2016 Jawulke | 52 farmers from District Pune |
| Integrated Pest and Disease Management in onion | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 30 November, 201 Khairewadi | 50 farmers from District Pune |
| Application of inputs for onion and garlic | TSP, ICAR-DOGR, Rajgurunagar, Pune | 1 December, 2016 Khandbara | 25 farmers from District Nandurbar |
| Application of inputs for onion and garlic | TSP, ICAR-DOGR, Rajgurunagar, Pune | 2 December, 2016 Savrat | 25 farmers from District Nandurbar |
| Onion production technology and soil health | ICAR-DOGR, Rajgurunagar, Pune | 5 December, 2016 ICAR-DOGR | 100 farmers from Pune and Nandurbar districts |
| Integrated pest and disease management in onion crop | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 22 December, 2016 Gulani | 36 farmers from District Pune |
| Commercial cultivation of onion and garlic | TSP, ICAR-DOGR, Rajgurunagar, Pune | 3-4 January, 2017 Savrat, Nibhoni, | 155 farmers from Nandurbar |
| Pest and disease management in onion | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 7 January, 2017 Kanhur Mesai | 50 farmers from District Pune |
| Pest and disease management in onion | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 6 February, 2017 Gadakwadi | 28 farmers from District Pune |
| Onion and Garlic Cultivation | Project Director, ATMA, Khandwa | 7 March, 2017 ICAR-DOGR | 45 farmers from Khandwa (M.P.) |
| *Rabi* onion harvesting and storage management | MGMG, ICAR-DOGR, Rajgurunagar, Pune | 20 March, 2017 Jawulke | 36 farmers from District Pune |

## Participation in Exhibitions

| Exhibition | Organizer | Date | Venue |
|---|---|---|---|
| Exhibition on farmers' day | IARI Regional Station, Baner, Pune | 15 October, 2016 | IARI-RS, Pune |
| Exhibition for National Symposium on Edible Alliums | Indian Society of Alliums, Pune | 7-9 November, 2016 | Jalna |
| Kisan Agri Expo 2016 | Kisan Forum Pvt. Ltd., Pune | 14-18 December, 2016 | Moshi, Pune |
| Maha Agro 2016 | Marathwada Sheti Sahay Mandal, Aurangabad | 24-27 December, 2016 | Aurangabad |
| Global Agri Exhibition 2017 | KVK, Narayangaon | 6-8 January, 2017 | Narayangaon |

| Exhibition | Organizer | Date | Venue |
|---|---|---|---|
| Science Day | Giant Metrewave Radio Telescope, Tata Institute of Fundamental Research, Khodad, Narayangaon | 28 February-1 March, 2017 | GMRT, TIFR, Khodad, Narayangaon |
| Krishi Unnati Mela 2017 | Indian Agricultural Research Institute, Pusa Campus, New Delhi | 15-17 March, 2017 | IARI, New Delhi |


Participation in Kisan Expo

## Lectures delivered

| Topic | Event and Organizer | Date and Venue |
|---|---|---|
| **V. Mahajan** | | |
| Importance, benefits, approaches and available technologies of IPM in onion cultivation | ICAR-DOGR, Pune in collaboration with ICAR-NCIPM, New Delhi | 30 November, 2016 Khairewadi, District Pune |
| Research, education and extension in various spheres of agricultural sciences - shaping career in the field of agriculture | "Agriculture Education Day" ICAR-DOGR, Rajgurunagar | 3 December, 2016 Mahatma Gandhi High School and Junior College, Rajgurunagar |
| Importance of soil testing and soil health card for balanced fertilizer application based on soil test for higher crop production | "World Soil day" ICAR-DOGR, Rajgurunagar | 5 December, 2016 ICAR-DOGR, Rajgurunagar |
| Kanda utpadan va sathavanook | "Global Agri Exhibition 2017" KVK, Narayangaon | 6 January, 2017 KVK, Narayangaon |
| Prospects in onion & garlic entrepreneurship | "Agro-Industry meet" ATARI, Jabalpur | 11, 12 January, 2017 KVK , Neemuch (M.P.) |

| Topic | Event and Organizer | Date and Venue |
|---|---|---|
| **A.J. Gupta** | | |
| Construction of low cost onion storage structure to improve bulb storability | Training on "construction of low cost onion storage structure to improve bulb storability under TSP" by ICAR-DOGR. | 19-20 May, 2016<br>Shravani & Palsuun, Nandurbar |
| Commercial cultivation of onion and garlic | Training on "Commercial cultivation of onion and garlic under TSP" by ICAR-DOGR. | 4 October, 2016<br>Savrat, Nandurbar |
| Improved varieties of onion and garlic and Impact of TSP | Training on "Commercial cultivation of onion and garlic under TSP" by ICAR-DOGR. | 5 October, 2016<br>KVK, Nandurbar |
| Commercial cultivation of onion and garlic | Training on "Commercial cultivation of onion and garlic under TSP" by ICAR-DOGR. | 6 October, 2016<br>Kairve, Nandurbar |
| Screening of onion varieties suitable for raising early *kharif* crop through sets. | 2nd National Symposium on Edible Alliums: Challenges and future strategies for sustainable production by ISA-DOGR and BSF, Jalna | 7 November, 2016<br>Jalna |
| Commercial cultivation of onion | Training on "Commercial cultivation of onion under TSP" by ICAR-DOGR. | 3 January, 2017<br>Savrat, Nandurbar |
| Quality seed production of onion and garlic | Training on "Commercial cultivation of onion under TSP" by ICAR-DOGR. | 4 January, 2017<br>Nimbhoni, Nandurbar |
| **S.S. Gadge** | | |
| Onion cultivation | Training on "Post-harvest management and storage of onion" by KVK, Narayangaon | 11 April, 2016<br>ICAR-DOGR, Rajgurunagar |
| *Kharif* onion production | Training on "*Kharif* onion production technology" under MGMG by ICAR-DOGR | 14 June, 2016<br>Rase, District Pune |
| Advance onion and garlic cultivation technology | Training on "Onion and Garlic Technologies developed by ICAR-DOGR" on 19th Foundation Day of ICAR-DOGR | 16 June, 2016<br>ICAR-DOGR, Rajgurunagar |
| *Kharif* onion nursery management | Training on "*Kharif* onion production technology" under MGMG by ICAR-DOGR | 4 July, 2016<br>Pabal, District Pune |
| Late *kharif* nursery management | Training on "Late *kharif* nursery management" under MGMG by ICAR-DOGR | 3 August, 2016<br>Khairewadi, District Pune |
| Late *kharif* nursery preparation | Training on "Late *kharif* nursery preparation" under MGMG by ICAR-DOGR | 6 August, 2016<br>Dattawadi, District Pune |
| Advance onion and garlic cultivation technology | Training on "Advance onion and garlic cultivation technology" for farmers of Godhra (Gujarat) by AGRI, New Delhi | 11 August, 2016<br>ICAR-DOGR, Rajgurunagar |
| Onion storage technology | Training on "Construction of low cost onion and garlic storage structures to improve bulb storability" under TSP by ICAR-DOGR | 23 August, 2016<br>Bandharpada, District Nandurbar |
| *Rabi* onion production technology | Training on "*Rabi* onion production technology" under TSP by ICAR-DOGR | 24 August, 2016<br>Raingan, District Nandurbar |

| Topic | Event and Organizer | Date and Venue |
|---|---|---|
| Post-harvest management of onion | Training on "Post-harvest management of onion, potato and tomato" by KVK, Narayangaon | 3 September, 2016<br>KVK, Narayangaon |
| *Rabi* onion production technology | Training on "*Rabi* onion production" under MGMG by ICAR-DOGR | 6 September, 2016<br>Varude, District Pune |
| *Rabi* onion production technology | Training on "*Rabi* onion production" under MGMG by ICAR-DOGR | 15 September, 2016<br>Khairewadi, District Pune |
| *Rabi* onion production technology | Training on "*Rabi* onion production" under MGMG by ICAR-DOGR | 17 September, 2016<br>Daundkarwadi, District Pune |
| *Rabi* onion production technology | Training on "*Rabi* onion production" under MGMG by ICAR-DOGR | 19 September, 2016<br>Wafgaon, District Pune |
| Onion cultivation technology | Training on "Cultivation of Onion Crop" by Agrowon, Sakal Media Group, Pune | 13 October, 2016<br>Chambali, Tal. Purandar, District Pune |
| Pest and Disease management in onion crop | Training on "Disease and Pest Management in Onion Crop" under MGMG by ICAR-DOGR | 16 November, 2016<br>Mitgudwadi, District Pune |
| Pest and Disease management in onion crop | Training on "Onion: Pest and disease management" under MGMG by ICAR-DOGR | 25 November, 2016<br>Jawulke, District Pune |
| Application of various inputs in onion and garlic cultivation | Training on "Application of inputs for onion and garlic" under TSP by ICAR-DOGR | 1 December, 2016<br>Khandbara, District Nandurbar |
| Application of various inputs in onion and garlic cultivation | Training on "Application of inputs for onion and garlic" under TSP by ICAR-DOGR | 2 December, 2016<br>Savrat, District Nandurbar |
| Importance of Agriculture, organizational set up of ICAR and its role in agricultural research, education and development activities | "Agricultural Education Day" by ICAR-DOGR | 3 December, 2016<br>Mahatma Gandhi Vidyalaya, Rajgurunagar |
| Recently developed technologies of onion and garlic | Training on "Onion production technology and soil health" by ICAR-DOGR | 5 December, 2016<br>ICAR-DOGR, Rajgurunagar |
| Disease management in onion crop | Training on "Integrated pest and disease management in onion crop" under MGMG by ICAR-DOGR | 22 December, 2016<br>Gulani, District Pune |
| Pest and disease management in onion crop | Training on "Integrated pest and disease management in onion crop" under MGMG by ICAR-DOGR | 6 February, 2017<br>Gadakwadi, District Pune |
| Onion and garlic cultivation technology | Training on "Onion and garlic cultivation" by Project Director, ATMA, Khandwa (M.P.) | 7 March, 2017<br>ICAR-DOGR, Rajgurunagar |
| Harvesting and storage of *Rabi* onion | Training on "*Rabi* onion harvesting and storage management" under MGMG by ICAR-DOGR | 20 March, 2017<br>Jawulke, District Pune |
| **S.J. Gawande** | | |
| Onion and garlic viruses | 2nd National Symposium on Edible *Alliums*: Chllanges and Future Strategies for Sustainable Production | 7-9 November, 2016<br>Jalna |

| Topic | Event and Organizer | Date and Venue |
|---|---|---|
| Onion and garlic viruses and their vectors | National Conference on "Recent Trends in Plant Sciences" | 1-2 March, 2017<br>Jalna |
| **S. Anandhan** | | |
| Application of haploidy as a technique in short day onion improvement programme | 2nd National Symposium on Edible *Alliums*: Challenges and Future Strategies for Sustainable Production | 7-9 November, 2016<br>Jalna |
| **A. Thangasamy** | | |
| Organic cultivation in onion and garlic | 2nd National Symposium on Edible *Alliums*: Challenges and Future Strategies for Sustainable Production | 7-9 November, 2016<br>Jalna |
| Organic farming for improved onion quality and sustainable soil health | International Seminar on Emerging Trends in Organic Farming and Sustainable Agriculture | 29-31December, 2016<br>Mahatma Gandhi University, Kottayam |
| **V.N. Salunkhe** | | |
| Integrated insect and pest management of onion | Training on "Improved technology for production and post harvest management of onion" for a batch of participants from abroad by NHRDF, Nashik | 21 July, 2016<br>NHRDF, Nashik |
| Onion cultivation | "Farmers training" by National Mission on Oilseeds and Oil Palm (NMOOP) | 10 October, 2016<br>Chandoli, District Pune |
| Onion cultivation | Farmers training on "Improved onion & potato cultivation" by AFARM | 3 December, 2016<br>Kendur, Shirur, District Pune |
| Integrated approaches for onion anthracnose management | Indian Phytopathological Society's (West zone) National symposium on "Plant health management for sustainable agriculture" by College of Agriculture, Udgir in collaboration with VNMKV, Parbhani | 11-12, December, 2016<br>Udgir, District Latur |

## A Farmer's Success Story under *Mera Gaon Mera Gaurav* scheme

Shri. Ravindra Namdeo Gorde, a farmer of Gosasi village, District Pune under *'Mera Gaon Mera Gaurav'* scheme of ICAR-DOGR narrated his success story. He told that he had got tremendous increase in onion bulb yield after applying ICAR-DOGR technologies. According to him, previously he was cultivating onion crop by using traditional practices. He was spraying pesticides and insecticides after seeing incidences of diseases and insects. Now he takes precautions before diseases and insects occur. He treats onion seed with thirum before sowing in nursery. He transplants onion seedlings after dipping roots in carbendazim and carbosulfan solution for two hours. Afterwards, he sprays insecticides and pesticides time to time as per DOGR advice. Last year on 22 July 2015, Shri. Gorde had sown seed of Bhima Shakti in nursery. He transplanted seedlings on 5 September 2015. He harvested onion crop on 25 December, 2015 and sold onion in market on 5 January, 2016. Shri. Gorde was previously getting only 60 bags (1 bag = 65 kg) /acre of onion bulbs. But last year after using advance technology of onion cultivation, he got 150 bags of onion bulbs in one acre. As his onion bulbs were of good quality, he received market rate of Rs. 21

per kg. Previously, he was getting only Rs. 10 per kg. Thus, Shri. Gorde says that he has been benefitted by '*Mera Gaon Mera Gaurav*' scheme.

## Bhima Kiran -A Success Story under Tribal Sub-Plan

"Bhima Kiran" - a light red onion variety developed by ICAR-DOGR has become a success story in Maharashtra and adjoining states. This variety was recommended at national level in 1st Annual Group Meeting of AINPORG held at CITH, Srinagar (J&K) during 10-11 May, 2010 for cultivation in *rabi* season in Andhra Pradesh, Bihar, Delhi, Haryana, Karnataka, Maharashtra, Punjab and Uttar Pradesh. It matures in 125-135 days after transplanting and has light red attractive bulbs with good storability. It has field tolerance to thrips and foliar diseases. Mr. Harish Nurjee Vadvi, a group leader of tribal farmers of Merali Yaha Shetkari Bachat Gat, Palipada, Tal. Navapur, Dist. Nandurbar, Maharashtra raised onion bulb crop adopting ICAR-DOGR recommended technologies and produced 200 q per acre marketable bulb yield and earned net income of Rs. 80,000/- per acre even when onion bulbs were sold at the rate of Rs. 6/- per kg. Mrs. Archana Surupsingh Valvi, a group leader of tribal women farmers of Saraswati Mahila Bachat Gat, Palipada also raised onion seed crop as per ICAR-DOGR recommended technology and produced 279 kg per acre onion seed and earned net income of Rs. 1, 04,000/- per acre. Several demonstrations were conducted in different parts of the country on onion bulb and seed production of Bhima Kiran variety including 15 demonstrations in tribal district Nandurbar. Farmers found Bhima Kiran best for bulb storage (up to five months) during *rabi* season. This variety is now grown over thousand hectares area in different states. Most of the farmers are earning a net profit of more than Rs. 1.0 lakh per acre by cultivating Bhima Kiran. Mr. Harish Nurjee Vadvi and Mrs. Archana Surupsingh Valvi felicitated on the occasion of 19th Foundation Day of ICAR-DOGR (16 June, 2016) for their significant contribution in onion cultivation.

Performance of Bhima Kiran at farmers' fields in Nandurbar

# Research Projects

## Institute Research Projects

### Project 1:

**Conservation, Characterization and utilization of genetic resources of *Allium* species**

V. Mahajan, PI, A.J. Gupta, S.J. Gawande, S. Anandhan , Ashwini P. Benke, Vanita Salunkhe, Kalyani Gorrepati, Pranjali Ghodke, Manjunatha Gowda D.C., Geetika Sheemar (CITH, Srinagar)

### Project 2:

**Devising efficient breeding techniques and genetic improvement of onion and garlic through conventional breeding and biotechnological approaches**

A.J. Gupta, PI, V. Mahajan, S. Anandhan, Ashwini P. Benke, Pranjali Ghodke, Manjunatha Gowda D.C.

### Project 3:

**Integrated water and nutrient management and physiological manipulation for improving productivity of onion and garlic**

A. Thangasamy, PI, Kalyani Gorrepati, Pranjali Ghodke, Manjunatha Gowda D.C., Shabeer Ahmed (ICAR-NRCG, Pune)

### Project 4:

**Integrated pest and disease management for minimization of losses and improving productivity of onion and garlic**

S.J. Gawande, PI, Vanita Salunkhe, S. Anandhan, V. Karuppaiah, Soumia P.S.

### Project 5:

**Development and refinement of post harvest handling, storage and processing techniques for minimization of losses and improving productivity of onion and garlic**

Kalyani Gorrepati, PI, Vanita Salunkhe, V. Karuppaiah

### Project 6:

**Improving knowledge and skill of stakeholders for improving production of onion and garlic**

S. S. Gadge, PI, A. Thangasamy

## Other Projects

### Project 1:

**All India network research project on onion and garlic**

V. Mahajan, Nodal Officer, Funding: ICAR

### Project 2:

**DUS testing through ICAR-SAU's system**

A.J. Gupta, Nodal Officer, Funding: PPV & FRA

### Project 3:

**Mega Seed Project: Seed production in agricultural crops and fisheries**

S. J. Gawande, Nodal Officer, Funding: ICAR

### Project 4:

**Outreach Research Programme on sucking pests**

S.J. Gawande, PI, Funding: ICAR

### Project 5:

**Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme (IPMT-CATS), ICAR**

Kalyani Gorrepati, Member Secretary, Funding: ICAR

### Project 6:

**Development of hybrids in onion: A joint venture with Bejo Sheetal**

A.J. Gupta, PI, Funding: Bejo Sheetal Seeds Pvt. Ltd. and ICAR-DOGR

### Project 7:

**IPM project: Formulation, Validation and Promotion of Adaptable IPM Technology for Bulb (Onion) Vegetable Crops**

S.J. Gawande, PI, V. Karuppaiah, Funding: ICAR-NCIPM

### Project 8:

**Tribal Sub-Plan for onion and garlic**

A.J. Gupta, Nodal Officer, S. S. Gadge, A. R. Wakhare, H. S. Gawali, Funding: ICAR

### Project 9:

**Studies on Male sterility systems to increase the efficiency of F1 hybrids in horticultural crops**

A.J. Gupta, Nodal Officer, Funding: ICAR-IIHR

### Project 10:

**National Innovation on Climate Resilient Agriculture (NICRA)**

A. Thangasamy, PI, V. Karuppaiah, Vanita Salunkhe, Pranjali Ghodke, Funding: ICAR-CRIDA

### Project 11:

**CRP on Agro biodiversity**

V. Mahajan, Nodal Officer, Funding: ICAR

### Project 12

**North East Hill Plan**

V. Mahajan, Nodal Officer, Funding: ICAR

# Publications

## Papers in referred journals


1. Gopal J. and Gadge S.S. 2016. Onion and garlic adding wealthy flavour. *Indian Hort.*, 61(6): 52-56.
2. Mahajan V. and Gupta A.J. 2016. Development of photo and thermo- insensitive cultivars of short day onion in India. *Acta Hort.*, 1143: 61-68.
3. Mahajan V. and Gupta A.J. 2016. Breeding white onion varieties for processing under short day conditions of India. *Acta Hort.*, 1143: 303-310.
4. Murkute A.A. and Anandhan S. 2016. Onion quality affected by ethanol and ethephon during storage. *Natl. Acad. Sci. Lett.*, 39:163–169.
5. Thangasamy A. 2016. 4R stewardship approach for nutrient management in onion and garlic. *Better crops-South Asia*, X (10). No. 1: 8-12.
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9. Sujayanand G.K. and Karuppaiah V. 2016.Aftermath of climate change on insect migration: a review. *Agri Rev.*, 37(3): 221-227.
10. Karuppaiah V., Srivastava C. and Subramanian S. 2017. Variation in insecticide detoxification enzymes activity in *Spodoptera litura* (Fabricius) of different geographic origin. *J. Entomol. Zool. Stud.*, 5(3): 770-773.
11. Gorrepati K., Thangasamy A., Bhagat Y. and Murkute A.A. 2017. Curing of onion: a review. *Indian Hort. J.*, 7(1): 08-14.
12. Kuldip J., Mahajan P., Singh G., Parmar R., Seth R., Raina A., Swarnkar M.K., Singh A.K., Sankar R., Sharma R.K. 2016. Transcriptome analysis reveals candidate genes involved in blister blight defense in tea (*Camellia sinensis* (L) Kuntze). *Nat. Sci. Rep.*, 6, 30412; doi: 10.1038/srep30412.
13. Soumia P.S., Srivastava C., Guru Prasanna Pandi G. and Subramanian S. 2017. Varietal preference of pulse beetle, *Callosobruchus maculatus* (F.) in green gram. *Indian J. Entomol.*, 79 (1): 86-91.


## Papers and Abstracts in Conference/Symposia


1. Mahajan V., Gupta A.J., Negi K.S., Mehta P.S. and Khar A. 2016. Exploration and collection of Allium species

from Himalayan ranges of J&K and NEH region. Abs. *In:* 2nd National Symposium on Edible Alliums: Challenges and Future Strategies for Sustainable Production. 7-9 November. Jalna. ISA, Pune. p. 203.

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## Book/Newsletter/Annual Report

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3. Gadge S.S., Gorrepati K., Kuldip and Gopal J. 2016. Annual Report 2015-16. ICAR-DOGR, Rajgurunagar, Pune. 159 p.

4. Gadge S.S., Gorrepati K., Kuldip and Gopal J. 2016. ICAR-DOGR News. 20 (1). January-June. ICAR-DOGR, Rajgurunagar, Pune. 16 p.
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## Book Chapters

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3. Pathak C.S., Mahajan V. and Gupta A.J. 2016. Onion history, breeding and improvement needs *In:* Edible Alliums: Challenges and Future Strategies for Sustainable Production Eds. Mahajan V. *et al.,* ISA, Pune. pp. 1-19.
4. Singh R.K., Gupta R.P. and Mahajan V. 2017. Garlic *In:* Genesis and evolution of horticultural crops. Ed. Peter K.V. pp. 157-175.
5. Gupta R.P., Singh R.K. and Mahajan V. 2017. Onion *In:* Genesis and evolution of horticultural crops. Ed. Peter K.V. pp. 223-250.
6. Gupta A.J. and Singh, B.K. 2016. Development of hybrids and hybrid seed production of onion. *In:* Training manual on principles and production techniques of hybrid seeds in vegetables. 27 September- 8 October. ICAR-IIVR, Varanasi. pp. 101-111.
7. Devi A., Anandan S., Khar A., Mahajan V. and Lawande K. E. 2016. Application of haploidy as a technique in short day onion improvement program in "Edible Alliums: Challenges and Future Strategies for Sustainable Production. Eds. Mahajan V. *et al.,* ISA, Pune. pp. 71-73.
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4. Mahajan V., Tripathi P.C., Srinivas P.S., Gawande S.J., Anandhan S., Thangasamy A., Gadge S.S. and Singh R.P. 2016. Lead papers & abstracts: 2nd National Symposium on Edible Alliums: Challenges and Future Strategies for Sustainable Production. ISA, Pune. 291p.

5. Thangasamy A., Gadge S.S. and Mahajan V. 2017. Nursery Management in Onion. Extension Bulletin No. 7. ICAR-DOGR, Pune. 6p.

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## Technical/Popular Articles

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2. Mahajan V. 2016. *Rabi kanda laagawad va peek niyojan.* Shetakari. September. Pune. pp. 19-22.

3. Mahajan V. 2016. *Lasun lagawadi sathi vyavaasthapan.* Shetakari. October. Pune. pp. 34-38.

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43. Karuppaiah, V., Wagh P.D. and Soumia, P.S. 2016. A new pest of *kharif* onion- Green looper *Chrysodeixix* sp. ICAR-DOGR News. 20 (2), July-December, ICAR-DOGR, Pune. p. 6.

44. Karuppaiah, V., Priyanka D. Wagh and Soumia, P.S. 2016. Quantification of role pollinator in onion seed production. ICAR-DOGR News. 20 (2), July-December, ICAR-DOGR, Pune. p. 5.

45. Gorrepati K. and Salunkhe V.N. 2016. *Pyaj ka bhandaran.* Kandika-Rajbhasha Hindi Patrika. (3). ICAR-DOGR, Pune. pp. 23-25.

46. Salunkhe V.N., Gorrepati K. and Mahajan V. 2017. *Kanda sathvanukitil rog va tyanche vyavsthapan.* Shetkari. February. Pune. pp 27-28.

47. Salunkhe V.N. and Singh B. 2017. *Pyaj rog prabandhan.* Phal-Phool, March-April. ICAR, New Delhi. pp. 3-6.

48. Khade Y.P. and Thangasamy A. 2016. *Pyaj me kharpatvar ka niyantran.* Kandika-Rajbhasha Hindi Patrika. (3). ICAR-DOGR, Pune. pp. 20-22.

## Mobile App

1. Mahajan V., Gorrepati K. and Gadge S.S. 2017. Mobile app. – technologies and advisory for the farmers. ICAR-DOGR, Rajgurunagar, Pune.

## TV Shows and Radio Talks

- Dr. Vijay Mahajan delivered a radio talk on "*Kandyache vyavasthapan ani sathvan*" broadcasted on 9 July, 2016 from All India Radio, Pune.
- Dr. A. J. Gupta interacted with farmers on "*Pyaj evam lahsun ki kheti*" in TV programme 'Hello Kisan' of DD Kisan channel telecasted live on 12 October, 2016 from New Delhi.
- Dr. S. S. Gadge delivered two radio talks on "*kharif kandyachi lagwad*" and "*Rangda kandyachi lagwad*" broadcasted respectively on 21 May, 2016 and 4 August, 2016 from All India Radio, Pune.
- Dr. Vanita N. Salunkhe delivered radio talk on "*kharif kandyavaril rog ani keed vyavsthapan*" broadcasted on 4 June, 2016 and interacted with farmers in the programme on *"Rog niyantran, Shetkari bandhavanchya shanka ani Prashna"* broadcasted live on 25 August, 2016 from All India Radio, Pune.

# Institutional Activities

## 19th Research Advisory Committee Meeting of Directorate

The nineteenth Research Advisory Committee meeting of ICAR-Directorate of Onion and Garlic Research was held during 17-18 March, 2017 at Rajgurunagar under the chairmanship of Dr. Y.S. Nerkar, Former Vice Chancellor, MPKV, Rahuri. Other members; Dr. C.S. Pathak, Advisor-Vegetable Research, Nath Bio-Genes (I) Ltd., Aurangabad, Dr. R.P. Gupta, Ex-Director, NHRDF & Chief Consultant (MIDH), Ministry of Agriculture and Farmers Welfare, Govt. of India, Krishi Bhawan, New Delhi, Dr. R. Srinivasan, Emeritus Scientist (ICAR), Former Professor & Project Director, NRC Plant Biotechnology, IARI, New Delhi, Mr. Suryakant Palande, Ex-MLA, Shirur, Dist. Pune, Dr. Vijay Mahajan, Director (Acting), ICAR-DOGR and scientists of ICAR-DOGR; Dr. A. J. Gupta, Dr. S. S. Gadge, Dr. S. J. Gawande, Dr. S. Anandhan, Dr. A. Thangasamy, Mrs. Ashwini Benke, Dr. Vanita Salunkhe, Dr. Pranjali Ghodke, Dr. V. Karuppaiah, Dr. Soumia P. S., Mr. Yogesh Khade and Mr. Kuldip participated in the meeting. Dr. Vijay Mahajan welcomed the Chairman and members of RAC and highlighted the achievements made during the year. Dr. A. J. Gupta, Member Secretary presented the Action Taken Report on the 18th RAC recommendations. The progress made in various research projects was presented by the respective scientists. The Chairman and members of the RAC critically reviewed the progress, discussed the results in detail and made several recommendations. Dr. S. S. Gadge and Dr. S. Anandhan were rapporteurs for RAC meeting. The members of RAC also visited field and laboratory experiments. They were satisfied with the work of the ICAR-DOGR.

## Annual Workshop of Onion & Garlic (AINRPOG) organized at Kanpur

ICAR-Directorate of Onion & Garlic Research (DOGR), Rajgurunagar, Pune organized the VIIth Annual Group meeting of All India Network Research Project on Onion and Garlic at Indian Institute of Pulse Research (IIPR), Kanpur in collaboration with Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur during April 4-5, 2016. The group meeting was attended by more than 80

delegates from various parts of the country. Farmers, students and other faculty members were also present.

The inaugural session was chaired by Dr. N. K. Krishna Kumar, DDG (HS), New Delhi. Dr. Rajendra Prasad, Dean, College of Agriculture, CSAUAT, Kanpur and Dr. N. P. Singh, Director, IIPR, Kanpur were the guests of honour. Welcome address was given by Dr. H. G. Prakash, Director Research, CSAUAT, Kanpur. Dr. Jai Gopal, Director, ICAR-DOGR, presented the project report wherein he elaborated the achievements of AINRPOG and possibilities of increasing area and production of onion and garlic in India. Emphasis was laid on development of onion hybrids, virus free planting material of garlic and weed management studies. Dr. Vijay Mahajan, Nodal Officer presented action taken report. Dr. B. Singh, Director, IIVR, Varanasi, Dr. R.P. Gupta, Director, NHRDF, Nashik, Dr. Dip Jyoti Rajkhowa, Joint Director, ICAR Research Complex, Nagaland, Dr. J.R. Yadav and Dr. J.P. Srivastava, Ex- Prof.& Head, Veg. Sci., CSAUAT, Kanpur chaired various sessions and gave valuable input for refining the technical programme. Recommendations were finalized in plenary session which was chaired by Dr. T. Janaki Ram, ADG (HS), ICAR, New Delhi. Dr. S. L. Goswami, Vice-Chancellor, CSAUAT, Kanpur was the Chief Guest on this occasion.

One light red onion variety DOGR-571, one long day garlic variety CITH-G-3 and two production technologies; one on use of micronutrients and another on salicylic acid were recommended in the workshop.

## Swachh Bharat Abhiyan

Under the Swachh Bharat Abhiyan, Swachh Bharat Pakhwara was observed by ICAR-DOGR during May 16-31, 2016. On the first day of the programme, Swachh Bharat pledge was administered to all the staff of ICAR-DOGR. Office, labs, premises of DOGR, quarters and guest house were cleaned. Apart from the regular weekly cleaning activities of the institute, staff of DOGR also visited the villages adopted by the Directorate under *Mera Gaon Mera Gaurav* programme and imparted awareness on the importance of cleanliness. Cleaning of the public places by involving the villagers was also done. On the last day of Swachh Bharat Pakhwara, Dr. Manik Bichkar was the chief guest. Dr. Bichkar is physician by profession and also actively involved in cleaning and other social activities for more than 20 years to create awareness among the people of Rajgurunagar. She delivered a talk on the importance of cleanliness, hygiene, how to avoid the use of plastic in day to day life, waste disposal and use of waste as compost. As a regular practice, every Wednesday from 4.00 PM onward ICAR-DOGR staff undertakes community work for cleaning office, residential area and other places.

ICAR-DOGR celebrated Swachh Bharat Pakhwada (Clean India Fortnight) also during 15-31 October, 2016. On the first day of Pakhwada, Dr. Jai Gopal, Director, ICAR-DOGR administered Swachh Bharat pledge to all staff of the Directorate. During the

period, cleaning activities were carried out within premises of the Directorate for one hour every day. Awareness was imparted on the importance of cleanliness were conducted by group of scientists in the villages adopted under *Mera Gaon Mera Gaurav* programme. Cleaning activities were also carried out at the primary public areas like Panchayat offices, temple premises, etc. of these villages.

Staff taking Swachh Bharat pledge

Lab cleaning

Cleaning inside the office

ICAR- DOGR vicinity cleaning

Dr. Bichkar addressing the staff

## Foundation Day of ICAR-DOGR

The 19th Foundation Day of ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune was celebrated on June 16, 2016. Besides the present and past DOGR staff, it was attended by 55 farmers from different states of India. Dr. T.A. More, Ex-VC, MPKV, Rahuri was the Chief Guest, Dr. P.G. Adsule, Ex-Director, NRC Grapes, Pune, Dr. P.S. Naik, Ex-Director, IIVR, Varanasi and Dr. S.K. Sharma, Head, IARI RS, Pune were the guests of honour. Principal Investigators from seven centres of All India Network Research Project on Onion and Garlic and their representatives were also present on this occasion. Dr. Jai Gopal, Director, ICAR-DOGR welcomed the guests and presented brief summary of the DOGR achievements and benefit it resulted in for the farming community. The Chief Guest and guests of honour appreciated the work being done by the DOGR and congratulated the staff on this occasion. Ten progressive farmers of onion and garlic from different parts of India were also felicitated on this occasion for their contribution to onion and garlic cultivation. Samples of onion and garlic brought by the farmers were also displayed. Recently created infrastructural facilities i.e. exhibition-cum-communication centre, Library, AKMU and Conference Room in the new building of DOGR were inaugurated by the chief guest and guests of honour. A talk on improved cultivation practices for onion and garlic was delivered by Dr. S. S. Gadge, Senior Scientist (Agricultural Extension) for the benefit of the farmers. They were also shown the onion and garlic activities being carried out at DOGR. The programme ended with the vote of thanks expressed by Dr. S. S. Gadge and national anthem.


## ICAR-DOGR celebrated International Yoga Day

The International Yoga Day was organized at ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune on June 21, 2016, in which all staff members participated. Yoga lesson was delivered by Shri. Yashwant Bombale and Shri. Ramdas Tambe, Yoga Instructors from Patanjali Yog

Peeth. After welcoming the guests, Director spoke briefly on importance of Yoga. The message for this occasion from the Hon'ble Prime Minister of India was read by the Nodal Officer, Shri. Ram Bombale. This was followed by 45 minutes yoga practice in which various yoga asanas were performed by the staff members under the supervision of the yoga instructors. The progamme ended with vote of thanks.

## Secretary, DARE & DG, ICAR's visit to DOGR

Dr. Trilochan Mohapatra, Secretary, DARE & Director General, Indian Council of Agricultural Research visited Directorate of Onion and Garlic Research on 21-22 October, 2016 and monitored the activities of the Directorate. He had discussion with scientists and other staff of ICAR-DOGR. Dr. Mohapatra also felicitated Dr. Jai Gopal, Director, ICAR-DOGR on the occasion as his retirement was due on 31 October, 2016. He appreciated the work and achievements of the Directorate and gave valuable suggestions for further improvement. DOGR staff thanked honourable DG for his whole hearted support to the Directorate and the valuable time spared by him for the visit.

## Activities under Tribal Sub-Plan

ICAR-DOGR organized various training programmes under TSP scheme in collaboration with KVK, Nandurbar on "Construction of low cost onion storage structure to improve bulb storability", ''Onion storage technology'', ''*Rabi* onion production technology'', "Commercial cultivation of onion and garlic", "Application of various inputs in onion and garlic" at Shravani, Palsun, Bandharpada, Raingan, Savrat, Khairve, Nimboni and Khandbara of Nandurbar district on 19-20 May 2016, 23-24 August 2016, 4-6 October 2016, 19 December 2016 and 3-4 January 2017. Total 695 farmers from various villages of Nandurbar district were participated in these trainings. Vegetable Growers Meet was also organized on 5 October, 2016. In training programmes, Dr. A. J. Gupta, Nodal Officer, TSP delivered lectures on improved varieties of onion and garlic, and impact of activities of TSP in Nandurbar, and Dr. S. S. Gadge, Senior Scientist (Agricultural Extension) delivered lectures on onion storage technology, *rabi* onion production technology and application of various inputs in onion and garlic. Dr. Rajendra Dahatonde, Head and Mr. R. M. Patil, SMS (Horti.), KVK, Nandurbar also guided the farmers. Mr. A. R. Wakhare, Senior Technical Assistant and Mr. H. S. Gawali, Senior Technician assisted in successful conduction of training programmes. A total of 24 demonstrations were conducted in Navapur taluka of Nandurbar including 10 demonstrations on bulb production of onion variety Bhima Kiran, 4 demonstrations on garlic production of Bhima Purple and 10 demonstrations on seed production of onion varieties *viz.,* Bhima Kiran and Bhima Super. All the field demonstrations were successfully carried out on drip irrigation as per DOGR recommendations under TSP. Onion variety 'Bhima Kiran' produced 200 q per acre marketable bulb yield at the field of Merali Yaha Bachat Gat, Palipada. The farmers earned net income of Rs. 80,000/- per acre even when onion bulbs were sold at the rate of Rs. 6/- per kg. At Khandbara and Navapur areas of Nandurbar, DOGR varieties *viz.,* Bhima Kiran and Bhima Super

respectively produced 320 kg and 487 kg seed. In total, 41 demonstrations were conducted during *rabi* season. Out of these, thirty were on bulb production of onion varieties Bhima Kiran and Bhima Shakti; ten on seed production of onion varieties Bhima Shakti, Bhima Super and Bhima Red; and one on garlic production of Bhima Purple. All the demonstrations were conducted at farmers' fields as per ICAR-DOGR recommendations.




## Activities under *Mera Gaon Mera Gaurav* scheme

The activities were carried out in the fifteen villages *viz.,* Gadakwadi, Varude, Gulani, Wafgaon, Jawulke, Rase, Dattawadi, Shel Pimpalgaon, Bhose, Daundkarwadi, Gosasi, Mitgudwadi, Kanhur Mesai, Khairewadi and Khairenagar by three teams (consisting five scientists in each) as per guidelines of *Mera Gaon Mera Gaurav* scheme. The scientists of ICAR-DOGR provided scientific information to the farmers about improved technology of onion and garlic time to time. Total 45 Demonstrations on *kharif*, late *kharif* and *rabi* onion crop of ICAR-DOGR varieties were conducted in the villages adopted in this scheme. In total, 106 meetings of scientists with villagers were organized and information about various schemes related to agriculture was provided to the villagers. Awareness was imparted on the importance of cleanliness were conducted by group of scientists in the villages adopted under *Mera Gaon Mera Gaurav* scheme. Cleaning activities were carried out at Panchayat offices, temples, etc. primary public areas in the adopted villages during Swachh Bharat Pakhwada (15-31 October, 2016). Total 18 training programmes on different topics such as, improved technology of onion and garlic production, integrated pest disease management, post-harvest management, soil sampling, etc. were organized in the adopted villages. The scientists of ICAR-DOGR were in constant touch with the villagers and visited identified villages to address various technical issues in cultivation of various crops by the farmers. ICAR-DOGR publications were provided to farmers of the selected villages under the scheme. Soil samples from these villages

were collected, analyzed and Soil Health Cards distributed to the 100 farmers on World Soil Day on 5 December, 2016 at ICAR-DOGR. Apart from these, Kisan Sangoshti was also organized to emphasize the importance of Integrated Pest Management (IPM) in onion at Khairewadi village on 30 November, 2016. It was organized in collaboration with ICAR-NCIPM, New Delhi under the project 'Formulation, Validation and Promotion of Adaptable IPM Technology for bulb (onion)'. Fifty onion growers including women of Khairewadi village and representatives of local run NGO 'Harita' attended the Sanghosti. Dr. V. Mahajan, Director (Acting), ICAR-DOGR briefed the importance, benefits, approaches and available technologies of IPM in onion cultivation. Dr. S. J. Sardana, Principal Scientist, ICAR-NCIPM elaborated the important eco-friendly approaches as well as ETL based use of reduce risk insecticides for onion thrips management. Dr. S. J. Gawande, Senior Scientist, ICAR-DOGR explained about various onion diseases and ICAR-DOGR developed technologies for onion pest and disease management. Dr. Narayan Bhat, Principal Scientist, ICAR-NCIPM and Dr. V. Karuppaiah, Scientist, ICAR-DOGR also interacted with the farmers during the Sangoshti.

Kisan Sangoshti at Khairewadi

## Celebration of Independence Day and Republic Day

ICAR-DOGR celebrated 70th Independence Day and 68th Republic Day, respectively on 15th August 2016 and 26th January 2017 with great joy. Dr. Vijay Mahajan, Principal Scientist, ICAR-DOGR hoisted the national flag. Dr. Mahajan, Acting Director, ICAR-DOGR reminded the sacrifices made by the great leaders for the country and asked all the staff to get inspired by their work and devotion and contribute in progress of the Directorate with cooperation and unity.

## Hindi Week

ICAR-DOGR observed Hindi week during 8-14 September, 2016. The work done in Hindi in previous year and its future prospects were discussed in detail by Rajbhasha Secretary. Various competitions were organized for staff of the Directorate during Hindi week. Staff participated in these competitions with huge enthusiasm. Mr. Mitesh Ghatte, DSP, Khed Taluka was the chief guest and Mr. Sanjay Bharadwaj, President, Hindi Andolan Pariwar was the special guest for the closing ceremony of the Hindi week. Dr. Jai Gopal, Director, ICAR-DOGR briefed the major

achievements of the Directorate and highlighted the efforts made for the use of Hindi at ICAR-DOGR. The third issue of Directorate's Rajbhasha Patrika 'Kandika' was released on this occasion. Winners of various competitions were given prizes. Subsequently Mr. Sanjay Bharadwaj expressed his views on use of Hindi language, status and achievements of Hindi in World. Mr. Mitesh Ghatte, in his speech, focused on the need of spreading Indian culture and language. Dr. S. S. Gadge was compere of this programme. Dr. A. J. Gupa gave vote of thanks at the end of the programme.

## Vigilance Awareness Week

ICAR-DOGR observed vigilance awareness week during 26-31 October, 2016. This year, the main aim of observing vigilance awareness week was "Public participation in promoting integrity and eradicating corruption". Banners and posters were displayed in premises and at entrance of the Directorate to create awareness regarding vigilance in public. A pledge was administered by all staff of ICAR-DOGR on 29 November, 2016 to maintain the Directorate corruption free. On the last day of vigilance awareness week, discussion session was also held to find the ways to eradicate the corruption activities.

## National Unity Day

As per the directions of the Ministry of Home Affairs, Govt. of India, the birth anniversary of Iron Man of India Sardar Vallabhbhai Patel was observed as National Unity Day on 31October, 2016 at ICAR-DOGR. A pledge to maintain the unity and integrity of the country was taken by all the staff of ICAR-DOGR.

Presentation during National Symposium

## National Symposium on Edible Alliums

Indian Society of Alliums (ISA), Pune organized 2nd National Symposium on "Edible Alliums: Challenges and future strategies for sustainable production" in collaboration with ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, National Horticultural Research and Development Foundation, New Delhi and Beej Sheetal Bio Science Foundation, Jalna during 7-9 November, 2016 at Jalna. Total 103 scientists working on onion and garlic, from India and abroad attended the symposium. It was also attended by seedsmen, progressive farmers, onion traders and authorities from development departments. Dr. C. D. Mayee, Ex Chairman, ASRB, New Delhi, Dr. B. Venkateswarlu, Vice Chancellor, MAU, Parbhani, Dr. Y. S. Nerkar, Ex Vice Chancellor, MPKV, Rahuri, Dr. K. E. Lawande, Ex Vice Chancellor, DBSKK, Dapoli, Dr. N. P. Singh, Director, ICAR-National Institute of Abiotic Stress Management, Baramati, Dr. Vijay Mahajan, Director (Acting), ICAR- Directorate of Onion and Garlic Research, Rajgurunagar and Shri. Suresh Agrawal, President, Beej Sheetal Bio Science Foundation, Jalna were the important dignitaries participated in the symposium. There were 17 lead speakers presented their view points on different issues, 18 scientists delivered oral presentations and 55 scientists presented their research findings in poster sessions.

Release of publication during National Symposium

## Communal Harmony Week and Flag Day

As per the instructions received from National Foundation for Communal Harmony (NFFCH), New Delhi, Communal Harmony week was observed during 19- 25 November, 2016 at ICAR-DOGR. Flag Day was celebrated on 25 November, 2016. Dr. Vijay Mahajan, Director (Acting), ICAR–DOGR inaugurated the programme and inspired the staff to maintain communal harmony. All staff of ICAR-DOGR contributed for the National Foundation for Communal Harmony fund on the Flag Day which was sent to Secretary, NFFCH.

## Constitution Day

ICAR-DOGR celebrated Constitution Day on 26 November, 2016. Mr. Sunil Kumar, Senior Administrative Officer briefed about the constitution and rights of the citizen. Dr. Vijay Mahajan, Director (Acting), ICAR-DOGR expressed views on importance of the constitution. On this occasion, the preamble of the constitution was read by all staff of the Directorate.

## Agricultural Education Day

ICAR- DOGR celebrated Agricultural Education Day on 3 December, 2016 to commemorate the birth anniversary of first Union Minister of Agriculture and first President of Independent India, Bharat Ratna Dr. Rajendra Prasad. The programme was organized at Mahatma Gandhi High School and Junior College, Rajgurunagar for promoting the spirit of agriculture and allied subjects among the students. About 50 students of Class IX along with their teachers and management representatives of Mahatma Gandhi High School and Junior College participated in the programme. Dr. Vijay Mahajan, Director (Acting), ICAR-DOGR explained the background behind celebrating Agricultural Education Day. He emphasized on the importance of research, education and extension in various spheres of agricultural sciences and motivated students to put the best efforts in shaping their career in the field of agriculture. He expressed pleasure about students' enthusiastic participation in this programme. Dr. S. S. Gadge, Senior Scientist, ICAR-DOGR briefed about the importance of agriculture, organizational set up of ICAR and its role in agricultural research, education and development activities. Dr. S. Anandhan, Senior Scientist, ICAR-DOGR conducted a quiz competition. The prizes were distributed to the winners. Shri. S. S. Jadhav, Principal of School praised ICAR-DOGR for its active role in providing scientific information to onion and garlic farmers. He thanked ICAR-DOGR for organizing Agricultural Education Day programme at Mahatma Gandhi High School and Junior College.


## ICAR-DOGR celebrated World Soil Day

'World Soil Day' was celebrated on 5 December, 2016 at ICAR-DOGR, Rajgurunagar. Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR, in his welcome address, briefed about importance of soil testing and soil health card. He emphasized on balanced fertilizer application based on soil test for higher crop production. Dr. S. S. Gadge, Senior

Scientist (Agricultural Extension) explained the recently developed technologies of onion and garlic to the farmers. Dr. A. Thangasamy, Scientist (Soil Science) delivered a lecture on 'Balanced fertilization for crop production and soil health'. The chief guest Mr. Bapusaheb Thigale, City President, Rajgurunagar Parishad expressed his views on importance of soil health and requested ICAR-DOGR to conduct such programmes on regular basis to create awareness among the farmers about fertilizer application based on soil test. Total 65 farmers attended the programme. The soil health cards were distributed to the farmers on the occasion.

Distribution of soil health cards

## ICAR-DOGR Mobile App launched by Dr. T. Janakiram, ADG (Horticulture Science)

ICTs play a key role in transfer of the information from the institutes to the farmers and other beneficiaries and their importance in Agriculture is increasing day by day. In this direction ICAR-DOGR has made an attempt to disseminate the information on onion and garlic cultivation to more farmers through their mobile. ICAR-DOGR has developed a Mobile App in which the farmers can readily access the information on the Directorate, improved onion and garlic cultivation practices, onion and garlic varieties developed by the Directorate and their unique characteristics, monthly advisory to keep the farmers alert based on the monthly climatic changes and technologies developed, besides the information on location and contact numbers. The Mobile App of the ICAR-DOGR was launched by Dr. T. Janakiram, ADG (Horticulture Science) on 4 February, 2017 at ICAR-DOGR, Rajgurunagar. It is compiled and edited by Dr. Vijay Mahajan, Dr. Kalyani Gorrepati and Dr. S.S. Gadge. Dr. T. Janakiram appreciated efforts of the Directorate to benefit the farmers/stakeholders and augment the visibility of the Directorate through another mile-stone in the form of Mobile App. The Mobile App is made in two languages (English and Hindi) and ICAR-DOGR will make efforts for continuous improvement and also to make it available in different languages.

# Human Resource Development

## A. Trainings

| Name and Designation | Title of Training | Date | Venue |
|---|---|---|---|
| **Dr. V. Mahajan** Principal Scientist | Management Development Programme on Leadership Development (a pre-RMP Programme) | 7-18 June, 2016 | ICAR-NAARM, Hyderabad |
| **Dr. S. S. Gadge** Senior Scientist | Training on Impact Assessment of Agricultural Extension | 6-10 June, 2016 | ICAR-NAARM, Hyderabad |
| | Training on Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR | 13-15 February, 2017 | ICAR-NAARM, Hyderabad |
| **Dr. A. Thangasamy** Scientist Senior Scale | Training on Crop Simulation Models in Climate Change Impact Assessment | 14-18 February, 2017 | ICAR-IISS, Bhopal |
| **Mr. Kuldip** Scientist | Summer School programme on Contemporary methods of conservation and management of Horticulture genetic resources | 7-27 June, 2016 | ICAR-IIHR, Bangalore |
| **Mr. R. B. Baria** Senior Technical Assistant | Refresher course on farm management | 19-24 September, 2016 | ICAR-IIFSR, Modipuram, Meerut |
| **Mrs. Poonam V. Shelke** Technician | Training cum Workshop on J-gate @ CeRA organized by ICAR-DKMA, New Delhi | 8 October, 2016 | Agricultural University, Navsari, Gujarat |
| **Mr. Sunil Kumar** Senior Administrative Officer | Training for Nodal Officers under RTI Act | 28 November, 2016 | DOPT, New Delhi |
| | Training on Capacity building of general administration and management | 14-16 December, 2016 | ICAR Research Complex for Eastern Region, Patna |
| **Mr. D. B. Mundharikar** PS to Director | Training on Enhancing efficiency and behaviourial skills | 4-10 January, 2017 | ICAR-NAARM, Hyderabad |
| **Mr. S.P. Kandwal** Assistant | Supply Chain Management (Procurement and Store) Module | 16-17 June, 2016 | ICAR-IASRI, New Delhi |
| **Mrs. M. S. Salve** Assistant | Training programme on Pay roll | 2-3 May, 2016 | ICAR-IASRI, New Delhi |
| **Mrs. N. R. Gaikwad** Upper Division Clerk | Training Programme on Implementation of NIC's e-Procurement solution through CPP Portal | 27-28 April, 2016 | ICAR-NAARM, Hyderabad |

| Name and Designation | Title of Training | Date | Venue |
|---|---|---|---|
| **B. Conferences/Symposiums/Seminars/Workshops/Group Meetings** | | | |
| **Dr. Jai Gopal**<br>Director | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | 'Academia-Industry Interaction Meet' organized by ICAR-CIAE, Bhopal | 3 May, 2016 | College of Agriculture, Pune |
| | XXXIV group meeting AICRP (VC) organized by ICAR-AICRPVC, IIVR, Varanasi | 12 May, 2016 | ICAR-IARI, New Delhi |
| | Brainstorming session on 'Phytochemicals: possible application in nutraceuticals and bio-medical fields' jointly organized by ICAR-NRCG, ICAR-DFR in association with SAVE | 17 June, 2016 | ICAR-NRC Grapes, Pune |
| | Workshop on PPV&FRA organized by PPV&FRA, New Delhi | 30 June, 2016 | NASC Complex, New Delhi |
| | Meeting with Hon'ble Union Minister of Agriculture & Farmers Welfare along with Director General, ICAR | 3-4 July, 2016 | CIFE Mumbai |
| | 5th Science Export 2016 | 19-20 July, 2016 | Solan |
| | 24th ICAR Regional Committee (No.7) meeting Goa-2016 | 7-9 September, 2016 | Goa |
| | National Rajbhasha Workshop | 28 September, 2016 | Puri |
| | 24th meeting of CSCCSN&RV for Horticulture Crops | 22 September, 2016 | New Delhi |
| **Dr. V. Mahajan**<br>Principal Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | Consumer forum | 15 July, 2016 | Nashik |
| | Brain storming on Mechanization in horticultural crops | 24-25 October, 2016 | CIAE, Bhopal |
| | 2nd National Symposium on Edible Alliums: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | 7th Indian Horticulture Congress 2016 | 15-18 November, 2016 | New Delhi |
| | One day brain storming session on The germplasm introduction and exchange related issues | 19 November, 2016 | HSD, ICAR, New Delhi |
| | Interactive workshop on administrative matters of the ICAR institutes located in West Zone | 24 November, 2016 | Mumbai |
| | Brain storming session on Ornamental plants nursery standards | 12 December, 2016 | MCCIA Trade Tower, Pune |
| | Agri-Industry Meet | 11-12 January, 2017 | Neemuch |

| Name and Designation | Title of Training | Date | Venue |
|---|---|---|---|
| | Attended as a member of Assessment Committee of CAS | 1 February, 2017 | ASRB, New Delhi |
| | Directors' Conference | 14-15 February, 2017 | New Delhi |
| | 'Kaushal Vikas se Krishi Vikas' regional workshop on skill development in agriculture | 20 February, 2017 | NAARM, Hyderabad |
| **Dr. A. J. Gupta** Principal Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | 24th Meeting of Central Sub-Committee on Crop Standards, Notifications and Release of Varieties for Horticultural Crops | 22 September, 2016 | Krishi Bhavan, New Delhi |
| | 2nd National Symposium on Edible Alliums: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | Indo German Bilateral Cooperation Joint Workshop | 29-30 November, 2016 | New Delhi |
| | 11th Review Meeting of DUS Test Centres at IGKV, Raipur, Chhattisgarh | 27-28 February, 2017 | IGKV, Raipur |
| | XIII Agricultural Science Congress 2017 organized by National Academy of Agricultural Sciences and UAS, Bengaluru | 21-23 February, 2017 | Bengaluru |
| | 24th Meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops at Krishi Bhawan, New Delhi | 22 September, 2016 | New Delhi |
| **Dr. S. S. Gadge** Senior Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | Programme coordination meeting of All India Radio, Pune | 9 June, 2016 | Akashwani Bhawan, Pune |
| | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | Workshop on Increase in production through horticultural innovations | 16 January, 2017 | Commission orate of Agriculture, Pune |
| **Dr. S. J. Gawande** Senior Scientist | 2nd National Symposium on Edible Alliums: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| **Dr. S. Anandhan** Senior Scientist | 2nd National Symposium on Edible Alliums: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | 7th Indian Horticulture Congress 2016 | 15-18 November, 2016 | IARI, New Delhi |
| **Dr. A. Thangasamy** Scientist Senior Scale | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | NICRA Financial and Technical Review Meeting | 15-17 September, 2016 | ICAR-CRIDA, Hyderabad |

| Name and Designation | Title of Training | Date | Venue |
|---|---|---|---|
| | 2nd National Symposium on Edible Alliums: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | 7th Indian Horticulture Congress | 15-18 November, 2016 | CAR-IARI, New Delhi |
| | Review meeting of Virtual modelling group under NICRA | 30 November, 2016 | ICAR-IARI, New Delhi |
| | 5th NICRA Annual Workshop | 9-10 December, 2016 | NASC complex, New Delhi |
| | International Seminar on Emerging Trends on Organic Farming and Sustainable Agriculture | 29-31 December, 2016 | Mahatma Gandhi University, Kottayam |
| | Expert's Consultation meeting on Management of Abiotic Stress in Agriculture: Roadmap for Future Research and Education held at NIASM, Baramati | 30-31 January, 2017 | NIASM, Baramati |
| **Dr. V. Karuppaiah** Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | 3rd International IUPAC Conference on Agrochemical Protecting Crops, Health and Environment | 6-9 April, 2016 | NASC Complex, New Delhi |
| | Interface meeting on enhanced preparedness in Maharashtra for *kharif* 2016 organized by CRIDA | 14 May , 2016 | Pune |
| | NICRA Financial and Technical Review Meeting | 15-17 September, 2016 | ICAR-CRIDA, Hyderabad |
| | NICRA Annual Review Workshop | 9-10 December, 2016 | NASC Complex, New Delhi |
| | International Conference on Food and Agriculture | 20-22 February, 2017 | JNU, New Delhi |
| **Dr. Kalyani Gorrepati** Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | Start up Samvad, by ICAR-NAARM in association with FICCI & SIIB | 21 December, 2016 | Symbiosis Institute of International Business, Hinjwadi, Pune |
| **Dr. Vanita Salunkhe** Scientist | 7th AINRPOG group meeting | 4-5 April, 2016 | CSAUA&T, Kanpur |
| | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | National Symposium on Plant health management for sustainable agriculture organized by Indian Phytopathological Society (West zone) | 11-12 December, 2016 | College of Agriculture, Udgir Dist. Latur (Maharashtra) |

| Name and Designation | Title of Training | Date | Venue |
|---|---|---|---|
| **Mrs. Ashwini Benke** Scientist | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| **Dr. Pranjali Ghodke** Scientist | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| | Consultation meeting on Management of abiotic stress in agriculture: roadmap for future research and education | 30-31 January, 2017 | NIASM, Baramati, Maharashtra |
| **Mr. Yogesh Khade** Scientist | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| **Mr. D. B. Mundharikar** Private Secretary to Director | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| **Mr. A. R. Wakhare** Senior Technical Assistant | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |
| **Mr. V. S. Gurav** Technical Assistant | 2nd National Symposium on Edible *Alliums*: Challenges and Future strategies for sustainable production | 7-9 November, 2016 | Jalna, Maharashtra |

## Awards

- Dr. S. Anandhan has been awarded for the best oral presentation on "Evaluation of genetic diversity among the *Allium* species using SRAP markers" authored by Anandhan S., Dukare S., Ingle A.A., Pingle P.S., Mahajan V. in 2nd National Symposium on Edible Alliums: Challenges and future strategies for sustainable production during 7- 9 November, 2016 at Jalna.
- Dr. S. Anandhan has been awarded as ICAR-National fellow for the project entitled: Haploid induction onion (*Allium cepa* L.) through genome elimination.
- Dr. Vanita Salunkhe has been awarded for the best poster on "Screening for resistance to anthracnose (*Colletotrichum gloeosporiodes* Penz.) in wild onion" authored by Vanita Salunkhe, V. Mahajan and Jai Gopal in 2nd National Symposium on Edible *Alliums*: Challenges and future strategies for sustainable production during 7- 9 November, 2016 at Jalna.
- Dr. Pranjali Ghodke has been awarded for the best oral presentation on "Identification of critical growth stages in onion for water deficit stress" authored by Pranjali Ghodke and A. Thangasamy in 2nd National Symposium on Edible *Alliums*: Challenges and future strategies for sustainable production during 7- 9 November, 2016 at Jalna.
- Dr. Vijay Mahajan has been honoured by appreciation letter for special achievement in 2nd National Symposium on Edible Alliums: Challenges and future strategies for sustainable production during 7- 9 November, 2016 at Jalna.
- Mr. Dilip Mundharikar has also been awarded by appreciation letter in 2nd National Symposium on Edible Alliums: Challenges and future strategies for sustainable production during 7- 9 November, 2016 at Jalna.

# Visitors

The list of distinguished visitors to ICAR-DOGR is given below.

| Visitor | Designation | Date |
|---|---|---|
| Dr. C. S. Pathak | Advisor, Nath Bio-Genes, Aurangabad | 17-18 March, 2017 |
| Dr. H. R. Sardana | Principal Scientist, ICAR-NCIPM, New Delhi | 30 November, 2016 |
| Dr. K.B. Asodariya | Co-PI, AINRPOG, JAU, Junagarh | 16 June, 2016 |
| Mr. Kevin Ashford | Expert, UPL, Europe | 27 April, 2016 |
| Mr. Kwit Fernando Schmitt | Expert, U&H, Brazil | 27 April,2016 |
| Mr. Laxmana Reglan | Expert, UPL, Europe | 27 April, 2016 |
| Dr. Manik Bichkar | Physician & Social Activist, Rajgurunagar | 31 May, 2016 |
| Mr. Mrinmog | Expert, UPL, Europe | 27 April, 2016 |
| Mr. Naveen Chand | CEO,UPL, India | 27 April, 2016 |
| Dr. Narayan Bhat | Principal Scientist, ICAR-NCIPM, New Delhi | 30 November, 2016 |
| Mr. Nitin Bhosale | Vice President, UPL, India | 27 April, 2016 |
| Dr. P.G. Adsule | Ex-Director, ICAR-NRC Grapes, Pune | 16 June, 2016 |
| Dr. P.R. Dharmatti | PI-AINRPOG, UAS, Dharwad | 16 June, 2016 |
| Dr. P.S. Naik | Ex-Director, ICAR-IIVR, Varanasi | 16 June, 2016 |
| Dr. R. P. Gupta | Ex-Director, NHRDF, Nashik | 17-18 March, 2017 |
| Dr. R. Srinivasan | Emeritus Scientist, ICAR, New Delhi | 17-18 March, 2017 |
| Mr. Ramdas Tambe | Yoga Instructor, Patanjali Yog Peeth, Rajgurunagar | 21 June, 2016 |
| Mr. Robert Wlker | Expert, UPL, Europe | 27 April, 2016 |
| Mr. Suryakant Palande | Ex-MLA, Shirur | 17-18 March, 2017 |
| Dr. S.K. Sharma | Head, IARI RS, Pune | 16 June, 2016 |
| Dr. S.M. Hiremath | Co-PI-AINRPOG, UAS, Dharwad | 16 June, 2016 |
| Dr. S.H. Sahane | CEO, Bhagyalaxmi Dairy Farm, Manchar | 12 February, 2017 |
| Dr. S.S. Kushwah | PI-AINRPOG, College of Horticulture, Mandsaur | 16 June, 2016 |
| Mrs. Sujata Joshi | Director (OL), ICAR, New Delhi | 12 September, 2016 |
| Dr. T.A. More | Ex-VC, MPKV, Rahuri | 16 June, 2016 |
| Dr. T. Janakiram | ADG (HS), ICAR, New Delhi | 4 February, 2017 |

| Visitor | Designation | Date |
|---|---|---|
| Dr. T. Mohapatra | Secretary, DARE & Director General, ICAR, New Delhi | 21-22 October, 2016 |
| Mr. Tony Kievit | Expert, UPL, Europe | 27 April, 2016 |
| Dr. Y. S. Nerkar | Ex-VC, MPKV, Rahuri | 17-18 March, 2017 |
| Dr. Umamaheshwarappa | PI-AINRPOG, ZAHRS, Hiriyur, Chitradurga | 16 June, 2016 |
| Mr. Yashwant Bombale | Yoga Instructor, Patanjali Yog Peeth, Rajgurunagar | 21 June, 2016 |

A total of 2689 farmers, students and private and govt. officials visited the Directorate during this period. They were guided regarding the different technologies developed by ICAR-DOGR.

# Personnel

**Dr. Jai Gopal**
Director,
ICAR-DOGR superannuated on 31 October, 2016.

**Mr. D. M. Panchal**
Technical Assistant (Lab.) promoted to Senior Technical Assistant (Lab.) from 23 April 2016.

**Dr. Vijay Mahajan**
Principal Scientist (Horticulture) assumed the charge of Director (Acting) from 1 November, 2016 to 12 April, 2017.

**Mrs. N. R. Gaikwad**
promoted from Upper Division Clerk to Assistant from 2 September, 2016.

**Dr. Major Singh**
assumed the charge of Director from 13 April, 2017.

**Mr. Nilesh Warkar**
promoted from Lower Division Clerk to Upper Division Clerk from 25 March, 2017.

**Dr. Amar Jeet Gupta**
Senior Scientist (Horticulture) promoted to Principal Scientist (Horticulture) from 6 December 2014.

**Mr. S. D. Waghmare**
Skilled Supporting Staff promoted from Pay Matrix Level-2 to Pay Matrix Level-3 from 17 October, 2017.

**Mr. R. B. Baria**
Senior Technical Assistant (Field/Farm) promoted to Technical Officer (Field/Farm) from 27 April 2016.

**Mr. Naeem Sheikh**
Skilled Supporting Staff promoted from Pay Matrix Level-2 to Pay Matrix Level-3 from 17 October, 2017.

**Mr. S. B. Tapkir**
Skilled Supporting Staff promoted from Pay Matrix Level-1 to Pay Matrix Level-2 from 1 December, 2016.

**Mr. A. D. Fulsundar**
Skilled Supporting Staff promoted from Pay Matrix Level-1to Pay Matrix Level-2 from 13 December, 2016.

## Staff Position

| Category | Sanctioned Posts | Filled up Posts | Vacant | Surplus |
|---|---|---|---|---|
| RMP | 01 | 01 | - | - |
| Scientific | 16 | 16 | - | - |
| Technical | 10 | 10 | - | - |
| Administrative | 10 | 09 | 01 | - |
| Skilled Supporting Staff | 11 | 11 | - | - |
| **Total** | **48** | **47** | **01** | **-** |

# List of Staff

| Sl. No. | Name | Post |
|---|---|---|
| **RMP** | | |
| 1. | Dr. Major Singh | Director |
| **Scientific Staff** | | |
| 1. | Dr. V. Mahajan | Principle Scientist (Horticulture) |
| 2. | Dr. A. J. Gupta | Principle Scientist (Horticulture) |
| 3. | Dr. S. S. Gadge | Sr. Scientist (Agri. Extension) |
| 4. | Dr. S. J. Gawande | Sr. Scientist (Plant Pathology) |
| 5. | Dr. S. Anandhan | Sr. Scientist (Biotechnology) |
| 6. | Dr. A. Thangasamy | Scientist Sr. Scale (Soil Science) |
| 7. | Mr. V. R. Yalamalle | Scientist (Seed Technology) |
| 8. | Mrs. Ashwini P. Benke | Scientist (Genetics) |
| 9. | Dr. Kalyani Gorrepati | Scientist (Agriculture Structures & Process Engineering) |
| 10. | Dr. Vanita N. Salunkhe | Scientist (Plant Pathology) |
| 11. | Dr. Pranjali H. Ghodke | Scientist (Plant Physiology) |
| 12. | Mr. Manjunatha Gowda, D.C. | Scientist (Vegetable Science) |
| 13. | Dr. V. Karuppaiah | Scientist (Agriculture Entomology) |
| 14. | Mr. Kuldip | Scientist (Biotechnology) |
| 15. | Mr. Yogesh Popat Khade | Scientist (Vegetable Science) |
| 16. | Dr. Soumia P.S. | Scientist (Agriculture Entomology) |
| **Technical Staff** | | |
| 1. | Mr. H.S.C. Shaikh | Sr. Technical Officer (Computer) |
| 2. | Mr. R. B. Baria | Sr. Technical Assistant (Field/Farm) |
| 3. | Mr. S. P. Yeole | Sr. Tech. Assistant (Driver) |
| 4. | Mr. A. R. Wakhare | Sr. Tech. Assistant (Field/Farm) |
| 5. | Mr. D. M. Panchal | Technical Assistant (Lab.) |
| 6. | Mr. B. A. Dahale | Technical Assistant (Tractor Driver) |
| 7. | Mr. V. S. Gurav | Technical Assistant (Field/Farm) |
| 8. | Mr. H. S. Gawali | Sr. Technician (Field/Farm) |

| Sl. No. | Name | Post |
|---|---|---|
| 9. | Mr. R. Y. Bomble | Technician (Field/Farm) |
| 10. | Mrs. P. V. Shelke | Technician (Lab.) |
| **Administrative Staff** | | |
| 1. | Mr. Shitanshu Kumar | Administrative Officer |
| 2. | Mr. D. B. Mundharikar | Private Secretary to Director |
| 3. | Mrs. V. A. Bhumkar | Assistant Finance & Account Officer |
| 4. | Mr. P. S. Tanwar | Assistant Administrative Officer |
| 5. | Mr. S. P. Kandwal | Assistant |
| 6. | Mrs. M. S. Salve | Assistant |
| 7. | Mrs. N. R. Gaikwad | Assistant |
| 8. | Mr. R. K. Dedge | Upper Division Clerk |
| 9. | Mr. Nilesh Warkar | Upper Division Clerk |
| **Supporting Staff** | | |
| 1. | Mr. Sunil K. Said | Skilled Supporting Staff |
| 2. | Mr. Pradeep K. Khanna | Skilled Supporting Staff |
| 3. | Mr. Pandharinath R. Sonawane | Skilled Supporting Staff |
| 4. | Mr. Popat E. Tadge | Skilled Supporting Staff |
| 5. | Mr. Mahadu S. Kale | Skilled Supporting Staff |
| 6. | Mr. Rajendra S. Kulkarni | Skilled Supporting Staff |
| 7. | Mr. Sanjay D. Waghmare | Skilled Supporting Staff |
| 8. | Mr. Naeem H. Sheikh | Skilled Supporting Staff |
| 9. | Mr. Satish B. Tapkir | Skilled Supporting Staff |
| 10. | Mr. Amol D. Fulsundar | Skilled Supporting Staff |
| 11. | Mr. Shivaji S. Gopale | Skilled Supporting Staff |

# Financial Statement
## (2016-17)

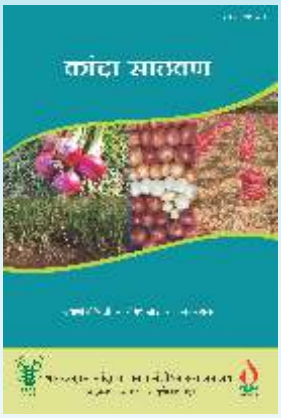
| Head of Accounts | Rupees (Lakhs) | |
|---|---|---|
| | Budget Allocation | Expenditure |
| **Non-Plan** | **467.32** | **430.69** |
| **Plan including NEH and TSP** | **579.58** | **579.58** |
| **HRD** | **0.42** | **0.42** |
| **Pension and Retirement** | **45.06** | **45.06** |
| **P Loans and Advance** | **2.75** | **1.47** |
| **R-Deposit** | **93.70** | **92.05** |
| DUS | 6.00 | 5.03 |
| DHO | 1.60 | 0.95 |
| IPR | 7.26 | 7.26 |
| ORP | 2.30 | 2.30 |
| Flagship programme | 2.00 | 1.97 |
| NICRA | 70.04 | 70.04 |
| IPM on onion | 2.00 | 2.00 |
| CRB Ap | 2.50 | 2.50 |
| **Total** | **1188.83** | **1149.27** |

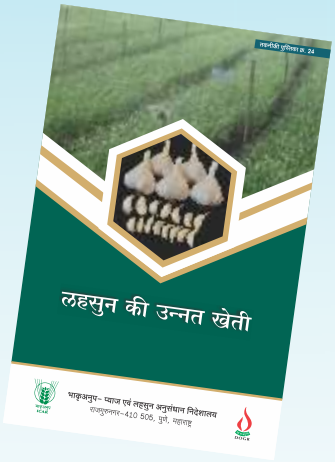
| Centre | Target | Achieved |
|---|---|---|
| Receipts from sale of farm produce | 31.33 | 17.77 |
| Other receipts | - | 19.30 |
| **RFS** | | |
| Sale of farm produce | - | 59.53 |
| Other Income | - | 2.76 |
| **Total** | **31.33** | **99.36** |

# Meteorological Data
## (2016-17)

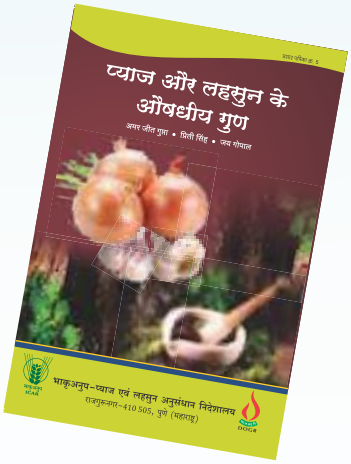
| Month | Av. Temperature (°C) | | Av. Relative Humidity (%) | | Av. Sunshine hours/day | Total Rainfall (mm) | Av. Evaporation (mm) |
|---|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | | | |
| April | 38.9 | 16.2 | 69 | 49 | 9.2 | 6.3 | 6.3 |
| May | 39.5 | 20.5 | 73 | 50 | 9.0 | 4.0 | 6.3 |
| June | 33.5 | 20.6 | 84 | 67 | 4.0 | 45.6 | 7.6 |
| July | 27.3 | 17.6 | 90 | 82 | 3.4 | 177.8 | 6.6 |
| August | 27.9 | 18.4 | 87 | 80 | 3.1 | 137.6 | 2.6 |
| September | 28.7 | 17.1 | 86 | 76 | 7.1 | 120.0 | 2.8 |
| October | 29.0. | 13.5 | 80 | 58 | 6.7 | 0.0 | 4.0 |
| November | 31.4 | 9.7 | 69 | 42 | 8.7 | 0.0 | 4.2 |
| December | 32.7 | 9.8 | 72 | 39 | 8.2 | 0.0 | 3.7 |
| January | 29.2 | 10.6 | 73 | 45 | 8.2 | 0.0 | 4.0 |
| February | 33.4 | 13 | 67 | 51 | 4.5 | 0.0 | 4.0 |
| March | 35.3 | 13.7 | 81 | 48 | 9.0 | 0.0 | 4.8 |

# Recent Publications

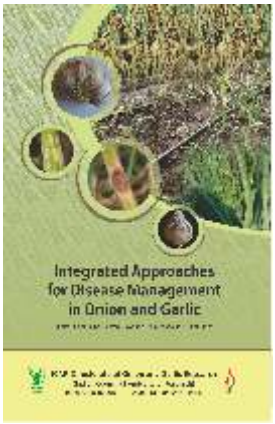


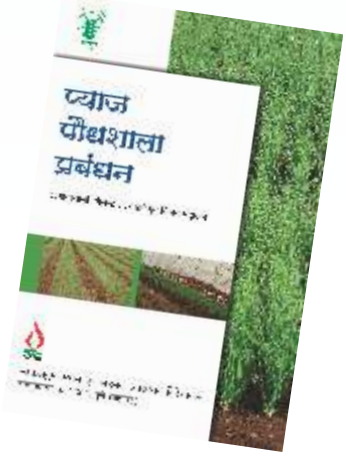













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