# Annual Report

## 2013-14


**Central Institute for Arid Horticulture**
(Indian Council of Agricultural Research)
Bikaner- 334006 (Rajasthan)

# Annual Report
# 2013-14

**Central Institute for Arid Horticulture**
**(Indian Council of Agricultural Research)**
**Bikaner-334006, Rajasthan**

## Published by

**Dr. S. K. Sharma**
Director
Central Institute for Arid Horticulture
Sri Ganganagar Highway, Beechwal,
Bikaner-334006, Rajasthan
Tel: +91-151-2250147, 2250960;
Fax: +91-151-2250145
E-mail: ciah@nic.in
Website: http://www.ciah.ernet.in

## Compiled & Edited by

Dr. R. Bhargava
Dr. R. S. Singh
Dr. S. M. Haldhar
Dr. Hare Krishna
Dr. S. R. Meena

## Correct Citation

Annual Report 2013-14
Central Institute for Arid Horticulture, Bikaner, Rajasthan

## Laser setting, desing, photography, hindi translation

Er. B. R. Khatri
Shri M. K. Jain
Shri Sanjay Patil
Shri P. P. Pareek

## Disclaimer/Copyright



**Printed at**
M/s Yugantar Prakashan Pvt. Ltd.
WH-23, Mayapuri Industrial Area, Phase-I, New Delhi-110064
Ph.: 011-28115949; Mob.: 09811349619, 033953134595

**Dr. S. K. Sharma**
**Director**

**Central Institute for Arid Horticulture**
**Beechwal, Bikaner-334006,**
**Rajasthan**

# PREFACE

It gives me immense pleasure in bringing out the Annual Report 2013-2014 of the Central Institute for Arid Horticulture, Bikaner. Owing to their strength such as vast area, ample solar radiation, low incidence of disease and pest and low population, arid and semi arid regions have potential to become the horticultural bowl of India provided adequate technologies are developed. In view of this, Central Institute for Arid Horticulture, Bikaner is dedicated to develop technologies for production of horticultural crops under low water input, value addition of the horticultural produce, introduction of crops from iso-climatic conditions and development of quality planting material for farmers, etc.

The present report highlights glimpses of 4 mega research projects and 9 externally funded projects, new methodologies developed, significant advisory services provided, dissemination of knowledge acquired, human resource development, linkages cultivated/nurtured with various ICAR institutes, SAUs and other research organization of India. I take this opportunity to place on record my appreciation to all the members of the Institute Research Committee (IRC) who have discussed all the activities at length and come out with well laid out plan of action within a definite time frame. I also thank technical personnel, administrative, finance and other staff of the Institute who have put their lot of efforts to take policies and programmes of the Institute forward.

I take this opportunity to place on record my sincere thanks and deep sanse of gratitude to Dr. S. Ayyapan, Secretary, DARE and D. G., ICAR for his constant support in executing the mandate of the Institute. I also express my gratitude to Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture) for this ciritcal remarks and valuable suggestions.

This Annual Report is the culmination of dedicated and sustained efforts by our Scientists and other staff of the institute. I wish to express my sincere appreciation to Dr. R. Bhargava and Dr. R. S. Singh for their sincere and whole-hearted support in bringing out the Annual Report. The technical support in terms of computerization by Sh. Bhoj Raj Khatri is appreciated.

**Dated: May 2014**
**Bikaner**

**(S. K. Sharma)**
**Director**

# CONTENTS

# EXECUTIVE SUMMARY

## Plant Genetic Resources and Crop Improvement

### Fruits

The institute is maintaining a rich germplasm of mandate crops in the field gene bank. During the period under report, 7 new accessions of date palm, 3 of ber, 1 each of wood apple, khirni and jamun, 5 of mulberry 31 of bael, 3 each of bottle gourd, long melon, 21 of brinjal & 40 of tomato were collected and added to the germplasm gene bank.

Studies on the effect of frost on ber revealed that the petiole of leaves tend to be green when temperature is around 25$^0$C or higher; however, with the fall in temperature, the petioles of *ber* leaves develop pigmentation. The intensity of pigmentation increases with further dip in temperature. Interestingly, the more susceptible a variety is to frost; greater was the intensity of pigmentation on *ber* leaves.

Varietal trial consisting of cvs. Halawy, Khalas, Zahidi, Medjool and Khadawy were carried out and it was observed that Halawy recorded maximum height. Evaluation of tissue culture plants showed that spathe emergence was recorded in Barhee within three years of planting.

50 tissue culture plants of each of date palm cvs. Barhee, Khalas, Khuneizi & Medjool were procured from RHDS, Govt. of Rajasthan and planted in October 2013 along with one male cultivar "Ghanami". The survival of plants in all variety was good (100%).

Three clones of cactus pear viz. 1308, 1269 and Mount Abu and 30 tissue culture plants of vegetable type cactus pear were planted in field for evaluation. The survival of plants was about 80%.

Evaluation of beal germplasm showed 5 elite types viz. CHES-B-5, CHES-B-8, CHES-B11, CHESB 21 and CHESB 29 to be superior among the genotypes evaluated under rainfed semi-arid ecosystem.

A total of 26 genotypes of jamun, 24 of tamarind, 30 of mahua, 40 of karonda, 32 of khirini were evaluated for yield and yield attributing parameters.

Exotic fruit species (Marula nut, Argan, Carob, Chinese jujube) were maintained and evaluated for growth and flowering/ fruiting.Marula nut plants were susceptible to frost.

### Vegetables

Among vegetable crops, six native and potential germplasm of vegetable crops were identified based on specific traits and collected one each in cucumber, tinda, mat kachari and 3 land races of dual purpose cluster bean.

In water melon, a total of 24 germplasm lines were evaluated for yield and yield contributing parameters. 10 germplasm lines were evaluated for various health promoting bioactive compounds.

In musk melon, a monoecious line ( AHM/BR-8) was identified which could be utilized in hybrid production of muskmelon. In long melon a line (AHLM-2) was found promising with respect to earliness, fruit length, fruit weight and fruits per plant.

The bittergourd germplasm maintained at the institute were evaluated (04) for trait specific characterization during rainy season of 2013 and sufficient quantity of seeds was produced and deposited for conservation. The germplasm exhibited variations for growth, flowering, fruit and yield component characters and also screened for incidence of diseases and fruit fly infestation. The

line AHBT-2 was found to be most potential for use in breeding programme.

During 2013, seed multiplication of potential sehjna line (Moringa AHMO-1-4s) was done to fulfill the national indents and is characterized as unique line for pod quality and yield.

During the period under report, potential lines/ varieties (>15) of arid zone vegetables such as kachri, snap melon, bottle gourd, palak, cluster bean, beans and Moringa, were supplied under national network for testing or breeding material for yield, drought and high temperature tolerance.

During summer season of 2013, nineteen advanced breeding material of round melon ($F_4$ generation) was evaluated and wide range of variations were recorded for the desired characters, and potential individuals were identified from the progenies to advance the generation.

Similarly, twelve advanced progenies of long fruited bottle gourd ($F_5$ generation) developed with a breeding objective for high temperature tolerance were evaluated in rainy season for growth, flowering, fruit set, fruit quality and yield component characters. Likewise, eight entries of bottle gourd were tested under AVT-II trial and all were susceptible to abiotic and high temperature conditions of the arid region.

During summer season of 2013, advanced material of muskmelon line CIAH-1 was tested for growth and fruit characters under abiotic stresses and high temperature conditions. The line CIAH-1 has uniform and better quality fruit yield and found to be potential under hot arid agro-climate. During spring-summer and rainy-winter season of 2013-14, advanced breeding line of tomato (AHSL-1) and brinjal (CIAH-22) were tested as replicated trial for fruit yield, uniformity and stability of the characters.

The performance data of two varietal trials of Indian bean (pole and bush type) conducted at 18 centres of AICRP (VC) from 2010 – 2013 were analyzed. Among ten entries of pole type, two were from CIAH such as AHDB–03 (Thar Maghi) and AHDB–16 (Thar Kartiki) and were tested alongwith national checks (Pusa Early Prolific and Swarna Utkrist). The results revealed that the low temperature and frost conditions are the limiting factors in beans and the normal maturing varieties are not suitable for the cultivation under arid agro-climate. During 2013, five cluster bean germplasm having dual purpose potentiality were identified from the rainfed fields and the var. Thar Bhadavi was analyzed for fraction yield for guar gum (%) content i.e. endosperm (31.40), germ (55.27) and husk (13.31).

In khejri, 14 elite genotypes for *ex situ* conservation were maintained with good management practices and three additional types were studied for horticultural characters. The variety Thar Shobha out yielded for tender pod, loong and total bio-mass production.

Evaluation of advance lines of pumpkin revealed that line CM4 X CM 22, CM 16 X CM 19, CM 16 X CM 17 and CM 13 X CM 15 were found promising. Among these, CM 13 X CM 15 was found suitable for industrial purpose.

## Crop Management and Agrotechniques

The growth, yield, physiological and fruit quality parameters were recorded in eight years old established plants of ber, bael, khejri and drumstick grown in association with aonla in the various cropping models. The highest yield of aonla was recorded in aonla-ber (51.4 kg per plant) system followed by aonla- khejri (48.1 kg/plant), aonla-kinnow (44.3 kg/ plant) and aonla- mulbery (42.8 kg/plan), while the lowest was recorded in aonla- moringa (39.7 kg/ plant).

Attempts were made to study the effect of pruning in karonda. The plants were pruned with different pruning intensities viz. mild, medium and severe. The results revealed that medium pruning registered an increase in yield, and hastened the harvesting of fruits.

Studies on mango based cropping system under rain fed condition revealed that maximum yield per plot was recorded with mango + bottle gourd followed by mango + pumpkin. The effect of organic manure and biofertilizers showed that treatment FYM + Std. dose of NPK + *Azotobactor* + PSB gave best performance of mango crop.

Khejri based cropping models were studied during 2013–14 and no significant differences were observed in growth characters of khejri variety Thar Shobha under varying planting models. Intensive training and pruning operations were done and studied to frame-up the budded plants of khejri in the planting models. Similar operations were also demonstrated to the framers for establishment of khejri based crop production sites. Studies on ker and jharber were undertaken for germination and growth characters of seedlings under nursery conditions and also on field establishment and growth characters as inter-cropping crops with wide spaced khejri planting models. Similarly, plant establishment and growth studies were conducted in native species such as khejri, rohida and lasora as seedlings planted around the production site. In addition, studies on naturally perpetuated plants of phog and khimp were undertaken in the khejri based production site.

## Integrated Nutrient and Water Management

Analysis of microbial population of 0-0.15 and 0.15-0.30 m depth revealed that total microbial population was minimum in absolute control and maximum in treatment recommended dose of N, P, K + FYM and consortium of biofertilizer. Similarly, in kinnow the best fruit weight, fruit yield, TSS, acidity and juice recovery was also observed in above treatment.

## Organic farming

Application of various leaf compost like aonla, eucalyptus, jamun, mahua, mango, neen, *P. dulce*, sapota, subabul and tamarind in pumpkin and bitter gourd demonstrated that maximum yield was observed with neem compost followed by subabul and lowest in control.

## Crop Physiology and Biotechnology

The effect of water stress on seedling growth, water potential of seedling, RWC of seedling and membrane stability index was assessed in Kachari, musk melon and water melon. The results demonastrate that kachari has potential to maintain growth under water stress condition and its membrane stability is high.

Studies on date palm tissue culture were undertaken extensively. The protocols for development of aseptic cultures, induction of embryogenic callus, somatic embryo induction and germination of somatic embryos were undertaken and success were achieved.

## Post Harvest Technology

RTS from bael pulp powder was prepared. The bael pulp powder was dried and stored at room temperature and it was observed that bael pulp powder can be stored upto 5 months at room temperature and RTS had high acceptability. In addition to this, various value added products such as date biscuits; pickle of karonda and kachari; dehydrated snapmelon, kachari and khejri; honey of mulberry; aonla pandhari; kachari hajmola, chutney of kachari, toffee and chocolate of ber fruits.

## Crop Protection

Integrated disease management of powdery mildew in ber and leaf spot of pomegranate, fruit rot of aonla and cercospora leaf spot of bottle gourd were worked out. The major diseases affecting bael, chilli, tomato and cucurbits were also identified.

The incidence of hadda beetle was high in northern part of Rajasthan and very less incidence in southern part of Rajasthan. Identified the incidence of pests like, fruit fly, hadda beetle, aphid, white fly, leaf minor, surface grasshopper, *Anthicus crinitus*,

*Anthrenus subclaviger* and natural enemies like, carabid beetle, coccinellids like *Coccinella septempunctata, Cheilomenes sexmaculata, Scymnus coccivora, Chrysoperla*, praying mentid and hadda beetle parasitoid, *Pediobius foveolatus*. The incidence of beetles, *Mylabris macilenta, Anthicus crinitus* and *Anthrenus subclaviger* on cucurbits flowers was also noticed during survey. The average incidence of flower beetles on watermelon ranged between 1.07 to 5.13 per plant of *M. macilenta*, 3.33 to 7.60 per plant of *A. crinitus* and 2.87 to 8.60 per plant of *A. subclaviger*. The incidence and the numbers were higher in the months of (first fortnight of June) than during other months.

## Agricultural Extension

The information on traditional vegetables grown, their use and marketing system, change in cropping patterns and socio-economic characteristics of farmers, ITKs were investigated. The major constraints faced by farmers in adopting the technologies were also collected. The information on rural wisdom of inhabitants of arid region of district Bikaner was assessed and information on value added products developed by them was collected. On and Off campus training were organized and demonstration on arid vegetable were laid on farmers field.

## Externally funded projects

A total of nine externally funded projects were in operation.

Under project "Bioprospecting of genes and allele mining for abiotic stress tolerance" molecular diversity of *Ziziphus nummularia* was assessed and it was found that this species has high genetic diversity within the population and limited gene flow between the population.The transcriptome profiling was done in *Z. nummularia* and it was recorded that 283 transcripts were found down regulated and 554 up regulated in stressed plants as compared to control.

Under the DUS project on ber, the DUS descriptor of ber was submitted to PPV& FRA and the same has been published in their journal.

Under the project "Validation of DUS testing guidelines for cucurbits i.e. watermelon and muskmelon" in depth studies on the morphological parameters of watermelon and muskmelon were undertaken to develop the DUS characters. The draft DUS descriptor for water melon was submitted.

Under DUS project on date palm, detailed morphological data of different varieties were collected and analyzed. Similarly, the morphological & quality parameters were recorded under DUS project on bael, DUS project on aonla and DUS project on jamun.

Survey in Gujarat was undertaken to access genetic variability in genus *Morinda* under the project "Identification, collection, characterization, evaluation and conservation of Noni (Morinda spp.) of western India (Gujarat and M.P.). In this project the characterization and evaluation of collected material was undertaken and conserved at Vejalpur, Godhra.

# 1. INTRODUCTION

The SWOT analysis of arid ecosystem reveals that it has strengths, such as ample sunshine, vast land, human labour, biodiversity harbouring important genes, low humidity, low incidence of pests and diseases, etc. for the production of quality arid fruits and vegetables. In addition to this, the arid ecosystem also has opportunities to improve the horticultural scenario which can lead to overall development of socio-economic and nutrition security of the inhabitants. This can be achieved provided adequate technologies are provided for sustainable agricultural prtoduction in this region.

In view of this, the National Research Centre for Arid Horticulture came into existence on 1st April 1993. This was later upgraded to Central Institute for Arid Horticulture on 27th September 2000 and CHES, Godhra (earlier Regional Station of IIHR, Bangalore) was merged with it as its Regional Station on 1st October, 2000. Subsequently, two divisions were created in the Institute w.e.f. 1st August, 2013.

## Mandate

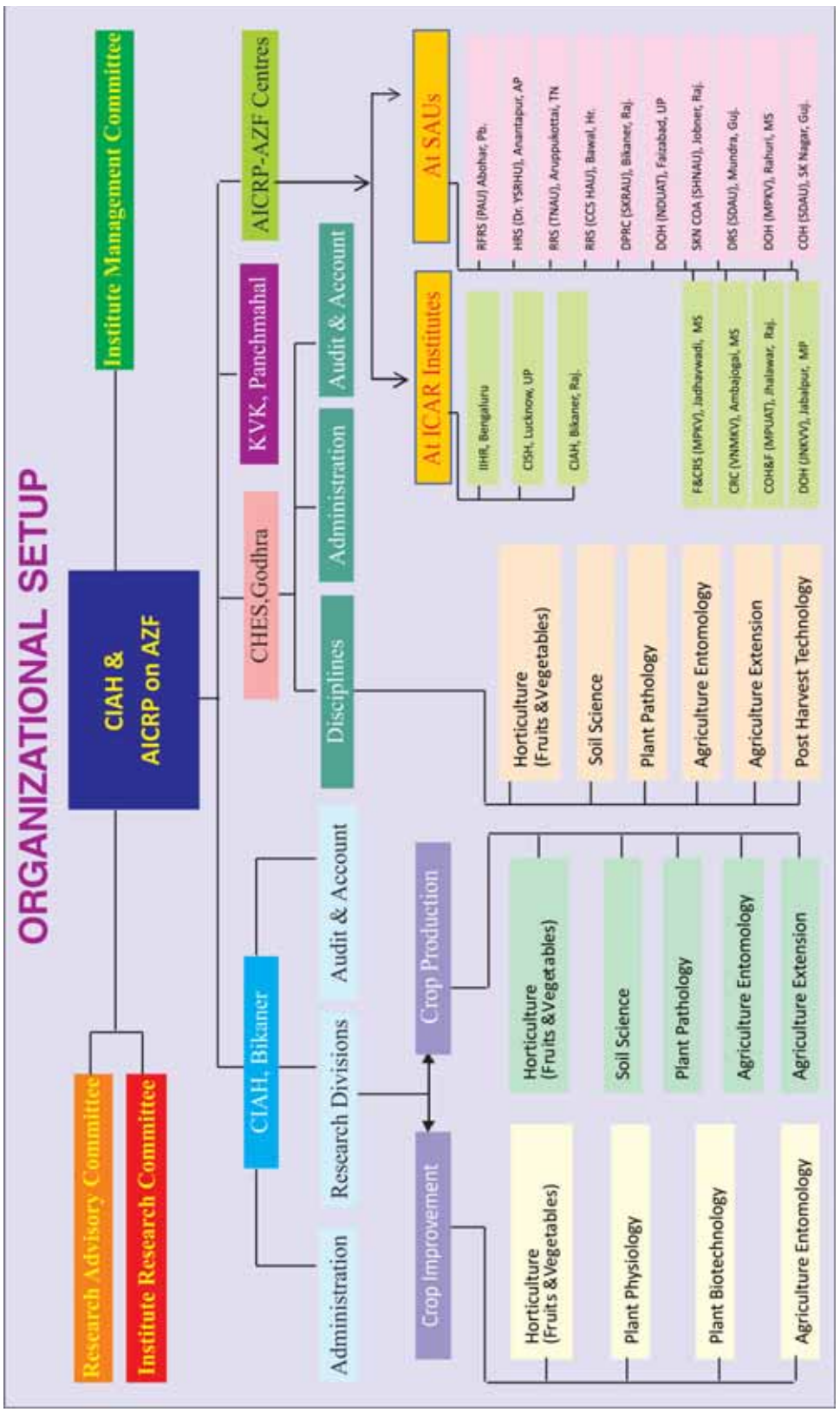
1. To undertake basic, applied and strategic studies for developing technologies to enhance productivity and utilization of arid horticultural crops.
2. To act as a national gene bank of arid horticultural crops.
3. To develop multistorey horticulture based sustainable cropping system under arid environment.
4. To act as a national repository of scientific information related to arid horticulture.
5. To coordinate network research with State Agricultural Universities and line departments and to act as a centre for Human Resource Development in arid horticulture.
6. To provide consultancy in research and development of arid horticulture.

## Mission/objectives

- To introduce, collect, characterize, conserve and evaluate the biodiversity of horticultural crops under arid and semi arid environment.
- To utilize the available biodiversity and improve the target fruit crops such as ber, pomegranate, aonla, date palm, sapota, custard apple, tamarind, fig and cucurbitaceous, leguminous and solanaceous vegetable crops to develop high quality and productive types having tolerance to biotic and abiotic stresses.
- To study the factors related to rapid multiplication of propagules in case of established as well as new crops and the problems related to their growth and fruit development.
- To standardize agrotechniques with respect to efficient use of soil, water and nutrients for increased horticultural productivity involving water harvesting and conservation techniques under rainfed conditions, efficient use of the scarce irrigation water and nutrient management.
- To study the eco-physiological parameters of cropping system models for utilization of high temperature and radiation resources.
- To develop post harvest technology package for extended use of the horticultural produce of arid region.
- To develop integrated pest and disease management technologies for horticultural crops under arid environment.

- To transfer the innovative technologies generated on the above aspects to farmer's field for effective horticultural development and socio-economic upliftment of the farmers
- To carry out the impact assessment of the technologies and constraint analysis.
- To serve as a repository of information related to arid and semi arid horticulture.
- To collaborate with relevant national and international agencies for achieving the above.

Keeping in view the above mandate and objectives, the research and extension works were carried out during 2013-14 and the significant results obtained in different projects are presented hereunder.


ORGANIZATIONAL SETUP
Institute Management Committee
Research Advisory Committee
Institute Research Committee
CIAH & AICRP on AZF
CIAH, Bikaner
Administration
Research Divisions
Crop Improvement
Horticulture (Fruits &Vegetables)
Plant Physiology
Plant Biotechnology
Agriculture Entomology
Audit & Account
Crop Production
Horticulture (Fruits &Vegetables)
Soil Science
Plant Pathology
Agriculture Entomology
Agriculture Extension
CHES,Godhra
KVK, Panchmahal
AICRP-AZF Centres
Disciplines
Administration
Audit & Account
Horticulture (Fruits &Vegetables)
Soil Science
Plant Pathology
Agriculture Entomology
Agriculture Extension
Post Harvest Technology
At ICAR Institutes
IIHR, Bengaluru
CSH, Lucknow, UP
CIAH, Bikaner, Raj.
At SAUs
RFRS (PAU) Abohar, Pb.
HRS (Dr. YSRHU), Anantapur, AP
RRS (TNAU), Aruppukottai, TN
RRS (CCS HAU), Bawal, Hr.
DPRC (SKRAU), Bikaner, Raj.
DOH (NDUAT), Faizabad, UP
SKN COA (SHNAU), Jobner, Raj.
DRS (SDAU), Mundra, Guj.
DOH (MPKV), Rahuri, MS
COH (SDAU), SK Nagar, Guj.
F&CRS (MPKV), Jadharwadi, MS
CRC (VNMKV), Ambajogai, MS
COH&F (MPUAT), Jhalawar, Raj.
DOH (JNKVV), Jabalpur, MP

# 2. RESEARCH ACHIEVEMENTS

## GENETIC RESOURCES

### Introduction, collection, characterization, conservation and evaluation under hot arid environment

### FRUIT

### Ber (*Ziziphus mauritiana* Lamk)

#### At Bikaner

With the concerted efforts the Institute has collected 318 ber germplasm in the field repository of CIAH, Bikaner. The germplasm comprised of popular varieties viz. Gola, Banarasi Karaka, Banarasi Pawandi, Umran, Seo, Rashmi, Ponda, Mundia, Kaithali, Illaichi, etc. The national repository is also maintaining germplasm of *Ziziphus rotundifolia*, *Z. nummularia*, *Z. spina-cristi* and *Z. zuzube*.

Fig. 1 'Frost burn' of foliage

Fig. 2 Mummified fruits of *ber*

Fig. 3 Severe frost injury

Fig. 4 Moderate frost injury

During the period under report, the impact of frost injury was noted on shoots, leaves and fruits. Unlike past, this year the extent of damage wreaked by frost was more and as a result a heavy loss in economic yield was noted. Due to frost, the developing fruits in most of the plants became 'mummified'. The injury was more conspicuous on plants with relatively smaller canopy. In such affected plants, the foliage exhibited a typical 'frost burn' appearance. This usually occurs when thawing of ice crystals formed in intercellular spaces is slow and as a result the cells are deprived of water and become dehydrated; thereby, giving the 'frost burn' appearance (Fig. 1-4).

During 2013-14, the gene pool of *Ziziphus* was used under NAIP project to generate information on morphological, biochemical and molecular aspects of ber. The Field gene repository was made available to other user scientists for crop improvement, bioprospecting for drought resistance genes, post harvest studies and germplasm propagation activities.

## Date palm (*Phoenix dectylifera* L.)

### At Bikaner

### Collection and conservation

Sixty one date palm varieties/genotypes including exotics were maintained in the field repository. Exotic cultivars Siwi and Amhat introduced from Egypt are growing well and spathe emergence was noted in cv. Amhat after four years of planting. The offshoots of cv. Halawy, Khalas and Medjool from RFRS, Abohar and Gizaj from DRS, Bikaner were procured and planted for evaluation. Out of seven collections, the offshoots of cvs. Meznaj, Sopari, Anand TP, MDP-07 and MDP-12 and Zagloul survived under field conditions.

### Evaluation of germplasm

The maximum palm height 8.10 m and spread (6.8 x 6.5m) was observed in cv. Muscat followed by cv. Halawy (7.00m).The spathe emergence started from third week of February and completed in the month of March. About 7 to 10 days delay in emergence of spathe were observed among germplsam during the year 2013 due to change in climatic conditions. It was also observed that emergence of spathes in male plants were delayed. The spathe emergence/opening and fruiting were observed in 30 genotypes out of 60 germplasm. Among germplasms, early emergence of spathe/ flowering and fruit maturity was recorded in cv. Muscat.

Variation in rachis length from 1.21- 3.47 m, leaf length from 1.23 – 3.48m was observed, whereas leaf width ranged from 28.5-77.5 cm. The number of thorns ranged from 8 to 22 per leaf whose length and breadth ranged from 4.02-12.48 cm and 0.13 – 0.47 cm, respectively. The spines showed variation in the shape also which were either needle like or curved. The number of bunches 1-10 per palm and fruit's yield varied from 0.78 -79.0 kg/plant among germplasm due to age of plants. Similarly, number of strands per bunch ranged from 11-72, number of berries/strand varied from 13-39. Maximum fruit yield at doka stage was observed in cv. Khalas (79kg/tree) followed by Dayari (62kg), Chip-chap (46kg/tree) and Shamran (41kg/tree). However, minimum fruit yield (0.78kg/ plant) was observed in cv. Punjab Red possibly due to young plant. The maximum number of bunches/ plant were observed in Khalas (10) followed by Sewi, (8) Sabiah (7) and Chip-chap (6). The number of berries (20 per strand) was observed in cvs. Zahidi followed by Khuneizi (18). The early doka stage was observed in cv. Muscat and harvested in last week of June 2013. Maximum fruit drop was observed in cvs. Muscat, Tayer, Sayer and Khalas. The bigger size and fruit weight (23.50g) was observed in cv. Medjool followed by Punjab Red (16.2g) and Khalas (15.10g) and minimum fruit weight 7.50g was in Zahidi. The weight of stone varied from 0.7-1.87 g. The maturity of fruits (doka stage) recorded in maximum cultivars in third week of July. Cultivars

Medjool, Dayari and Sewi were harvested late in August. During the year, pind (Tamer) stage was not observed in any genotypes/cultivars.

## Varietal evaluation

Varietal trial consisting cvs. Halawy, Khalas, Zahidi, Medjool and Khadrawy were carried out for growth, flowering/fruiting, yield and quality of fruits under drip irrigation. Maximum plant height was observed in cv. Halawy (5.50m) and spread (5.10m x 4.90m) followed by height of 2 - 3m was observed in cv. Medjool. Khadrawy and Zahidi varieties. The plant growth was vigorous in Halawy and Khalas than that of Zahidi,Khadrawy and Medjool. Flowering and fruiting was observed in all varieties and five to seven bunches/palm recorded at an age of nine years.

## Evaluation of Tissue culture plants

Tissue culture plants of cv. Barhee and KCS-143 were evaluated for growth and flowering under arid conditions. The vegetative growth in respect of height, spread and number of leaves was better after four years of planting. There was no spathe emergence during the year 2013. The vegetative growth of Barhee plant was better than KCS-143 plant. However, spathe emergence/ flowering in Barhee plant was observed during the year 2014.

## Performance of seedlings

Flowering and fruiting was observed in seedlings after 8 years and the ratio of plant was 1:1 with respect to male and female. The morphological characters of berry of seedling type were noted and the fruit was astringent in taste at doka stage**.**

## Pomegranate (*Punica granatum*)

A total of 154 germplasm at CIAH, Bikaner and 45 at CHES, Vejalpur, Godhra was carried out during the year.

The cuttings of 10 cultivars of pomegranate were supplied to HAU, Hisar during July 2013 for conservation and evaluation. All germplasm were affected by low temperature/frost under hot arid conditions during the month of January, 2014. Out of total germplasm, 13 germplasm were less affected. Sprouting and growth in plants started after employing cultural practices which varied among germplasm. Sprouting was also started 10-15 days late in comparison to previous year which may be due to prolong low temperature. Flowering was observed during month of March however, de-blossoming was done to avoid crop because of poor moisture and high temperature during summer season. Cuttings of Super Bhagawa-1 cultivar were collected to raise plants in nursery for evaluation.

## Evaluation of Anardana type

Cuttings of three genotypes No. 1, 2 and 3 were collected from MPKV, Rahuri and plants were raised in nursery for planting in field for evaluation. Flowering was observed in all anardana types. Plant height varied from 1.15 to 3.50 m among germplasm. During this year, top portion of plants were less affected by frost/low temperature during January. The size of fruits was small ranging from 60 to 100g weight and number of fruits/plant varied from 20 to 40. The aril was small and hard in all anardana types.

## Bael (*Aegle marmelas*)

### At Bikaner

Bael germplasm (17) were maintained in the field repository at CIAH, Bikaner and evaluated for growth, flowering and effect of frost/low temperature. The vegetative growth of plants varied from 1.90m to 4.58m under hot arid conditions. The maximum genotypes are of seedling types. The maximum height of plant 4.5 m and spread (3.9m N-S and 4.2 m E-W) was recorded in a seedling type after 11 years of planting. Fruiting was noted in one genotype in which flesh colour was dark yellow; fruit weight 250g having high mucilage content.

During the year 2013, flowering and fruit set was observed in 02 genotypes in May, 2013 but flowers and immature fruits dropped due to poor soil moisture conditions during summer. During the year, effect of frost on bael germplasm was very less.

For development of varietal block of NB-5, NB-9, CISHB-1, CISHB-2, Pant Sujata, CIAH Bael Sel-2, Bael Sel. -1 and Goma Yashi, i*n situ* budding was tried. However, success percentage varied from 50 to 75 per cent during July, 2013. The highest in-*situ* budding success (75%) was observed in cv. Pant Sujata followed by NB-5 (70%). However, slow initial growth in young plants and effect of frost was also noted in plants during winter season 2013-14.

Bael rootstocks were planted at four spacing *i.e.* 8x8m, 4x4, 6 x 4m and 6x6m and survival rate of plants varied from 40-50% among spacing's treatment during 2013. *In situ* budding was tried but it was not successful due to improper thickness of rootstocks.

## At Godhra

Apart from the 12 varieties, 101 germplasm of bael have been established and evaluated for growth parameters. Vegetative parameters of these genotypes were recorded under rainfed conditions. All the genotypes showed wide variation in growth characters in terms of growth habit, leaf morphology, spine and bark morphology. Flowering and fruiting was noticed in 31 genotypes during the year 2013-14. Annual growth extension in terms of plant height was recorded maximum in CHESB-5 (45.20cm) and minimum in CHESB-27 (30.10cm), whereas girth of stem (3.32cm) was recorded maximum in CHESB-31 and it was minimum CHESB-19 (3.15cm) in all the genotypes evaluated for growth under rainfed conditions of semi-arid ecosystem. Based on the observation on various aspects particularly fruiting behavior and quality attributes, CHESB-5, CHESB-8, CHESB-11, CHESB-21 and CHESB-29 were found to be superior among the genotypes evaluated under rainfed semi-arid ecosystem.

## Salient features of identified genotypes of bael

### CHESB-5

Plant height, stem girth, plant spread was recorded 5.70 m, 45.32cm and 5.37 m, respectively during 7$^{th}$year of orchard life. Average yield 62.50 kg in 7$^{th}$ year, fruit weight 1.53 kg, fruit size 20.70 cm x 14.97 cm, fruit girth 45.30 cm, shell thickness 1.9 mm, total number of seed 128, seed weight 0.14g, total seed weight 33.00g, fibre weight 60 g, shell weight 245g, locules in cross section 13-16, pulp 70.50%, TSS pulp 36$^0$B, TSS mucilage 49.00$^0$B, acidity (0.29%) and vitamin C 19.82 mg / 100 g pulp were recorded. It is an early maturing variety (1$^{st}$ week of March).The fruits of this genotype is less affected (40% less than other varieties) by sun scald owing to compact and luxuriant growth of plant.

### CHESB-8

Plant height, stem girth and plant spread were recorded 4.35 m, 36.32 cm and 4.10 m, respectively during 5$^{th}$year of orchard life. Average yield per plant 30.23 kg in 5$^{th}$ year, fruit weight 1.85 kg, fruit size 16.15 cm x 16.20 cm, fruit girth 48.50 cm, shell thickness 0.18cm, total number of seed 70, seed weight 0.23g, total seed weight 22.10g, fibre weight 118.10 g, shell weight 295.00g, locules in cross section 13-16, pulp 70.50%, TSS pulp 38$^0$B, TSS mucilage 50.00$^0$B, acidity (0.30%) and vitamin C 20.80 mg / 100 g pulp were recorded. It is an early maturing variety (2$^{st}$ week of March).The fruits of this genotype is having good flavour and aroma. It is highly suitable for preparation of sherbet, powder and squash.

### CHESB-11

Vegetative growth in terms of plant height, stem girth, plant spread was recorded 3.60 m, 33.10cm and 3.45 m, respectively during 2013-14. Average yield per plant 20.00 kg in 4$^{th}$ year, fruit weight 1.58 kg, fruit size 15.10 cm x 15.45 cm, fruit girth 45.25 cm, shell thickness 0.22cm, total number

of seed 82, seed weight 0.21g, total seed weight 24.24g, fibre weight 130.68 g, shell weight 230.22g, locules in cross section 14-17, TSS pulp 37$^0$B, TSS mucilage 49.85$^0$B, acidity (0.28%) and vitamin C 22.80 mg / 100 g pulp were recorded. It is medium maturing variety (1$^{st}$ week of April). The fruits of this genotype are having good flavour and aroma. It is highly suitable for sherbet, candy and m*urabba* making.

## Pilu (*Salvadora oleoides*)

## At Bikaner

### Morphological characterization of *pilu* (*Salvadora oleoides*)

The fruits of *pilu* (red and green type) (Fig. 5) were morphologically characterized during the period under report. The comparison of these two genotypes is presented in Table 1.

**Table 1. Morphological characteristics of *pilu* genotypes**

| Sr. No. | Morphological characteristics | Red *pilu* | Green *pilu* |
|---|---|---|---|
| 1. | Leaf arrangement | Opposite | Opposite |
| 2. | Leaf shape | Lanceolate | Lanceolate |
| 3. | Leaf apex | Acute | Acute |
| 4. | Leaf base | Acute | Acute |
| 5. | Leaf length | 40.7 mm | 57.1 mm |
| 6. | Leaf width | 20.3 mm | 22.4 mm |
| 7. | Leaf surface | Smooth | Smooth |
| 8. | Petiole length | 15.9 mm | 23.7 mm |
| 9. | Leaf margin | Smooth | Smooth |
| 10. | Nature of fruit surface | Smooth | Smooth |
| 11. | Fruit colour | Red | Green |
| 12. | Fruit length | 4.9 mm | 5.3 mm |
| 13. | Fruit width | 5.8 mm | 4.8 mm |
| 14. | Fruit weight | 0.11 g | 0.07 g |
| 15. | Fruit shape | Globose | Globose |
| 16. | Seed shape | Globose | Globose |
| 17. | Seed length | 4.8 mm | 4.2 mm |
| 18. | Seed width | 4.4 | 4.1 mm |
| 19. | Seed weight | 0.05 g | 0.04 g |

**Fig. 5. View of red and green fruited *pilu***

Most of the qualitative characteristics were common among red and green type *pilu*; however, they could be distinguished with their fruit colour at maturity i.e. red and green, respectively. Besides fruit colour, distinction could also be made easily with traits associated with leaf such as leaf length, leaf width and petiole length. Green *pilu* genotype registered higher values for these leaf characters; however, fruit size was relatively larger in red *pilu* genotype.

## Wood apple (*Feronia linonia*)

### At Bikaner

Five elite type wood apple was planted in field. Twenty plants of promising type of wood apple were collected from Godhra during September 2013 and planted in the field for evaluation. The survival rate of plant was 70 per cent. The initial growth of plant was slow in all genotype and susceptible to frost. Under nursery conditions, pre-treatment of seeds with $GA_3$ (100ppm) for 12 hrs gave 60% germination of seeds when sown during September month in polybags.

### At Godhra

#### Vegetable growth characters of wood apple germplasm

There were significant differences in respect of all the growth parameters of wood apple during the year except stock diameter. Maximum plant height was recorded in line CHES-10 (7.37 m) and least in CHES-11(5.5 m). Stock and scion diameter was highest in line CHES-1 and least in CHES-11.Plant spread in both North-South and East-West direction was maximum in line CHES-8 (5.56and 5.30m) and least in line CHES-10 (3.71 and 3.8m) (Table 2).

#### Wood apple yield per plant/fruit retention and physical characters of fruit

There were significant differences amongst the various characters viz. yield per plant, fruit retention, fruit weight, skull weight, pulp weight, Pulp skull ratio and pulp seed ratio. The clone CHES-2 retained maximum fruit per plant and highest yield per plant (90.40kg/plant). However, fruit weight was

**Table 2. Plant morphomatric parameters of wood apple germplasm**

| Line no. | Plant height (m) | Stock Dia.(cm) | Scion Dia.(cm) | Plant spread (m) | |
|---|---|---|---|---|---|
| | | | | NS | EW |
| CHES-1 | 6.12 | 29.5 | 26.46 | 4.38 | 4.53 |
| CHES-2 | 6.44 | 25.36 | 21.86 | 4.12 | 3.91 |
| CHES-3 | 6.05 | 23.36 | 23.43 | 4.54 | 4.10 |
| CHES-4 | 5.95 | 23.53 | 23.66 | 4.72 | 4.41 |
| CHES-5 | 6.12 | 26.36 | 22.43 | 4.18 | 4.10 |
| CHES-6 | 6.26 | 26.43 | 22.43 | 5.49 | 5.18 |
| CHES-7 | 6.37 | 26.00 | 25.23 | 4.65 | 4.31 |
| CHES-8 | 7.16 | 25.46 | 23.00 | 5.56 | 5.30 |
| CHES-9 | 6.44 | 26.23 | 23.73 | 5.46 | 5.13 |
| CHES-10 | 7.37 | 24.40 | 23.43 | 3.71 | 3.8 |
| CHES-11 | 5.5 | 21.53 | 21.33 | 4.32 | 5.2 |
| CD5% | 0.297 | NS | 1.46 | 0.185 | 0.194 |

highest in Line CHES-4 (627.33g) followed by CHES-2. Least fruit retention (46.67) and yield per plant (12.97 kg) was recorded in CHES-10 and least fruit weight in CHES-9 (174g).Least skull weight and pulp weight in line CHES-9 (48.13g an 55g respectively). It was highest in CHES-4 (179.33and 319g respectively) (Table 3). Similarly pulp skull ratio and pulp seed ratio was highest in the selections. Based on fruit retention, fruit weight, yield per plant CHES-2 and CHES-4 were found to outperform.

## Wood apple fruit analysis

There were significant differences amongst the various characters viz. Seed number per fruit, seed weight per fruit, reducing sugar, total sugar, TSS, pulp-skull ratio and pulp-seed ratio. Highest seed number and seed weight per fruit was recorded in line CHES-8 (638.33 and 19.33 g respectively).The superior type CHES-4 and CHES 2 had medium composition. Least seed number and seed weight per fruit was recorded in line CHES-5 (388.33 and 11.67 g, respectively).Reducing sugar and total sugar were highest in superior clones CHES-4 (1.42 and 3.07%) followed by CHES-2. The results clearly indicated the superiority of clones CHES-4 and CHES 2 in respect of the above characters. Maximum TSS was observed in line CHES-2 ($11.6^0$ Brix) and least CHES-8 ($6^0$ Brix). Percent acidity was highest in Line CHES-9 (4.81%) and least in CHES-4(2.08%). pH of the juice was maximum in line CHES-3 (3.62) and least in CHES-5 and CHES-9 (3.28) (Table 4).

Nutritional composition of wood apple indicated that there were significant differences amongst the various characters viz. N, P, K, Ca, Mg, Protein content. Maximum P, Ca, Mg content was recorded in clone CHES-4 (0.071%, 0.39%, and 0.71% respectively).However maximum N, K and protein content was recorded in clone CHES-2(5.31, 1.87% and 33.58%). Least N, K, Ca and protein content was in line CHES-11(3.04%, 1.26%, 0.12 and 19.69% respectively), P in line CHES-5 (0.017%), and Mg in line CHES-6 (0.35%).The superior clones CHES-4 and CHES 2 had better nutritional composition (Table 5).

**Table 3. Fruit characters of wood apple germplasm**

| Line | Fruit no/plant | Fruit weight (g) | Yield kg/plant | Fruit length (mm) | Fruit Dia. (mm) | Skull weight (g) | Pulp wt. (g) | Pulp Skull ratio | Pulp Seed ratio |
|---|---|---|---|---|---|---|---|---|---|
| CHES-1 | 106.67 | 423.33 | 43.45 | 85.00 | 92.66 | 116.00 | 178.33 | 1.54 | 10.69 |
| CHES-2 | 206.67 | 440.00 | 90.40 | 88.33 | 89.33 | 107.33 | 185.67 | 1.73 | 12.11 |
| CHES-3 | 87.00 | 421.00 | 35.57 | 87.66 | 90.00 | 150.33 | 211.33 | 1.41 | 11.95 |
| CHES-4 | 134.00 | 627.33 | 85.25 | 96.66 | 103.67 | 179.3 | 319.00 | 1.78 | 27.33 |
| CHES-5 | 181.00 | 26633 | 48.60 | 79.33 | 80.66 | 88.67 | 98.33 | 1.11 | 8.44 |
| CHES-6 | 141.00 | 370.33 | 52.11 | 83.00 | 83.67 | 124.67 | 156.00 | 1.25 | 12.31 |
| CHES-7 | 114.67 | 426.00 | 60.52 | 82.33 | 91.90 | 149.33 | 217.00 | 1.46 | 15.14 |
| CHES-8 | 72.67 | 227.00 | 20.88 | 76.33 | 75.00 | 95.33 | 151.67 | 1.59 | 7.84 |
| CHES-9 | 402.00 | 174.00 | 67.75 | 69.00 | 65.00 | 48.33 | 55.00 | 1.14 | 3.88 |
| CHES-10 | 46.67 | 283.33 | 12.97 | 78.17 | 75.67 | 74.00 | 126.67 | 1.71 | 7.31 |
| CHES-11 | 73.33 | 299.33 | 21.98 | 75.33 | 82.67 | 98.00 | 136.33 | 1.88 | 11.36 |
| CD5% | 23.35 | 53.24 | 2.37 | 3.43 | 4.35 | 8.12 | 7.24 | — | — |

**Table 4. Chemical composition of fruits of wood apple germplasm**

| Line | Seed no./ fruit | Seed wt. g | TSS° Brix | Acidity % | pH | Reducing sugar % | Total sugar % |
|---|---|---|---|---|---|---|---|
| CHES-1 | 516.33 | 16.67 | 7.60 | 2.31 | 3.47 | 1.01 | 2.59 |
| CHES-2 | 493.67 | 17.67 | 11.60 | 3.25 | 3.31 | 1.39 | 2.17 |
| CHES-3 | 488.87 | 15.33 | 11.00 | 2.54 | 3.62 | 1.11 | 1.95 |
| CHES-4 | 570.67 | 16.67 | 9.60 | 2.08 | 3.48 | 1.42 | 3.07 |
| CHES-5 | 388.33 | 11.67 | 9.60 | 2.31 | 3.28 | 1.12 | 2.90 |
| CHES-6 | 450.33 | 12.67 | 11.00 | 2.33 | 3.70 | 0.99 | 2.79 |
| CHES-7 | 574.00 | 16.00 | 9.00 | 2.62 | 3.72 | 0.65 | 2.06 |
| CHES-8 | 638.33 | 19.33 | 6.00 | 2.54 | 3.57 | 1.01 | 2.83 |
| CHES-9 | 490.33 | 14.33 | 7.30 | 4.81 | 3.28 | 1.03 | 1.91 |
| CHES-10 | 449.33 | 17.33 | 11.0 | 3.08 | 3.51 | 0.69 | 2.21 |
| CHES-11 | 451.33 | 12.00 | 5.30 | 3.65 | 3.51 | 0.65 | 1.77 |
| CD5% | 37.41 | 1.74 | 1.27 | 0.196 | 0.208 | 0.22 | 0.20 |

**Table 5. Chemical composition of wood apple germplasm**

| Line | N % | P % | K % | Ca % | Mg % | Protein |
|---|---|---|---|---|---|---|
| CHES-1 | 5.31 | 0.074 | 1.38 | 0.34 | 0.53 | 33.58 |
| CHES-2 | 3.58 | 0.048 | 1.87 | 0.13 | 0.58 | 23.45 |
| CHES-3 | 3.27 | 0.071 | 1.61 | 0.196 | 0.64 | 20.56 |
| CHES-4 | 4.30 | 0.071 | 1.76 | 0.39 | 0.71 | 27.36 |
| CHES-5 | 3.10 | 0.017 | 1.55 | 0.27 | 0.49 | 20.41 |
| CHES-6 | 3.54 | 0.030 | 1.36 | 0.113 | 0.35 | 21.63 |
| CHES-7 | 3.16 | 0.059 | 1.62 | 0.22 | 0.38 | 25.42 |
| CHES-8 | 3.79 | 0.049 | 1.76 | 0.12 | 0.52 | 20.84 |
| CHES-9 | 4.21 | 0.034 | 1.41 | 0.12 | 0.45 | 26.41 |
| CHES-10 | 3.76 | 0.053 | 1.29 | 0.29 | 0.45 | 22.61 |
| CHES-11 | 3.04 | 0.044 | 1.26 | 0.12 | 0.57 | 19.69 |
| CD5% | 0.204 | 0.0073 | 0.14 | 0.196 | 0.063 | 1.701 |

## Fruit drop in wood apple

Data on fruit drop at weekly interval showed heavy fruit drop in line CHES-5 (7530 no.) least fruit drop was recorded in line CHES-2 which resulted in higher fruit retention and yield per plant followed by CHES-4.The initiation of fruit drop started immediately after 10 days of fruit set from last week of March. It was at peak during middle of May and continued till June. The fruit drop continued due to continuous growth during the hot summer months. Most of the drop occurred at pin head stage of the fruit (Table 6).

**Table 6. Fruit drop in Wood apple germplasm at different days**

| Date | CHES 1 | CHES 2 | CHES 3 | CHES 4 | CHES 5 | CHES 7 |
|---|---|---|---|---|---|---|
| 06/04/2013 | 25 | 247 | 21 | 150 | 380 | 21 |
| 10/04/2013 | 31 | 338 | 15 | 485 | 994 | 49 |
| 16/04/2013 | 85 | 861 | 41 | 930 | 2390 | 288 |
| 20/04/2013 | 65 | 483 | 58 | 805 | 555 | 286 |
| 25/04/2013 | 35 | 520 | 41 | 310 | 490 | 218 |
| 30//4/2013 | 51 | 612 | 71 | 396 | 583 | 200 |
| 06/05/2013 | 60 | 415 | 75 | 510 | 415 | 225 |
| 15/05/2013 | 84 | 388 | 88 | 348 | 330 | 385 |
| 21/05/2013 | 40 | 136 | 80 | 150 | 812 | 60 |
| 30/05/2013 | 18 | 95 | 42 | 101 | 131 | 47 |
| 14/06/2013 | 15 | 124 | 39 | 100 | 165 | 75 |
| 21/06/2013 | 35 | 180 | 110 | 90 | 148 | 35 |
| 02/09/2013 | 50 | 225 | 145 | 226 | 137 | 21 |
| Total | 594 | 4624 | 826 | 4601 | 7530 | 1910 |

## Chironji (*Buchanania lanzan*)

### At Godhra

Thirty promising genotypes of chironji were evaluated for growth, flowering, fruiting and fruit quality attributes. The average plant height ranged between 5.70m –3.55 m, plant spread ie N-S 1.60m – 5.50 m and E-W 1.70 m – 5.60 and stem girth 25.50 cm- 55.60 cm in different genotypes. The peak period of flowering and fruit set in chironji was recorded in the month of February and March respectively. Maximum panicle length (27.10cm) and fruit set per panicle was recorded in CHESC-7, closely followed by CHESC-2. After evaluation, CHES-7 and CHESC-2 were found promising.

### Brief characteristics of Chironji

#### CHESC-7

It has semi-spreading growth habit, thick trunk, dense foliage and drooping branches. Peak period of ripening time was May. It recorded 1.20 g fruit weight, 0.56 g pulp weight, 23.00°Brix TSS, 13.00 % total sugar and 48.10 mg/100g vitamin C, 0.09g kernel weight and 31.00 % kernel protein.

#### CHESC-2

It is having up right growth habit. Peak period of ripening time was May. It recorded 1.30 g fruit weight, 23.10°Brix TSS, 12.10 % total sugar and 48.50 mg/100g vitamin C. Kernel protein was recorded 31.00 %.

## Custard apple (*Annona squamosa*)

### At Godhra

The results revealed significant differences amongst eight cultivars of Custard apple in respect of most of the vegetative as well as physico-chemical characters of fruits under rainfed conditions of Panchmahals (Table 7). As regards vegetative growth parameters, stem diameter and plant spread was significantly influenced however plant height was found to be non significant but was maximum

**Table 7. Plant morphomatric parameters of custard apple**

| Variety | Plant Ht. (m) | Stem Dia (mm) | Pl. Spread (m) | | Fruit wt. (g) | Pulp wt. (g) | Skin wt. (g) | Pulp skin ratio | Seed wt. (g) | TSS (°Brix) | Yield/ plant (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NS | EW | | | | | | | |
| Balanagar | 2.78 | 65.1 | 3.12 | 3.25 | 176.25 | 61.0 | 75.7 | 0.81 | 15.0 | 20.2 | 9.74 |
| Washington 98797 | 3.84 | 102.5 | 5.60 | 5.30 | 128.00 | 47.7 | 59.5 | 0.80 | 14.0 | 18.0 | 1.68 |
| Seedless Atemoya | 3.39 | 73.4 | 4.0 | 4.05 | 173.50 | 85.7 | 58.5 | 1.46 | 13.2 | 20.0 | 6.29 |
| Pink Mammoth | 3.46 | 96.1 | 3.9 | 4.28 | 152.00 | 62.5 | 53.5 | 1.16 | 14.0 | 16.5 | 25.17 |
| Island Gem | 4.16 | 103.3 | 5.27 | 4.66 | 195.50 | 99.2 | 68.5 | 1.44 | 6.50 | 23.0 | 2.64 |
| Atemoya x Balanagar | 3.21 | 88.3 | 4.05 | 3.75 | 188.75 | 77.2 | 66.2 | 1.16 | 11.5 | 20.0 | 26.84 |
| Local Sitaphal | 2.87 | 67.8 | 3.52 | 3.47 | 132.75 | 55.7 | 43.2 | 1.28 | 15.7 | 30.0 | 20.70 |
| CD 5% | NS | 26.8 | 1.08 | 0.90 | 47.13 | 22.5 | 18.7 | — | 4.55 | 1.44 | 15.89 |

(4.16m) in Island Gem. However, stem diameter and plant spread was found to be significantly influenced. Maximum stem diameter (103.33mm) was recorded in Island Gem. Plant spread (N-S & E-W) was maximum in Washington (5.60m and 5.30 m). Observations on fruit set per tree recorded revealed that it was maximum in Atemoya x Balanagar (263.67).Fruit and pulp weight was highest in Island Gem (195.50 and 99.25g, respectively). Whereas, maximum, skin weight was noted in Balanagar (75.75g) and seed weight in Local Sitaphal (15.75g). T.S.S. was maximum in Local Sitaphal (30.00 $^{0}$Brix) and least in Pink Mammoth (16.50 0Brix). Yield per plant was highest in Atemoya x Balanagar (26.84 kg/ plant).

## Jamun (*Syzigium cuminii*)

### At Godhra

Promising genotypes (26 no) of jamun were evaluated for growth, flowering , fruiting and fruit quality attributes. Peak period of panicle emergence was recorded in the month of February. Peak period of flowering and fruit set was recorded in the month of March in all genotypes. Maximum panicle length and fruit set per panicle was recorded in GJ-2, closely followed by GJ-8. Time taken for complete development of flower bud ranged from 22-26 days in different genotypes. Peak period of ripening was recorded in the month of June. Maximum fruit yield per plant was recorded (48.00 kg) in Goma Priyanka. Fruit weight (20.00 g),pulp weight (17.20 g), pulp percent (85.00 %) and TSS (17.20 $^{0}$ Brix) was also recorded maximum in Goma Priyanka, closely followed by GJ-8 under rainfed conditions of hot semi-arid ecosystem.

Further, 40 genotypes including Konkan Bahadoli, Gokak 1, Gokak 2, Gokak 3, Seedless and Seeded Jamun have been evaluated for growth, flowering, fruiting and fruit quality attributes. Maximum fruit weight (18.50 g) and TSS (15.60 $^{0}$ Brix) was recorded in GJ-30.

## Tamarind (*Tamarindus indica*)

### At Godhra

Promising genotypes (24 no.) of tamarind were evaluated for growth, flowering, fruiting and fruit quality attributes. The maximum number of fruits per

panicle was recorded in Pratisthan (4.00), closely followed by Goma Prateek (3.50), Sweet Type (3.20) and T-263 (3.00). Peak period of ripening time in majority of genotypes was March. Maximum fruit yield per plant (85.00 kg) was recorded in Goma Prateek during 12th year of orchard life under rainfed conditions of hot semi-arid ecosystem, closely followed by T-10 (43.00 kg/plant), while minimum was recorded in PKM-1 (12.00kg/plant). Goma Prateek also recorded maximum pod weight (25.10 g), pulp percent (52.50 %) and TSS (72.00°Brix). Developmental pattern and maturity standards in tamarind were studied. Separation of peel from the pulp at the time of ripening was one of easiest methods for assessment of ripening in tamarind. Further, 3 genotypes of tamarind collected from Aruppukottai, Tamil Nadu have been established in the field.

## Argan (*Argania spinosa*)

### At Bikaner

Cuttings of Argan treated with 500, 1000 ppm IBA + Thymine (1000ppm) were planted in nursery on 12th July, 2013 for multiplication of Argan (*Argania spinosa*) plants, which is very hardy to root. IBA 1000 ppm treatment was responsive for sprouting in cuttings after a month of planting. However, no root development took place because of which the cutting dried.

## Karonda (*Carisa carandus*)

### At Bikaner

The genotypes of karonda were evaluated for growth, flowering and fruiting under arid conditions. Flowering was observed but fruit set was very less due to poor soil moisture condition. The upper top 40-50% portion of plants was affected by frost in all genotypes during 2014. The growth features of germplasm were of bushy type.

### At Godhra

Total 40 genotypes were evaluated in karonda. Konkan Bold recorded maximum fruit weight (5.10g) and TSS (11.00$^0$ Brix) but fruit yield was 4.20 kg per plant only. Minimum acidity (0.45 %) was recorded in Konkan Bold during ripening. Maximum fruit yield (14.00 kg/ plant), fruit weight (5.10 g) and TSS ( 9.17$^0$ Brix) was recorded in CHESK-2, closely followed by CHESK-3. CHESK-1 recorded 4.80 g fruit weight, 8.10 kg yield/ plant.The fruit colour of CHESK-2 and CHESK-3 was recorded red and purple respectively at the time of maturity.

## Phalsa (*Grewia*)

### At Bikaner

A study on time of seed sowing in phalsa was conducted in nursery and better germination percentage was observed when seeds were sown during month of June and July in comparison to May in hot arid region. However, survival and growth of plant was better when the seeds sown were in the month of May.

### At Godhra

In phalsa, 1 genotype from AAU, Anand, 1 from CIAH, Bikaner and 9 from Lawarpur, Gandhinagar were collected. Maximum fruit weight was recorded in CHESP-1 (2.08 g) closely followed by CHESP-2 and CHESP-4. Maximum TSS was also recorded in CHESP-1 (36.00 Degree Brix). Maximum vitamin C was noted in CHESP-3.

## Cactus pear (*Opuntia ficus indica*)

### At Bikaner

Cactus pear genotypes were maintained in the nursery mother block. Three cactus clones 1308, 1269 and Mount Abu Collection including 30 tissue culture plant of vegetable type were planted and

evaluated for survival and growth. The clone 1308 sprouted earlier than other clones. Average 5 to 10 cladodes/ plant were produced. Survival of plant was 80-90% and sprouting started after15-20days and growth of clones was good in all three genotypes. Cactus clones were supplied to CAZRI, RRS, Bikaner and CSWRI, Avika nagar for multiplication and evaluation.

## Manila tamarind (*Pithecelobium dulce*)

### At Bikaner

Three genotypes were evaluated under field conditions and it was observed that plants were susceptible to frost/ low temperature.

## Mahua (*Bassis latifolia*)

### At Godhra

Promising genotypes (30 No) of Mahua were evaluated for growth, flowering, fruiting and fruit quality attributes. The highest total soluble solids, total sugar and vitamin C content was recorded in flowers of MH-10, however juice content was found to be highest in MH-18. Maximum fruit weight (29.00 g) and seed weight (12.00 g) was found in MH-10., while MH-14 recorded 27.00g fruit weight and 11.10 g seed weight.

## Khirni (*Manilkara hexandra*)

### At Godhra

Thirty genotypes were evaluated for flowering, fruiting and fruit quality attributes. Number of flowers per cluster ranged from 3.20-4.40 in different genotypes being highest in CHESK-10. Fruit set per cluster ranged from 2.60 to 4.10 being highest in CHESK-10. Peak period of ripening was recorded from last week of April and May in all the genotypes. Maximum fruit weight (5.10 g) and TSS (25.20$^{o}$Brix) was recorded in CHESK-10, closely followed by CHESK-1, CHESK-6, CHESK-11, CHESK-12 and CHESK-16.

## Mango (*Mangifera indica*)

### At Godhra

Efforts were continued to collect the variability in mango cv. Kesar to identify superior types. Total five collections were planted in the field and were evaluated for growth parameters. There were significant differences in respect of plant height, stock and scion diameter of the collections. Plant height was maximum in collection CHES-1(2.43m). It was least in CHES-5 (1.47). Highest stock and scion diameter was recorded in line CHES-2 (68.43 and 62.53 mm).Data in respect of plant spread

**Table 8. Plant morphomatric parameters of germplasm lines of mango cv. Kesar**

| Line | Plant height (m) | Stock Dia. (mm) | Scion Dia. (mm) | Plant spread (m) | | Cluster/ plant (No.) | Fruit set/ cluster | Fruit set/ plant |
|---|---|---|---|---|---|---|---|---|
| CHES1 | 2.43 | 66.73 | 51.2 | 1.66 | 1.41 | 4.66 | 19.66 | 30 |
| CHES2 | 1.96 | 68.43 | 62.53 | 1.70 | 1.66 | 11.6 | 27.66 | 155 |
| CHES3 | 1.69 | 47.03 | 37.66 | 1.06 | 1.13 | 2.33 | 12.66 | 26 |
| CHES4 | 1.76 | 42.43 | 32.04 | 0.98 | 0.96 | 16.66 | 31.00 | 182.66 |
| CHES5 | 1.47 | 44.43 | 42.43 | 0.90 | 1.01 | 2.33 | 11.66 | 22 |
| CD5% | 0.57 | 9.26 | 9.02 | 0.46 | 0.46 | 7.28 | 11.44 | 27.56 |

**Table 9. Plant morphomatric parameters of Sapota**

| Variety | Plant height (m) | Stock Dia. (mm) | Scion Dia. (mm) | Plant spread (m) | | Fruit set/ cluster | Fruit retained/ shoot | Fruit set/ plant |
|---|---|---|---|---|---|---|---|---|
| | | | | NS | FW | | | |
| PKM-1 | 2.83 | 108.96 | 88.33 | 3.48 | 3.64 | 4.33 | 36.00 | 1216.66 |
| PKM-2 | 3.25 | 121.67 | 109.00 | 3.53 | 4.18 | 4.00 | 29.66 | 312.66 |
| PKM-3 | 3.01 | 103.67 | 83.67 | 2.34 | 2.40 | 2.00 | 14.66 | 95.00 |
| DHS-1 | 1.85 | 66.16 | 52.90 | 1.28 | 1.36 | 2.33 | 12.33 | 64.66 |
| DHS-2 | 2.18 | 78.93 | 61.40 | 1.83 | 1.86 | 1.66 | 13.00 | 58.00 |
| CO3 | 1.88 | 70.16 | 55.77 | 1.55 | 1.06 | 1.66 | 15.33 | 51.66 |
| CD5% | 0.84 | 24.39 | 22.49 | 0.917 | 0.95 | 1.36 | 4.54 | 45.02 |

indicated that both North-South and East-West spread was maximum in line CHES-2(1.70 and 1.66m) closely followed by CHES-1. Some plants started flowering and the initial data recorded indicated that number of clusters per plant were highest in line CHES-4(16.66) and minimum in line CHES-3 and 4 (2.33). Fruit set per cluster was highest in line CHES-4 (31.00) and least in line CHES-5(11.66). Similar results were obtained in respect of fruit set per plant (Table 8).

## Sapota (*Manilkara sapota*)

### At Godhra

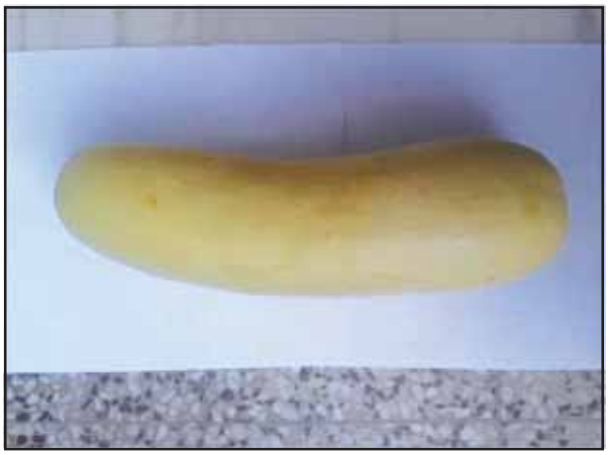
Vegetative growth parameters recorded during the year indicated that cv. PKM-2 was most vigorous in respect of all the growth parameters followed by PKM-1. Least growth was recorded in DSH-2. Data recorded indicated that maximum number of fruits per clusters were recorded in cv. PKM-1 (4.33), while it was least in DHS2 and CO-3 (1.66). However maximum number of fruit retained per shoot was in PKM-1 (36.00) and least in DHS-1 (12.33).Maximum number of fruits set per plant was recorded in cv.PKM-1 (1216.66) and least in CO-3 (51.66) (Table 9).

# VEGETABLE

Realizing the importance of vegetables, in particular cucurbitaceous crops, in the arid region, the germplasm collection was started since 1994 at CIAH and a large number of cultivars, landraces, semi-domesticated and wild forms of mateera / watermelon (*Citrullus lanatus*), round melon (*Praecitrullus fistulosus*), kachri (*Cucumis melo* var. *callosus* / *agrestis*), snap melon (*Cucumis melo* var. *momordica*), muskmelon (*Cucumis melo*), kakdi (*Cucumis melo* var. *utilissimus* / *fluxuosus* / *acidulus*), bottle gourd (*Lagenaria siceraria*) and *Luffa* gourds were collected, evaluated and maintained for conservation and utilization in breeding programme at the institute. In addition, the germplasm of unexploited and native crops/plants of future prospects as well potential vegetables of hot arid region were also collected and conserved under mission mode programmes of the institute from 1994-2008, and are being maintained as genetic resource management programme of arid zone vegetables.

## Germplasm collection

Six native and potential germplasm of vegetable crops were identified based on specific



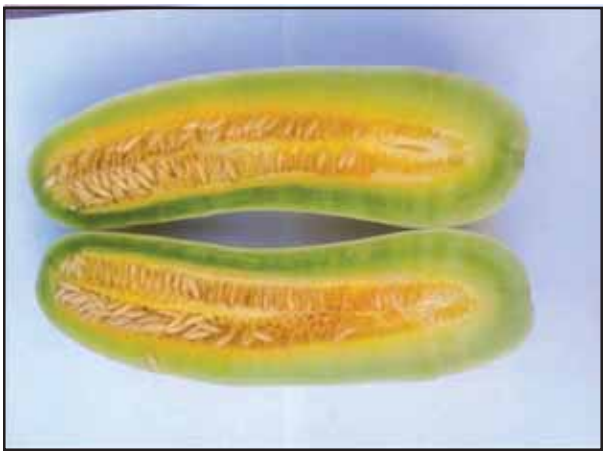


**Fig. 6. Fruits of cucumber locally known as *chikan kakri* in southern parts of Rajasthan**

**Fig. 7. Fruits of round melon**

**Fig. 8. Fruits of kachri**

traits and collected one each in cucumber (unique fruit quality type from tribal area) (Fig. 6), tinda (better fruit shape and drought tolerant) (Fig. 7) and kachri (better fruit quality and shape) (Fig. 8) and dual purpose type cluster bean (three landraces from rainfed field of arid areas).

## Germplasm exchange

Potential breeding lines / varieties (>15) of arid zone vegetable crops such as kachri, snap melon, bottle gourd, cluster bean, Indian beans, Moringa and palak were supplied to national institutes, SAU's and state agencies for performance studies as new crop varieties or use in breeding programmes as genes for drought hardiness and tolerance to high temperature conditions.

## Conservation of germplasm

Landraces and local cultivars are source of genes for stresses, adaptability, quality and yield. The systematic collection of vegetable germplasm was started since 1994 at CIAH, Bikaner under mission mode and institutional programmes. From 1994 - 2008, several crop specific and multi-crop explorations were made for survey and collection of vegetable germplasm from parts of arid, semi-arid and tribal areas of Rajasthan and Gujarat. Besides, augmentation of germplasm from national net-work was also taken up at CIAH. A data base was developed for compilation of work on genetic resource management in arid vegetables at the institute and up to 2008, a total 1725 germplasm accessions were collected and evaluated and out of

them 1059 were deposited in NGB at NBPGR for long term conservation. Presently, about 500 lines of potential vegetables are being maintained as active germplasm at CIAH, Bikaner under deep freeze (-20$^0$ C) facilities and these comprised of mateera (65), kachri (68), snap melon (65), muskmelon (60), round melon (10), kakdi (18), bottle gourd (20), ridge gourd (20), sponge gourd (15), bitter gourd (4), chillies (45), brinjal (30), tomato (14), khejri (14), Indian bean (30), sword bean (01), cluster bean (02) and others (15).

## Monitoring of germplasm

During the period under report, monitoring and maintenance of dessertic melons (125), non-dessertic melons (161) and gourds (60) germplasm lines of cucurbitaceous crops was done for safe conservation in gene bank (-20$^0$ C) facilities at the institute. As per maintenance and seed enhancement work plan, bitter gourd (04) germplasm was taken during rainy season of 2013. On the basis of germination and vigour, the seed storage studies revealed that bitter gourd germplasm can be stored for five years under ambient conditions and about 10 years under deep freeze conditions (-20$^0$ C) as active material for utilization. Sufficient quantity of seeds was produced under seed enhancement work during the rainy season of 2013 and deposited for safe conservation and this bitter gourd material has to be regenerated after 2024 through seed enhancement for safe conservation. During the period, monitoring of conserved germplasm was done periodically and it is observed that mateera, sponge gourd, Indian bean, cowpea and methi lines needs regeneration through seed enhancement during 2014 – 2015.

## Maintenance of bitter gourd germplasm

Bitter gourd (*Momordica charantia*) is potential cucurbit vegetable but yet not systematically exploited under high temperature and abiotic stressed conditions of arid region. As a result of varietal and germplasm collections, about 13 genotypes were evaluated in phase manner as well altogether for seed enhancement and conservation from 1997 - 2009 at CIAH. Out of them, 04 lines maintained at the institute were evaluated during rainy-winter season of 2013 for trait specific characterization and seed enhancement for conservation (Table 10).

**Table 10. Evaluation of bitter gourd germplasm during rainy-winter season of 2013-14**

| Character | Range values |
|---|---|
| Days to appearance of first male flower (DAS) | 36.21 – 48.37 |
| Node number to appearance of first male flower | 10.21 – 18.24 |
| Days to appearance of first female flower (DAS) | 42.84 – 54.26 |
| Node number to appearance of first female flower | 15.24 – 28.64 |
| Days to first harvest (DAS) | 51.24 – 65.48 |
| Fruit weight (g) | 24.5 – 175.8 |
| Fruit length (cm) | 6.92 – 21.31 |
| Fruit diameter (cm) | 2.65 – 5.65 |
| Total number of fruits/plant | 7.92 – 16.48 |
| Number of non-marketable fruits/plant | 3.24 – 5.41 |
| Number of marketable fruits/plant | 2.94 – 12.71 |
| Fruit yield/plant (kg) | 0.083 – 1.125 |
| Vine length (m) | 1.78 – 2.45 |
| Number of seeds/ fruit | 5.8 – 24.4 |
| Seed length (cm) | 1.21 – 1.52 |
| Seed width (cm) | 0.61 – 1.02 |
| Weight of 100 seeds (g) | 12.24 – 19.04 |

The bitter gourd germplasm exhibited wide range of variations with respect to days to appearance of first male flower (36.21 – 48.37 DAS), node number to appearance of first male flower (10.21 – 18.24), days to appearance of first female flower (42.84 – 54.26 DAS), node number to appearance of first female flower (15.24 – 28.64), days to first harvest (51.24 – 65.48 DAS), fruit weight (24.5 – 175.8 g), fruit length (6.92 – 21.31 cm), fruit diameter (2.65 – 5.65 cm), number of

fruits/ plant (7.92 – 16.48), number of non-marketable fruits/ plant (3.24 – 5.41), number of marketable fruits/ plant (2.94 – 12.71), fruit yield/ plant (0.083 – 1.125 kg), vine length (1.78 – 2.45 m), number of seeds/ fruit (5.8 – 24.4), seed length (1.21 – 1.52 cm), seed width (0.61 – 1.02 cm) and weight of 100 seeds (12.24 – 19.04 g).

The evaluated material also exhibited variations for fruit size (small to large), shape (long, oblong, elliptical or long with beak) and skin colour (light green, green or dark green). A high level of fruit fly infestation (65 – 85%) and viral incidence in the plants was observed. The line AHBT-2 was found to be potential for fruit quality and yield component characters and can be further purified for use in breeding programme (Fig. 9).

**Fig. 9. Fruiting in promising bitter gourd line AHBT-2**

## Evaluation of bottle gourd genotypes

During the summer season of 2013, eight bottle gourd genotypes were studied for their performance as AVT–II of AICRP (VC) trial under high temperature conditions of arid agro-climate (Table-11&12). The high temperature and dryness condition during peak summers in the months of May and June affected the fruit quality and yield potential drastically in all the evaluated long fruited entries. The genotypes took 75 – 94 days for harvesting of first marketable fruits and recorded low yield potential (64 – 121 q/ha). A very high number of fruits were of non-marketable quality due to misshaped at early growth and development stages and this might be due to susceptibility of genotypes from extremeness of high temperature and aridity conditions. The incessant high temperature conditions (45 - 47$^0$ C) from 15 - 25 May 2013 alongwith dryness in the environment resulted to no female flower production, and also tender portion of plants exhibited heat burning and drying due to extremeness of weather conditions. This depicted that the genotypes from favourable agro-climate failed to express the potentiality under hot arid conditions and this might be due to susceptibility of genotypes towards abiotic stressed conditions. Therefore, none of the evaluated genotype is potential for arid agro-climate.

**Table 11. Fruit yield characters of evaluated bottle gourd genotypes during summer season of 2013.**

| Entry | Days to first harvest (DAS) | Fruit weight at marketable stage (g) | Fruit length at marketable stage (cm) | Fruit diameter at marketable stage (cm) | Fruit yield (q/ha) |
|---|---|---|---|---|---|
| 10/BOGVAR-1 | 94.2 | 405.4 | 24.5 | 5.6 | 65.48 |
| 10/BOGVAR-2 | 83.5 | 455.3 | 22.7 | 6.4 | 69.56 |
| 10/BOGVAR-3 | 86.3 | 405.7 | 19.8 | 6.5 | 64.82 |
| 10/BOGVAR-4 | 92.4 | 535.5 | 25.8 | 6.5 | 78.17 |
| 10/BOGVAR-5 | 92.6 | 395.3 | 19.9 | 5.9 | 77.31 |
| NDBG-104 (C) | 79.5 | 505.3 | 25.5 | 6.5 | 121.63 |
| Pusa Naveen (C) | 75.1 | 395.4 | 20.2 | 6.4 | 79.87 |
| Pusa Samridhi (C) | 75.8 | 495.2 | 21.5 | 6.6 | 96.15 |
| CD (5%) | 1.25 | 3.8 | 1.65 | 0.24 | 4.72 |
| CV (%) | 2.25 | 8.42 | 2.85 | 2.05 | 13.55 |

**Table 12. Fruit quality and crop performance of bottle gourd genotypes during summer season of 2013.**

| Entry | Fruit shape at marketable stage | Crop performance under high temperature and abiotic stressed conditions of the arid agro-climate - remarks |
|---|---|---|
| 10/BOGVAR-1 | Necked, crooked | Poor crop growth and very poor quality marketable fruits |
| 10/BOGVAR-2 | Necked, crooked | Poor crop growth and poor quality marketable fruits |
| 10/BOGVAR-3 | Necked, crooked | Poor crop growth and poor quality marketable fruits |
| 10/BOGVAR-4 | Necked, crooked | Poor crop growth and very poor quality marketable fruits |
| 10/BOGVAR-5 | Necked, crooked | Good crop growth and very poor quality marketable fruits |
| NDBG-104 (C) | Necked | Good crop growth and good quality marketable fruits |
| Pusa Naveen (C) | Crooked | Medium crop growth and poor quality marketable fruits |
| Pusa Samridhi (C) | Crooked | Medium crop growth and poor quality marketable fruits |

## Watermelon

### Germplasm evaluation and maintenance

A total of twenty germplasm (including advance lines) were evaluated for yield, its contributing traits and quality traits during summer and rainy season of 2013. Among the evaluated lines the maximum number of fruits/ plant were recorded in AHW/BR-16 (3.67) followed by YF-5 (3.20). All the lines have been maintained through selfing/ sibbing for further use in breeding programme. Twenty nine lines including identified/ released varieties were maintained as active collection.

### Evaluation for antioxidant properties

Ten genotypes of red-fleshed watermelon were evaluated and analyzed for various health promoting bioactive compounds. The evaluated genotypes showed significant difference for different phytochemicals and antioxidants. The total phenols varied from 16.77 mg/g (AHW-65) to 21.41 mg/g (Asahi Yamato), total flavonoids 55.60 mg/100g (AHW-19) to 100.93 mg/100g (Asahi Yamato) and tannin content 35.07 mg/100g (AHW-19) to 60.83 mg/100g (Durgapura Lal) on dry weight basis. The average antioxidant activity was found to vary from 40.13 µmol TE/100g (AHW-19) to 84.05 µmol TE/ 100g (Asahi Yamato) on fresh weight basis. The results indicate that red-fleshed genotypes of watermelon are good source of antioxidants and showed wide variability for different phytochemicals and antioxidants. Similarly, variation in total carotenoids and lycopene content was also recorded (Fig. 10).

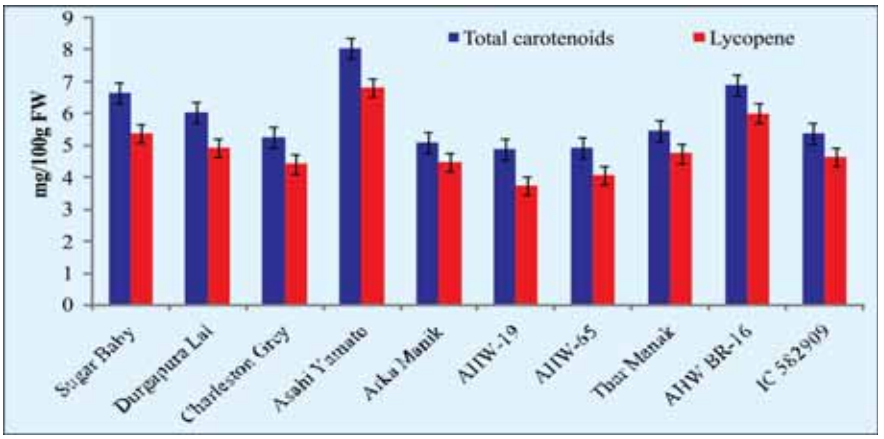



**Fig. 10. Total carotenoids and lycopene content of watermelon genotypes**

## Performance evaluation of advance line

Evaluated the performance of an advance line of watermelon (AHW/BR-16) for yield and quality traits during summer and rainy seasons of 2013. The fruits are red fleshed, round and free from cracking, weighing (3.0-3.6 kg) with 11-12% TSS. The flesh contains total phenols (20.67mg/g DW), total flavonoids (87.27mg/100g DW), tannin content (51.30mg/100g DW), total carotenoids (6.90mg/100g FW), lycopene (6.01mg/100g FW) and antioxidant activity (72.98µmol TE/100g FW).

## Seed enhancement

Seed of AHW/BR-16 was multiplied to test its performance and acceptance at farmer's field.

# Muskmelon

## Germplasm enhancement, evaluation and maintenance

A total of 10 new collections were made during the year. Thirty germplasm (including advance lines) were evaluated for yield and quality traits. The maximum number of fruits/ plant was observed in AHMM/BR-1 (4.60) followed by AHMM/BR-35 (4.27) and AHMM/BR-8 (4.13). All the lines are being maintained through selfing/ sibbing for their further utilization. A total of 43 lines including identified/ released varieties from different sources were maintained as active collection.

## Characterization of monoecious line

Characterized a monoecious line of muskmelon (AHMM/BR-8) for different horticultural and biochemical traits. Plants start to produce female flowers in 45-48 days after sowing. Plants of this line produced round fruits with salmon orange coloured flesh of 3.2-4.0 cm thickness, 10.8-11.3% TSS and 478-570 g/cm$^2$ hardness. The number of fruits/ plant was found to be 3.47-4.27 weighing 0.8-1.10 kg which develop full slip at ripening. The biochemical analysis was also done for total sugar (336.9 mg/g), tannin content (0.12 mg/g), phenol content (34.7 mg/g) and flavonoid content (1.05 mg/g) on dry weight basis. The monoecious sex form is stable in AHMM/BR-8 line and could be utilized in $F_1$ hybrid production of muskmelon after testing combining ability.

## Selection of superior lines and performance evaluation

Among the evaluated genotypes of muskmelon, AHMM/BR-1 (Fig. 11) was found promising and single plant selection was exercised to develop inbred line. A total of 5 progenies were selected for further evaluation. The selected progenies of this line produced deep red rinded fruits

**Fig. 11. Muskmelon (AHMM/BR-1)**

with 10 light green coloured prominent sutures weighing 0.5-0.6 kg, fruit diameter (10.6-12.8 cm), flesh thickness (2.5-3.1 cm), seed cavity (4.5-5.5 cm), TSS (11.3-12.2%), flesh hardness (250-285g/ $cm^2$), fruits/ plant (4.20-4.67) having light green flesh.

## Seed enhancement

Seeds of muskmelon (AHMM/BR-8) were multiplied and deposited to NBPGR, New Delhi for obtaining IC number.

# Sponge gourd

## Germplasm maintenance and evaluation

During rainy season of 2013, 16 lines including advance lines were evaluated for yield and other horticultural traits. A wide variation in overy length and seed colour was observed (Fig. 12). The best performing line AHSG-28 was again evaluated and found consistent with respect to number of fruits/ plant (31.8-35.2) and yield (2.4-2.7 kg/ plant). Among the lines the maximum yield was recorded in AHSG-34 (2.6-3.0 kg/ plant) and AHSG-29 (2.5-2.8 kg/ plant), these lines are being used to generate more lines (Table 13). Also identified a white seeded line of sponge gourd (AHSG-23) from the evaluated genetic stock. Maintained the seed of all lines through selfing for further utilization in breeding programme.

**Table 13. Genetic variability in fruiting and yield traits among sponge gourd genotypes**

| Characters | Range | Mean |
|---|---|---|
| Node on which 1st fruit appeared | 11.8-18.8 | 16.1 |
| Days to 50% female flowering | 44.60-53.93 | 48.4 |
| Ovary length (cm) | 4.2-5.6 | 4.7 |
| Fruit length (cm) | 10.8-19.5 | 16.3 |
| Fruit diameter (cm) | 2.9-3.4 | 3.0 |
| Fruit weight (g) | 62.4-97.0 | 83.8 |
| Marketable fruits per plant | 21.20-35.53 | 28.8 |
| Fruit yield per plant (kg) | 1.47-3.18 | 2.4 |

# Longmelon

## Germplasm enhancement, evaluation and maintenance

One new collection was made during the year. Evaluated a total of six germplasm including advance lines for different horticultural traits. Single plant selection for superior types was made for generation advancement and maintained all lines through selfing.

## Selection of superior lines

Among the evaluated genotypes of longmelon, AHLM-2 was found to be promising in respect to earliness (47.13-52.67 days for 50% female flowering), fruit length (31.3-40.2 cm), fruit weight (98.1-121.3 g), fruits per plant (10.53-13.93) and marketable fruit yield per plant (1.2-1.6 kg) which has been selected for further evaluation.

**Fig. 12. Variation in ovary and seed colour of sponge gourd**

# CROP IMPROVEMENT

## Vegetable

## Bikaner

## Round melon

### Breeding for high temperature tolerance and fruit quality

Round melon commonly known as tinda is potential arid zone cucurbits. In general, dark-green and whitish-green colour fruit type landraces are found growing in traditional cropping of arid region as rainfed crop. The tender fruit quality of dark green colour type (popularly known as Bikaneri Green) is very poor but it is adapted to drought and abiotic stresses including high temperature conditions ($\pm 44^0$ C) of arid region. The tender fruit quality of whitish-green colour type is good for vegetable use but it is highly susceptible to high temperature ($40^0$ – $42^0$ C) and abiotic stresses, in addition the plants exhibited slow initial growth, susceptible to mites, viral diseases and high level of fruit fly infestation. Therefore, systematic breeding work was initiated in 2007 at CIAH.

During the summer season of 2013, nineteen advanced breeding material of round melon progenies ($F_4$ generation) developed through hybridization between the lines of AHRM-1 and AHRM-2 were evaluated for growth, flowering and fruiting behaviour, fruit and seed characters. A good amount of variations were observed in the developed progenies and recorded for the characters such as days to appearance of first male flower (38.4 – 54.6 DAS), node number to appearance of first male flower (1.7 – 3.2), days to appearance of first female flower (45.8 – 58.5 DAS), node number to appearance of first female flower (3.7 – 4.5), days to first harvesting of tender fruits (55.7 – 68.4 DAS), mature fruit weight (185.3 – 680.5 g), mature fruit length (4.66 – 7.85 cm), mature fruit girth (21.25 – 36.43 cm), number of seeds/ fruit (68.8 – 328.6), mature fruit shape (flat, round, oblong) and colour (whitish green, green, dark green, yellowish green) (Table 14; Fig. 13).

The progenies were also studied for heat tolerance and potential individuals were identified based on field performance. Most of the progenies recorded high range of fruit fly incidence and susceptibility to high temperature conditions (above

**Table 14. Evaluation of breeding material of round melon during summer season of 2013**

| Character | Range ($F_4$ generation) |
|---|---|
| Days to appearance of first male flower (DAS) | 38.4 – 54.6 |
| Node number to appearance of first male flower | 1.7 – 3.2 |
| Days to appearance of first female flower (DAS) | 45.8 – 58.5 |
| Node number to appearance of first female flower | 3.7 – 4.5 |
| Days to first harvesting of tender fruits (DAS) | 55.7 – 68.4 |
| Mature fruit weight (g) | 185.3 – 680.5 |
| Mature fruit length (cm) | 4.66 – 7.85 |
| Mature fruit girth (cm) | 21.25 – 36.43 |
| Number of seeds/ fruit | 68.8 – 328.6 |
| Mature fruit shape | Flat, round, oblong |
| Mature fruit colour | Whitish green, green, dark green, yellowish green |

**Fig. 13. Fruit variability recorded in identified round melon lines**

$42^0$ C). In $F_4$ generation, the progenies from AHRM-2b x AHRM-1b, AHRM-2a x AHRM-1a and AHRM-1a x AHRM-2a exhibited maximum variations for fruit and other desirable characters. The potential individuals were identified for advancement of generation and further selection breeding for better fruit quality and marketable yield under abiotic and high temperature conditions. Similarly, four breeding lines were evaluated during rainy season of 2013 and individual were identified for advancement of generation.

## Bottle gourd

### Breeding for high temperature tolerance and marketable yield in long fruited bottle gourd

During the rainy-winter season of 2013, twelve advanced breeding material ($F_5$ generation) of long fruited bottle gourd developed at the institute were evaluated for growth, flowering, fruit set, fruit quality and yield component characters. Detailed observations were recorded to screen the material under high temperature and abiotic stresses, and also advancement of generation. A good amount of variations were observed between the progenies with respect to days to appearance of first male flower (43.6 – 49.4 DAS), node number to appearance of first male flower (2.4 – 3.2), days to appearance of first female flower (49.5 – 55.5 DAS), node number to appearance of first female flower (3.3 – 4.5), days to first harvesting of tender fruits (59.5 – 67.2 DAS), fruit weight (0.455 – 0.915 kg), fruit length (26.2 – 31.3 cm) and fruit diameter (5.6 – 7.6 cm) at marketable stages. The variations were also recorded for fruit colour (greenish and whitish green), shape (necked, crooked, straight) and quality at marketable stages. The line $F_5$/1 and $F_5$/9

were found to be potential for better fruit quality and yield, and seeds of selfed fruits of identified individuals from the progenies were harvested for advancement of generation.

## Breeding for varietal maintenance and seed production trials in bottle gourd

For improving quality fruit and seed yield potential and varietal maintenance in bottle gourd var. Thar Samridhi, a series of treatment combinations adopting production site management approaches and seed production methods were studied from 2009 - 2013 with channel and drip technology of crop cultivation. As a result, information on sowing time, season and techniques, crop production and management practices under low and high temperature conditions, irrigation scheduling and methods with limited rains and water, fruit growth and development studies for harvesting of marketable or seed fruit crop, maintenance of genetic purity of variety and seed production techniques were generated.

On pooled basis, an improvement in marketable fruit yield potential in bottle gourd var.

**Table 15. Performance of bottle gourd var. Thar Samridhi with varying production systems and over the seasons under hot arid agro-climate from 2009- 2013**

| Character | Channel technology of crop cultivation | Drip technology of crop cultivation |
|---|---|---|
| Days to appearance of first male flower (DAS) | 42.45 | 45.25 |
| Node number to appearance of first male flower | 10.25 | 13.54 |
| Days to appearance of first female flower (DAS) | 46.56 | 49.82 |
| Node number to appearance of first female flower | 13.18 | 14.65 |
| Days to first harvesting (DAS) of marketable fruits | 54.85 | 58.37 |
| Fruit weight (g) at marketable stages, “A” grade | 545.88 | 565.15 |
| Fruit length (cm) at marketable stages | 13.65 | 14.28 |
| Fruit girth (cm) at marketable stages | 28.36 | 30.25 |
| Number of marketable fruits/plant | 7.86 | 9.75 |
| Fruit yield/plant (kg) | 4.21 | 5.43 |
| Marketable fruit yield (q/ha) | 291.45 | 365.82 |
| Increase in fruit yield with drip over channel (%) | — | 25.5 % |
| Mature fruit length (cm) | 21.65 | 24.21 |
| Mature fruit girth (cm) | 56.43 | 62.43 |
| Number of seed fruits/plant | 3.23 | 4.31 |
| Seed length (cm) | 1.58 | 1.78 |
| Seed width (cm) | 0.71 | 0.79 |
| Weight of 100 seeds (g) | 16.847 | 17.539 |
| Number of seeds/fruit | 527.22 | 552.21 |
| Seed yield/fruit (g) | 87.284 | 91.499 |
| Seed yield/plant (g) | 281.872 | 392.911 |
| Seed yield (q/ha) | 14.05 | 19.62 |
| Increase in seed yield with drip over channel (%) | — | 39.64 % |
| Vine length (m) | 2.68 | 3.21 |
| Number of branches/plant | 5.45 | 6.12 |

Thar Samridhi was recorded under drip technology (365.82 q/ha) of crop cultivation (lateral lines at 2.0 m and 4lph in-line drippers at 0.50 m apart) and it was 25.5 % higher from channel technology (291.45 q/ha) of crop cultivation with limited irrigation water. Similarly, the improvement in seed yield potential in bottle gourd var. Thar Samridhi was recorded with drip technology (19.62 q/ha) of crop cultivation and it was 39.64 % higher from channel technology (14.05 q/ha) with limited irrigation water over the seasons and years (Table 15).

**Fig. 14. Bottle gourd crop under channel technology of production**

**Fig. 15. Bottle gourd crop under drip technology of production**

**Fig. 16. Bottle gourd var. Thar Samridhi in bearing for marketable fruits and seed production**

To minimize the adverse effects of low and high temperature conditions of hot arid agro-climate and promotion of spring-summer season bottle gourd cultivation, an innovative Tent Technology (modifications in low tunnel) has been standardized in which the crop sowing is done in the first week of January only and resulted to the earliest harvesting of tender fruits from the middle of March (Fig 14-16).

## Muskmelon

### Breeding for high temperature tolerance and fruit quality

As a result of evaluation of 115 genotypes of muskmelon over the period (1997–2008) under high temperature conditions of arid region at CIAH, Bikaner, some potential lines were identified and used in breeding programme. The purification and advancement of breeding lines in muskmelon at Bikaner from 2007 to 2012 resulted to stabilization of CIAH-1 for uniform and better quality fruit yield potential under hot arid agro-climate. During the summer season of 2013, the developed line CIAH – 1 was evaluated as large scale replicated varietal trial and performance studies were done for plant growth, maturity, yield and fruit characters under high temperature conditions. The developed genotype is early maturing and took 83.5 days from sowing for first harvesting. It is high yielding and marketable fruit yield potential is 3.57 kg/plant during summer seasons of 2013 (Fig. 17).

**Fig. 17. Fruits of developed muskmelon line CIAH-1**

## Brinjal

### Screening of brinjal lines for biotic and abiotic stresses and evaluation for performance studies

On the basis of evaluation, selection and generation advancement, seven elite lines such as CIAH-1, CIAH-2, CIAH-12, CIAH-16, CIAH-21, CIAH-22 and CIAH-67 were identified for performance studies over the seasons and years. These were selected based on earliness, reduced infestation of FSB, consistent better fruit quality and marketable yield under high temperature conditions. During the spring-summer and rainy-winter season of 2013-14, the developed genotype CIAH-22 was studied under replication for large scale testing.

**Performance of brinjal genotype CIAH-22:** As a result of intensive germplasm evaluation and selection breeding, a high yielding and better fruit quality brinjal genotype CIAH-22 has been developed from original germplasm line AHB-03 at CIAH. During 2013-14, the genotype was studied and characterized for leaf length (14.2 – 15.7 cm), leaf width (10.2 – 14.5 cm), number of flowers/ cluster (2.1 – 4.4), days to flowering (36.5 – 39.2 DAT), days to first harvest (53.4 – 56.3 DAT), number of fruits/ cluster (1.4 – 3.4), number of fruits/ plant (48.5 – 61.4), fruit yield/ plant (2.53 – 3.14 kg), fruit yield (396.5 – 409.1 q/ha), plant height at 90 days (49.2 – 67.5 cm), number of branches/ plant (3.3 – 5.4), tender fruit length (5.1 – 6.9 cm), tender fruit diameter (4.0 – 6.5 cm), tender fruit weight (33.6 – 105.4 g), mature fruit length (8.5 – 9.3 cm), mature fruit girth (23.1 – 29.6 cm), mature fruit weight (151.8 – 316.3 g), number of seeds/ fruit (1183 – 3139), weight of seeds/ fruit (4.813 – 10.136 g), weight of 1000 seeds (3.31- 4.436 g) and seed yield/plant (96.8 – 118.45 g, based on average 15 fruits/ plant) (Table 16). The data were also

**Table 16. Characterization and performance trial of brinjal genotype CIAH - 22 during summer and rainy-winter season of 2013**

| Character | Range | Average |
|---|---|---|
| Leaf length (cm) | 14.2 – 15.7 | 14.88 |
| Leaf width (cm) | 10.2 – 14.5 | 12.06 |
| Number of flowers/ cluster | 2.1 – 4.4 | 3.3 |
| Days to flowering (DAT) | 36.5 – 39.2 | 38.1 |
| Days to first harvest (DAT) | 53.4 – 56.3 | 54.3 |
| Number of fruits/ cluster | 1.4 – 3.4 | 2.6 |
| Number of fruits/ plant | 48.5 – 61.4 | 58.8 |
| Fruit yield/ plant (kg) | 2.53 – 3.14 | 2.89 |
| Fruit yield (q/ha) | 396.5 – 409.1 | 404.6 |
| Plant height at 90 days (cm) | 49.2 – 67.5 | 62.7 |
| Number of branches/ plant | 3.3 – 5.4 | 4.2 |
| Tender fruit length (cm) | 5.1 – 6.9 | 6.07 |
| Tender fruit diameter (cm) | 4.0 – 6.5 | 5.47 |
| Tender fruit weight (g) | 33.6 – 105.4 | 63.27 |
| Mature fruit length (cm) | 8.5 – 9.3 | 8.84 |
| Mature fruit girth (cm) | 23.1 – 29.6 | 26.22 |
| Mature fruit weight (g) | 151.8 – 316.3 | 223.2 |
| Number of seeds/ fruit | 1183 – 3139 | 2072.79 |
| Weight of seeds/ fruit (g) | 4.813 – 10.136 | 7.537 |
| Weight of 1000 seeds (g) | 3.31- 4.436 | 3.628 |
| Seed yield/plant (g) (Av. on 15 fruits/ plant) | 96.8 – 118.45 | 112.35 |
| Leaf colour | | Green |
| Leaf pubescence | | High |
| Flower colour | | Whitish-purple |
| Tender fruit colour | | Bluish-purple |
| Fruit shape | | Round-oblong |
| Fruit size | | Medium |
| Fruit calyx colour | | Green |
| Fruit calyx pubescence | | Low |
| Fruit flesh colour | | Whitish-green |
| Seed colour | | Light orange |
| Plant growth habit | | Medium growth, semi- erect |

**Table 17. Characterization and performance of developed brinjal genotypes under hot arid environment over the seasons and years from 2010 – 2013 at CIAH, Bikaner**

| Character | CIAH-1 | CIAH-22 |
|---|---|---|
| Pedigree | $F_8$ generation from cross of AHB-04 x PPC | $F_6$ generation purification from germplasm AHB-03 and selection |
| Leaf length (cm) | 11.9 | 14.88 |
| Leaf width (cm) | 8.3 | 12.06 |
| Number of flowers/ cluster | 4.8 | 3.3 |
| Days to flowering (DAT) | 26.1 | 34.3 |
| Days to first harvest (DAT) | 45.2 | 52.7 |
| Number of fruits/ cluster | - | 2.6 |
| Number of fruits/ plant | 85.4 | 68.4 |
| Fruit yield/ plant (kg) | 3.92 | 3.58 |
| Fruit yield (q/ha) | 638.8 | 501.1 |
| Plant height at 90 days (cm) | 61 .2 | 62.7 |
| Number of branches/ plant | 5.8 | 4.2 |
| Tender fruit length (cm) | 5.23 | 6.07 |
| Tender fruit diameter (cm) | 4.31 | 5.47 |
| Tender fruit weight (g) | 42.8 | 55.2 |
| Mature fruit length (cm) | - | 8.84 |
| Mature fruit girth (cm) | - | 26.22 |
| Mature fruit weight (g) | 63.2 | 223.2 |
| Number of seeds/ fruit | 607.5 | 2072.79 |
| Weight of seeds/ fruit (g) | 1.767 | 7.537 |
| Weight of 1000 seeds (g) | 2.91 | 3.628 |
| Seed yield/plant (g) (Av. on 15 fruits/ plant) | - | 112.35 |
| Leaf colour | Purple | Green |
| Leaf pubescence | High | High |
| Flower colour | Whitish-purple | Whitish-purple |
| Tender fruit colour | Dark-purple | Bluish-purple |
| Fruit shape | Oblong-round | Round-oblong |
| Fruit size | Small | Medium |
| Fruit calyx colour | Dark purple | Green |
| Fruit calyx pubescence | - | Low |
| Fruit flesh colour | - | Whitish-green |
| Seed colour | Light brown | Light orange |
| Plant growth habit | Medium growth, semi-erect | Medium growth, semi-erect |

recorded for important characters such as leaf colour (green), leaf pubescence (high), flower colour (whitish-purple), tender fruit colour (bluish-purple), fruit shape (round-oblong) (Fig. 18), fruit size (medium), fruit calyx colour (green), fruit calyx pubescence (low), fruit flesh colour (whitish-green), seed colour (light orange) and plant growth habit (medium growth and semi-erect). After six successive cycles of selection and advancement for better fruit shape, fruit set, yield and plant structure under high temperature conditions it is found to be uniform and stable during testing seasons of 2013. The comparative performance of CIAH-1 and CIAH-22 is presented in Table 17.

## Tomato

### Breeding for high quality tomato yield under hot arid environment

During spring-summer and rainy-winter season of 2013, the tomato breeding line AHSL-1 (developed through mutation breeding and $M_6$ generation of selection) was evaluated and studied for growth, flowering, fruit set, maturity, fruit yield and quality characters. The line was also studied for uniformity, stability and response to environmental stresses both under high and low temperature conditions of arid agro-climate.

Based on field performance over the seasons, the developed line AHSL-1 is characterized for leaf length (6.98 cm), leaf width (4.16 cm), days to flowering (21.5 DAT), days to first harvest (58.5 DAT), number of flowers/ cluster (4.4), number of fruits/ cluster (4.1), number of fruits/ plant (67.4), fruit yield/ plant (3.15 kg), plant height at 90 days (59.5 cm), number of branches/ plant (6.22), fruit weight (45.13 g), fruit length (4.48 cm), fruit diameter (4.16 cm) and TSS ($7.26^0$ Brix) (Table 18). The medium sized fruits are oblong-round in shape and reddish in colour. The ripen fruits are firm, less-seeded and sweet-sour in taste. The fruit ripening is highly affected both in summer and winter season from extremeness of high and low temperature conditions, respectively. Thereby, it recorded low yield potential for quality marketable fruits. However, more number of fruit/plant was at unripe stages and recorded non-marketable quality fruits.

## Cluster bean

### Breeding for dual purpose genotypes

In hot arid region, cluster bean is predominantly grown for seed grain, however, the tender pods of the grain type genotypes is extensively used for vegetable purpose in the western parts and rainfed crop cultivation areas of

**Fig. 18. Field view of crop and fruits of brinjal genotype CIAH-22**

**Table 18. Characterization and performance trial of tomato genotype AHSL-1 (developed through mutation breeding and $M_6$ generation of selection) during summer and rainy season of 2013**

| Character | Range | Mean |
|---|---|---|
| Leaf length (cm) | 6.3 – 8.2 | 6.98 |
| Leaf width (cm) | 4.0 – 4.3 | 4.16 |
| Days to flowering (DAT) | 20.5 – 25.4 | 21.5 |
| Days to first harvest (DAT) | 56.6 – 64.3 | 58.5 |
| Number of flowers/ cluster | 3.2 – 6.1 | 4.4 |
| Number of fruits/ cluster | 2.4 – 6.1 | 4.1 |
| Number of fruits/ plant | 59.5 – 75.8 | 67.4 |
| Fruit yield/ plant (kg) | 2.45 – 3.62 | 3.15 |
| Plant height at 90 days (cm) | 55.7 – 78.4 | 59.5 |
| Number of branches/ plant | 5.1 – 8.2 | 6.22 |
| Fruit weight (g) | 41.2 – 49.6 | 45.13 |
| Fruit length (cm) | 4.3 – 4.7 | 4.48 |
| Fruit diameter (cm) | 3.9 – 4.3 | 4.16 |
| TSS ($^0$ Brix) | 6.7 – 8.3 | 7.26 |
| Fruit shape | | Oblong-round |
| Fruit size | | Medium |
| Fruit colour | | Red |
| Fruit taste | | Sweet-sour |
| Fruit firmness | | Good |
| Seediness of fruit | | Less seeded |

Rajasthan. As a result of intensive surveys from 1995 – 2002 in the rainfed areas of hot arid region, some land races of vegetable potential were collected in cluster bean and purified over more than 10 years for better quality and yield of tender pods under the prevailing agro-climatic conditions, and the variety Thar Bhadavi (Fig. 19) was released in 2010 by the institute for the cultivation.

During rainy season of 2013, five germplasm having dual purpose potentiality (moderate quality of tender pods for vegetable use and grain yield) were identified from the rainfed fields of Bikaner and Churu districts and three germplasm were collected from the population for evaluation. In addition, the var. Thar Bhadavi was analyzed for seed yield (23.94 g/plant) and fraction yield for guar gum (%) content i.e. endosperm (31.40%), germ (55.27%) and husk (13.31%) (Table 19).

**Table 19. Analysis of cluster bean var. Thar Bhadavi for seed yield and guar gum content**

| Character | Average |
|---|---|
| Seed yield/plant (g) | 23.94 |
| Grain size | Normal |
| Weight of 1000 seeds (g) | 30.54 |
| Fraction yield for guar gum (%) | |
| a) Endosperm | 31.40 |
| b) Germ | 55.27 |
| c) Husk | 13.31 |
| Potential viscosity (2 hrs) | 5500 cps |

**Fig 19. Cluster bean var. Thar Bhadavi in bearing as kept for seed production studies**

## Indian bean

### Varietal trial of Indian bean and performance of institute varieties under national net-work

During 2013, the performance data of two varietal trials of Indian bean (pole and bush type) conducted from 2010 – 2013 under AICRP on vegetable crops at CIAH, Bikaner was analyzed for the generation of scientific information and conclusions. Among ten entries of pole type, two were from CIAH such as AHDB–03 (Thar Maghi) and AHDB–16 (Thar Kartiki) and were tested alongwith checks (Pusa Early Prolific and Swarna Utkrist). During the crop evaluation years, the minimum low temperature dips down below zero degree in December and January and at the same time the mild to severe frost conditions resulted in high level of damages in flower, pods and plants or complete crop. This revealed that the low temperature and frost conditions are the limiting factors in beans and the normal season maturing varieties are not suitable for the cultivation under arid agro-climate.

Among the pole type, very low pod harvest was recorded in most of the entries due to late maturing group where first pod harvesting started from second or third week of December. The early maturing entries (second or third week of October to first week of November) recorded good pod

**Table 20. Performance of Indian bean (pod yield, q/ha) variety Thar Maghi (AHDB-03) under AICRP - vegetable crop net-work during 2010-11 to 2012-13 (Three years)**

| Centre name | IET (2010-11) | AVT-I (2011-12) | AVT-II (2012-13) | Mean |
|---|---|---|---|---|
| Coimbatore | 142.60 | 113.00 | 171.60 | 142.40 |
| Kalyani | NR | 232.30 | 226.20 | **229.25** |
| Rahuri | 166.78 | 166.78 | 164.86 | 166.14 |
| Junagadh | 108.55 | 81.36 | 108.93 | 99.61 |
| Parbhani | 164.37 | 154.20 | 138.43 | 152.33 |
| Kalyanpur | NR | 62.57 | 52.82 | 57.69 |
| Sabour | 85.10 | 95.55 | 104.30 | 94.98 |
| Durgapura (Jaipur) | 101.20 | 134.00 | 108.30 | 114.50 |
| HARP, Ranchi | NR | 206.30 | NR | **206.30** |
| Jabalpur | 212.91 | 198.00 | NR | **205.45** |
| Raipur | 72.57 | 81.70 | 111.72 | 88.66 |
| CARI, Portblair | 46.50 | NR | NR | 46.50 |
| IIVR, Varanasi | NR | NR | NR | -NA- |
| Barapani | NR | 54.79 | NR | 54.79 |
| IIHR, Bangalore | NR | 113.30 | 181.67 | 147.48 |
| CIAH, Bikaner | 105.06 | 101.00 | 103.15 | **103.07** |
| Mean | | | | 119.32 |
| Range | | | | 46.50 – 232.30 |

harvest till the onset of low temperature and frost injuries with the end of December month. The institute varieties, Thar Maghi and Thar Kartiki, recorded the superiority for tender pod yield 103.07 q/ha and 103.41 q/ha, respectively on pooled basis under extremes of arid environmental conditions. The tender pod yield (q/ha) potential of both the institute entries was very wide i.e. AHDB – 03 (46.50 – 232.30) and AHDB – 16 (41.52 – 370.00) under varying agro-climatic conditions of the country and this indicated that the environmental conditions are playing significant role in their performance (Table 20 & 21).

The varietal trials were conducted at 18 centers under national network of AICRP (VC) and the institute entry AHDB – 16 (10/DOLVAR – 9) was found to be superior over the national checks at Kalyani, Rahuri, Bikaner and Kalyanpur. The institute line AHDB–16 recorded the highest yield (q/ha) potential at Kalyani (359.30), Varanasi (343.67) and Ranchi (305.10) in comparison to overall mean of the centers (148.96) and the line AHDB–03 recorded the highest yield (q/ha) potential at Kalyani (229.25), Ranchi (206.30) and Jabalpur (205.45) in comparison to overall mean of the centers (119.32).

**Table 21. Performance of Indian bean (pod yield, q/ha) variety Thar Kartiki (AHDB-16) under AICRP - vegetable crop net-work during 2010-11 to 2012-13 (Three years)**

| Centre name | IET (2010-11) | AVT-I (2011-12) | AVT-II (2012-13) | Mean |
|---|---|---|---|---|
| Coimbatore | 124.40 | 111.10 | 162.30 | 132.60 |
| Kalyani | 370.00 | 359.60 | 348.30 | 359.30 |
| Rahuri | 155.78 | 155.78 | 174.56 | 162.04 |
| Junagadh | 84.23 | 137.78 | 114.37 | 112.13 |
| Parbhani | 150.06 | 127.93 | 110.06 | 129.35 |
| Kalyanpur | 55.62 | 61.03 | 94.24 | 70.29 |
| Sabour | 124.58 | 86.66 | 94.44 | 101.89 |
| Durgapura (Jaipur) | 76.20 | 111.00 | 104.90 | 97.36 |
| HARP, Ranchi | NR | 305.10 | NR | 305.10 |
| Jabalpur | 227.04 | 173.50 | NR | 200.27 |
| Raipur | 54.24 | 74.00 | 114.94 | 81.06 |
| CARI, Portblair | 34.90 | NR | NR | 34.90 |
| IIVR, Varanasi | 337.03 | 367.00 | 327.00 | 343.67 |
| Barapani | NR | 41.52 | NR | 41.52 |
| IIHR, Bangalore | NR | 85.33 | 131.67 | 108.50 |
| CIAH, Bikaner | 103.78 | 103.00 | 103.46 | 103.41 |
| Mean | | | | 148.96 |
| Range | | | | 41.52 – 370.00 |

## Khejri

### Maintenance and evaluation of khejri genotypes

Fourteen elite genotypes identified by the CIAH from 2002 - 2005 and collected clonally in khejri germplasm plot for *ex situ* conservation were maintained with good management practices during the period under report. The khejri var. Thar Shobha and three additional types were characterized with reference to phenological and horticultural characters over the seasons for generation of information. Based on preliminary evaluation, a new genotype Khejri Selection - 2 has been identified for detailed studies.

## Ridge gourd

### Germplasm enhancement, evaluation and maintenance

During the year collected 02 entries to increase the existing genetic stock. Evaluated a total of 30 lines including advance lines and released varieties from different centres during summer season of 2013 for yield, reaction to diseases and high temperature tolerance. The best performing plants based on yield and high temperature tolerance were selected, selfed and harvested the seed separately for generation advancement and inbred development. Among the evaluated genotypes, AHRG-29 (1.39 kg/ plant), AHRG-61 (1.34 kg/ plant), and AHRG-28 (1.13 kg/ plant) gave maximum yield under high temperature conditions (Table 22).

### Development and evaluation of hybrids

During summer season of 2013 developed 18 hybrids by random crossing. These hybrids were evaluated during rainy season of 2013 for horticultural and quality parameters. Among the evaluated hybrids, Swarna Manjri x AHRG-41, AHRG-29 x AHRG-28 and AHRG-28 x Swarna Manjri were found promising for fruit yield/ plant (Table 23).

**Table 22. Fruit characters and yield of Ridge gourd promising lines**

| Lines | Fruit length (cm) | Fruit diameter (cm) | Fruit weight (g) | Fruits/ plant | Fruit yield/ plant (kg) |
|---|---|---|---|---|---|
| AHRG-28 | 18.23 | 2.42 | 62.16 | 18.00 | 1.13 |
| AHRG-29 | 19.73 | 2.81 | 66.18 | 20.80 | 1.39 |
| AHRG-46 | 15.94 | 2.34 | 62.11 | 17.47 | 1.09 |
| AHRG-61 | 37.71 | 2.64 | 75.59 | 17.80 | 1.34 |

**Table 23. Fruit characters and yield of cross combination in ridge gourd**

| Cross combination | Fruit length (cm) | Fruit diameter (cm) | Fruit weight (g) | Fruits/ plant | Fruit yield/ plant (kg) |
|---|---|---|---|---|---|
| AHRG-28 x Swarna Manjri | 17.24 | 27.22 | 70.40 | 18.73 | 1.32 |
| AHRG-29 x AHRG-28 | 21.32 | 28.45 | 62.80 | 22.80 | 1.43 |
| AHRG-29 x Swarna Manjri | 16.09 | 28.03 | 59.32 | 19.80 | 1.17 |
| AHRG-41 x Swarna Manjri | 13.11 | 29.24 | 56.07 | 20.60 | 1.17 |
| AHRG-41 x Arka Sujath | 22.47 | 26.09 | 66.71 | 19.53 | 1.30 |
| Swarna Manjri x AHRG-41 | 21.60 | 31.65 | 69.86 | 23.13 | 1.62 |

**Table 24. Morphomatric parameters of advance lines of ridge gourd**

| Entry | Node number at which first female flower appears | Days to 50% flowering | Fruit length (cm) | Fruit girth (cm) | Number of fruits/ plant | Fruit weight (g) | Days to first fruit harvesting | Number of ridges/ fruit | Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|---|
| 2012/RGVAR-1 | 11.00 | 49.00 | 19.11 | 9.38 | 12.20 | 85.31 | 57.33 | 10.00 | 62.01 |
| 2012/RGVAR-2 | 10.33 | 47.00 | 22.05 | 10.73 | 14.60 | 94.27 | 54.00 | 10.00 | 82.52 |
| 2012/RGVAR-3 | 12.00 | 46.33 | 20.75 | 9.13 | 11.40 | 62.23 | 51.87 | 10.00 | 42.79 |
| 2012/RGVAR-4 | 11.07 | 49.33 | 18.56 | 8.94 | 12.20 | 73.49 | 56.93 | 10.00 | 53.57 |
| 2012/RGVAR-5 | 9.13 | 50.67 | 16.40 | 9.42 | 11.60 | 75.71 | 55.60 | 10.00 | 52.60 |
| Pant Torai-1 (C) | 7.60 | 43.00 | 12.06 | 7.50 | 11.67 | 51.30 | 48.53 | 10.00 | 35.89 |
| Arka Sujath (C) | 11.00 | 51.00 | 18.70 | 9.43 | 13.93 | 81.06 | 58.47 | 10.00 | 67.12 |
| CD at 5% | 1.67 | 4.86 | 2.69 | 1.22 | 2.21 | 9.99 | 6.06 | - | 10.33 |
| CV (%) | 9.13 | 5.69 | 8.30 | 7.42 | 9.94 | 7.51 | 6.23 | - | 10.25 |

## Ridge gourd Varietal Trial IET I

Five entries of ridge gourd along with two checks were evaluated during summer season of 2013. The maximum fruit yield was recorded in RGVAR-2 (82.52 q/ha) which was significant over all the entries and both the checks (Table 24).

## Godhra

## Advancement of promising hybrids derivatives of pumpkin for high yield and quality (F8 generation) under replicated yield trial

The analysis of variance in the evaluation of advanced hybrid derivative lines of pumpkin showed significant differences among them for majority of characters under study; except for fruit flesh thickness which indicates the genotypic involvement in expression of the character. Their mean performances indicated CM4xCM22 derivatives are larger and vigorous growing types; however the node to first female flower was found higher as against the CM16xCM19, which recorded the lowest value. The node at which the first female appeared was lowest in CM16xCM19 as against the derivative CM16xCM17. Average number of fruits produced per plant was found highest in CM16xCM19, followed by CM4xCM22, which was found to produced smaller fruit sizes against the other derivatives (>4.0kg each). Among the derivatives, the earlier the harvest the higher the fruits per plant were found in the CM16xCM19 and CM4xCM22. However, the similar trend was not found in CM19xCM12, CM13xCM15 and CM16xCM17. The oblong fruit derivatives (CM19xCM12, CM13xCM15) recorded the higher fruit flesh thickness (>4.0cm) as compared to the round, flat round derivatives. Considering the yield parameter, the highest yield per plant and yield per hectare was found in CM13xCM15 (15.34 kg and 30.67t/ha, respectively) despite the larger fruit size. Invariably, the larger fruit derivatives registered the yellow to orange flesh color with TSS of 14.48$^{o}$ brix and less than 10mg/100g of total carotene (CM19xCM12 and CM13xCM15) as against the smaller fruit derivatives, which recorded the higher TSS and total carotene values. The higher value for

**Table 25. Analysis of variance in pumpkin hybrid derivatives for yield and quality**

| Source | Replications df=3 | Treatments df=4 | Error df=12 | Total df=19 |
|---|---|---|---|---|
| Plant height | 0.26 | 2.74** | 0.17 | 0.73 |
| Node to first male flower appeared | 0.88 | 16.55** | 0.49 | 3.93 |
| Days to male flower opening | 1.24 | 468.46** | 7.58 | 103.6 |
| Node to first female flower appeared | 4.19 | 64.07** | 4 | 16.68 |
| Days to female flower opening | 0.98 | 456.05** | 7.65 | 101 |
| Number of fruits per plant | 0.18 | 75.38** | 0.98 | 16.51 |
| Fruit weight | 0.15 | 23.19** | 0.15 | 5 |
| Average fruit length | 0.58 | 531.04** | 1.89 | 113.08 |
| Average fruit girth | 3.22 | 1030.01** | 3.45 | 219.53 |
| Fruit flesh thickness | 0.01 | 0.16 | 0.11 | 0.09 |
| Yield per plant | 10.07 | 23.44** | 9.3 | 12.4 |
| Yield per ha | 40.26 | 93.77* | 37.19 | 49.59 |
| TSS | 0.73 | 4.13** | 0.38 | 1.23 |
| Total Carotene (mg/100g) | 0.197 | 5.053** | 0.3 | 1.285 |
| Ascorbic acid (mg/100g) | 0.276 | 2.271** | 0.191 | 0.642 |

Ascorbic acid was recorded in CM19xCM12 and CM13xCM15 (Table 25).

## Pumpkin CM13xCM15- For industrial purpose

The pumpkin derivative CM13xCM15 tested consecutively for three years (2010-2013) indicated superior performances for growth and yield and quality related parameters. Plants are highly vigorous, growing up to 5.94m. The male and female flowers are produced at 6$^{th}$ and 27$^{th}$ node respectively. Each plant produces about 3 larger size oblong cylindrical fruits (48.8cmx 70.5cm). Each fruit weighs about 6-6.5kg. An average yield per plant was found to 15.34kg. The flesh thickness was 4.12cm; TSS 9.5-11.5$^{o}$ Brix, total carotene 9.42mg/100g and ascorbic acid content 5.39mg/100g. In total, 413 bold and larger sized seeds were present in each fruit, weighing about 86g/fruit (Fig 20).

**Fig. 20. Fruits of advance line (CM13xCM15) of pumpkin**

## CM4xCM22-28-1

It is a single plant selection from population of CM4xCM22 at $F_3$ generation. Plants are vigorous (6.42m), producing male and female flowers on 3$^{rd}$ and 11$^{th}$ node respectively. Each plant produces 3-4 fruits, very large and globular in shape. The fruits weight is 5.2kg (37.5x75.5cm) with having flesh

**Fig. 21. Fruits of advance line (CM4xCM22-28-1) of pumpkin**

thickness of 4.1cm, TSS 8.5. The seeds are larger in size, 404 seeds found in each fruit (136g). Yield potential is 13-17kg/plant. It is suitable to grow both rainy and summer season (Fig 21).

## Identification of promising genotypes from advanced breeding lines of pumpkin

In advancement of superior breeding lines, 43 and 31 promising types of pumpkin were raised during rainy and summer season, respectively. Significant variation among the breeding lines was found for vegetative, floral and fruiting parameters.

## CM13xCM15-135

Among the breeding lines, a progeny selected form CM13xCM15 exhibited uniformly green fruits without white dots on the fruit surface. The plants are vigorous (7.5m length) densely branched (6). Plants produced higher number of (190) male flowers and 5 female flowers. Fruits are oblong, green weighing about 4.6-7.0kg, having TSS of 7.5° Brix (Fig 22).

## CM16xCM19-114

It was identified from the progeny of CM16xCM19. It is a medium vigorous (2.18m), produced 129 male flowers and 8 female flowers. Female flowers emerged from 10$^{th}$ node. The fruits are of uniformly pale green, globular, weighing about 1.1-1.95kg (28.2x59.2cm). The yield potential is 8.5-12kg per plant. The fruit flesh is yellow, thickness of 4.12cm, TSS 9.2° Brix.

**Evaluation of silvery leaf pumpkin:** Selfed population of white/silvery leaf with un-serration on margins was advanced. The thirty five progenies showed variations for plant vigor and fruiting parameters. None of the progenies exhibited silvery leaf, however there was difference for growth parameters. Each plant produces about 5 globular

**Fig. 22. Fruits of advance line (CM13xCM15-135) of pumpkin**

fruits weighing each 0.750 -3.2kg each. TSS was observed ranging from 6.5-9.5° Brix. Fruits contain 339seeds/fruit weighing 42.8g.

**Screening for PMV:** Among the tested lines, 5 lines exhibited severe infestation from pre flowering stage itself which caused drastic yield reduction estimated to the tone of about 80-90 per cent. Majority of them falls under moderately resistant category which did not affect the fruit set as the infestation was initiated after flowering (CM13xCM15) caused the yield loss of 15-20 per cent. Arka Suryamuki, CHES-1 did not exhibit mosaic symptom till harvesting during the evaluation.

## Advancement of hybrids derivatives of bottle gourd for high yield and quality (F7 generation)

The promising derivatives of bottle gourd viz. LS-4xLS3-2, LS-20-1xLS14-1, LS-28-1x LS20-2, LS-3xLS2 and LS-42-xLS32-2 was raised under replicated trail to assess the vegetative, flowering, fruit and yield related parameters. The results revealed that all the characters showed significant differences among the derivatives indicate the genotypic effect in expressing the phenotype (Table 26).

Among the hybrid derivative identified with different fruit shape from round, thump bell, and cylindrical for consecutively six generation (2009-2013) indicated consistent performance for their yield potential under semiarid condition. The characteristics of the superior hybrid derivatives with attractive shape and quality are given below.

**LS28-1xLS20-2:** Plants are highly vigorous (6.03m), male and female flowers emerges from 12th and 18th nodes respectively. Each plant produces about 18-20 female flowers and set harvestable sized fruits in 60-65days after sowing. The fruits are cylindrical in shape without crooknecks, with 44-45cm in length weighing 860g each. Each plant

**Table 26. Analysis of variance in bottle gourd hybrid derivatives for yield and quality**

| Source | Replications df=3 | Treatments df=4 | Error df=12 | Total df=19 |
|---|---|---|---|---|
| Plant length (m) | 0.08 | 8.59** | 0.11 | 1.44 |
| Node to first male flower appeared | 0.93 | 23.92** | 0.96 | 4.58 |
| Days to male flower opening | 2.58 | 144.72** | 4.84 | 26.45 |
| Node to first fe male flower appeared | 0.33 | 183.6** | 3.23 | 31.09 |
| Days to female flower opening | 2.3 | 88.98** | 4.57 | 17.42 |
| Number of fruits per plant | 5.68 | 24.2** | 3.58 | 7.27 |
| Fruit weight(g) | 0.01 | 0.06* | 0.01 | 0.01 |
| Average fruit length(cm) | 1.97 | 72.68** | 4.76 | 14.9 |
| Average fruit girth(cm) | 2.62 | 87.97** | 2.45 | 15.99 |
| Yield per plant(kg) | 5.07 | 14.97* | 2.66 | 5.11 |
| Yield per ha(t) | 56.4 | 166.36* | 29.57 | 56.82 |
| Crude fiber content (%) | 0.03 | 0.13* | 0.09 | 0.08 |
| Crude protein content(g/100g) | 4.7 | 21.51* | 3.18 | 6.39 |
| Ascorbic acid (mg/100g) | 0.166 | 2.793* | 0.354 | 0.699 |

produces about 15.67kg with per ha yield potential of 52.25t. The fruits are with attractive flavor, crude fiber (2.33%), crude protein (23.04g) and ascorbic acid content (10.15mg) (Fig. 23).

**Fig. 23. Fruits advance line LS28-1xLS20-2 of bottle gourd**

**LS4xLS3-2:** Plants are medium vigorous (3.79m), the male and female flowers emerges from 8$^{th}$ and 14$^{th}$ node respectively. The plants produces 17-19 globular shaped, green colored fruits, weighing each 750g. The marketable fruits are ready for harvest within 60days. The yield potential per hectare is 46.2t. It has comparatively more crude fiber (2.61%) and high crude protein (27.36g) and moderate level of ascorbic acid (11.29mg) (Fig. 24)

## Evaluation of segregating population of bottle gourd (Rainy season)

During the year, about 55 segregating populations were evaluated to assess the yield potential of the progenies. It was found that LS10-1-26 and LS13-2-5 having obovate fruit shape with high yield potential was found. The main characteristic of these progenies are given in Table 27.

**Table 27. Plant characteristics of segregating population of bottle gourd**

| Characters |  |  |
|---|---|---|
| Name of the progeny | LS10-1-26 | LS13-2-5 |
| Plant length (m) | 5.68 | 6.63 |
| Node to first male flower appeared | 4 | 5 |
| Days to male flower opening | 48 | 50 |
| Node to first fe male flower appeared | 12 | 9 |
| Days to female flower opening | 59 | 62 |
| Number of fruits per plant | 13-15 | 15-18 |
| Fruit weight(g) | 920 | 700 |
| Average fruit length(cm) | 23.5 | 22.8 |
| Average fruit girth(cm) | 40.1 | 37.6 |
| Yield per plant(kg) | 12.5 | 13.5 |
| Crude fiber content (%) | 2.63 | 2.35 |
| Crude protein content(g/100g) | 24.08 | 23.90 |
| Ascorbic acid (mg/100g) | 11.15 | 12.40 |

**Fig. 24. Fruits advance line LS4xLS3-2of bottle gourd**

## CROP MANAGEMENT AND AGRO-TECHNIQUES

### Planting models

### Khejri based cropping models

Khejri (*Prosopis cineraria*) is an important multipurpose tree species and life-line of Indian desert. It is most potential perennial component compatible to almost any companion crop in the traditional farming systems in the hot arid region. With the development of bud grafting techniques at CIAH, Bikaner, the institute has developed and recommended variety 'Thar Shobha' for establishing uniform plantations. This would result into development of systematic cultivation as orchards of horticultural significances (sangri) and to develop farming systems of crop production with khejri as perennial base crop. Now, the long term strategic objective is to develop khejri based crop production models and to understand the impact of cropping systems both under rainfed and irrigated situations for sustainable resource utilization and maximize income under resource constraints arid environment. The khejri based planting models under studies are KM-1 (4 x 4 m), KM-2 (6 x 6 m), KM-3 (8 x 8 m), KM-4 (8 x 4 m), KM-5 (8 x 4 x 4 m), KM-6 (16 x 4 m), KM-7 (16 x 4 x 4 m), KM-8 (24 x 4 m), KM-9 (24 x 4 x 4 m), KM-10 (48 x 4 m), KM-11 (48 x 4 x 4 m) and KM-12 (c).

#### (a) Growth and development studies

To develop khejri based cropping models adopting Horticulture Based Crop Production Site Management Approaches (HBCPSMA), an area of two hectare was developed through *in situ* establishment of khejri variety Thar Shobha by planting the seedling in 2007 and budding in 2009 under absolute rainfed situations. During 2013–14, the plant growth and development observations were recorded through out the year and no significant differences were observed in growth characters of khejri variety Thar Shobha under varying planting models.

During the period, the production site was maintained adopting good management practices as technological recommendations such as ploughing of field by cross harrowing with the end of June after assessing the weather forecasting for monsoon rains in the region. This year, the monsoon rains were in time in the arid region and pre-monsoon rains were scattered, localized and started from third week of June 2013, and rainfed crop sowing was done after good rains from 21-07-2013 in the production site. The kharif season was normal with long dry spell in middle of August, and limited rains in September month. Therefore, inter-cropping of annual crops was done, and crop performance was normal. Similarly, the plants of jharber and ker exhibited normal growth and development, and observations were recorded. After harvesting of cluster bean in November, the area between the planting models was ploughed by cross harrowing in December as post-monsoon field operation and recommended practice for conserving soil moisture, buried-out of monsoon supported weeds, crop residues and thereby improving fertility of sandy soils. Detailed observations on main and inter-cropping crops were recorded for the compilation of experimental data.

During November - December, intensive training and pruning operations were done to develop better frame-work in the budded plants. Small basins were prepared around the plants and the main stem of the plants were painted up to 30 cm height.

Pinching or removal of un-desirable new sprouts and removal of wild suckers and sprouts was done in the month of February - March as an essential operations in the budded khejri plants (1-5 years age) and this operation is essential to remove unwanted sprouts and for better frame-work and growth in the plants.

## (b) Studies on boundary plantations and native species

During the period under report, studies on plant establishment, growth and development in khejri, rohida and lasora seedling was undertaken as boundary plantations under production site management approaches. Similarly, observations were also recorded on native plant species such as phog and khimp in the production site to understand growth and development in the naturally perpetuated shrubs.

## (c) Studies on plant establishment and growth

During the period, studies on ker, jharber and khejri were undertaken for germination and seedling growth characters under nursery conditions and also for field establishment and growth characters under wide spaced khejri planting model as inter-cropping crops and as scattered plantation of khejri seedlings.

## (d) Development of khejri nursery, studies for *in situ* establishment and demonstration

During the period, about 300 poly-bags were filled with 1:1:1 mixture of sandy soil, sheep manure and vermi-compost and 2-3 healthy seeds were sown in each bag as per technological advancement standardized for development of khejri seedlings in the nursery. After three weeks of seedling growth, one seedling was retained in each bag. About twelve month old seedlings were used for field planting. Regular observations were recorded on germination, seedling growth in nursery, plant establishment and growth under field conditions (Table 28). In addition, seedling plants were also studied in the field to understand the growth and development up to two years for *in situ* budding studies both at institute farm and farmer's field. The nursery raising of khejri seedling, field planting and *in situ* budding operations and after care were regularly demonstrated to the farmers visited institute experimental plot as well as at farmers fields through method demonstration. The details of the experiments are presented in Table 28-33 and Fig 25-27.

**Table 28. Germination studies in desert plant species under nursery conditions**

| Plant species | Number of poly-bags used for seed sowing | Number of poly-bags in which seedlings ready for studies | Success rate (%) for Seedling production |
|---|---|---|---|
| Khejri | 500 | 396 | 79.20 |
| Jharber | 250 | 178 | 71.20 |
| Ker | 250 | 145 | 58.00 |
| Lasora | 50 | 43 | 86.00 |

**Table 29. Growth character of nursery raised seedlings of desert plant species at 12 months age**

| Plant species | Seedling height (cm) | | Seedling stem diameter (cm) | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Khejri | 45.2 – 58.7 | 54.77 | 0.51 – 0.72 | 0.58 |
| Jharber | 19.2 – 28.3 | 23.03 | 0.18 – 0.22 | 0.20 |
| Ker | 14.7 – 18.1 | 16.44 | 0.14 – 0.21 | 0.19 |
| Lasora | 40.4 – 102.2 | 72.85 | 0.72 – 1.84 | 1.21 |
| Rohida | 38.5 – 46.5 | 41.25 | 0.26 – 0.35 | 0.29 |

**Table 30. Field establishment and growth of seedlings of desert plant species after 12 months age under khejri planting models (2011 - 2013)**

| Plant species | Number of seedlings planted for field study | Number of seedlings survived | Survival (%) after 12 months of establishment | plant height (cm) | Stem diameter (cm) | Number of branch or sprout/plant |
|---|---|---|---|---|---|---|
| Lasora | 25 | 21 | 84.00 | 115.22 | 1.95 | 7.85 |
| Rohida | 25 | 20 | 80.00 | 73.36 | 1.81 | 5.42 |
| Khejri | 50 | 41 | 82.00 | 57.58 | 0.76 | 3.48 |
| Jharber | 150 | 122 | 81.33 | 97.90 | 2.06 | 8.20 |
| Ker | 150 | 85 | 56.66 | 38.45 | 0.48 | 3.42 |

**Table 31. Plant growth characters in jharber (at 12 months age) as intercrop (4m x 4m) with varying khejri planting models under rainfed conditions (2012 and 2013)**

| Khejri as base crop in planting models | Plant height (cm) | Number of breanches (initial) | Plant spread (cm) | | Stem diameter (cm) |
|---|---|---|---|---|---|
| | | | North-south | East-west | |
| KM-6 (16m x 4m) + Jharber | 90.5 | 7.4 | 105.3 | 95.4 | 1.9 |
| KM-7 (16m x 4m x 4m) + Jharber | 86.3 | 10.1 | 102.5 | 82.6 | 1.8 |
| KM-8 (24m x 4m) + Jharber | 108.2 | 8.5 | 105.4 | 112.3 | 2.1 |
| KM-9 (24m x 4m x 4m) + Jharber | 118.1 | 6.5 | 91.8 | 96.4 | 2.2 |
| KM-12 (Control) + Jharber | 86.4 | 8.5 | 84.6 | 108.2 | 2.3 |
| Mean | 97.90 | 8.20 | 97.92 | 98.98 | 2.06 |

**Table 32. Plant growth characters in jharber (at 18 months age) as intercrop (4m x 4m) with varying khejri planting models under rainfed conditions (2012 and 2013)**

| Khejri as base crop in planting models | Plant height (cm) | Number of breanches (initial) | Plant spread (cm) | | Stem diameter (cm) |
|---|---|---|---|---|---|
| | | | North-south | East-west | |
| KM-6 (16m x 4m) + Jharber | 174.3 | 9.8 | 148.4 | 102.5 | 2.6 |
| KM-7 (16m x 4m x 4m) + Jharber | 182.1 | 10.8 | 148.2 | 108.8 | 2.8 |
| KM-8 (24m x 4m) + Jharber | 152.5 | 8.7 | 112.5 | 145.4 | 2.8 |
| KM-9 (24m x 4m x 4m) + Jharber | 175.4 | 6.8 | 121.6 | 126.5 | 2.6 |
| KM-12 (Control) + Jharber | 147.8 | 8.8 | 131.7 | 136.6 | 2.7 |
| Mean | 166.42 | 8.98 | 132.48 | 123.96 | 2.70 |

**Table 33. Plant growth characters in jharber (at 24 months age) as intercrop (4m x 4m) with varying khejri planting models under rainfed conditions (2013 – 2014)**

| Khejri as base crop in planting models | Plant height (m) | Plant spread (m) | |
|---|---|---|---|
| | | North-south | East-west |
| KM-6 (16m x 4m) + Jharber | 2.78 | 2.55 | 2.52 |
| KM-7 (16m x 4m x 4m) + Jharber | 2.64 | 2.35 | 1.98 |
| KM-8 (24m x 4m) + Jharber | 2.19 | 2.12 | 1.89 |
| KM-9 (24m x 4m x 4m) + Jharber | 2.65 | 2.56 | 2.18 |
| KM-12 (Control) + Jharber | 2.44 | 2.41 | 2.43 |
| Mean | 2.54 | 2.39 | 2.21 |

## Evaluation of fruit based diversified cropping models for arid region

### Intercropping and yield assessment of over storey and ground storey crops

The average yield of *aonla* varied considerably in different cropping model systems with highest being recorded in *aonla-ber* (51.4) *aonla-khejri* (48.1 kg per plant) followed by *aonla*-Kinnow (44.3 kg/plant) and *aonla*-mulberry (42.8), while the lowest was recorded in *aonla*-moringa (39.7 kg/plant). The average yield of *bael* was recorded to be 20-25 kg per tree, while a single fruit weighed around 1.4 kg with maximum and minimum fruit weights recorded to be 2.5 and 0.8 kg, respectively. The average yield of *karonda* was recorded up to 14.3 kg/plant planted in between *aonla* plants (Fig 28-30). Likewise, the yield of *ber* cv. Seb was recorded to be 34.8 kg/plant in model M-1. The yield of sewan grass was recorded to be an average of 1.92 kg/$m^2$ on dry weight basis.

### Canopy management in *karonda* and its impact on yield and harvesting season

*Karonda*, under diversified fruit based cropping system, were pruned with different pruning intensities *viz*., mild pruning (involving thinning of criss-crossed and dried branches), medium pruning (by retaining 4-6 scaffold branches) and severe pruning (heading back at 45 cm height from ground) during the month of February-March, 2012. During February-March, 2013, plants were pruned so as to maintain them as per aforesaid treatments, except heading back of severely pruned plants. Additionally, thinning of crowded shoots was performed in severely pruned plants. Like previous year, the unpruned plants yielded 7-9 kg fruits, while mild pruned plants recorded 10-12 kg fruits per tree. However unlike previous year, this year medium pruned registered an increase in the yield i.e. 12-14 kg fruits per tree. As a result of medium pruning, on one hand yield was increased, while on the other hand, the harvesting period was also hastened by about three weeks (first week of August) in comparison to mild pruned plants. The severe pruned plants exhibited sparse flowering and bore only few fruits. Though, *karonda* is a shrub like evergreen fruit crop; however, the findings of this study suggest that medium pruning could be an essential operation to strike a balance between vegetative and reproductive growth.

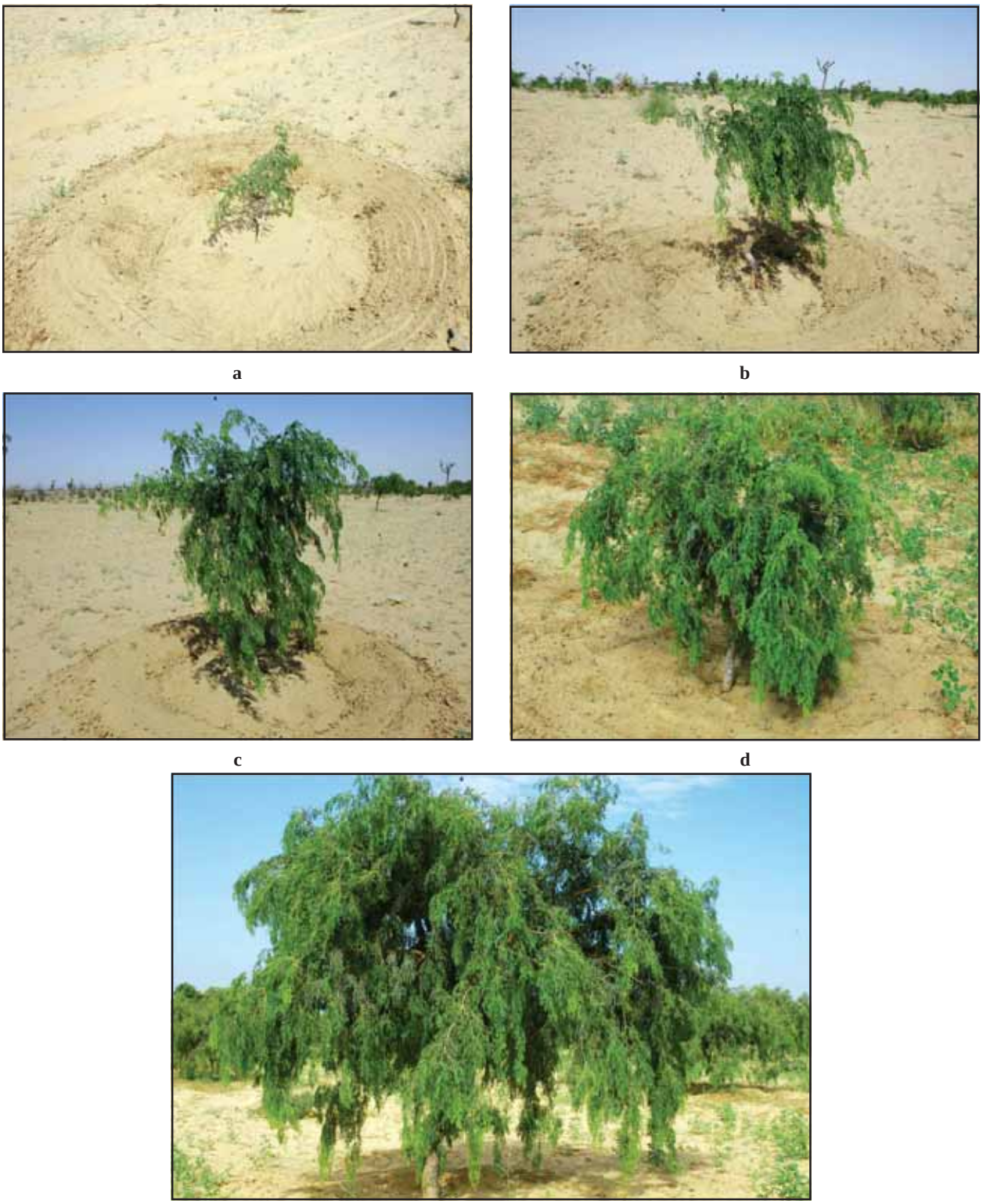


**Fig. 25. Growth and development of in- situ established plant of khejri Var. Thar Shobha (a- first year, b- second year, c- third year, d- fourth year & e- fifth year)**

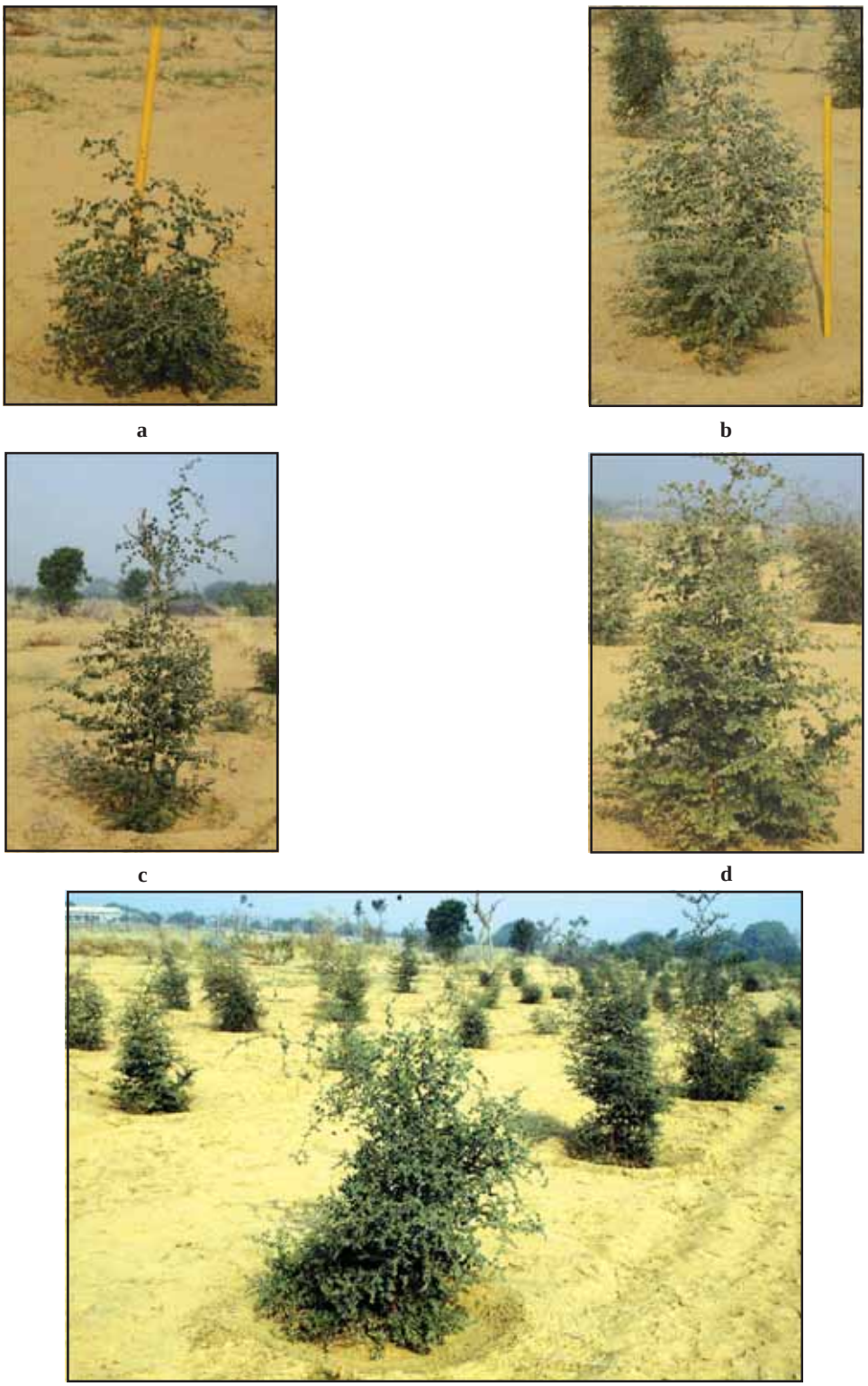



**Fig. 26. Growth and development of jharber plant with khejri planting model (a- 6 months, b- 12 months, c- 18 months, d- 24 months & e- 2 years)**

Planting model KM-1

Planting model - KM – 2

Planting model - KM – 3

Planting model -KM – 4

**Fig. 27. Inter-crops of cluster bean with khejri in different planting models**

**Fig. 28. Fruiting in *aonla* in *aonla-khejri*-Cluster bean-*ajowain* (M-3) cropping model**

**Fig. 29. Fruiting in *Bael* in *Aonla-Bael*-Cluster bean-Coriander (M-2)**

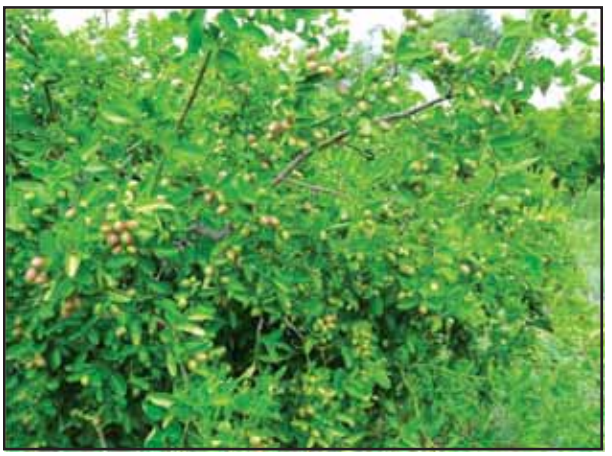


**Fig. 30. Flowering and fruiting in *karonda* as filler crop in *Aonla-Bael*-Cluster bean-Fennel cropping model**

## Godhra

### Standardization of production technology of mango cv Kesar and sweet orange cv. Sathgudi

#### Soil temperature

In general, soil mulched with organic mulches showed beneficial effect in suppressing the fluctuation of soil temperature at 20 cm depth throughout the experimentation. Significant differences in soil temperature were recorded at different months owing to various types of soil covering treatments (mulches). Among the organic mulches tried, soil temperature was lowered significantly with paddy straw followed by maize straw mulch.

#### Soil moisture

Among the organic mulches, soil moisture content was recorded maximum with paddy straw mulch at 0-15 cm and 15-30 cm soil depth. Amongst the organic mulches evaluated, soil moisture ranged 19.60-14.95, 20.40-16.50% in paddy straw and it was 14.80-11.90, 15.95-13.30 % in control at both the depths from soil surface after mulching.

### Mango cv. Kesar

#### Vegetative growth

Growth in terms of stem girth, plant height and spread was recorded maximum with paddy straw mulch followed by black polythene mulch, while minimum was observed in control.

#### Fruit yield and quality attributes

Plants treated with paddy straw mulch recorded highest yield (45.00 kg/ plant), followed by black polythene mulch (40.00 kg/plant) and it was recorded minimum in control (35.10 kg/plant). Maximum TSS (20.40 $^{0}$ Brix) was noted in paddy straw mulch followed by polythene mulch.

### Mango based cropping system under rainfed condition of semi-arid ecosystem

Experiment was set in randomized block design which was replicated four times. Inter crops (bottle gourd, pumpkin, bitter gourd, sponge gourd, cucumber excluding control) were sown during rainy season between spaces of two rows of mango, planted at 10 mX10 m distance. Economic analysis of mango based cropping system revealed that maximum yield per plot was recorded with mango

+ bottle gourd combination followed by mango + pumpkin among the different combinations under rain fed conditions of semi-arid ecosystem. Growth pattern of the mango plants is satisfactory.

## Effect of organic manure and fertilizers on mango cv. Kesar

A field experiment was conducted in mango cv. Kesar, planted in the year 2008 at 10x10m distance. Soil properties and growth of the mango plants were considerably influenced by the application of different types of cakes, FYM, fertilizers and biofertilizers in different combinations under rainfed conditions of hot semi-arid ecosystem of western India. Maximum plant height (2.50 m), plant spread East- West (1.90 m), north-south (1.80m) and scion girth (25.00 cm**)** was recorded in $T_6$-FYM + std. dose of NPK + *Azotobactor* + PSB closely followed by $T_8$-Castor cake + standard dose of NPK+ *Azotobactor* + PSB. Maximum TSS (20.60 $^0$ Brix) was also recorded in T-6, closely followed by T-8.

## Effect of different mulches on soil properties, growth, yield and quality of sweet orange cv. Sathgudi

Maximum fruit yield per plant (30.00kg) was recorded in paddy straw mulch followed by black polythene mulch (26.10 kg). Minimum fruit yield (20.00 kg/ plant) was recorded under control. Maximum fruit weight (232.00g) and TSS (13.00$^o$Brix) was also recorded in paddy straw mulch.

## Sweet orange based cropping system under rainfed condition of semi-arid ecosystem

Experiment was set in randomized block design which was replicated four times. Inter crops (bottle gourd, pumpkin, bitter gourd, sponge gourd, cucumber excluding control) were sown during rainy season between spaces of two rows of sweet orange, planted at 5 m X 5 m distance. Maximum yield per plot was recorded with sweet orange + bottle gourd combination followed by sweet orange + pumpkin among the different combinations.

## Effect of organic manure and fertilizers on sweet orange cv Sathgudi

Maximum plant height (2.10 m), plant spread East- West (1.50 m), North-South (1.70m) and scion girth (15.00 cm) was recorded in $T_6$-FYM + std. dose of NPK + *Azotobactor* + PSB closely followed by $T_8$-Castor cake + standard dose of NPK+ *Azotobactor* + PSB.

# INTEGRATED SOIL, WATER AND NUTRIENT MANAGEMENT

## Effect of different INM treatments on microbial population

Monitoring of microbial population at two depths (0.00 - 0.15 and 0.15 - 0.30 m) during 2013-2014 was carried out in bael and kinnow field experiments of integrated nutrient management. The bacterial population in different treatments ranged from 120 to 210 x$10^4$ cfu $g^{-1}$ soil, fungal from 60 to 145 x$10^4$ cfu $g^{-1}$ soil and actinomycetes from 55-90 cfu $g^{-1}$ soil in different INM treatments in Kinnow orchard. Total microbial population was minimum in the absolute control and significantly highest in the treatment where recommended dose of N, P and K was associated with FYM and consortium of biofertilizers at both the depths. (Table 34 and Fig 31-33). Total population as well as individual population of different microorganism increased with involvement FYM and consortium of biofertilizers. This is because most of the soil micro-organisms are chemoheterotrophs which require organic source of carbon as food and oxidation for organic substances provides energy. Under different INM treatments, the total and individual population of different micro-organisms was higher where nutrients were provided by RDF of N, P, K + FYM + PSB + Azotobactor +

**Table 34. Effect of different INM treatments on microbial population (cfu x10$^4$ g$^{-1}$ soil) in kinnow orchard (13 year old plants)**

| Treatments | 0-15 cm depth | | | | 15-30 cm depth | | | |
|---|---|---|---|---|---|---|---|---|
| | Bacteria | Fungal | Actinomycetes | Total | Bacterial | Fungal | Actinomycetes | Total |
| Control | 90 | 50 | 45 | 185 | 80 | 40 | 40 | 160 |
| RDF | 100 | 50 | 50 | 200 | 90 | 50 | 45 | 185 |
| RDF + FYM | 140 | 100 | 70 | 310 | 120 | 90 | 60 | 270 |
| RDF +Azotobactor | 120 | 55 | 50 | 225 | 120 | 50 | 50 | 220 |
| RDF + PSB | 130 | 55 | 55 | 240 | 130 | 50 | 50 | 230 |
| RDF + VAM | 100 | 110 | 55 | 265 | 100 | 100 | 50 | 250 |
| RDF+FYM + AZB | 145 | 130 | 75 | 350 | 135 | 120 | 70 | 325 |
| RDF + FYM + PSB | 140 | 130 | 80 | 350 | 135 | 120 | 75 | 330 |
| RDF + FYM + VAM | 140 | 140 | 80 | 360 | 130 | 125 | 75 | 330 |
| RDF +FYM + PSB + AZB | 165 | 140 | 85 | 390 | 150 | 130 | 80 | 360 |
| RDF + FYM + PSB + AZB + VAM | 165 | 150 | 85 | 400 | 155 | 130 | 85 | 370 |
| SE± | 5.89 | 6.23 | 4.23 | - | 5.12 | 5.98 | 4.12 | - |
| CD 5% | 17.56 | 18.63 | 12.69 | - | 15.89 | 16.23 | 12.85 | - |

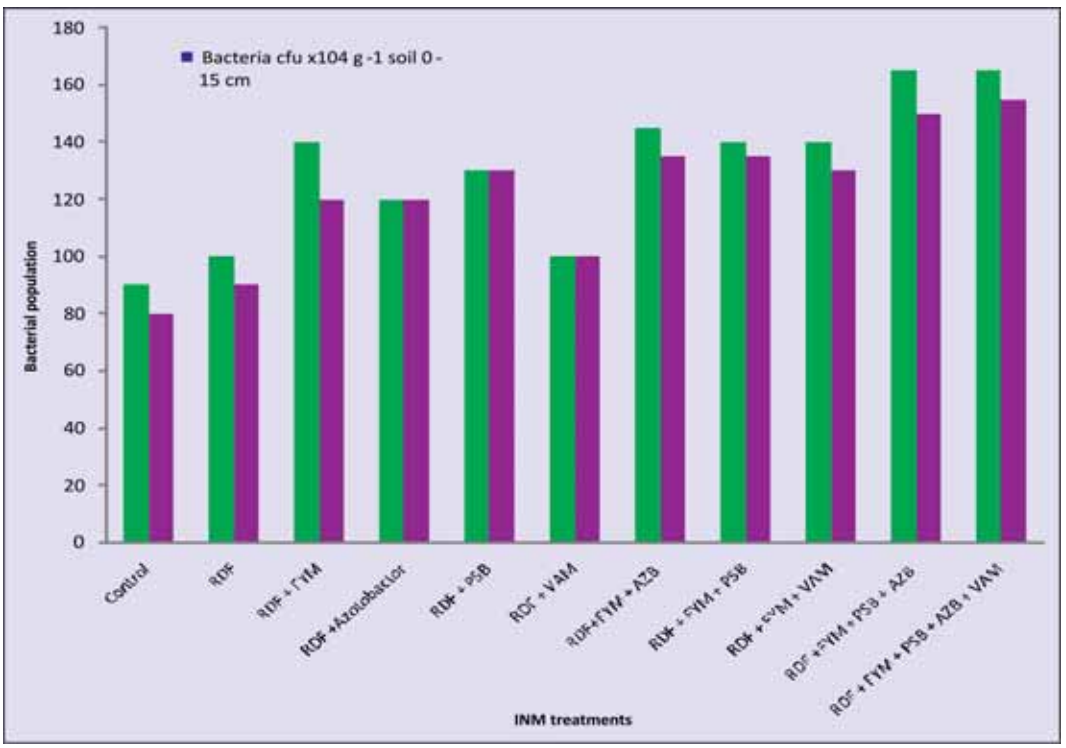



**Fig. 31. Microbial population in INM of Kinnow**

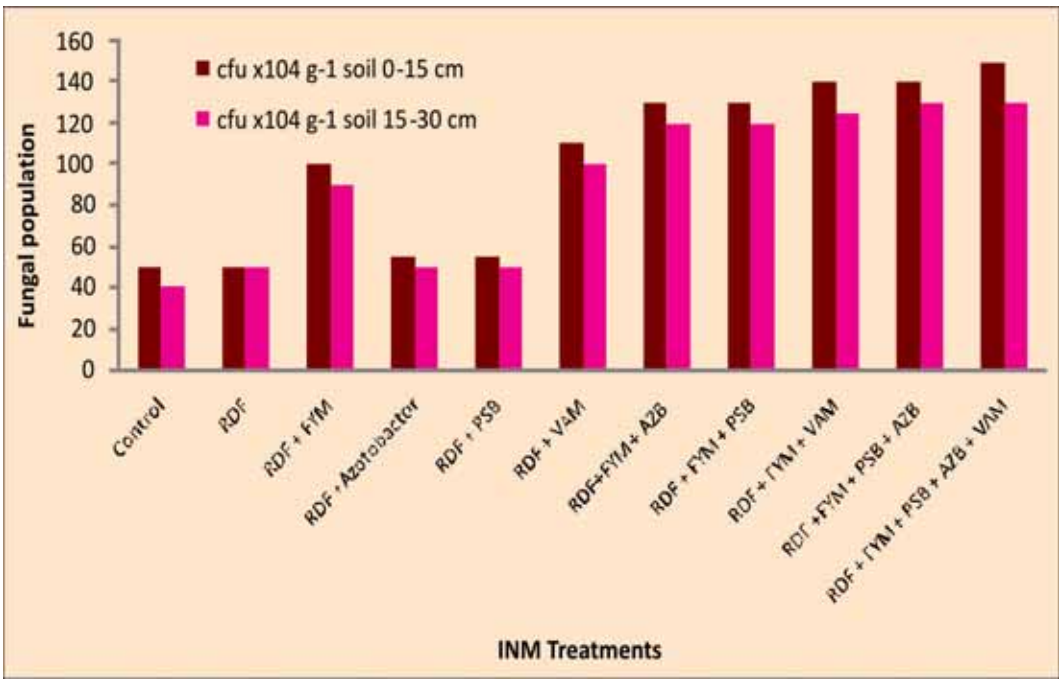



**Fig. 32. Fungal population in INM of Kinnow**

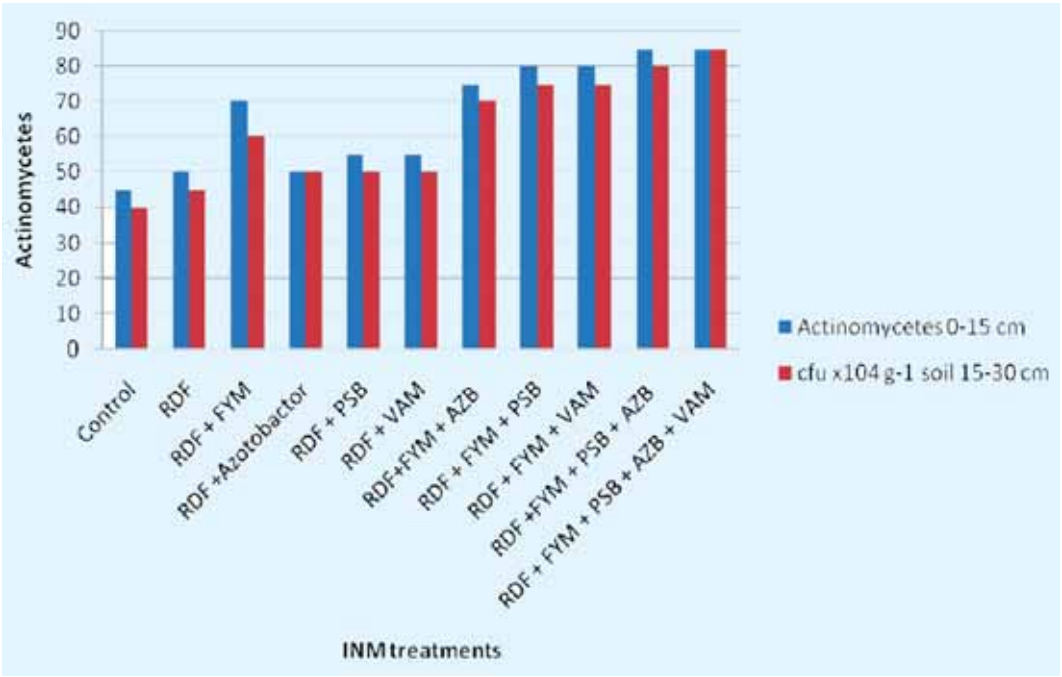



**Fig. 33. Actinomycetes population in INM of Kinnow**

VAM combinations followed by RDF of N, P, K +FYM + Azotobactor treatment and minimum population of micro-organism were observed in control treatment. In FYM treated plants, C: N ratio was wide which proved more carbon and low rate of mineralization, this might have resulted in increased total population as well as individual microbial population. Total as well as individual microbial population was higher in the surface than subsurface soil.

The data presented in Table 35 revealed that status of total microbial population was less in bael orchard in all INM treatments in comparison to kinnow orchard. The bael orchard was only 5 year old and added only small amount of FYM and biofertilizers. In different treatment of INM in bael, bacterial population ranged from 70 to 110 cfu $g^{-1}$ soil, fungal 55 to 90 cfu $g^{-1}$ soil and actinomycetes 65 to 120 cfu $g^{-1}$ soil. In this crop also, addition of organic matter and biofertilizers increased the total microbial population in the bael orchard.

## Effect of different INM treatments on morphological parameter of kinnow

The data presented in Table 36 revealed that significantly maximum plant height (2.90 m) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatment and minimum was in control (2.55 m). The pattern in plant height revealed that addition of RDF along with FYM and consortium of biofertilizers has the highest increment in plant growth. Likewise, plant spread in both the directions was also more in the same INM treatment. The data on stem diameter was also significantly differed among INM treatments and maximum stem diameter was recorded in RDF + FYM + PSB + AZB + VAM and RDF +FYM + PSB + AZB treatments.

**Table 35. Effect of different INM treatments on microbial population (cfu x$10^4$ $g^{-1}$ soil) in bael orchard**

| Treatments | 0-15 cm depth | | | | 15-30 cm depth | | | |
|---|---|---|---|---|---|---|---|---|
| | Bacteria | Fungal | Actinomycetes | Total | Bacterial | Fungal | Actinomycetes | Total |
| Control | 50 | 40 | 35 | 125 | 40 | 35 | 30 | 105 |
| RDF | 60 | 45 | 40 | 145 | 50 | 40 | 35 | 125 |
| RDF + FYM | 80 | 55 | 55 | 190 | 75 | 50 | 50 | 175 |
| RDF +Azotobactor | 80 | 50 | 35 | 165 | 75 | 50 | 30 | 155 |
| RDF + PSB | 80 | 65 | 35 | 180 | 75 | 60 | 30 | 165 |
| RDF + VAM | 65 | 75 | 40 | 180 | 60 | 70 | 40 | 170 |
| RDF+FYM + AZB | 95 | 70 | 45 | 210 | 90 | 70 | 40 | 200 |
| RDF + FYM + PSB | 90 | 65 | 45 | 200 | 80 | 60 | 40 | 180 |
| RDF + FYM + VAM | 80 | 80 | 45 | 205 | 80 | 70 | 40 | 190 |
| RDF +FYM + PSB + AZB | 100 | 100 | 50 | 250 | 95 | 85 | 50 | 230 |
| RDF + FYM + PSB + AZB + VAM | 100 | 90 | 60 | 250 | 95 | 90 | 60 | 245 |
| SE± | 6.23 | 5.65 | 5.52 | - | 5.89 | 5.62 | 5.12 | - |
| CD 5% | 19.26 | 17.59 | 16.21 | - | 17.59 | 17.23 | 16.13 | - |

**Table 36. Effect of different INM treatments on morphological parameter of kinnow orchard (Average age of plant: 13 years)**

| Treatment | Tree height (m) | Tree Spread N-S (m) | Tree Spread E-W (m) | Stem diameter (cm) |
|---|---|---|---|---|
| Control | 2.75 | 2.45 | 2.30 | 50 |
| RDF | 2.80 | 2.50 | 2.20 | 50 |
| RDF + FYM | 3.00 | 2.70 | 2.50 | 60 |
| RDF +Azotobactor | 2.80 | 2.20 | 2.30 | 50 |
| RDF + PSB | 2.65 | 2.30 | 2.25 | 50 |
| RDF + VAM | 2.70 | 2.20 | 2.30 | 50 |
| RDF+FYM + AZB | 3.10 | 2.80 | 2.70 | 70 |
| RDF + FYM + PSB | 3.20 | 2.85 | 2.80 | 70 |
| RDF + FYM + VAM | 3.00 | 2.80 | 2.80 | 70 |
| RDF +FYM + PSB + AZB | 3.20 | 2.90 | 2.70 | 75 |
| RDF + FYM + PSB + AZB + VAM | 3.30 | 2.90 | 2.70 | 75 |
| SE± | 0.16 | 0.13 | 0.13 | 5.03 |
| CD 5% | 0.36 | 0.29 | 0.30 | 12.32 |

## Effect of INM treatments on yield and fruit quality parameters of kinnow

The fruit weight, fruit yield, TSS, acidity and juice recovery were measured in different INM treatment and data given in Table 37 and Figure 34 revealed that maximum fruit weight (230 g) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM which was significantly at par with RDF of N, P, K +FYM + Azotobactor treatment. The minimum fruit weight (120 g) was recorded in control treatment. The fruit yield was estimated and maximum fruit yield (150 t/ha) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatment and minimum (70 t/ha) yield was estimated in control treatment. The TSS was measured in mature fruits from all treatment and recorded in the range of 10.50 to 13.00 ° Brix and data revealed that addition of FYM, inorganic fertilizers increased the TSS content. The acidity content was maximum in control and inorganically fertilized treatments while FYM reduced the juice acidity. The juice recovery was ranged from 40 to 55 percent and maximum juice (55 %) was recorded in those treatments where FYM was the component of the treatment.

## Effect of different INM treatments on morphological parameter of bael

The parameters on plant height, tree spread and stem diameter were measured and data presented in table 38. The data revealed that maximum plant height (1.10 m) was recorded in RDF of N, P, K +FYM +PSB + Azotobactor and RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatments and minimum plant height was recorded in control treatment. Likewise same pattern was recorded in tree spread and stem diameter.

The soil physico-chemical properties of the soil under different INM treatments were measured periodically and data presented in Table 39 depicts the changes in the different properties over the year. The data revealed that pH of the soil did not change

**Table 37. Effect of different INM treatments on yield and fruit quality parameters of kinnow orchard (Average age of plant: 13 years)**

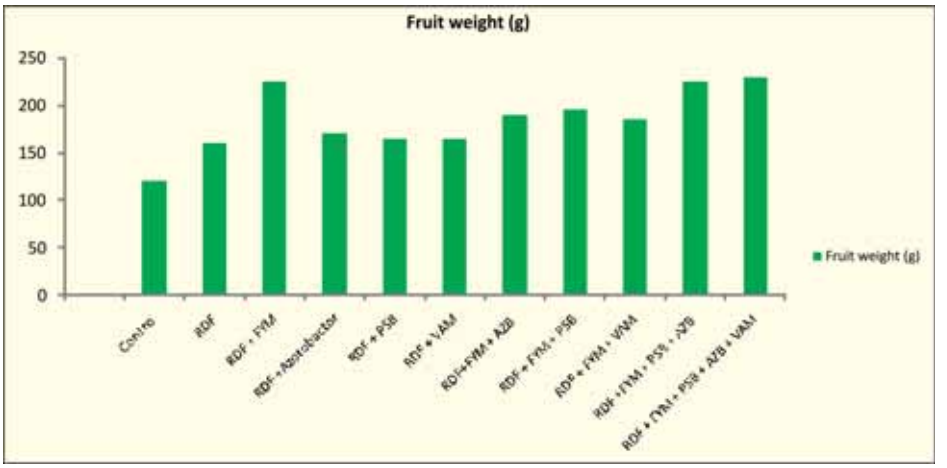
| Treatment | Fruit weight (g) | Fruit yield (q/ha) | TSS (° Brix) | Acidity (%) | Juice (%) |
|---|---|---|---|---|---|
| Control | 120 | 70.00 | 10.50 | 0.85 | 40.00 |
| RDF | 160 | 100.00 | 11.00 | 0.70 | 50.00 |
| RDF + FYM | 225 | 135.00 | 12.50 | 0.60 | 55.00 |
| RDF +Azotobactor | 170 | 110.00 | 12.50 | 0.60 | 50.00 |
| RDF + PSB | 165 | 100.00 | 12.50 | 0.70 | 55.00 |
| RDF + VAM | 165 | 105.00 | 11.50 | 0.70 | 50.00 |
| RDF+FYM + AZB | 190 | 140.00 | 13.00 | 0.70 | 55.00 |
| RDF + FYM + PSB | 195 | 130.00 | 13.00 | 0.70 | 55.00 |
| RDF + FYM + VAM | 185 | 125.00 | 11.50 | 0.70 | 55.00 |
| RDF +FYM + PSB + AZB | 225 | 150.00 | 13.00 | 0.65 | 55.00 |
| RDF + FYM + PSB + AZB + VAM | 230 | 150.00 | 13.00 | 0.65 | 55.00 |
| SE± | 15.25 | 12.23 | 0.65 | 0.26 | 1.20 |
| CD 5% | 45.90 | 30.56 | 1.78 | NS | 3.50 |

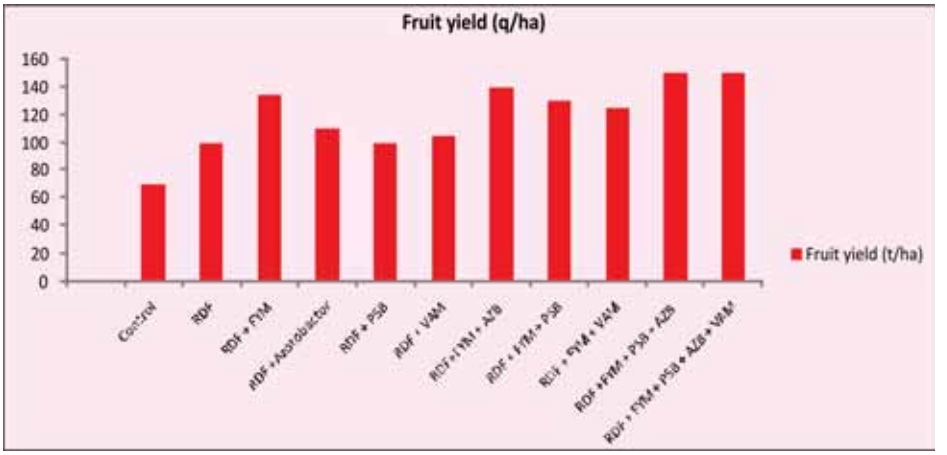
**Table 38. Effect of different INM treatments on morphological parameter of bael orchard (Average age of plant: 5 years)**

| Treatment | Tree height (m) | Tree Spread | | Stem diameter |
|---|---|---|---|---|
| | | N-S (m) | E-W (m) | (cm) |
| Control | 0.70 | 0.20 | 0.30 | 18 |
| RDF | 0.85 | 0.28 | 0.28 | 20 |
| RDF + FYM | 0.90 | 0.30 | 0.30 | 25 |
| RDF +Azotobactor | 0.85 | 0.28 | 0.28 | 25 |
| RDF + PSB | 0.90 | 0.28 | 0.30 | 22 |
| RDF + VAM | 0.90 | 0.28 | 0.25 | 22 |
| RDF+FYM + AZB | 0.85 | 0.30 | 0.35 | 22 |
| RDF + FYM + PSB | 0.90 | 0.35 | 0.35 | 25 |
| RDF + FYM + VAM | 0.90 | 0.35 | 0.35 | 25 |
| RDF +FYM + PSB + AZB | 1.10 | 0.35 | 0.35 | 28 |
| RDF + FYM + PSB + AZB + VAM | 1.10 | 0.35 | 0.35 | 28 |
| SE± | 0.15 | 0.15 | 0.14 | 4.10 |
| CD 5% | 0.42 | NS | NS | NS |

**Table 39. Effect of different INM treatments on physico-chemical properties of the soil**

| Treatment | pH | Organic carbon (%) | Available P (kg/ha) | Available $K_2O$ (kg/ha) | Available Zn (ppm) | Available Iron (ppm) |
|---|---|---|---|---|---|---|
| Control | 8.10 | 0.08 | 08.20 | 175.00 | 0.50 | 3.50 |
| RDF | 8.20 | 0.08 | 13.50 | 210.00 | 0.50 | 3.50 |
| RDF + FYM | 7.50 | 0.15 | 14.50 | 215.00 | 0.60 | 4.25 |
| RDF +Azotobactor | 8.00 | 0.10 | 14.00 | 200.00 | 0.60 | 3.80 |
| RDF + PSB | 8.00 | 0.10 | 16.00 | 200.00 | 0.60 | 3.80 |
| RDF + VAM | 8.00 | 0.10 | 16.50 | 200.00 | 0.60 | 3.80 |
| RDF+FYM + AZB | 7.60 | 0.12 | 14.50 | 210.00 | 0.65 | 4.80 |
| RDF + FYM + PSB | 7.60 | 0.12 | 16.50 | 210.00 | 0.65 | 4.80 |
| RDF + FYM + VAM | 7.60 | 0.12 | 15.50 | 220.00 | 0.65 | 4.80 |
| RDF +FYM + PSB + AZB | 7.60 | 0.15 | 16.50 | 220.00 | 0.65 | 5.00 |
| RDF + FYM + PSB + AZB + VAM | 7.50 | 0.15 | 16.50 | 220.00 | 0.65 | 5.00 |
| Initial level | 8.20 | 0.08 | 08.00 | 180.50 | 0.50 | 3.50 |



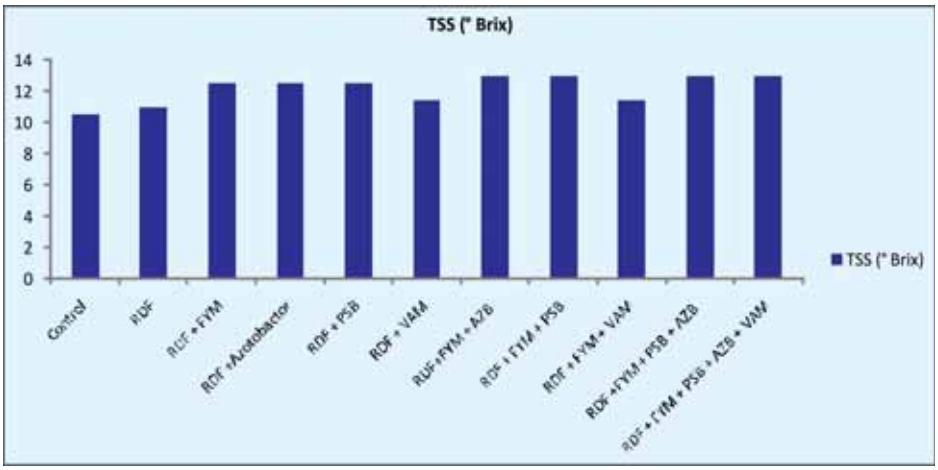



**Figure 34. response of INM treatments on fruit yield and fruit characters**

much when only chemical fertilizers were applied but on the application of FYM, pH of the soil lower down. On the application of biofertilizers, pH of the soil did not change much. Data regarding the organic carbon status revealed that application of FYM increased the level of OC while inorganic fertilizers and biofertilizers have not changed the OC status of the soil. Available P and $K_2O$ also have been affected by the application of INM treatments and recommended dose of N, P and K increased the availability of P and $K_2O$ in the soil and their maximum status were recorded on the application of application of inorganic fertilizers along with FYM. Likewise availability of zinc and iron content in the soil also increased over the application of FYM.

The soil moisture status of the soil under different INM treatment was monitored and results revealed that application of FYM alone or in combination with inorganic and biofertilizers increased the soil moisture status at both the strata. Monitoring of soil status at two depths revealed the more moisture has been accumulated at lower depths (Table 40). Application of biofertilizers alone did not improve the soil moisture status of the soil.

**Table 40. Effect of different INM treatments on soil moisture of the soil**

| Treatment | Soil moisture (%) after 24hrs of irrigation | |
|---|---|---|
| | 0-0.30m | 0.30-0.60m |
| Control | 2.80 | 3.50 |
| RDF | 3.50 | 3.50 |
| RDF + FYM | 5.50 | 6.00 |
| RDF +Azotobactor | 3.40 | 3.50 |
| RDF + PSB | 3.50 | 3.50 |
| RDF + VAM | 3.80 | 4.50 |
| RDF+FYM + AZB | 5.50 | 6.50 |
| RDF + FYM + PSB | 500 | 6.00 |
| RDF + FYM + VAM | 6.00 | 6.00 |
| RDF +FYM + PSB + AZB | 6.50 | 6.50 |
| RDF + FYM + PSB + AZB + VAM | 6.00 | 6.00 |

## Godhra

## ORGANIC FARMING

An experiment consisting of various leaf composts like aonla, eucalyptus, jamun, mahua, mango, neem, *P. dulce*, sapota, subabul and

tamarind was conducted in pumpkin and bitter gourd in rainy season of 2013. The leaf composts were applied @ 2.5 kg/hill and 3 replications were maintained.

In pumpkin, the observations like number of fruits per hill (2 plants), average fruit weight, average leaf weight, and stem weight/hill were taken. The treatment which received neem compost gave maximum yield (41.1 t/ha), followed by subabul (37.6 t/ha), *Pithacellobium dulce* (36.9 t/ha) and lowest in control. The leaf and fruit analysis was carried out and leaf analysis reveals that nitrogen, phosphorous, potassium, calcium, magnesium and sulphur varied from 2.75-4.6, 0.13-0.17, 0.66-1.38, 0.82-3.02, 2.04-2.5, and 0.13-0.18 percent, respectively.

The fruit analysis of mature fruits showed nitrogen, phosphorous, potassium, calcium, magnesium and sulphur in the range of 3.52-5.64, 0.14-0.18, 1.72-2.1, 3.44-7.14, 4.4-7.7, 0.13-0.2 percent, respectively.

A similar experiment with bitter gourd as test crop was conducted in rainy season of 2013 and similar type of observations were taken as in case pumpkin. The maximum yield (15.4 t/ha) in bitter gourd was noticed in neem treated plot and followed by subabul (14.9 t/ha) and *Pithacellobium dulce* (12.7 t/ha) and lowest yields (5.3 t/ha) were observed in control.

The analysis of leaf showed the nutrients like nitrogen, phosphorous, potassium, calcium, magnesium and sulphur varied from 3.8-5.19, 0.26-0.6, 3.75-1.62, 1.54-3.66, 1.23-2.46, 0.14-0.27 percent respectively. Similarly the fruit analysis of bitter gourd reveals that the nutrients like nitrogen, phosphorous, potassium, calcium, magnesium and sulphur ranged as 4.46-6.32,0.28-0.30, 2.49-2.93,1.38-1.8, 2.15-2.4,0.16-0.19 percent respectively.

## CROP PHYSIOLOGY AND BIOTECHNOLOGY

### Physiological and biochemical investigations in horticultural crops under abiotic stresses.

### Impact of water stress on growth of seedling

An experiment was conducted using kachari, muskmelon and water melon as the test material. The seeds were sown in pots and irrigated with the solution of 0.2 MPa and 0.5 MPa solutions of PEG 6000. The controls were irrigated with normal water. After one month the seedlings were harvested and their morphological observations were recorded. The results are presented in table 41. Perusal of table reveals that in kachari the length of root was longest in control (15.41cm) followed by in 0.2 MPa (14.45 cm) and least in 0.5MPa (13.68 cm). Similar results were also obtained for Muskmelon where the longest root was recorded in control (10.43 cm) which slightly decreased at 0.2MPa (10.36 cm) and further decreased to 9.92cm at 0.5 MPa. Similar trend was also observed in water melon also. Thus the results showed that the length of root decreased with imposition of water stress.

The data on shoot length revealed that shoot length decreased with imposition of water stress in all plant species. The magnitude of reduction was highest in water melon where shoot length was 31.03 cm in control which dropped to 15.67cm with irrigation of 0.5MPa solution. Similar results were also shown by Muskmelon. However, the reduction of shoot length in Kachari was low as is illustrated by the fact that shoot length was 51.63 cm in control which dropped to 40.39 cm in plants irrigated with 0.5 MPa solution.

**Table 41. Morphometeric parameters of seedling under water stress at one month after sowing**

| Plant species | Control | 0.2 MPa | 0.5MPa |
|---|---|---|---|
| **Length (cm)** | | | |
| Kachari (AHK 119) | | | |
| Root | 15.41± 7.44 | 14.45± 3.55 | 13.68 ± 5.15 |
| Shoot | 51.63 ± 23.35 | 46.35 ± 6.65 | 40.39 ± 6.12 |
| Muskmelon | | | |
| Root | 10.43 ± 4.43 | 10.36 ± 4.57 | 9.92 ± 4.83 |
| Shoot | 48.40 ± 17.17 | 32.09 ± 8.16 | 29.01 ± 8.15 |
| Water melon | | | |
| Root | 11.71 ± 5.96 | 9.35 ± 3.28 | 8.61 ± 4.75 |
| Shoot | 31.03 ± 17.07 | 30.22 ± 12.52 | 15.67 ± 6.70 |
| **Fresh weight (g)** | | | |
| Kachari | 60.3 | 57.8 | 44.28 |
| Muskmelon | 93.34 | 53.98 | 44.7 |
| Water melon | 81.10 | 42.94 | 34.51 |

The biomass produced by the seedlings after one month of sowing shows that in control maximum weight was muskmelon (93.34g) followed by water melon (81.10g) and least in kachari (60.30g). The percentage reduction in biomass production reveals that kachari showed minimum reduction as is illustrated by fact that only 4.14% and 26.56% reduction took place under 0.2 and 0.5 MPa solutions. However, in other materials the percentage reduction was to the tune of 42.16% and 52.11% with 0.2MPa and 0.5 MPa solutions, respectively in muskmelon and 47.05% and 57.44% with 0.2 MPa and 0.5MPa, respectively in water melon.

## Impact of water stress on water potential of seedling

In the above experiment, water potential was estimated in leaf by using water potential meter. The results are presented in table 42. Perusal of data reveals that in kachari, the leaf water potential was -3.22 in controls which dropped to -4.41 in plants irrigated with 0.2 MPa solutions and further remained nearly constant in plants irrigated with at 0.5 MPa solutions. In musk melon, the magnitude of water potential was -2.88 in controls which dropped to -3.40 and -4.50 in plants irrigated with 0.2 MPa and 0.5 MPa solutions, respectively. Similar results were also obtained with Water melon, showing thereby that in Kachari the water potential is maintained under water stress whereas in other drought susceptible crops, it declined.

**Table 42. Osmotic potential of seedlings grown under water stress**

| Plant species | Control | 0.2 MPa | 0.5MPa |
|---|---|---|---|
| **Water potential (MPa)** | | | |
| Kachari (AHK 119) | -3.22 | -4.41 | -4.46 |
| Muskmelon | -2.88 | -3.40 | -4.50 |
| Water melon | -1.36 | -2.14 | -2.30 |

## Impact of water stress on relative water content of seedling

In the above experiment, the relative water content of the leaves was estimated and data thus obtained is presented in table 43. Perusal of data reveals that relative water content in the leaves of kachari was 77.45% in control followed by 74.58% and 74.44% in 0.2Ma and 0.5MPa PEG solution. However, in water melon and musk melon, the magnitude of RWC decreased on imposition of water stress. This is illustrated by the fact that in muskmelon the RWC was 78.73%, 67.0% and 54.21% in control and plants irrigated with PEG 0.2MPa and 0.5MPa solution, respectively. Similar results were also obtained with water melon.

**Table 43. Relative water content of seedling grown under water stress**

| Plant species | Control | 0.2 MPa | 0.5MPa |
|---|---|---|---|
| **Relative water content** | | | |
| Kachari (AHK 119) | 77.45 | 74.58 | 74.44 |
| Muskmelon | 78.73 | 67.00 | 54.21 |
| Water melon | 84.94 | 67.41 | 52.72 |

## Impact of water stress on membrane stability index of seedling

Membrane stability of leaves in the above experiment was estimated and the results are presented in table 44. Perusal of data reveals that maximum values for membrane stability was recorded in kachari in all treatments. The value was 75.37 in control which slightly dropped to 69.43 at 0.2MPa and 62.75 at 0.5MPa. However, in other drought susceptible species, the membrane stability index dropped drastically under water stress condition. This is illustrated by the fact that in muskmelon, the MSI was 65.60, 61.14 and 52.14 in control, 0.2MPa and 0.5 MPa treated plants, respectively. Similarly, in water melon the values were 69.32, 59.44 and 52.36 at control, 0.2 MPa and 0.5 MPa, respectively.

**Table 44. Membrane stability index of seedling grown under water stress**

| Plant species | Control | 0.2 MPa | 0.5MPa |
|---|---|---|---|
| **Membrane stability index** | | | |
| Kachari (AHK 119) | 75.37 | 69.43 | 62.75 |
| Muskmelon | 65.60 | 61.14 | 52.14 |
| Water melon | 69.32 | 59.44 | 52.36 |

## Impact of water stress on Catalase activity of seedling

The catalase activity in seedlings of three plant species was estimated after one month of sowing. The seedlings were harvested and separated into leaf, stem and root. After processing the catalase activity was estimated. The results revealed that in tolerant variety (Kachari) the catalase activity increased with the imposition of water stress. This is illustrated by the fact that in leaves the catalase activity was 0.12 unit, 0.16unit and 0.19 unit in control 0.2MPa and 0.5MPa treatments, respectively. The maximum activity was recorded in leaves followed by root. In tolerant cultivars, the Catalase activity does not change much with the imposition of water stress.

## Impact of water stress on Peroxidase activity of seedling

The peroxidase activity in seedlings of three plant species was estimated after one month of sowing. The seedlings were harvested and separated into leaf, stem and root. After processing the peroxidase activity was estimated. The data revealed that in tolerant variety (Kachari) the peroxidase activity increased with the imposition of water stress. This is illustrated by the fact that in leaves the peroxidase activity was 0.64 unit, 1.113 unit and 1.076 unit in control 0.2MPa and 0.5MPa treatments, respectively. The maximum activity was recorded in leaves followed by root. In root also the peroxidase activity was 0.22, 0.29 and 0.34 units in control, 0.2MPa and 0.5MPa treatments, respectively.

In susceptible plants, such as water melon, the peroxidase activity in leaves increased with imposition of water stress. It was 0.555, 0.72 and 0.84 units in control, 0.2MPa and 0.5 MPa treatments, respectively. Similarly, in roots the magnitude was 0.979, 1.324 and 1.28 units at control, 0.2 MPa and 0.5 MPa treatments, respectively.

## Impact of water stress on PGR levels in germinating seeds

In order to understand the mechanism of drought tolerance in arid horticultural crops, an experiment was conducted to assess the effect of water stress on the PGR levels during the germination of seeds. The experiment consisted of three treatments viz. control, 0.2 MPa and 0.5 MPa solution of PEG. The seeds of watermelon and musk melon were germinated under the above three treatments and germination percentage was recorded. The seeds of all above plant materials were sampled at 24, 48, 72, 96, 120 and 144 hours after sowing and fixed in methanol for estimation of PGRs. During the present study ABA, GA and IAA were estimated.

## Impact of water stress on ABA levels in germinating seeds

The impact of water stress on the ABA level in three plant species was assessed using HPLC. The samples were fixed at 24, 48, 72, 96, 120 and 144 hrs after sowing and analysed after purification on HPLC using methanol: water as solvent system. ABA levels were recorded to the tune of 4.0 µg/g dry seed at 24 hrs after sowing which dropped to 2.8 µg/g dry seed by 96 hrs and further to 2.34 µg/g dry seed by 144 hrs. However, when the seeds were exposed to water stress, the magnitude of ABA in the seeds increased. This is illustrated by the fact that it reached to 14.13 µg/g dry seed by 72 hrs and after that dropped slightly at 0.2 MPa. Similar trend was observed at 0.5 MPa also where it peaked at 16.15 µg/g dry seed at 96 hrs and after that it dropped slightly.

In case of watermelon the trend observed was similar to that for muskmelon. In this case also the seeds germinated under control condition showed lower level and of ABA which declined after germination (7.46 -4.0 µg/g dry seed). However when the seeds were exposed to water stress, there was a marked increase in ABA level. It can be seen that level of ABA increased to 40.41 µg/g dry seed by 48 hrs and remained more than 30 µg/g dry seed throughout the experimental period when seeds were exposed to 0.2 MPa solution. Similarly when the seeds were exposed to 0.5 MPa solution of PEG the value reached up to 42.77 µg/g dry seed by 72 hrs and remained high throughout.

## Impact of water stress on GA levels in germinating seeds

The GA level in two species viz. watermelon and musk melon was examined under control and water stress. Perusal of data revealed that in case of musk melon, the seeds sown under control condition showed high level of GA. This is illustrated by the fact that GA content was 23.62 µg/g dry seed at 24 hrs which increased further to 32.88 µg/g dry seed by 120 hrs. The level remained high throughout the germination period. However, when the seeds were exposed to 0.2 MPa solution of PEG, level initially increased but dropped subsequently.

The GA level in watermelon also shows the similar trend as depicted above. Under control condition, the GA levels remained high but when the seeds were germinated under stress condition, the GA content declined.

## Development of phyto-chemical markers for arid horticultural crops

A total of eleven varieties/ germplasm lines of aonla were collected from CHES, Godhra and analyzed for RAPD profile using OPD primers. A total of 20 primers were attempted but the amplification was given by 9 primers. The data reveals that primer OPD 1 gave a total of 8 bands of which band no. 6 was present in all the varieties.

On the other hand other bands had restricted occurrence. For instance band No., 8 was found only in BSR 1 and band no. 7 was found only in Agra bold. Similarly, OPD 3 gave a total of 6 bands of which band Nos. 4, 5 and 6 were present in all varieties and other have restricted occurrence. Thus, using either singly or collectively, the cultivars can be identified using different bands.

## RAPD profile of date palm cultivars/ germplasm lines

A total of 10 date palm cultivars were screened for RAPD profile during the period under report. A total of 20 primers were tested and amplification was obtained with 12 OPD primers. Perusal of data reveals that the cultivars can be identified using the RAPD profiles. Among these maximum bands were obtained with OPD 1, 2 and 3 whereas OPD 11 and 12 gave few bands.

The polymorphism with respect to each primer was calculated and it was observed that OPD 4 & 16 has the maximum polymorphism and the least polymorphism was recorded with OPD 2, 13 and 20 (Table 45).

**Table 45. Details of Primer and their polymorphism**

| Primers | Total no. of bands | Percent polymorphism | PIC |
|---|---|---|---|
| OPD1 | 11 | 64.0 | 0.44 |
| OPD2 | 9 | 33.3 | 0.23 |
| OPD3 | 10 | 40.0 | 0.31 |
| OPD4 | 5 | 100.0 | 0.49 |
| OPD5 | 7 | 57.1 | 0.43 |
| OPD7 | 8 | 37.5 | 0.35 |
| OPD8 | 4 | 50.0 | 0.42 |
| OPD11 | 4 | 75.0 | 0.32 |
| OPD12 | 4 | 50.0 | 0.48 |
| OPD13 | 6 | 33.3 | 0.15 |
| OPD16 | 6 | 100.0 | 0.50 |
| OPD20 | 3 | 33.3 | 0.36 |

# Biotechnology

## Establishment of aseptic cultures of different cultivars of date palm

Different explants such as shoot tip, meristem pieces, leaf explants and immature fruit tissues of date palm cultivar Halawy, Medjool, Khalas and Khuneizi were subjected for initiation of aseptic culture for callus induction and somatic embryogenesis. Initially, sterilization procedure was standardized with different explants of date palm cv. Halawy. Thereafter the best treatment was applied to other explants of different cultivars. The explants were initially washed thoroughly by tap water and thereafter subjected for different sterilization procedures using following treatments:

1. Sterilisation with 0.01% mercuric chloride solution for 1 hour
2. Sterilisation with 0.1% mercuric chloride solution for 10 minutes
3. Sterilisation with 0.01% mercuric chloride solution for 1 hour+ ascorbic acid and citric acid (0.01%)
4. Sterilisation with 0.1% mercuric chloride solution for 10 minute + ascorbic acid and citric acid (0.01%)
5. Sterilisation with 300mg/L of $KMnO_4$ during dissection + 0.1% mercuric chloride solution for 10 minute + ascorbic acid and citric acid(0.01%)
6. Sterilisation with 300mg/L of $KMnO_4$ during dissection + 500mg each Copper Oxychloride and Carbendazim + 0.1% mercuric chloride solution for 10 minute + ascorbic acid and citric acid(0.01%)

These treatments were found to show varied response to different explants. The maximum (70%) aseptic culture of shoot tip explants were established with the procedure of sterilization with 300mg/L of $KMnO_4$ during dissection + 500mg each Copper

Oxychloride and Carbendazim + 0.1% mercuric chloride solution for 10 minute + ascorbic acid and citric acid(0.01%). The better response (80%) was also observed with the procedure of sterilization with 0.01% mercuric chloride solution for 1 hour + ascorbic acid and citric acid (0.01%) when applied to leaf and fruit tissue explants. Whereas, other sterilization treatments showed poor response for establishment of contamination free explants during subsequent sub-culturing. During subsequent sub-culturing, the shoot tip explants were found to be infected with endophytic bacterial contamination to the tune of 50 per cent.

## Studies on embryogenic callus induction of date palm

The following MS medium containing different additives and different plant growth regulators alone or in combinations were used for callus induction on both zygotic and off-shoot explants of date palm varieties such as Halawy, Medzool, Khalas and Khuneizi. All the explants were surface sterilized with 300mg/L of $KMnO_4$ during dissection + 500mg each Copper Oxychloride and Carbendazim + 0.1% mercuric chloride solution for 10 minute + ascorbic acid and citric acid(0.01%). In addition, all these treatments were tested with or without activated charcoal @ 1.5 g/l and 3.0 g/l. These explants were sub-cultured once in 20-25 days for six months in case of explants of zygotic seedling explants and up to eight months for off-shoot explants.

## Callus multiplication

Among the four date palm cultivars used in the study, cv. Halawy and Khalas responded well for callus growth in the subsequent sub-culturing after four months. More amount of creamy whitish embryogenic callus was obtained from the seedling explants of these two varieties compared to off-shoot explants. The growth of callus from shoot tip of off-shoot was found slower and some of the cultures started browning even after six months. Increasing activated charcoal content from 1.5 g/L to 3.0 g/L in MS medium also did not support to prevent callus browning. Application of complete dark and light (16hr light and 8hr dark cycle) on callus from shoot-tip of off-shoots were also tried and found that the light has no effect on the callus. In the presence of light the callus turned to whitish green and later they changed to brown and died. The callus obtained from shoot tip explants of off-shoot of date palm cv. Halawy and Khalas are being sub-cultured for enough growth to induce somatic embryos through solid media and suspension culture media approaches. Interestingly, callus obtained from shoot tip seedling explants are produced enough amount for induction of somatic embryogenesis within six months. Therefore, callus from shoot tip of seedling explants were selected for further standardization experiments of somatic embryogenesis. Callus formation in fruit mesocarp tissue of cv. Medjool and Khuneji and leaf and root tip explants date palm cv. Halawy and Khalas. Maintained embyogenc callus and obtained profuse somatic embryo proliferation.

## Mass multiplication of somatic embryos of date palm

After the differentiation process, the callus transferred on different media composition consisting MS medium with different combination of 2,4-D, NAA and BA. The callus was subjected for transfer to two types of media (i) Agar solidified (Table 46 &47, Fig. 35) and (ii) liquid media for suspension initiation for mass multiplication of embryo. The multiplication of somatic embryos was further tried on media composition with or without charcoal. After two to three sub-culturing, the intensity of browning in the culture was increased without charcoal media. During embryo proliferation stage, three types of cultures were obtained which were embryogenic callus, somatic embryos and green shoots. Two types of somatic embryos were also obtained in these growing cultures one is individual somatic embryos and second is cluster of embryos. The growth behaviour of the individual embryo is to grow vertically to produce leaves and roots while the

**Table 46. Development of somatic embryos in solid media for date palm cv. Halawy**

| Media | Average number of Somatic embryos/flask (100 ml media) | Average length of Somatic embryos (mm) | Stages of majority of embryo |
|---|---|---|---|
| MS only | 3 | 3.1 | Globular |
| MS + NAA 0.1 mg/L | 12 | 3.2 | Globular |
| MS + NAA 0.1 mg/L + BA 0.05 mg/L | 22 | 7.2 | Mature |
| MS + NAA 0.1 mg/L + BA 0.5 mg/L | 18 | 5.9 | Juvenile |
| MS + NAA 0.1 mg/L + BA 1.5 mg/L | 8 | 5.2 | Juvenile |
| MS + NAA 0.1 mg/L + BA 3.0 mg/L | 4 | 2.8 | Globular |
| MS + NAA 0.1 mg/L + BA 0.1 mg/L + Kinetin 0.1 mg/L | 19 | 6.8 | Mature |

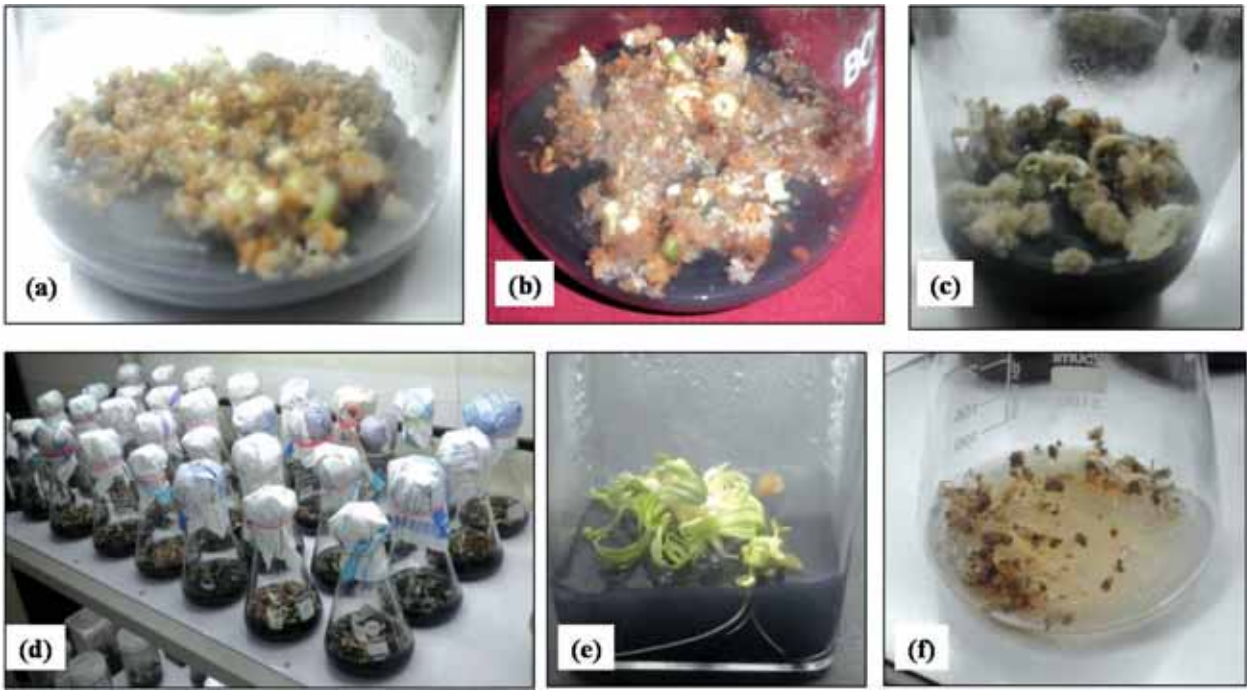



**Fig 35. Somatic embryo formation from callus on solid media of date palm cv. (a) Halawy (b) Khalas (c) somatic embryo germination (d) view of transformed embryo for germination (e) root and shoot emergence from somatic embryo and (f) somatic embryo formation from residual callus after transfer**

multiple embryos were found to proliferate additional shoots and embryos.

## Cell suspension cultures

200 mg of friable embryogeneic callus was chopped into small pieces and transferred aseptically into 50 ml of liquid MS media of above mentioned compositions containing 300 mg activated charcoal in 250 ml flask capacity. The suspension cultures were passed through a 500 micron mess filter. Cultures were maintained on a rotary shaker at 90, 120 and 150 rpm under a 16/8 hrs (light/ dark)

**Table 47. Development of somatic embryos in solid media for date palm cv. Khalas**

| Media | Average number of Somatic embryos/flask (100 ml media) | Average length of Somatic embryos (mm) | Stages of majority of embryo |
|---|---|---|---|
| MS only | 2 | 2.8 | Globular |
| MS + NAA 0.1 mg/L | 8 | 3.0 | Globular |
| MS + NAA 0.1 mg/L + BA 0.05 mg/L | 20 | 6.4 | Mature |
| MS + NAA 0.1 mg/L + BA 0.5 mg/L | 15 | 5.9 | Juvenile |
| MS + NAA 0.1 mg/L + BA 1.5 mg/L | 7 | 5.1 | Juvenile |
| MS + NAA 0.1 mg/L + BA 3.0 mg/L | 5 | 3.1 | Globular |
| MS + NAA 0.1 mg/L + BA 0.2 mg/L + Kinetin 0.2 mg/L | 22 | 6.1 | Mature |

photoperiod under 1000 lux intensity. Embryogenic cell suspension established by filtering suspension through 500 micro meter strainer. The suspensions were observed for cell shape, size and cell cluster formation. The suspensions were highly heterogeneous having embryos of different shape such as spherical, elongated and rooted and sizes 1 mm to 10 mm. The better results in term of embryo size were obtained at media composition of 1.0 mg/l 2,4-D. The resultant embryos were further, plated for germination on media with or without plant growth regulators. In the present study the germination of embryos was not found encouraging which need further experimentation. The following results were obtained with date palm cv. Halawy and Khalas (Fig. 36)

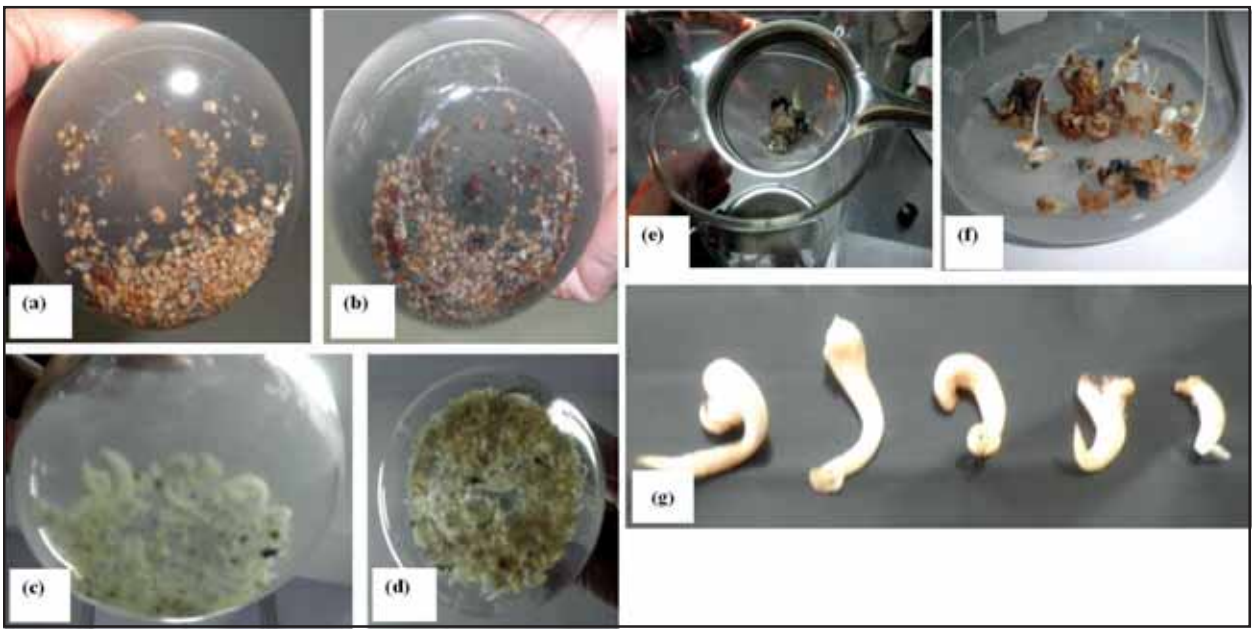



**Fig 36. Production of somatic embryo of date palm by suspension culture method with or without activated charcoal. (a & c) cv. Halawy (b & d) cv. Khalas (e) sieving of somatic embryos (f) transferring somatic embryos to solid media (g) different shape of somatic embryos**

# CROP PROTECTION

## Management of *mateera* diseases under field conditions

A field trial was carried out for management of *mateera* diseases through, bio-agents, botanicals and chemicals during summer season of 2013. One botanical (onion leaf extract @ 5%), 04 bio-agents (*Aspergillus niger*, *Pseudomonas fluorescens* strain CIAH-196, *Trichoderma viride* CIAH-240 and *Trichoderma viride* Non-Resistant @ 5% each) and 05 chemicals such as fungicides & insecticides (copper oxychloride @0.25%, carbendazim @ 0.1%, mancozeb, @ 0.25%, imidacloprid @ 0.05% and acephate @ 0.06%) were taken for this study. After seed treatment with imidacloprid @ 0.05%, one foliar spray each of the treatments was given, separately, on the standing crop. Among all the treatments, disease incidence and disease severity ranged from 14.30 to 33.33% and 8.25 to 26.75%, respectively. Imidacloprid (0.05%) was found the most effective as seed treatment and also one foliar spray against mosaic disease and shoe string with minimum disease incidence of 18.20 and 14.30%, respectively, followed by acephate (0.06%) containing disease incidence (20.0 and 18.20%). Highest disease incidence (30.0%) was recorded in onion leaf extract (5%) under natural conditions. Mancozeb (0.25%) was the best fungicide as foliar spray for reducing *Alternaria* leaf blight having lowest disease severity (8.25%) (Table 48).

## Disease management of bottle gourd under field conditions

A field trial was conducted for integrated disease management of bottle gourd through chemicals, bio-agents and botanicals during rainy season of 2013 in the field. Two fungicides (carbendazim @ 0.1%, mancozeb @ 0.25%), 01 bio-agent (*Pseudomonas fluorescens* strain CIAH-196 @ 5%) and 01 botanical (neem leaf extract @ 5%) as well as their combinations such as carbendazim + mancozeb, carbendazim + *Ps. fluorescens* CIAH-196, carbendazim + neem leaf extract, mancozeb + *Ps. fluorescens* CIAH-196, mancozeb + neem leaf extract, carbendazim +

**Table 48. Efficacy of chemicals, bio-agents and botanical on *mateera* diseases.**

| S.No. | Name of treatments with dose | Incidence of mosaic disease (%) | Disease incidence of shoe-string (%) | Disease severity of *Alternaria* leaf blight (%) |
|---|---|---|---|---|
| 1. | Copper oxychloride (0.25%) | 22.2 * (26.08) | 20.0 *(26.47) | 20.70 *(27.03) |
| 2. | Carbendazim (0.1%) | 30.0 (33.19) | 30.0 (33.16) | 17.50 (24.70) |
| 3. | Mancozeb (0.25%) | 25.0 (29.91) | 25.0 (29.91) | 8.25 (16.41) |
| 4. | Imidacloprid (0.05%) | 18.20 (25.23) | 14.30 (22.11) | 24.50 (29.63) |
| 5. | Acephate (0.06%) | 20.0 (26.51) | 18.20 (25.22) | 25.10 (29.98) |
| 6. | *Aspergillus niger* (5%) | 30.0 (33.20) | 30.0 (33.17) | 18.75 (25.63) |
| 7. | *Pseudomonas fluorescens* CIAH-196 (5%) | 25.0 (29.91) | 22.2 (28.06) | 21.90 (27.84) |
| 8. | *Trichoderma viride* CIAH-240 (5%) | 25.0 (29.91) | 22.2 (28.05) | 12.75 (20.83) |
| 9. | *Trichoderma viride* CIAH-NR (5%) | 30.0 (33.18) | 25.0 (29.92) | 14.25 (21.95) |
| 10. | Onion leaf extracts (5%) | 30.0 (33.19) | 30.0 (33.16) | 22.75 (28.43) |
| 11. | Control | 33.33 (35.24) | 33.33 (35.83) | 26.75 (31.08) |

*Figures in parenthesis are angular transformed value

mancozeb + *Ps. fluorescens* CIAH-196, carbendazim + mancozeb + neem leaf extract, carbendazim + mancozeb + *Ps. fluorescens* + neem leaf extract and also other combinations were taken for this study. Seed treatment of bottle gourd seeds with carbendazim @ 0.1%, mancozeb @ 0.25%), *Pseudomonas fluorescens* strain CIAH-196 @ 5% and neem leaf extract @ 5% was done before sowing followed by foliar spray in their combinations. After sowing, all agronomic practices were applied for its production. *Alternaria* leaf blight, *Cercospora* leaf spot and powdery mildew were noticed under field conditions during this season. Disease severity of *Alternaria* leaf blight, *Cercospora* leaf spot and powdery mildew was recorded ranging from 6.50-28.75%, 7.25-29.50% and 10.50-37.60%, respectively. The most effective results was observed in combined treatment of carbendazim (seed treatment) + mancozeb (foliar spray) + *Pseudomonas fluorescens* (foliar spray) + neem

**Table 49. Integrated disease management of bottle gourd diseases**

| S.No. | Name of treatments with dose | Disease severity of *Alternaria* leaf blight (%) | Disease severity of *Cercospora* leaf spot (%) | Disease severity of powdery mildew |
|---|---|---|---|---|
| 1. | Carbendazim (0.1%) ST | 22.10 *(28.04) | 24.10*(29.40) | 29.35*(32.80) |
| 2. | Mancozeb (0.25%) ST | 23.15(28.76) | 25.20(30.13) | 31.40(34.08) |
| 3. | *Pseudomonas fluorescens* CIAH-196 (5%) ST | 26.50(30.98) | 28.10(32.01) | 34.10(35.73) |
| 4. | Neem leaf extract (5%) ST | 25.15(30.10) | 26.40(30.92) | 33.15(35.15) |
| 5. | Carbendazim (ST) + Mancozeb (FS) | 17.20(24.50) | 18.60(25.55) | 25.10(30.07) |
| 6. | Carbendazim (ST) + *Ps. fluorescens* CIAH-196 FS | 18.90(25.77) | 20.75(27.10) | 25.90(30.59) |
| 7. | Carbendazim ST + Neem leaf extract | 19.50(26.20) | 21.80(27.83) | 27.30(31.50) |
| 8. | Mancozeb ST + Carbendazim (FS) | 18.50(25.47) | 19.70(26.35) | 26.80(31.18) |
| 9. | Mancozeb (0.25%) ST + *Ps. fluorescens* CIAH-196 (5%) FS | 20.95(26.67) | 23.30(28.86) | 27.90(31.88) |
| 10. | Mancozeb (0.25%) ST + Neem leaf extract (5%) FS | 21.50(27.62) | 22.50(28.32) | 28.10(32.01) |
| 11. | Carbendazim (ST) + Mancozeb (FS) + *Ps. fluorescens* CIAH-196 (5%) FS | 9.90(18.34) | 10.45(18.86) | 17.20(24.50) |
| 12. | Carbendazim (ST) + Mancozeb (FS) + Neem leaf extract (FS) | 11.25(19.60) | 12.60(20.79) | 19.80(26.42) |
| 13. | Carbendazim (ST) + Mancozeb (FS) + *Ps. fluorescens* (FS) + Neem leaf extract (FS) | 6.50(14.77) | 9.50(17.95) | 13.10(21.22) |
| 14. | Mancozeb (ST) + Carbendazim (FS) + *Ps. fluorescens* CIAH-196 (5%) FS | 13.75(21.76) | 15.10(22.87) | 22.30(28.18) |
| 15. | Mancozeb (0.2%) ST + Carbendazim (FS) + Neem leaf extract | 15.40(23.10) | 17.50(24.73) | 24.60(29.73) |
| 16. | Mancozeb (0.2%) ST + Carbendazim (FS) + *Ps. fluorescens* CIAH-196 FS + Neem leaf extract FS | 8.25(16.69) | 7.25(15.62) | 10.75(19.14) |
| 17. | Control | 28.75(32.42) | 29.50(32.90) | 37.60(37.82) |

*Figures in parenthesis are angular transformed value

leaf extract (foliar spray) for management of *Alternaria* leaf blight with minimum disease severity (6.50%). While, combination of mancozeb (seed treatment) + carbendazim (foliar spray) + *Pseudomonas fluorescens* (foliar spray) + neem leaf extract (foliar spray) was found the most effective for integrated management of both *Cercospora* leaf spot and powdery mildew of bottle gourd with minimum disease severity of 7.25 and 10.75%, respectively. Maximum disease severity of 26.50, 28.10 and 34.10% was noticed in seed treatment of *Pseudomonas fluorescens* CIAH -196 for reducing *Alternaria* leaf blight, *Cercospora* leaf spot and powdery mildew, followed by neem leaf extract with disease severity of 25.15, 26.40 and 33.15%, respectively (Table 49).

## At Godhra

### Ber Powdery Mildew

- Two sprays of $KH_2PO_4$ 0.5% i.e. @ 5g/l (Percent Disease Index, PDI=14.88), $NaHCO_3$, 0.5% (PDI=12.84), $MgSO_4$ (0.1%) (20.22), $CaCl_2$, 0.5% (22.72), Pot. Metabisulphite (KMS), 0.1% (18.2) were able to reduce the disease incidence of powdery mildew of ber.
- When $KH_2PO_4$ (0.5g./l) was mixed with Bayleton (PDI=2.88) and Sulfex (9.12), they controlled the disease much better (Table 50).

### *Cercospora* leaf and fruit spots of pomegranate

- Symptoms were seen only on leaves, and the fruiting failed both in *Mrug* and *Hasta bahar* season. Assessment was done in September, 2nd week.
- Fungicides were distinctly better to control the disease (Blitox 0.3%, PDI=4.2, Mancozeb, 0.2%, PDI=5.8).
- Two foliar sprays of $KH_2PO_4$ (PDI=7.2), KMS, 0.1%, (PDI=7.7), and $KMnO_4$, 0.1% (9.1), were superior to other treatments of foliar sprays of minerals (Table 51).

**Table 50. Management of ber powdery mildew through foliar sprays of minerals compounds and non-fungicidal organic compounds**

| Sr. No. | Chemicals/treatment spray | Percentage Disease Index Variety: Gola |
|---|---|---|
| 1. | $KH_2PO_4$ 0.5% | 14.88 |
| 2. | $NaHCO_3$ 0.5% | 12.84 |
| 3. | $MgSO_4$ 0.5% | 20.22 |
| 4. | $KH_2PO_4$ 0.5% + 1% Orera | 19.10 |
| 5. | $CaCl_2$ 0.5% | 22.72 |
| 6. | Diammonium phosphate 1% | 27.03 |
| 7. | Urea 1% | 28.04 |
| 8. | $KMnO_4$ 0.1% | 18.02 |
| 9. | Potassium metabisulphite (KMs) 0.1% | 27.03 |
| 10. | Bayleton 0.1% | 7.84 |
| 11. | Bayleton 0.1% + $KH_2PO_4$ (2 sprays) | 2.88 |
| 12. | Acetyl Salicylic acid 1000ppm | 26.06 |
| 13. | Phenol 0.05% | 28.02 |
| 14. | Dairy milk 10% | 30.02 |
| 15. | Sulfex 0.2% | 13.02 |
| 16. | Hexaconazole (0.1% confat | 7.92 |
| 17. | Ammionium bicarbonate 0.5% | 22.4 |
| 18. | Untreated control-I | 62.3 |
| | | 52.1 |

### Management of Aonla

Pink leaf and fruit spots were managed by copper oxychloride (Blotox 0.3%), PDI=2.5 sprays applied during middle of August followed by (PDI=4.1), $KH_2PO_4$, 0.5% (PDI=7.5) and $H_3BO_3$ (0.5%) (PDI=7.7) (Table 52).

### Disease Management in Cucurbit

Foliar sprays of $KH_2PO_4$, Phenol, KMS and $KMnO_4$ were superior treatment to control powdery mildew on bottle gourd and downy mildew on sponge gourd (Table 53).

**Table 51. Disease Management of foliar pathogens of pomegranate using foliar fertilizer spray (FFS) and SIR (systemic resistance) inducing chemicals sprays**

| Sr. No. | Treatment | PDI (Ps.punicae) (PDI) |
|---|---|---|
| 1. | $KH_2PO_4$ 0.5% | 7.2 |
| 2. | $NaHCO_3$ 0.5% | 7.7 |
| 3. | Mg $SO_4$ 0.5% | 9.0 |
| 4. | $KH_2PO_4$ + Urea 1% | 7.5 |
| 5. | Pot. Metabisulphite 0.1% (KMS) | 8.9 |
| 6. | Blitox (Copper oxychlorite 50wp,0.3%) | 4.2 |
| 7. | Phenol 0.1% | 8.0 |
| 8. | Blitox + $KH_2PO_4$ | 2.1 |
| 9. | Mancozeb 72 wp 0.2% + $NaHCo_3$ | 4.3 |
| 10. | Untreated co ntrol | 13.07 |
| 11. | Manozeb 0.2 | 65.8 |
| 12. | $KMnO_4$ 0.1% | 9.1 |

**Table 52. Disease Management in pink fruit spots of aonla using foliar sprays and post harvest fruit rot incidence of aonla using preharvest foliar sprays**

| Sl. No. | Treatment (preharvest sprays) | Disease severity of fruit spots |
|---|---|---|
| 1. | $KH_2PO_4$ 0.5% | 7.5 |
| 2. | $NaHCO_3$ 0.5% | |
| 3. | $MgSO_4$ 0.5% | 7.7 |
| 4. | Urea, 1% + $KH_2PO_4$ 0.5% | 8.5 |
| 5. | Calcium Chloride 1.0 | 8.3 |
| 6. | Phenol 0.05% | 6.9 |
| 7. | Fungicidal treatment Blitox 0.3% | 3.9 |
| 8. | Blitox 0.3% + $KH_2PO_4$ 0.5% | 1.1 |
| 9. | Borex 0.6% | 7.7 |
| 10. | Untreated control | 14.4 |

**Table 53. Disease Management in cucurbits through FS of minerals and organic compounds having antifungal activities or systemic resistance inducing properties**

| Sl. No. | Treatments | Bottlegourd | | |
|---|---|---|---|---|
| | | *Cercospora* leaf spots (PDI) | Powdery mildew (PDI) | Pumpkin PDI PMV |
| 1. | $KH_2PO_4$ 0.5% | 22.2 | 14.3 | 25.5 |
| 2. | $KMnO_4$ 0.1% | 13.3 | 10.3 | 23.3 |
| 3. | $CaCl_2$ 0.5% | 20.2. | 15.2 | 20.3 |
| 4. | Pot. Merabisulphite (KMs) 0.1% | 14.1 | 15.2 | 20.3 |
| 5. | Phenol 1000ppm | 10.1 | 12.8 | 20.2 |
| 6. | Acetyl salicylic acial 500ppm | 18.1 | 12.5 | 20.2 |
| 7. | Salicylic acid 500ppm | 20.3 | 19.2 | 19.5 |
| 8. | Bavistin (carbendazim 0.05%) | 6.9 | 6.0 | 13.1 |
| 9. | Bavistin + $KH_2PO_4$ 0.5% | 5.8 | 2.5 | 10.2 |
| 10. | Untreated control | 29.3 | 24.3 | 36.3 |
| 11. | Dairy milk | 22.0 | 15.7 | 18.3 |
| 12. | Buttermilk | 18.7 | 14.8 | 12.3 |
| 13. | $NaHCO_3$ | 15.3 | 15.2 | 20.2 |
| 14. | Copper oxychloride 0.2% | - | - | - |
| 15. | Mancozeb 0.2% | - | - | - |

## Disease Management in Chilli: (anthrocnose and powdery mildew)

- Only Chilli anthrocnose and tomato early blight was studied during the year.
- Pesticidal treatment using Blitox (0.3%), Bavistin (0.1%) and Captaf (0.2%) were superior.
- FFS viz. $KH_2PO_4$, $NaHCO_3$, KMS $CaCl_2$, etc. were superior over control but not better than fungicides (Table 54).

To stain the live hyaline fungal material including spores and mycelium, phloxine (1.0%) and a mixture of Rose Bengal and phloxine worked very well. Similarly, a stain Ruthenium Red also stained the fungal material and infected tissue having pectins

## Insect Pest Management

### Cucurbits

The survey was conducted in summer and rainy season during 2013-14 at different district of Rajasthan (Jodhpur, Pali, Sirohi, Udaipur, Chittor, Kota, Bara, Bundi, Tonk, Jaipur, Sikar districts). The fruit fly incidence ranged from 20 to 51 % in cucurbits in surveyed area of Rajasthan. The incidence of red pumpkin beetle was found very high ranging from 42 to 74 % in surveyed area of southern than the northern Rajasthan. The incidence of hadda beetle was high in northern part of Rajasthan and very less incidence in southern part of Rajasthan. The incidence of pests like, fruit fly, hadda beetle, aphid, white fly, leaf minor, surface grasshopper, *Anthicus crinitus*, *Anthrenus subclaviger* and natural enemies like, carabid beetle, coccinellids like *Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Scymnus coccivora*, *Chrysoperla*, praying mentid and hadda beetle parasitoid, *Pediobius foveolatus* were recorded. The incidence of beetles, *Mylabris macilenta*, *Anthicus crinitus* and *Anthrenus subclaviger* on cucurbits flowers were also recorded during survey (Fig. 37).

**Antixenotic mechanism of muskmelon genotypes:** The length of ovary pubescence, fruit

**Table 54. Disease management of major fungal diseases of fruit vegetable- chilli, tomato and okra**

| Sr. No. | Treatment | Chilli (Pusa Jwala) Kharif | Tomato sol.22 | | Okra Parbhani Kranti |
|---|---|---|---|---|---|
| | | Authracnose (ripe fruit rot) PDI | Early blight PDI | TLCV% incidence | |
| 1. | $KH_2PO_4$ 0.5% | 18.3 | 18.2 | 19.3 | 20.0 |
| 2. | $CaCl_2$ 0.5% | 18.2 | 18.9 | 22.8 | 25.0 |
| 3. | $MgSO_4$ 0.5% | 19.3 | 21.7 | 22.8 | 5.0 |
| 4. | Acetyl salicylic acid 250ppm | 15.2 | 15.3 | 19.7 | 20.0 |
| 5. | Phenol 0.05% | 15.7 | 15.3 | 19.7 | 20.0 |
| 6. | Sodium bicarbonate 0.5% | 12.9 | 15.0 | 16.3 | 18.3 |
| 7. | Untreated control | 30.3 | 32.0 | 40.3 | 40.3 |
| 8. | Mancozeb 0.2% | 5.3 | 5.3 | 31.4 | |
| 9. | Copper oxy chloride 50wp 0.3% | 6.2 | 9.9 | 32.2 | - |
| 10. | Sulfex 0.2 (Wettable S,80wp) | - | - | - | 11.0 |
| 11. | Sulfex 0.2% + $KH_2PO_4$ (0.5%) or Blitox 0.3 or sulphur | 8.3 | | 11.3 | 19.8 8.0 |

Beetle (*Mylabris macilenta*)Family: Meloidae

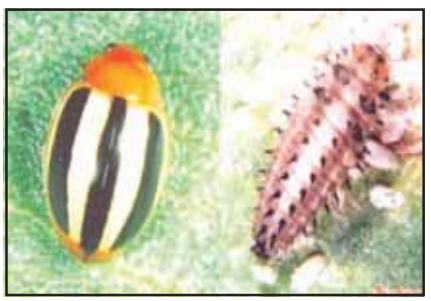
Beetle (*Anthrenus subclaviger* Reitter)Family: Dermestidae

Beetle (*Anthicus crinitus* Laferte)Family: Anthicidae

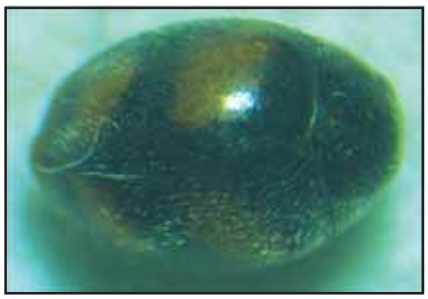
Ladybird beetle (*Coccinella septempunctata*)Family: Coccinellidae

Zigzag ladybird beetle (*Cheilomenes sexmaculata*)Family: Coccinellidae

Strip lady bird beetle (*Brumoides suturalis*) Family: Coccinellidae



Coccinelid beetle (*Scymnus coccivora*)Family: Coccinellidae



Hadda beetle parasitoid (*Pediobius foveolatus*)Family: Eulophidae

**Fig. 37. Pests and natural enemies of cucurbits in arid region of Rajasthan**

toughness, rind thickness and flesh thickness ranged from 5.06 to 2.28 mm, 8.93 to 4.07 kg/ $cm^2$, 0.407 to 0.127 cm and 2.61 to 1.54 cm, respectively, being significantly high in resistant and low in susceptible genotypes . However, the days to first harvest (68.40 to 79.00 days) and fruit diameter (9.41 to 13.51 cm) being significantly low in resistant and high in susceptible genotypes. The length of ovary pubescence, fruit toughness, rind thickness and flesh thickness had significant negative correlations

whereas; days to first harvest and fruit diameter had significant positive correlations with the percentage fruit infestation and the larval density per fruit (Table 55).

**Development of IPM modules against insect-pests of muskmelon:** The results showed that organic IPM module-III registered significantly lower aphid population followed by module-I. All the four modules were significantly superior in controlling the leaf eating caterpillar, *Diaphania indica* population than control module during investigation period. The significant difference in hadda beetle, *Epilachna vigintiopunctata* which was observed with least infestation in IPM module-III followed by module-I and at par with module-IV. The lowest fruit fly, *Bactrocera cucurbitae* incidence was found in IPM module-III followed by module-I. The module-II was found less effective than other module but it was better than control module. The marketable yield of muskmelon fruits differed significantly under different modules. The fresh fruit yield of muskmelon was observed in the order of organic IPM module-III> module-I> module-IV> module-II and least under control module in results. The higher B: C ratio was obtained in the organic IPM module-III followed by module-I and lowest B: C ration was obtained in module-II (Table 56 & 57).

**Morphomatrics study of lasora bug**: Data on linear measurements of *D. cheriani* was recorded. The female was distinctly larger than the male in respect to all body parts. This lace bug was typically characterized as having body oblong, pale testaceous with brownish or fuscous markings, with collar and hood yellowish brown, body beneath reddish dark with thoracic sterna darker. Antenna is yellowish brown; 1/3 part of 4 segment blackish. Antenna is rather slender, segmental measurements: I, 0.12 mm; II, 0.09 mm; III, 0.80 mm; IV, 0.22 mm. Length of body is 2.25 mm and width 0.88. Head is very short, strongly deflexed, bucculae wide, areolate, closed in front. Legs are fairly slender and yellowish brown. Pronotum is very strongly convex, tricarinate, with discal part on each side covered by the reflexed paranotum up to the lateral carina; backward projection of pronotum triangular, areolate; hood small, feebly produced anteriorly at the middle. Hemelytra are wider than width of pronotum across humeral angles, longer than abdomen (Fig. 38).

**Table 55. Antixenotic fruit traits of different genotypes of musk melon**

| Genotypes | Length of pubescence (mm) | Fruit toughness (Kg/cm$^2$)* | Rind thickness (cm) | Flesh thickness (cm) | Days to first harvest* | Fruit diameter (cm)* |
|---|---|---|---|---|---|---|
| AHMM/BR-8 | 4.36$^{de}$ | 7.83 (2.97)$^{d}$ | 0.407$^{e}$ | 2.61$^{bc}$ | 72.53 (8.57)$^{abc}$ | 09.41 (3.22)$^{a}$ |
| RM-50 | 5.06$^{g}$ | 8.93 (3.15)$^{e}$ | 0.293$^{d}$ | 2.50$^{bc}$ | 69.80 (8.41)$^{ab}$ | 09.63 (3.26)$^{a}$ |
| AHMM/BR-1 | 4.78$^{fg}$ | 7.54 (2.92)$^{d}$ | 0.303$^{d}$ | 2.47$^{bc}$ | 70.07 (8.43)$^{ab}$ | 11.09 (3.48)$^{ab}$ |
| MHY-5 | 3.61$^{cd}$ | 7.57 (2.93)$^{d}$ | 0.160$^{ab}$ | 2.21$^{ab}$ | 77.53 (8.86)$^{d}$ | 11.18 (3.49)$^{ab}$ |
| Durgapura Madhu | 3.98$^{d}$ | 6.10 (2.66)$^{c}$ | 0.147$^{ab}$ | 2.10$^{ab}$ | 68.40 (8.33)$^{a}$ | 10.38 (3.37)$^{ab}$ |
| Pusa Sarabati | 4.44$^{ef}$ | 6.40 (2.72)$^{c}$ | 0.170$^{ab}$ | 3.20$^{c}$ | 76.53 (8.80)$^{d}$ | 11.86 (3.58)$^{bc}$ |
| Arka Jeet | 2.28$^{a}$ | 4.07 (2.25)$^{a}$ | 0.140$^{ab}$ | 2.11$^{ab}$ | 78.40 (8.91)$^{d}$ | 09.69 (3.27)$^{a}$ |
| AHMM/BR-13 | 3.58$^{c}$ | 6.17 (2.68)$^{c}$ | 0.187$^{bc}$ | 2.33$^{abc}$ | 76.00 (8.77)$^{cd}$ | 10.02 (3.31)$^{a}$ |
| Pusa Madhuras | 4.67$^{efg}$ | 5.10 (2.47)$^{b}$ | 0.127$^{a}$ | 3.11$^{c}$ | 79.00 (8.94)$^{d}$ | 11.86 (3.58)$^{bc}$ |
| Arka Rajhans | 2.78$^{b}$ | 6.73 (2.78)$^{cd}$ | 0.160$^{ab}$ | 1.54$^{a}$ | 78.20 (8.90)$^{d}$ | 13.51 (3.81)$^{c}$ |
| GMM-3 | 2.35$^{a}$ | 4.74 (2.39)$^{ab}$ | 0.230$^{c}$ | 2.04$^{ab}$ | 74.27 (8.67)$^{bcd}$ | 11.92 (3.59)$^{bc}$ |

**Table 56. Incidence of aphid (*A. gossypii*) and leaf eating caterpillar (*D. indica*) in different management modules of muskmelon crop**

| Treatment | Aphid population per leaf | Leaf eating caterpillar per plant |
|---|---|---|
| Module-I | 18.15 (4.37)$^{b}$ | 17.08 (4.25)$^{c}$ |
| Module-II | 26.58 (5.25)$^{d}$ | 20.80 (4.66)$^{de}$ |
| Module-III | 11.63 (3.53)$^{a}$ | 8.23 (3.03)$^{a}$ |
| Module-IV | 21.30 (4.72)$^{c}$ | 12.25 (3.63)$^{b}$ |
| Control | 31.05 (5.66)$^{e}$ | 24.03 (5.00)$^{e}$ |

*Values in parenthesis are square root-transformed
Value following different letter are significantly different using Tukey's HSD test

**Table 57. Incidence of hadda beetle (*E. vigintiopunctata*) and cucurbit fruit fly (*B. cucurbitae*) in different management modules of muskmelon crop**

| Treatments | Hadda beetle per plant* | Fruit fly (%)** |
|---|---|---|
| Module-I | 6.90 (2.80)$^{bc}$ | 29.90 (33.11)$^{b}$ |
| Module-II | 9.48 (3.22)$^{de}$ | 46.99 (43.25)$^{d}$ |
| Module-III | 3.88 (2.20)$^{a}$ | 20.33 (26.78)$^{a}$ |
| Module-IV | 7.53 (2.91)$^{c}$ | 38.55 (38.33)$^{c}$ |
| Control | 11.00 (3.46)$^{e}$ | 61.90 (51.89)$^{e}$ |

*Values in parenthesis are square root-transformed
**Values in parenthesis are angular-transformed
Value following different letter are significantly different using Tukey's HSD test

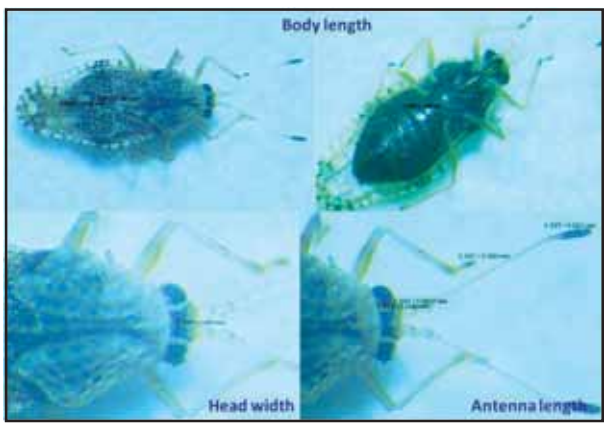



**Fig. 38. Linear measurement parts of *Dictyla cheriani***

# POST HARVEST MANAGEMENT AND VALUE ADDITION IN ARID HORTICULTURAL CROPS

## Bikaner

### Value addition in semiarid fruits

### Solar drying of fruits

Various solar dried products were prepared. Analysis of the fruits indicated that percent dry weight of different products varied with the type of the fruit. Maximum drying was recorded in aonla

powder 88.38% and least in Khirni 57.5 percent. Total soluble solid content was maximum in aonla candy 104.60 ° Brix; it was least in anardana 44.60 ° Brix. Percent total sugar content varied from 30.37 percent in Sapota to 7.29 percent in aonla powder. Reducing sugar content showed similar trend. Data on vitamin C content indicated that it was highest in aonla powder 416.16 mg/100 g and was least in Khirni 11.67 mg/100g. pH of different products did not show much variation which varied from 5.85 in Khirni to 3.04 in aonla powder (Table 58).

Methodology for preparation of fruit bars of wood apple and aonla and jelly of wood apple along with mix jelly of wood apple and aonla were standardized. Chemical analysis of the fruit bars indicated that T.S.S. of the bar prepared from matured date palm fruit was the highest 101.32 ° Brix and was least in wood apple aonla mix bar 83.50 ° Brix. Acidity was however maximum in the mix bar 2.34 percent, it was minimum in Sapota bar 0.70 percent. Similar trend was recorded in respect of pH and vitamin C content of the bar. Composition of reducing sugar was highest in wood apple bar 19.81percent and was least in date palm bar 1.56 percent. Similar trend was observed in respect of total sugar content. Another product from deshi ber was standardized named ber ketchup which has a TSS of 63.00 ° Brix. Acidity of the product was 1.23 and pH of 2.37 with reducing and total sugar content of 33.78% and 54.42 (Table 59).

**Table 58. Physico- chemical properties of different value added products**

| Product | Fresh wt. g. | Dry wt. g. | Moisture % | TSS ° Brix | Acidity % | Reducing sugar % | Total sugar % | VitaminC mg /100g | pH |
|---|---|---|---|---|---|---|---|---|---|
| Wood apple powder | 960.0 | 204.00 | 21.25 | 56.71 | 14.82 | 8.06 | 9.51 | 95.26 | 4.46 |
| Aonla powder | 1600. | 215.00 | 11.62 | 96.10 | 14.34 | 5.25 | 7.29 | 416.6 | 3.04 |
| Aonla candy( 10% salt treated ) | 800.0 | 315.00 | 39.37 | 104.60 | 0.99 | 8.00 | 13.76 | 93.34 | 3.25 |
| Khirni | 447.0 | 190.00 | 42.50 | 56.20 | 0.79 | 14.28 | 20.78 | 11.67 | 5.45 |
| Sapota pieces | 600.0 | 108.00 | 18.00 | 52.80 | 0.48 | 16.24 | 30.37 | 12.56 | 5.85 |
| Anardana | 230.0 | 66.00 | 28.69 | 44.60 | 4.48 | 11.65 | 18.28 | 25.15 | 4.25 |

**Table 59. Chemical analysis of Fruit bar, Jelly and ketchup**

| Product | TSS° Brix | Acidity % | pH | Vita.C | Reducing sugar % | Total sugar % |
|---|---|---|---|---|---|---|
| Sapota bar | 88.83 | 0.70 | 1.75 | 11.45 | 3.87 | 9.65 |
| Wood apple bar | 93.06 | 1.77 | 2.86 | 22.67 | 19.81 | 22.43 |
| Date palm bar | 101.32 | 0.19 | 1.92 | 12.53 | 1.56 | 5.84 |
| Wood apple Aonla bar | 83.50 | 2.32 | 3.13 | 40.34 | 9.87 | 12.05 |
| Wood apple jelly | 65.20 | 0.70 | 4.07 | 11.67 | 26.23 | 47.82 |
| Wood apple squash | 40.50 | 0.58 | 4.08 | 10.00 | 10.35 | 34.90 |
| Wood apple Aonla mix jelly | 68.40 | 1.05 | 3.95 | 40.00 | 34.96 | 55.00 |
| Ber ketchup | 63.00 | 1.23 | 2.37 | 47.00 | 33.78 | 54.42 |

# AGRICULTURAL EXTENSION

## At Bikaner

As per objectives and targets of the project, "*Technological intervention for arid horticultural development and its impact assessment"* various technological interventions/extension programmes were carried out/organized during 2013–14. Out of these; the major interventional activities/extension programmes carried out under this project during the year 2013 – 14 are being mentioned in short below.

**Visit and interaction/ meetings with farmers at the Institute :** More than 700 farmers (both men & women) from hot arid region of Rajasthan and other states of the country visited the Institute's farm/experimental blocks and had interaction / meetings with them to acquaint/ expose them with latest arid horticultural technologies as developed by the Institute.

**Research-extension-farmers-interface meetings:** During the reported period, a total of 18 Research-Extension-Farmers-interface meeting were held during their exposure visit at the Institute, farmer's field visits, during survey work and at the site of front line demonstrations, exhibitions and during the other programmes.

During the reported period, the work on organization of Farmer's Interest Groups / Commodity Interest Groups/ Self-Help Groups were also initiated at the different sites/ locations/ villages of Bikaner districts (Rajasthan) where front line demonstrations of improved varieties of arid fruits/ vegetables crops and their agro-techniques were conducted. Moreover, more than 11 Groups of farmers which had interest in propagation/ multiplication and growing of *Thar Shobha* variety of *khejri*, AHK-119 variety of *kachri* also organized. Later on, these groups were followed and their visit to the Institute was organized for technological interaction/ discussion with scientist. They were also motivated to adopt other improved arid horticultural technologies on their fields.

**Initiatives for popularization of arid horticultural technologies:** For the popularization of innovative arid horticultural technologies developed by the institute, various activities like creating technological awareness, interest and knowledge amongst the farmers/clients through daily news papers/ press media/ means of mass media on different occasions during the reported time. Other important activities like farmer's visits and research- extension-farmers-interface meetings, conduction of technological front line demonstrations/ adaptive trials on farmer's fields, method demonstrations, farmer's trainings, celebration of farm innovators day, visit to farmer's fields and organization of farmers interest groups to acquaint them with latest improved technologies arid fruits and vegetables crop production, organization of technological exhibitions, providing technical literature to farmers/ clients, online technical guidance and mobile advisory service/ ICT / e-extension based programmes, etc. were carried out during the reported time for the popularization of innovative arid horticultural technologies amongst the farmers / clients.

**Inter Institutional linkages/programmes organised/assisted:** Strengthened functional linkage with sister organization / Institutions of the ICAR, KVKs, ATIC and Directorate of Extension of SKRAU, Bikaner, CAZRI regional station Bikaner, state Govt. Deptt. of agriculture/ horticulture, CAD/IGNP departments, press media persons, NGOs, etc. to facilitate the transfer of technologies developed at CIAH on local farmer's field and to encourage the arid horticultural development. The above institutions were assisted and cooperated as and when they required our assistance and help in successful completion of their programmes like extension programmes, trainings, interface meetings, assistance in technological campaign/ programmes, technological support and advice, other issues related to human resource development.

**Refinement/ standardization traditional processes and products of value addition of arid horticultural crops:** Initiatives were taken to encourage the commercialization of arid horticultural technologies like improved varieties and value added products. The initiatives were taken to refine/ standardize some traditional processes and products of value addition like preparation of pickle of *aonla, karonda,* moringa pods; dehydration of *sangari* of *khejri, kachri,* snapmelon; aonla *Pandhari,* etc., for the commercialization and income generation at farmer's level.

**(i) Refinement/ standardization of the processes and techniques of preparation pickles of *aonla, karonda,* moringa pods:** The work on refinement / standardization of the processes and techniques of preparation of pickles of *aonla, karonda,* moringa pods was initiate. The mature and health fruits of *aonla, karonda and pods of* moringa were selected, washed with clean water and dried and chopped. After that the common salt was mixed with pieces of the *aonla, karonda and pods of* moringa *and* was left as it is for 24 hours. After 24 hours, the water generated due to salt was removed from the pieces and the same were left to dry shady place for 12 hours. They were slightly fried with mustard oil for a moment and mixed the condiments with them and left open for 12 hours at room temperatures. This pickle material of each (*aonla, karonda,* moringa pods) was filled in separate glassware along with warmed and cooled mustard oil. After a week it was ready for consumption. The further refinement and standardization work is in progress.

**Fig. 39. Pickle of *Karonda***

**(ii) Refinement/ standardization of the processes and techniques of dehydration of whole kachri fruits**: The mature and health fruits of *kachri fruits* were selected, washed with clean water and dried. They were peeled (skin was removed) and the whole fruits were treated with 2-3 % warm common salt solution for 20 minutes. Further the treated fruits were taken out from the salt solution and left to dry for 2-3 hour at shady place. The bead of these fruit was prepared with help of needle and threads. These beads were hanged and left to dry in airy-shaded place to avoid the brown spots on the fruits due to bright sunlight. These beaded fruits got full dry (with 10-14 % moisture content) within 15 days (Fig. 40). The dehydrated fruits were colleted, debeaded, filled in clean gunny bags and put at cool place for future use.The further refinement and standardization work is in progress.

**(iii) Refinement/ standardization of the processes and techniques of dehydration of snapmelon**: The mature and healthy fruits of snapmelon were selected, washed with clean water and dry them for some time to remove the water from their surface. After that, they were peeled (skin was removed) and cut vertically to make its slices. The seeds and waste material were removed and treated them with 2-3 % warm common salt solution for 20 minutes. Further the treated fruits were taken out from the salt solution and left them at neat and clean airy-shady place to dry. The slices were done up-down time to time to facilitate the dehydration / drying properly. These slices were got full dry (with 10-14 % moisture content) within 15 days. The dehydrated slices were colleted, filled in clean gunny bags and put at cool place for future use.

**Fig. 40. Dehydration processes whole of *kachri* fruits**

**(iv) Refinement/ standardization of the processes and techniques of dehydration of *sangari* of *khejri*:** The mature and health *sangari* of *khejri* were selected, washed with clean water and dry them for some time to remove the water from their surface. After that, they were boiled for 20 minutes in water having 2-3% common salt. Further the boiled *sangari* were taken out and left at neat and clean airy-shady place to dry. These slice got full dry (with 10-14 % moisture content) within 08 days. The dehydrated *sangari* were colleted, filled in clean gunny bags and put at cool place for future use.

**(v) Refinement/ standardization of the processes and techniques of preparing *aonla Pandgari:*** The mature and health *aonla* were selected, washed with clean water and dry them for some time to remove the water from their surface. After that, the fruits were boiled and their segment was separated and seeds were removed. These segments were grinded thoroughly in electric mixy. The grinded mixture/ material of the segments further processed in two ways (i) cooking/ frying the grinded mixture of *aonla + flour* with higher quantity of Ghee (300g/ kg mixture) for short duration (10minutes) or (ii) cooking/ frying the grinded mixture of *aonla + flour* with low quantity of Ghee (150g/ kg of matter) for long duration (20 minutes). The sugar and other ingredient/ condiments were thoroughly mixed in already cooked/ fried mixture of aonla + flour. Thus, final mixture was ready to prepare the round shaped sweet of aonla locally called *aonla Pandhari*.

**With high quantity of *Ghee***

**With low quantity of *Ghee***

**Fig 41. Aonla *Pandhari***

**Technological interventions and impact assessment:** The important activities for technological intervention and the impact assessment indicators as per feedback of farmers and personal observations are being presented in short in tabular form as below.

It was also observed that the farmers are very eager to grow improved variety of *khejri* "*Thar Shobha"* released by the institute. They expect a lot of benefit from the "*Thar Shobha"* variety of *khejri*. It is expected by the farmers that "*Thar Shobha"* will be a boon for socio-economic upliftment of rural people of hot arid regions.

| Technologies disseminated interventions/ disseminated | Means/ methods of technological | Technological impact as responded and assessed |
|---|---|---|
| **(1)** Improved varieties of arid vegetable crops released by the Institute (Kachri- AHK-119, Snaplmelon- AHS- 82; Thar Shobha) and their agro-techniques. | • Frontline demonstrations/ method demonstrations<br>• Distributions of improved seeds and planting materials.<br>• Trainings/ visits and<br>• Research- Extension- Farmers- interface meetings<br>• Farmer's field visits, meetings and group discussions<br>• On line/ personal technical advises and guidances<br>• Press publicity of the technologies.<br>• Technological film shows, talks/ lectures.<br>• Providing technological literature/ written advise to the farmers/ clients, etc. | Ø **Economic impact :**<br>• Farmers got net income of 42000 - 54000 / ha / season by growing improved varieties of arid vegetable.<br>• The farmers (15 -20%) are planning to produce the seeds of improved varieties of *kachri* (AHK- 119) and snaplmelon (AHS-82 at large commercial scale to earn money by selling the same to fellow farmers, local markets or NGOs.<br>• Increased the quality and quantity of the arid vegetable produces and also increased of then same in the local markets<br>• Increased the area under adoption of arid vegetable crops.<br>• Farmers are very eager to produce the crop of improved varieties of *kachri* (AHK-119) and snaplmelon (AHS-82 at large commercial scale.<br>Ø **Impact in terms of change in cognitive behavior :**<br>• Increased the knowledge, awareness, and interest among > 60% farmers of the areas where FLDs and training is conducted and seeds of the improved varieties and their agro-techniques<br>Ø **Impact in terms of social changes :**<br>• Increased the commodity interest groups in social system.<br>• Increased the cosmopolitism and scientific orientation of the farmers.<br>• Increasing flow of farmers from laggardism to innovatism, etc.<br>Ø **Impact in terms of environmental change :**<br>• Significant reduction in soil erosion and loss of soil.<br>• Increased the organic matter in the soil.<br>• Improvement in mild agro-climate of the crops field. |

## B. Extension research activities

The research activities under the new project entitled as "A study on rural wisdom and resources of arid Horticultural importance" were started in July, 2013. Under this project the preliminary information/ data about traditional technologies and their refinement/ standardized, socio-economic, and personal profile of respondents (farmers) and some other information were collected during July, 2013 to March, 2014. Out of these some important out comes are being narrated here in short.

**(1) Review and collection of literature and preparation of interview schedule:** The old literature and data/information pertaining to present study were reviewed and collected from secondary sources as well as from online sources to prepare the strategic plan to carry out the study and prepare the interview schedule to collect data of the study.

**(2) Preparation of interview schedule and pre-testing:** As per the requirement of data collection of the study, the interview schedule was prepared with the help of experts, colleted literature / information and self vision. After preparing the interview schedule, it was pre-tested, modified and relevant suggestions were incorporated in the same to give it final shape.

After finalization of the interview schedule, the preliminary data and information related to socio-economic and personal profile of the respondents and rural wisdom based processes /technologies of value addition were colleted from 60 respondents, secondary as well as from online sources.

(2) Collection, refinement and standardization of rural wisdom based value added products, processes /technologies.

During the period of the study, the researchers collected information (from respondents, secondary and online sources) about rural wisdom based traditional ideas/technologies to produce the value added products of arid horticultural fruits and vegetables like *kachri* pickle, *kachri hajmola*, *chutney* of fresh *kachri* , toffees and chokalets of *ber*, pickle of karonda, aonla, sanjan, Pandhari of aonla, honey of mulberry, etc. The work of the refinement and standardization was initiated on so collected above traditional technologies of producing value added products. The initial efforts are being mentioned here in short.

**(i) Refinement and standardization of the *kachri hajmola* making processes/ technique:** The work of refinement and standardization was initiated for the preparation of *hajmola* from *kachri* fruits. The mature and health fruits of *kachri* were selected and washed them. They were peeled (remove their skin) and cut down in two pieces. The seeds from the pieces from the kachri were removed. After that the pieces of the *kachri* were grinded thoroughly and sieve out through a fine and good quality of cotton cloth. Thus, a fine solution of *kachri* pulps was prepared. This solution was cooked with condiments. When the solution was became concentrated and slightly tuff, cooking process ended up. After that some other materials like asafoetida, black paper, black salt, etc. were mixed in it and *hajmola* type pills of the same were prepared manually. These pills were very tasty and useful like *hajmola* pills available in the market (Fig. 42).

**(ii) Refinement and standardization of the *kachri* pickle making processes/ technique:**

**(a) Preparation of *kachri* pickle without peeling and with seeds:** The mature and health fruits of *kachri* were selected, washed with clean water and dried them for some time to remove the water from their surface. They were cut in to two pieces. The seeds in the pieces of the *kachri* were retained as it is. The pieces of the *kachri* were left to dry for 24 hours at shady place. They were slightly fried with mustard oil for a moment and mixed

Fig. 42. Preparation of *Kachri Hajmola*

the condiments with them and left open for 12 hours at room temperatures. The pickle was filled in glass jar and filled with mustard oil. This prepared material of the pickle was put for a week in normal condition. After a week it was ready for consumption.

**(b) Preparation of *kachri* pickle without seeds**: The mature and health fruits of *kachri* were selected, washed with clean water and dried them for some time to remove the water from their surface. They were peeled (skin was removed) and cut in to two pieces. The seeds from these pieces were removed. After that the pieces of the *kachri* were left to dry for 24 hours in shady place. They were slightly fried with mustard oil for a moment and mixed the condiments with them and left open for 12 hours at room temperatures. The pickle filled in glass jar and filled with mustard oil and kept for a week in normal condition. After a week it was ready for consumption (Fig. 43).

**(iii) Refinement/standardization of the process of purification of *kachri juice* for long time preservation**

**(a) The purification and preservation of *kachri* juice with preservative (sugar)**: The work refinement and standardization was initiated for the purification of *kachri* juice for

(a) With peeling and without seeds

(b) *W*ithout peeling and with seeds

Fig. 43. Kachari pickles

future use. The mature and health fruits of *kachri* were selected and washed. They were cut down in two pieces and crushed. After that the pieces of the *kachri* were slightly grinded and juice of the same was filtered out twice using a fine and good quality double layered cotton cloth. This filtered juice was cooked and boiled with sugar (60%) for 20 minutes. After that, it was cooled, filtered again and poured into the cleaned glass bottles and kept at ambient conditions (September-October) for observations. It can be kept for 15 days.

**(b) The purification and preservation of *kachri* juice without preservative (sugar):** In this case, the mature and health fruits of *kachri* were selected and washed them. They were cut down in two pieces and crushed. After that the pieces of the *kachri* were slightly grinded and juice of the same was filtered out twice using a fine and good quality double layered cotton cloth. This filtered juice was boiled without sugar or without any other preservatives for 20 minutes. After that, it was cooled, filtered again and poured into the glass bottles and kept at ambient conditions (September- October) for observations. This juice can be kept for 6 months.

**Fig. 44. Kachri juice without preservative (sugar)**

**(iv) Refinement/ standardization of the process of preparing *chutney* of fresh *kachri*:** The work of refinement and standardization was initiated for preparation of chutney of fresh kachri fruits. The mature and healthy fruits of *kachri* were selected and washed them. They were peeled and cut down in two pieces. The seeds from the pieces of the *kachri* were removed. After that the pieces of the *kachri* were grinded thoroughly. Thus, a mixture (solution) of *kachri* pulps was made. This mixture was cooked in mustard oil with condiments. When the mixture became concentrated with release of oil, the cooking process was stopped. Thus, the *chutney* of the *kachri* was ready to serve (Fig 45). This *chutney* was neither spoiled nor gave any bad odour and had very good taste upto one and half month.

**Fig. 45. C*hutney* of fresh *kachri***

**(v) Preparation/ standardization of the process/techniques for making toffees and chocolates from *ber* fruits:** The work of refinement and standardization was initiated for preparation of toffees and chocolates of *ber* fruits. The mature and health *ber* fruits were selected and washed them. The whole fruits were cooked in pressure cooker. After that the cooked fruits were cooled down and meshed them thoroughly. The meshed material was sieve out through a fine and good quality of cotton cloth. Thus, a fine solution of *ber* fruits was received. This solution was cooked with 60% sugar (@ 600g/kg solution) with low heat. When the solution became concentrated and slightly tuff, cooking process ended up. After that black paper, black salt, cumin, etc. were mixed in it. Finally, *ber* toffees of the same were prepared manually. The toffees were very testy and no bad odour or bad taste occurred in them even upto 10 months at normal room conditions. The preparation of chocolates from *ber* fruits was also tried which indicated positive and desirable sign (Fig 46-47).

**(3) Socio-economic and personal profile of the respondents:** During the reported period (July, 2013 to March, 2014), the preliminary information/ data about socio-economic and personal profile of respondents (farmers) of the study were also collected using secondary sources, field workers and 62 respondents. It was observed that among senior farmers only 39 are literate and rest of them were illiterate. However, among young farmers (age group-25-35 years) > 70 % are illiterate and remaining were illiterate. There was observed high heterogeneity with respect to their socio-economic status, psychological characters, belief, understanding, preconception or prejudice, etc. High socio-economic disparities were prevalent. Majority of the respondents like mixed farming system. There was much difference between covert and invert behaviours of the farmers/ clients. Horticultural need of the farmers (respondents) was also analyzed. The felt/ basic needs of the farmers with respect to arid horticultural crop production were also analyzed. The basic urgent need of the farmers as observed during the study were: fundamental knowledge of arid horticultural crop production, motivation, improved seeds and planting material, knowledge of propagation techniques, techniques of water saving, reasonable marketing price of their products, etc.

**Fig. 46. Toffees of ber fruits**

**Fig. 47. Paste of *ber* fruits for chocolates**

# 3. EDUCATION, TRAINING AND TECHNOLOGICAL INTERVENTION

## At Bikaner

### Visit to Farmer's field

More than 20 farmer's fields were visited and they were provided with technical guidance / assistance overcome their problems related to arid horticultural crop production. The farmer's meeting/ interactions were carried out to guided and provided solution to their problems.

### Front line demonstrations/ adaptive trails

During the year, three frontline demonstrations of each improved varieties vegetable crop *viz* - Thar Mank (Mateera), AHS-82 (snap melon), AHK- 119 (Kachri), Thar Bhadvi (Cluster bean) and two front line demonstration of Thar Shobha ( Khejri) were conducted on farmers fields (at Chak No. 489/500, Sarehkunjiya dated-26.07.13; Chak No. 2,3 NGM, Naggasar dated- 07.08.13; Chak No. 493 RDL, Sarehkunjiya dated- 14.03.14; Chak No. 05KHM, Khinchiya village of Bikaner district dated- 19.03.14, Chak No. 2,3 NGM, Naggasar dated- 24.08.13 and Chak No. 439 RDL Khara) in Bikaner districts. In addition, 13 method demonstrations about improved agro-techniques of arid fruits and vegetable production were given to visiting farmers/ extension functionaries or during farmer's field visits/ interaction.

### Farmer's training

During the reported period, 06 farmer's training programme (on/off campus) were conducted /organised at the Institute and at farmer's fields (at Institute on 06.08.13, Chak No. 2,3 NGM, Naggasar dated- 07.08.13 and 24.08.13; Chak No. 489 RDL, Khara; Chak No. 493 RDL, Sarehkunjiya dated- 14.03.14; Chak No. 05KHM, Khinchiya village of Bikaner district dated- 19.03.14, Chak No. 2,3 NGM, Naggasar dated- 24.08.13 and Chak No. 439 RDL Khara) of Bikaner districts of Rajasthan.

### Participation in farmer's fair and arranging technological exhibition

During the reported period, participated and organized 02 exhibitions of arid horticultural technology in farmer's fairs organized by NRCSS, Ajmer from 04.02.14 to 07.02.14 and Krishi Vasant-2014 at Nagpur from 09 – 13 Feb. 2014.

### Celebration of Farm Innovators Day

Farm Innovators Day was held on 09.10.13 in the Institute in which more than 20 innovative farmers participated. They were acquainted with several scientific facts and improved technologies of arid horticulture developed by the Institute. The Farm Innovators also expressed/presented their experiences and innovative technological ideas and facts related to arid horticultural crop production. Their feedbacks and suggestions were also invited and recorded to encourage the horticultural development in hot arid regions.

### Mobile advisory service/ ICT based/ e-extension based activities

During the reported time**, t**he various farmers were answered & guided using mobile service, online telephonic conversation to solve their existing based problems related to horticultural crop production. Some advance farmers are replied for their technical guidance through e- mail, Institute's film show on computer system/ TV for client's

knowledge, production of online (Institute's website) technological news through six monthly newsletter, providing CD/DVD of the Institute's film and other programmes to needy clients, etc.

## Extension teaching- learning aids and e-learning materials developed

LED Boards, technological photographs, graphs, charts, written materials for training programmers, slides/ CD/ DVD for presentation of technical matter/ films, newsletters, etc. were prepared and communicated to needy clients.

**Visit and interaction with students/young farmers at the Institute:** Besides the farmers, 18 B.Sc (Ag)/ young farmers and school students came from different agricultural colleges/ university and schools of the Rajasthan state and other states of the country and visited experimental blocks and research laboratories of the Institute to acquaint them with latest technological know-how of the arid horticulture.

**Visit and interaction/ meetings with agricultural supervisors/professionals,at the Institute:** About 50 agricultural supervisors, professionals, lecturers, teachers, scientists/ trainees, and other dignitaries came from different line departments of state government, SAUs, colleges/ schools, ICAR research centres, NGOs etc. visited to experimental blocks & research laboratories of the institute and had interaction with them to acquaint with latest improved arid horticultural technologies and research and extension activities of the Institute.

# 4. WOMEN EMPOWERMENT

During the reported period, > 100 farm women visited the Institute and had research- extension-farmers-interface meetings with them. They were informed about modern arid horticultural crop production technologies, value addition techniques of arid fruits and vegetables during their visits. They were explained about the techniques which may be helpful in reducing the drudgery in crop production and post harvest management. They were motivated to participate in main stream of arid horticultural developmental programmes.

**Fig. 48. Farm women and field functionaries visited CIAH, Bikaner**

# 5. AWARDS AND RECOGNITIONS

## Award

### Dr. A. K. Singh

Best oral presentation was awarded to paper by Singh, A. K., Singh, Sanjay, and Joshi, H. K. (2013). Assessment of *Morinda tomentosa* genotypes for morphological and qualitative characters under rain fed semi-arid conditions of western India. Proceeding of Noni Search National Symposium on Noni for Sustainable Wellness held at G.K.V.K., Bangaluru, 29-30 October, 2013.

### Dr. B. R. Choudhary

Awarded Young Scientist Associate Award 2014 in the field of Vegetable Science by Bioved Research Institute of Agriculture & Technology, Allahabad (UP).

## Recognition

### Dr. S. K. Sharma

Co-chairman in the Technical Session on "Seed Production" in XXXIth Group Meeting of All India Coordinated Research Project (Vegetable Crops) held during 2nd to 5th May, 2013 at HPKV, Palampur.

### Dr. Sanjay Singh

Acted as expert in AGRESCO, Anand Agriculture University Anand. Also acted as chairman in the session for nutrient management (12-03-2014)

Acted as an expert for the post of Associate Professor, Horticulture (Fruits)in SDAU, S K Nagar, Palanpur.

Acted as Co-chairman in the session entitled Fertigation for enhancing the productivity of water and crops on 28-5-13 in International Conference on "Water Quality and Management for Climate Resilient Agriculture" from 28 to 31 May, 2013 at Jain Hills, Jalgaon.

Acted as rapporteur in Group workers meetng of AICRP Arid Fruits at MPKV, Rahuri, Maharastra during 26-28 December, 2013.

### Dr. B. D. Sharma

Director General, Indian Council of Agricultural Research, New Delhi nominated as Member Secretary, Research Advisory Committee, Central Institute for Arid Horticulture, Bikaner.

Director General, Indian Council of Agricultural Research, New Delhi nominated as Member, Institute Management Committee of National Research Centre on Camel, Bikaner for three years.

Director, CIAH, Bikaner nominated to act as Examination Coordinator of the AIEEA-UG-2013 Examination held at Bikaner on 18-04-2013

Acted as Rapporteurs in Nutrient management in Arid Fruit Crops Session, ATR and Plenary Sessions in XVIII Workshop of AICRP on AZF, held at MPKV, Rahuri during 26-28th December 2013.

### Dr. R. Bhargava

Vice-Chancellor, IASE University Sardarshahr nominated as member of Board of Studies (Biotechnology).

Nominated as Member Institute Technology Management Committee of NRC on Camel, Bikaner.

Editor-in-Chief, Indian Journal of Arid Horticulture, Bikaner

### Dr. S. S. Hiwale

Acted as Chairman in session 6th on Cropping System Research in National Seminar on Tropical and Subtropical fruits held at NAU, Navsari, Gujarat, on January 9-11, 2013.

### Dr. Hare Krishna

Selected as a Member of the on-line Paper Reviewing Panel to 2nd International Symposium on Minor Fruits and Medicinal Plants for Better Lives held at Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka from December, 20th- 21st 2013.

### Dr. B. R. Choudhary

Member of Editorial Board of a journal 'Trends in Life Sciences', DAMA International, Solapur-413004 (Maharashtra).

Member of Editorial Board of 'International Science Journal', DAMA International, Solapur-413004 (Maharashtra).

### Dr. S. Raja

Invited for delivering lecture on "Conventional and current breeding approaches and breeding problem in moringa" at Global Moringa Meet organized by BioDiesel Business Academy, Jaipur from 21-22, Nov.2013.

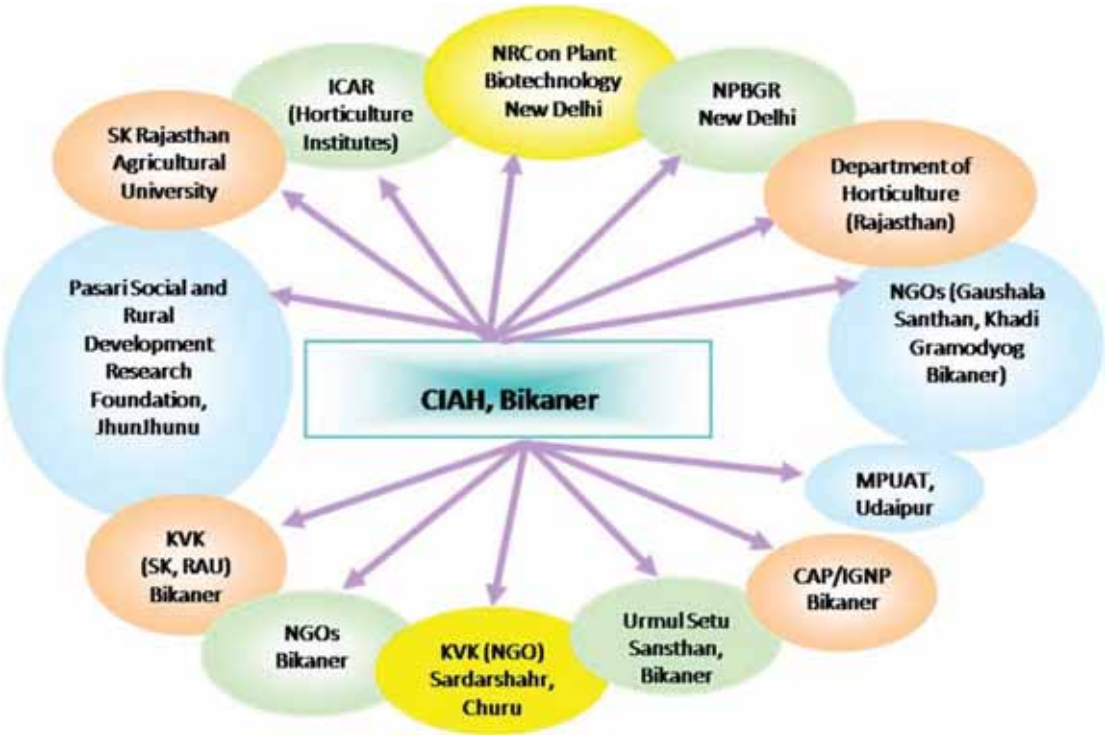
### Dr. S. M. Haldhar

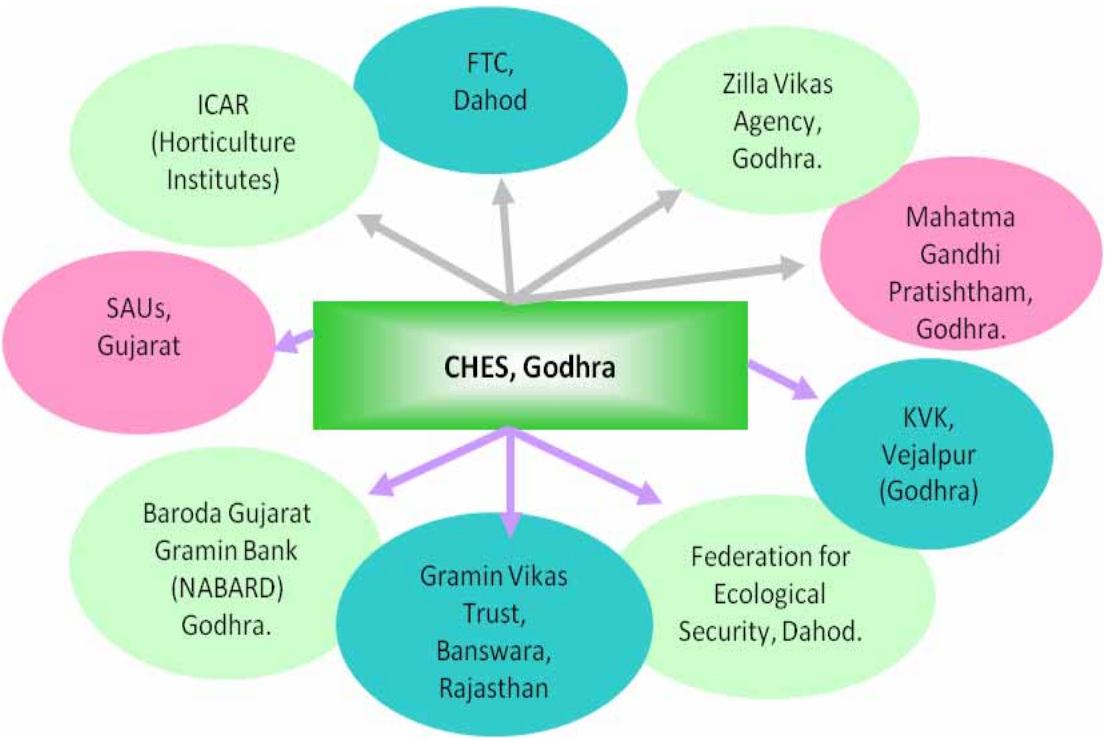
Editorial board of International Journal of Agricultural Sciences and Natural Resources published by American Association of Science and Technology (AASCIT), USA

Editor of Journal of Zoology (Reg. No. SH/311R/2-16AP/42/09)

Editor of Global Scholar Journal of Agronomy (http://www.globalscholarsjournals.org)

# 6. LINKAGES AND COLLABORATIONS



# 7. EXTERNALLY FUNDED PROJECTS

## Bikaner

### 1. Validation of DUS testing guidelines for cucurbits *i.e.* watermelon and muskmelon

Nodal Officer : Dr. S.K. Sharma, Director

Name of PI : Dr. B.R. Choudhary, Scientist

During 2013 a confirmatory trial was conducted consisting 09 watermelon and 13 muskmelon varieties to validate DUS testing guidelines. All the varieties of watermelon and muskmelon were evaluated in randomized block design (RBD) with three replications for various descriptor states according to the DUS minimal descriptors. Observations on 31 traits of watermelon and 32 traits of muskmelon were recorded. Based on the results, identified grouping traits to facilitate the assessment of distinctiveness of varieties. The important grouping traits along with example varieties are presented in table 60 & fig. 49 & 50.

### 2. Bioprospecting of genes and allele mining for abiotic stress tolerance - (*Ziziphus* and low moisture stress tolerance)

CCPI: P.N. Sivalingam

Co-PI: Dhurendra Singh

### Standardization of *in-vitro* technique for induction of low moisture stress in *Zizizphus nummularia*

Fruit stones of *Ziziphus nummularia* from Jaisalmer genotype were collected and seeds were extracted. These seeds were surface sterilized with 0.5% sodium-hypochlorite solution and then were

**Table 60. Grouping traits in watermelon and muskmelon**

| Watermelon | | | Muskmelon | | |
|---|---|---|---|---|---|
| **Trait** | **State** | **Example variety** | **Trait** | **State** | **Example variety** |
| Sex expression | Monoecious | Arka Manik, Durgapura Lal | Sex expression | Andromonoecious | Kashi Madhu, Pusa Madhuras |
| | Andro-monoecious | AHW-65 | Fruit: rind colour | Yellow | Kashi Madhu, Pusa Sharbati |
| | | | | Yellow Green | Durgapura Madhu |
| | | | | Orange | Arka Jeet |
| Fruit: shape in longitudinal section | Flat globe | Sugar Baby | Fruit: sutures | Absent | Arka Jeet, MHY-3 |
| | Cylindrical | Charleston Grey | | Present | Hara Madhu, Kashi Madhu |
| | Elongated globe | Asahi Yamato | | | |
| Fruit: ground color of skin | Green | Arka Manik, Durgapura Lal | Fruit: surface netting | Absent | Arka Jeet, MHY-5 |
| | | | | Moderate | RM-50, Arka Rajhans, Punjab Sunehri |
| Fruit: colour of flesh | Yellow | Durgapura Kesar | Fruit: flesh colour | Creamish white | Arka Jeet |
| | Reddish Pink | AHW-65 | | Grey orange | GMM-3 |
| | | | | Yellowish green | Durgapura Madhu |
| | Red | Sugar Baby | | Green | Hara Madhu |

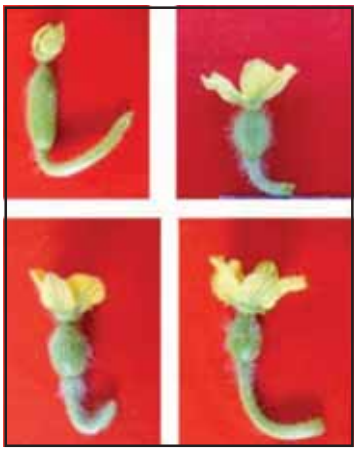


Fig. 49. Ovary traits of watermelon

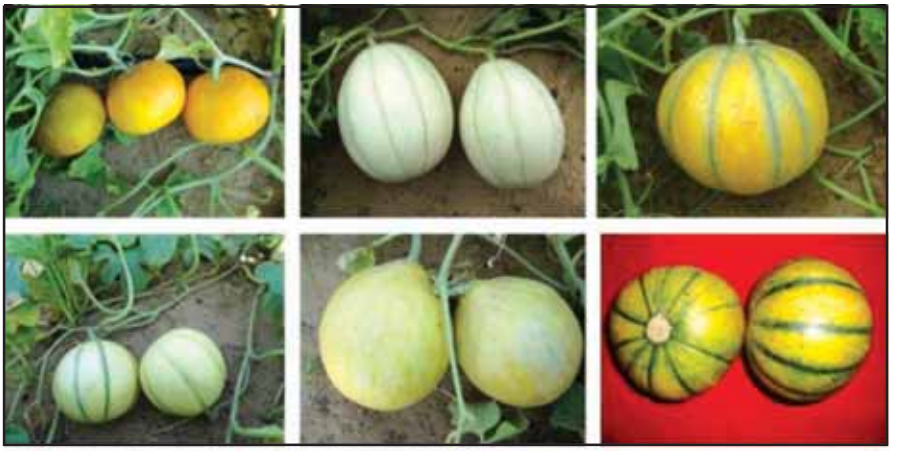


Fig. 50. Fruit traits of muskmelon

subsequently subjected to three washing with sterile distilled water. After surface sterilization, the seeds were inoculated on filter paper bridge in test tubes containing ¼ MS salt solution (15 ml each tube). After 2 weeks of germination at two leaf stage of the seedlings, they were transferred to ¼ MS salt solution with different osmotic potential *viz*., 0MPa, 0.3MPa and 0.49MPa in different experimental sets to examine the visual effects on growth of *Z. nummularia* seedlings for two weeks. Among the treatments, seedlings at 0.3MPa stress were found suitable for transcriptome profiling as they showed mild wilting and longer root growth. However, seedlings at 0.49MPa stress showed leaf blotching and no shoot growth with drying of roots (Fig. 51).

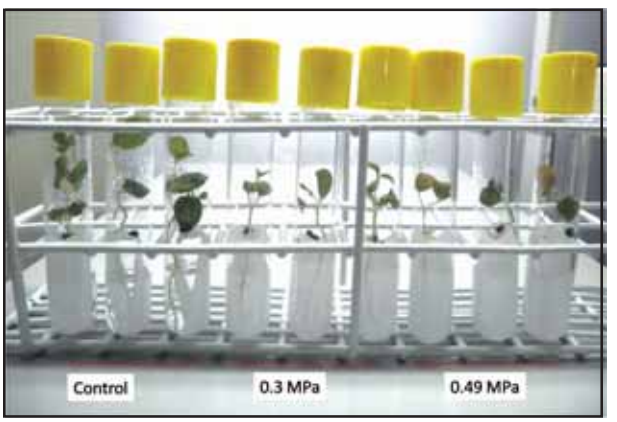



Fig. 51. *In-vitro* screening technique of *Z. nummularia* suitable for low moisture stress tolerance

This technique will be very useful in isolation of drought tolerance gene from *Ziziphus nummularia*.

## Molecular diversity of *Ziziphus* genotypes used for moisture stress tolerance and gene flow estimation

Fruit stones of *Ziziphus nummularia* from three different locations of north-western region of India receiving various amount of average rainfall *viz*., Jaisalmer (less than 150mm), Bikaner (250 to 400mm) and Godhra (more than 750mm) were collected and seedlings were established at the field gene bank of Central Institute for Arid Horticulture (CIAH), Bikaner. Genomic DNA of these three populations of *Z. nummularia* was tested with 27 polymorphic random decamer primers (RAPD) along with *Z. rotundifolia* and *Z. mauritiana*. The average polymorphic percentage revealed by these primers was 92.8 and polymorphic information content was 0.44. Jaccard's similarity co-efficient among *Z. nummularia* population was ranged from 0.69 to 0.76. Phylogenetic analysis based on UPGMA method showed that *Z. nummularia* populations from Jaisalmer and Bikaner were closely related than Godhra and formed one major cluster and populations of *Z. rotundifolia* and *Z. mauritiana* distantly formed separate clusters (Fig. 52). Further, within *Z. nummularia* a total of 241

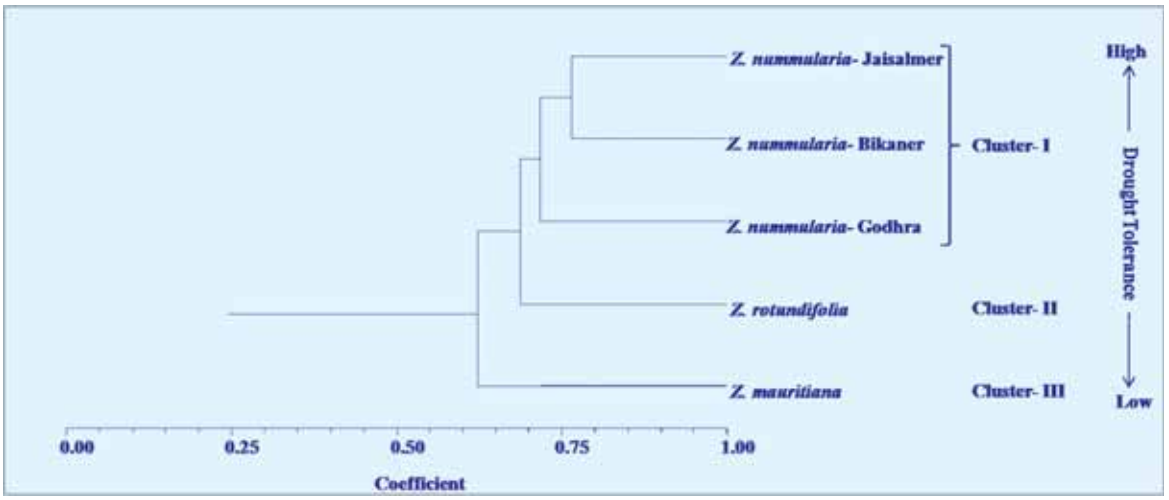



**Fig. 52 Phylogenetic tree constructed based on accessions of different *Ziziphus* species analysed by RAPD primers by UPGMA method using NTSYSpc-2.02e version 2.0.1.5 software. Vertical distance is arbitrary and horizontal distance indicates genetic distance**

bands generated by RAPD primers 220 were polymorphic (91.29) (Fig.53). Nei's gene diversity (*h*) ranged between 0.178 and 0.216 with overall diversity of 0.334 and Shannon's information index (*I*) value recorded between 0.258 and 0.323 with an average of 0.495. The estimated gene flow value (0.697), diversity among populations (0.418) and Fst value (0.419) demonstrated that overall *Z. nummularia* has high genetic diversity within the population and limited gene flow between populations indicate that *Z. nummularia* populations may be well adapted and stabilized according to the local geographical arid and semi-arid eco-system.

Lane M- 1Kb DNA ladder; lane 1 to 5- *Z.nummularia* from Jaisalmer (CIAH-Zn-J 1 to 5); lane 6 to 10- *Z. nummularia* from Bikaner (CIAH-Zn-B 1 to 5); lane 11to 15 – *Z. nummularia* from Godhra (CIAH-Zn-G 1 to 5); lane 16 to 20- Z. rotundifolia (CIAH-Zr 1 to 5); lane 21 to 25- Z.

## Transcriptome Profiling in *Z. nummularia* during low moisture stress

Using standardized *in-vitro* technique, mRNA isolated from leaf samples of control and stressed (0.3MPa) *Z. nummularia* of Jaisalmer genotype.

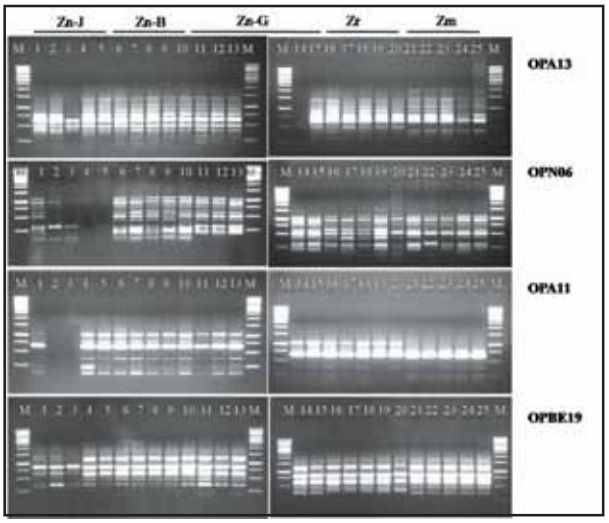



**Fig. 53. Polymorphism among five different genotypes of *Ziziphus* species given by different random decamer primers**

Transcriptome profiling was done and *De novo* transciptome were assembled for both control and stressed plant samples. The trimmed reads were aligned to the assembled transcriptome (length >= 150bp) using Bowtie2 program. Among transcripts identified, 283 transcripts found down regulated and 554 up regulated in comparison to control (Fig. 54 and 55).


**Fig. 54. Heat map of top 20 down regulated transcripts during drought stress (0.3MPa) from BLASTX search is shown**

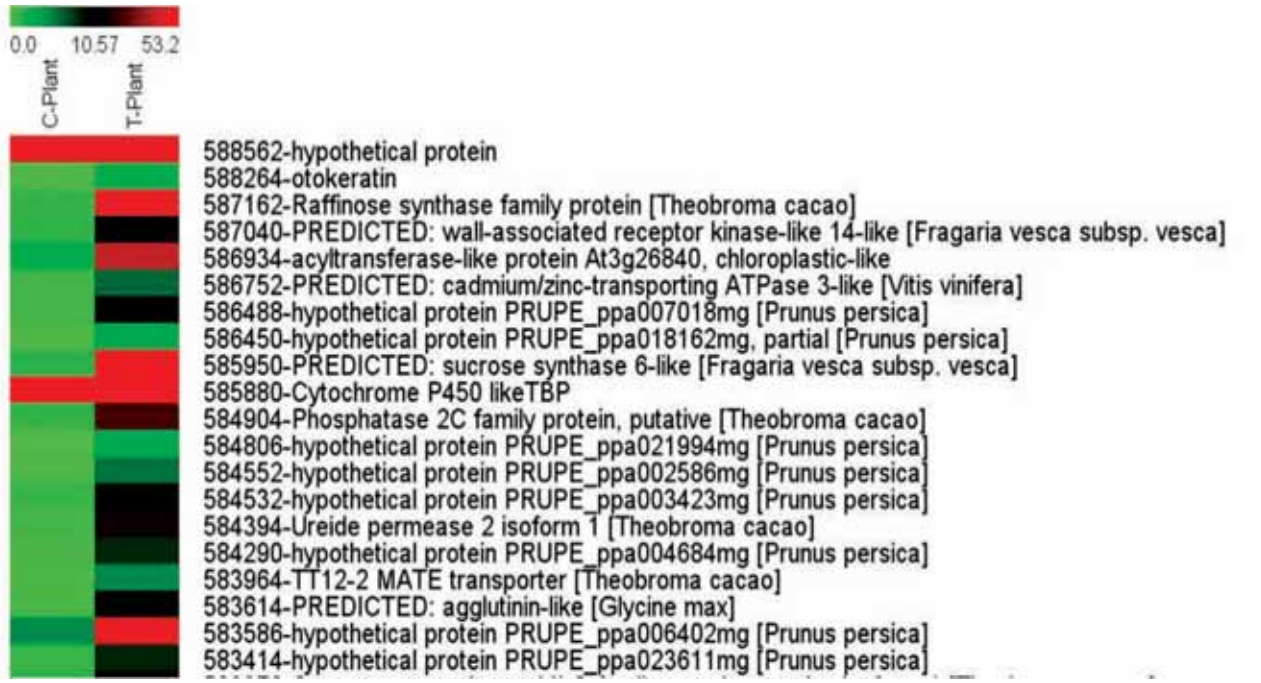



**Fig. 55. Heat map of top 20 up regulated transcripts during drought stress (0.3MPa) resulted from BLASTX search is shown**

## 3. DUS Centre for Date palm horticultural crops

PI: Dr. R. S. Singh

Co-PI: Dr. R. Bhargava

Under DUS centre on Date palm, morphological and fruit characters in 26 date palm varieties were recorded during second year. A wide genetic diversity with respect to plant morphological characters was observed among the date palm cultivars.

Perusal of data revealed that variation in rachis length from 1.21- 3.47 m, leaf length from 1.23 – 3.48m was observed, whereas leaf width ranged from 28.5-77.5 cm. The number of thorns ranged from 8 to 22 per leaf whose length and breadth ranged from 4.02-12.48 cm and 0.13 – 0.47 cm, respectively. The spines showed variation in the shape also which were either needle like or curved. The number of bunches 1-10 per palm and fruit's yield varied from 0.78 -79 kg/plant among germplasm. The number of strands/bunch ranged from 11-72, number of berries/strand varied from 13-39. The maximum number of bunches/ plant were observed in Khalas (10) followed by Sewi, (8) Sabiah (7) and Chip-chap, (6.). The bigger size and fruit weight (23.50g) was observed in cv. Medjool followed by Punjab Red(16.2g) and Khalas (15.10g) and minimum fruit weight 7.50g was in Zahidi. Maximum fruit yield at doka stage was observed in cvs. Khalas (79kg/tree) followed by Dayari (62kg), However, minimum fruit yield (0.78kg/ plant) was observed in cv. Punjab Red possibly due to young plant. The weight of stone varied from 0.7-1.87 g. Variation in TSS and acidity was also observed.

## 4. Validation of DUS descriptors for *ber* (*Ziziphus* sp.)

PI: Dr. Hare Krishna

Co-PI: Dr. R. Bhargava

During the period under report, the 'Draft Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) on Indian Jujube (*Ber*) (*Ziziphus mauritiana* Lamk.)' was submitted following the third meeting of sub task force on special characteristics identification in *ber* held at NAAS Complex, New Delhi on 07.08.2013. In total, 36 characteristics were identified comprising growth habit, leaf, thorn, maturity period, fruit and stone characteristics. These also included seven grouping characteristics [Growth habit (Characteristic 1); Leaf: Shape (Characteristic 5); Fruit maturity group (Characteristic 14); Mature fruit: Shape (Characteristic 18); Mature fruit: Colour (Characteristic 22); Pulp texture (Characteristic 24) and Stone shape (Characteristic 28)] and essential characteristics. A total of 26 reference varieties have been identified for various characteristics. The draft guidelines were also published in PPV&FRA's journal 'Plant Variety Journal' (Vol. 7 (9), September 2, 2013). In addition, database for the 86 varieties have been submitted for inclusion in INDUS (India Database for DUS).

## 5. Revolving fund scheme of ICAR funded seed project

For quality and high seed yield potentials, varietal maintenance and crop production trials on

**Table-61. Seed production in arid vegetable crop varieties at CIAH, Bikaner during 2013-14.**

| Crop - varieties for TFL seeds | Quantity (kg) |
|---|---|
| Kachri (AHK–119) | 127 |
| Snap melon (AHS–82) | 83 |
| Bottle gourd (Thar Samridhi) | 47 |
| Cluster bean (Thar Bhadavi) | 268 |
| Sword bean (Thar Mahi)** | 00 |
| Indian bean (Thar Kartiki)** | 06 |
| Indian bean (Thar Maghi)** | 00 |
| Moringa (AHMO -1)** | 00 |
| **Total** | **531** |

**Complete crop damage at pod maturity (prior to seed harvest) due to frost conditions on 01/01/2014 in the production site.

snap melon (AHS-82), kachri (AHK-119), bottle gourd (Thar Samridhi), Indian bean (Thar Maghi and Thar Kartiki), cluster bean (Thar Bhadavi), sword bean (Thar Mahi) and moringa (AHMO-1-4s) were undertaken adopting HBCPSMA and studied under breeder and TFL seed production crops during 2013–14. About 531.00 kg TFL seed of institute varieties of arid zone vegetables was produced (Table-61) during the period under report for distribution to the farmers, NGO's, KVK's and state and private agencies as initial spread of the varieties and further seed multiplication.

## Godhra

## 6. Validation of DUS descriptors for bael (*Aegle marmelos* Correa)

PI: Dr. A. K. Singh

Co-PI: Dr. Sanjay Singh

Varieties of bael *viz*, CISHB-1, CISHB-2, NB-5, NB-7, NB-9, NB-16, NB-17 Pant Aparna, Pant Sujata, Pant Urvashi, Pant Shivani and Goma Yashi were studied for distinct, uniform and stable characters under rain fed conditions of hot semi-arid ecosystem during the year 2013-14.

### Vegetative characters

### Growth

All the varieties exhibited significant variability among the non-measurable morphological characteristics. Among the varieties CISHB-1 and NB-16 had Upright habit; CISHB-2, Pant Sujata, NB-5, NB-7 and Goma Yashi had semi-spreading habit; Pant Urvashi, NB-17 and NB-9 had spreading habit, whereas Pant Aparna, Pant Shivani had drooping type tree growth habit. Based on density of foliage, all varieties can be categorized as dense, sparse and compact. Dense foliage was observed in Pant Aparna, Pant Sujata, Pant Shivani, NB-5, NB-7 and Goma Yashi, sparse in CISHB-1, CISHB-2, NB-16, NB-17 whereas compact was observed in Pant Urvashi and NB-9 under rainfed condition of western India.

### Bark characters

Variation in bark colour and splitting pattern was observed among the varieties, bark colours were observed yellowish grey in CISHB-1, GomaYashi and NB-17, greyish yellow in CISHB-2, Pant Shivani, blackish grey in Pant Aparna, Pant Sujata and grey in NB-5, NB-7, NB-16 whereas it was dark grey in Pant Urvashi and NB-9, but all the varieties showed more or less similar splitting pattern of bark which was irregular intersecting striations having either small rectangular or square triangle blocks.

### Leaf characters

### Leaf shape

Non-measurable characters of leaf shape varied in respect of leaflet shape, margin, leaf base, texture and colour in the leaves of different bael varieties. In certain varieties like, NB-5 and NB-9 central and lateral leaflets both showed variations with respect to their shapes. The leaflet shape of Pant Aparna, Pant Shivani and Pant Urvashi were ovate, whereas in CISHB-1 it was ovate to lanceolate, CISHB-2 was elliptical to ovate, Pant Sujata was broadly ovate to cordate, NB-9 was elliptical to lanceolate and NB-16 was ovate to lanceolate. In NB-5, central leaflet observed ovate to elliptic and lateral leaflet was elliptical and in NB-17, the central leaflet was observed elliptical and lateral leaflet was ovate.

### Leaf apex

Results of study on the visual observation of the leaf apex, the varieties showed four types of leaf apex *viz.*, acute, subacute, acuminate and aristate type. Varieties *viz.*, CISHB-1, NB-7, NB-5 and NB-17 had acuminate apex; Pant Aparna (sub acute), Pant Sujata, Pant Urvashi, Pant Shivani and NB-16 had acute type, however in certain varieties central

and lateral leaflet also exhibited variations in CISHB-2 and NB-9, which had acuminate in central leaflet and acute in lateral leaflets had leaf apex. GomaYashi had slightly aristate to acuminate in central leaflet and acuminate leaf apex in lateral leaflet under rainfed semi-arid region of western India.

## Leaf base

Almost all the varieties had cuneate type of leaf base but the degree of angle varied i.e. broadly cuneate and narrowly cuneate (tapering). The broadly cuneate leaf base was observed in Pant Aparna and Pant Shivani whereas narrowly cuneate was observed in NB-9, NB-16 and CISHB-1 (with tapering), but CISHB-2 and Pant Urvashi had rounded type of leaf base, however CISHB-1 had narrowly cuneate leaf base but oblique from one side, while in NB-7 central leaflet was narrowly cuneate and laterals had slightly attenuate leaf base whereas NB-17 had narrowly cuneate and Pant Shivani had broadly cuneate type central leaflet leaf base but lateral leaflet had rounded leaf base under semi-arid ecosystem of western India.

## Leaf margin

Among the varieties, leaf margin in CISHB-1, GomaYashi and Pant Urvashi had crenulate superficially, whereas NB-16, NB-17 and Pant Sujata had crenulate prominently, CISHB-2 was bicrenated prominently, Leaf margin of NB-7 and Pant Aparna were crenate prominently type whereas crenate superficially was observed in NB-9, NB-5, and Pant Shivani under semi arid ecosystem of western India.

## Leaf colour and leaf texture

There were significant differentiation into the dorsal and ventral colour of the leaflet and texture. Varieties CISHB-1, Pant Sujata, NB-9 and NB-16 were dark green coloured at both the side and shiny smooth excluding CISHB-1 which had dull, rough surface. The leaf colour in CISHB-2, Pant Aparna, NB-7 and Goma Yashi was dark green at dorsal surface and light green at ventral surface; texture was dull papery rough, shiny smooth, and dull smooth, respectively. Pant Urvashi and Pant Shivani had light green at both the side and texture was shiny smooth and dull rough, respectively. The leaf colour was light green at both side in Pant Urvashi and Pant Shivani and texture was shiny smooth and dull rough, respectively. In NB-17, dorsal side green and ventral side pale green and texture was papery dull rough under semi arid ecosystem of western India.

## Leaf length

Results of study revealed that the variety NB-7 (26.06 cm) had the longest leaf as compared to other varieties, whereas the shortest leaf was measured in NB-9 (15.35 cm) followed by CISHB-1 (15.54 cm). The length and width of central leaflet lamina ranged between 9.71-20.05 cm and 5.93-10.72 cm respectively, while the length and width of right lateral leaflet lamina ranged between 7.03-15.00cm and 3.50-8.27cm respectively. The length and width of left lateral leaflet lamina varied between 7.32-14.52 cm and 3.30-7.32 cm respectively being highest in NB-7 and the lowest in NB-16 among the varieties.

## Leaf thickness

The entire three leaflets had uniform thickness in each variety. The thickness in various cultivars ranged between 0.03-0.06 cm. The maximum value for leaf thickness (0.06 cm) was measured in Pant Aparna, Pant Urvashi, NB-5 and Goma Yashi but it was recorded minimum (0.03 cm) in both the cultivars Pant Sujata and Pant Shivani. The mean leaf thickness was observed 0.4 cm in NB-7, NB-16 and NB-17 under rainfed semi- arid condition of western India.

## Petiole length

Results of study revealed that the central petiolule length was measured maximum in CISHB-2 (3.96 cm) and it was minimum in Goma Yashi (1.50

cm) whereas the central petiolule width was found the highest in NB-5 (0.38 cm) followed by CISHB-2 (0.28 cm) and it was recorded the lowest in Pant Urvashi (0.8 cm) followed by NB-9 (0.11 cm) and Goma Yashi (0.12 cm) and NB-17 (0.13 cm). In all the varieties, lateral petiolule of both the leaflets had more or less small stalk which ranged between 0.3-0.7cm which could be designated as sessile in all the varieties. Petiole length and thickness ranged between 2.97 -5.73cm and 0.10, respectively. The distance between two internodes ranged between 3.00- 4.56 cm which was measured the maximum in NB-7 (4.56 cm) followed by NB-9 (4.53cm) and Pant Aparna (4.51 cm) whereas it was recorded the minimum in NB-5 (3.0 cm) followed by NB-16 (3.20 cm) under rainfed semi arid condition of western India.

## Phyllotaxy

The study on arrangement of leaves on the shoots (phyllotaxy) revealed that the various bael varieties had tristichous (1/3 phyllotaxy) type of phyllotaxy was commonly noted in CISHB-2, Pant Urvashi, Pant sujata, NB-5, NB-16, NB-17 and Goma Yashi whereas pentastichous (2/5 phyllotaxy) was observed in CISHB-1, Pant Aparna, Pant Shivani, NB-7 and NB-9 type however the phyllotaxy was specific to each variety under rainfed semi arid condition of western India.

## Fruit characters

Results of study on the quantitative and qualitative characters of fruits of different bael varieties showed differences for the physico-chemical parameters studied under rainfed conditions of western India.

## Stem and styler end cavity

Various other characters also ranged variedly as the bearing behaviour (shy to prolific bearer), maturity period (February to July) and flesh colour (creamy-yellow, whitish yellow, deep yellow and lemon colour), styler end cavity (sunken, depressed, highly depressed, slightly raised, levelled and shallow) and stem end ( narrowly raised, curved depressed), fruit surface (smooth, rough, shiny, dull), etc. among the genotypes. Thus, there is a wide genetic base available for choice of various desirable traits for amelioration of cultivated bael by developing new varieties.

## Quantitative

Fruit weight was recorded the highest in NB-7 (4.25 kg) followed by Pant Urvashi (2.90 kg), CISH-B-2 (2.58 kg) and Pant Shivani (2.45 kg), whereas the lowest fruit weight was recorded in NB-16 (0.43kg) followed by CISH-B-1 (0.96 kg). Fruit length (19.59cm) was found to be highest in CISH-B-2 and the same was recorded the lowest in NB-16 (10.61) followed by Pant Aparna and Pant Sujata. The maximum fruit width (22.00 cm) was measured the maximum in NB-7 followed by Pant Urvashi (19.40 cm), CISH-B-2 (17.50 cm) and Pant Shivani (16.30cm) and it was the minimum in NB-16 (9.40cm) followed by CISH-B-1.The maximum fruit girth (70.00 cm) was exhibited by NB-7 followed by Pant Urvashi (61.70 cm) and CISH-B-2 (54.12 cm) and the same was observed the lowest in NB-16 (29.10cm) followed by CISH-B-1 (34.53cm), Pant Sujata (41.25cm), Pant Aparna (43.30cm), NB-5 (43.20cm) and Goma Yashi (44.20cm).

## Physical composition

Shell weight, thickness, pulp content, total number of seed, seed sacs, fresh weight of seeds and fibre weight ranged between 115.25-510.75g, 0.16-0.31cm, 0.27-3.67 kg, 90.34-212.25, 10.23-19.17, 17.34 - 43.41 gm and 30.12-106, respectively.

## 7. Characterization of aonla varieties for developing DUS test guidelines

Co-Nodal Centre

Co-PI: Dr. A. K. Singh

A total of 10 aonla varieties were evaluated for morphological and quality characters. A wide

genetic diversity with respect to plant morphological characters was observed among the aonla varities *viz*. vegetative growth, leaf characters, fruit characters, fruit quality characters and seed characters.

## Vegetative characters

Almost all the varieties had significant different in vegetative characters like tree habit, it was observed upright spreading in Banarasi, Krishna, Chakaiya, tall, upright in Anand-1, Aanad-2 ,tall spread in NA-7, tall drooping in Francis, tall semi-spreading in Kanchan and tall, drooping in Francis. Plant height was observed maximum Anand-2 (4.67m) while it was observed minimum in Kanchan (3.59m) followed by Chakaiya(3.78 m).The foliage in Banarasi, Chakaiya, Krishna, Kanchan,Anand-1 and Anand-2 had sparse type whereas in Francis,NA-7, NA-10 had dense type.

The leaf shape was oblong in Banarasi, Krishna, Chakaiya, NA-10, Anand-1 and Anand-2, Oval oblong in Francis and Kanchan and elliptical was observed in NA-7. The leaf apex was mainly two kinds i.e., acute and obtuse. All the varieties had obtuse leaf apex excluding Chakaiya and Kanchan. The leaf length was observed maximum in Chakaiya (1.45 cm) and NA-7(1.39 cm) and it was recorded minimum in Francis and Anand-2(1.25 cm) followed by NA-10 (1.28cm) and Krishna (1.29 cm).The leaf width was measured maximum in Banarasi (0.37 cm) followed by Francis and Kanchan (0.32 cm) whereas same was recorded minimum in Anand -2 (0.23 cm) followed by Anand-1 (0.26 cm) (Table 62.)

## Physical characters of fruit

The fruit shape had great variation among observed varieties (Table 63).The fruit shape was triangular in Banarasi and Krishna, flattened round in Francis, NA-7, Chakaiya and Kanchan, whereas flattened oval in Anand -1 and Anand-2. Fruit stalk end was short and thick in Banarasi, Krishna and NA-7 whereas short and thin in Francis, Chakaiya, Kanchan, Aanand-1 and Anand-2. Fruit stem end cavity was shallow and deep kind, shallow was observed in Banarasi, Francis, Chakaiya, Kanchan, Anand-1 and Anand-2 whereas it was deep in Krishna and NA-7.Styler end was levelled in Banarasi, Francis, Chakaiya and Kanchan, prominent in Krishna and less prominent in NA-7, Anand-1 and Anand-2. Fruit ridges on stem end were observed less prominent in all the observed varieties excluding Banarasi and NA-10 which had prominent ridges on stem end. Number of segments in all the varieties had six but in some varieties like Krishna and Kanchan had 6-8 segments in the fruits. Fruit set was recorded the highest in Kanchan (5.78)

**Table 62. Vegetative characters of different aonla varieties**

| Characters | Banarasi | Krishna | Francis | Chakaiya | Kanchan | NA-7 | Anand-1 | Anand-2 |
|---|---|---|---|---|---|---|---|---|
| Tree habit | Upright | Upright | Tall | Upright | Tall | Tall | Tall | Tall |
| Tree height (m) | 3.93 | 3.59 | 4.34 | 3.78 | 4.31 | 4.55 | 4.52 | 4.67 |
| Tree form | Spreading | Spreading | Drooping | Spreading | Semi-spreading | spreading | Upright | Upright |
| Foliage | Sparse | Sparse | Dense | Sparse | Sparse | Dense | sparse | Sparse |
| Leaf length (cm) | 1.36 | 1.29 | 1.25 | 1.46 | 1.33 | 1.39 | 1.27 | 1.25 |
| Leaf width (cm) | 0.37 | 0.31 | 0.32 | 0.30 | 0.32 | 0.30 | 0.26 | 0.23 |
| Leaf Shape | Oblong | Oblong | Oval Oblong | Oblong | Oval oblong | Elliptical | Oblong | Oblong |
| Leaf apex | Obtuse | Obtuse | Obtuse | Acute | Acute | Obtuse | Obtuse | Obtuse |

**Table 63. Morphological characteristics of fruits of different a*onla* varieties**

| Characters | Banarasi | Krishna | Francis | NA-7 | Chakaiya | Kanchan | Anand-1 | Anand-2 |
|---|---|---|---|---|---|---|---|---|
| Fruit shape | Triangular | Triangular | Flattened Round | Flattened Round | Flattened Round | Flattened Round | Flattened oval | Flattened oval |
| Fruit stalk | Short and thick | Short and thick | Short and thin | Short and thick | Short and thin | Short and thin | Short and thin | Short and thin |
| Fruit stem end cavity | Shallow | Deep | Shallow | Deep | Sallow | Shallow | Shallow | Shallow |
| Fruit ridges on stem end | Prominent | Less Prominent | Less Prominent | Less Prominent | Less Prominent | Less Prominent | Less Prominent | Less Prominent |
| Styler end | Levelled | Prominent | Levelled Prominent | Less | Levelled | Levelled | Less Prominent | Less Prominent |
| No. of segments in fruits | 6 | 6-8 | 6 | 6 | 6 | 6-8 | 6 | 6 |

followed by NA-7 (4.98) and same was the lowest in Banarasi (1.98) followed by Chakaiya (2.34). Fruit size was large, medium and small. Fruit was observed large in Banarasi, Krishna, Francis, medium in NA-7, Chakaiya and small in Kanchan, Anand-1 and Anand-2.

## Quantitative characters

Physical attributes (Table 64) of fruit *viz*., fruit weight ranged from 24.15-33.90gm. The maximum fruit weight was observed in Banarasi (33.90 gm) followed by NA-7(33.76 gm) and it was measured the minimum in Kanchan (25.94 gm).The fruit length ranged between (3.07-3.73 cm) which was observed the maximum in NA-7(3.73 cm) followed by Krishna (3.70cm) whereas same was observed minimum in Francis (3.07 cm) followed by Anand-1 and Anand -2 (3.10,3.12cm, respectively). Fruit width ranged from (3.40-4.37cm), the maximum thickness was observed in Krishna (4.37 cm) followed by NA-7 and Chakaiya (4.00 cm) and the minimum was observed in Francis (3.40 cm) followed by Anand-2 (3.41 cm) and Anand -1 (3.45 cm)

## Qualitative characters

The juice content amongst all the observed varieties was maximum in Balwant (51.56 %) followed by Kanchan (48.92 %) and NA-7 (46.45%) same was observed minimum in Francis (39.52%) followed by Chakaiya (40.34%) and Banarasi (43.00%). The level of astringency was high and medium type among all the variety. The acidity ranged between 1.34-2.56 %, and it was estimated maximum in Kanchan (2.56%) followed by Krishna

**Table 64. Quantitative characters of fruit of different *Aonla* varieties**

| Characters | Banarasi | Krishna | Francis | NA-7 | Chakaiya | Kanchan | Anand-1 | Anand-2 |
|---|---|---|---|---|---|---|---|---|
| Fruit set(%) | 1.98 | 4.05 | 4.56 | 4.98 | 2.34 | 5.78 | 3.88 | 3.98 |
| Fruit size | Large | Large | Large | Medium | Medium | Small | Small | Small |
| Fruit length (cm) | 3.62 | 3.70 | 3.07 | 3.73 | 3.35 | 3.82 | 3.10 | 3.12 |
| Fruit width (cm) | 3.93cm | 4.37 | 3.40 | 4.00 | 4.00 | 3.99 | 3.45 | 3.41 |
| Fruit weight (g) | 33.90 | 33.56 | 30.41 | 33.76 | 30.66 | 25.94 | 28.53 | 26.63 |

(2.36 %) whereas same was observed minimum in Anand-1 followed by Anand-2 (1.67 %).The maximum pulp contents was recorded in Kanchan (35.98%) whereas it was found minimum in Francis (27.78%) followed by Chakaiya (30.45%).The vitamin C content estimated among all the varieties ranged between 334.12- 461.76 mg /100gm. It was observed maximum in NA-7 (453.20 mg/100gm) whereas it was found minimum in Banarasi (334.12mg/100gm) followed by Francis (345.34 mg/100gm) and Krishna (352.45 mg/100gm). The Total soluble sugar value was recorded the maximum in NA-7 (21.1% Brix) followed by Anand-1 (12.93% Brix) and Anand-2 (12.54% Brix), respectively whereas same was found minimum in Banarasi (7.55% Brix) followed by NA-10 (8.50% Brix). The value of specific gravity was ranged between 1.13-1.43, being maximum in Banarasi (1.42) same was recorded minimum in Francis (1.06) followed by NA-7 (1.13) (Table 65).

In addition to fruit quantitative and qualitative characters, there were also found variability in case of fruit stone shape, stone size and seed size (Table 66). Stone shape was triangular in Banarasi, Krishna, Round in Chakaiya, Kanchan, Anand-1and Anand-2, oval in Francis and oval round in NA-7. Stone and seed size was categorized into large, medium and small. Large stone and seed size was observed in Banarasi, Krishna, NA-7 whereas it was observed small in Chakaiya, Kanchan, Anand-1, Anand-2 and rest of the varieties had medium seed shape and stone size. In case of fruit pulp colour insignificantly varied from whitish green to yellowish green. Mostly all the observed variety shown whitish green coloured flesh excluding Krishna which had yellowish green colour.

**Table 65. Fruit Qualitative characters of different a*onla* varieties**

| Characters | Banarasi | Krishna | Francis | NA-7 | Chakaiya | Kanchan | Anand-1 | Anand-2 |
|---|---|---|---|---|---|---|---|---|
| Juice (%) | 43.00 | 45.12 | 39.52 | 46.45 | 40.34 | 48.92 | 48.67 | 45.34 |
| Astringency | Medium | High | Medium | Medium | High | Medium | Medium | Medium |
| Pulp (g) | 26.80 | 36.30 | 27.78 | 39.68 | 30.45 | 35.98 | 34.78 | 35.76 |
| TSS % | 7.55 | 8.90 | 12. 70 | 21.10 | 10.63 | 10.22 | 12.93 | 12.54 |
| Acidity (%) | 2.23 | 2.36 | 1.98 | 2.16 | 2.15 | 2.56 | 1.34 | 1.67 |
| Vitamin-C(mg 100/ g pulp) | 334.12 | 352.45 | 345.34 | 453.20 | 399.76 | 427.27 | 419.45 | 414.78 |
| Specific gravity | 1.43 | 1.25 | 1.06 | 1.13 | 1.29 | 1.34 | 1.35 | 1.30 |

**Table 66. Seed characters of different *Aonla* Varieties**

| Characters | Banarasi | Krishna | Francis | NA-7 | Chakaiya | Kanchan | Anand-1 | Anand-2 |
|---|---|---|---|---|---|---|---|---|
| Stone shape | Triangular | Triangular | Oval | Oval round | Round | Round | Round | Round |
| Stone size | Large | Large | Medium | Large | Small | Small | Small | Small |
| Seed | Large | Large | Medium | Large | Small | Small | small | small |
| Flesh colour | Whitish green | Pinkish to yellowish green | Whitish green | Whitish green | Whitish green | Whitish green | Whitish green | Whitish green |

Thus, the aonla cultivars can be identified using qualitative as well as quantitative characters of vegetative, fruit and seed which can be used for developing descriptor of different aonla varieties.

## 8. Development of morphological descriptors and DUS test guide lines for jamun.

Co-Nodal Centre

Co-PI: Dr. Sanjay Singh

Detailed characters like vegetative and fruiting attributes were recorded to develop the DUS descriptor. Total 10 genotypes were studied. It was observed that CHESJ-9 and CHESJ-10 were found to spreading type, while CHESJ-11 and CHESJ-12 were found to semi- spreading type. Leaf was elliptical lanceolate in CHESJ-9 and CHESJ-10, while it was broadly elliptical in CHESJ-11. Leaf length was 16.80 cm, 18.10 cm,17.60 cm and 16.80 cm in CHESJ-9, CHESJ-10, CHESJ-11 and CHESJ-12 respectively. Leaf breadth was 8.40 cm, 9.30 cm,7.70 cm and 8.40 cm in CHESJ-9, CHESJ-10, CHESJ-11 and CHESJ-12 respectively. Fruit shape of CHESJ-9, CHESJ-10 and CHESJ-11 was oblong, while it was Ovoid in CHESJ-12. TSS (Degree Brix) was recorded 16.00,17.20, 15.40 and 15.80 in CHESJ-1, CHESJ-2 CHESJ-3 and CHESJ-4 respectively.

## 9. Validation of DUS descriptors for chironji and tamarind.

Nodal Centre

PI: Dr. Sanjay Singh

Co-PI: Dr. R. Bhargava

Total 10 genotypes/ cultivars were studied**.** All cultivars were having semi- tall character. PKM-1, T-263 and Goma Prateek had semi spreading type growth habit, while Pratisthan was of drooping type growth pattern. Number of leaves/shoot (Annual extension growth) was 42.00,40.12,41.00 and 34.10 in PKM-1,Pratisthan, T-263 and Goma Prateek respectively. Length of panicle was 12.00 cm, 10.00 cm,13.40 cm and 15.50cm in PKM-1,Pratisthan, T-263 and Goma Prateek respectively. Number of fruits per panicle was 3.00,4.10, 3.10 and 3.80 in PKM-1,Pratisthan, T-263 and Goma Prateek respectively. Fruit colour was brown in PKM-1, T-263 and Goma Prateek, while it was reddish brown in case of Pratisthan.

## 10. Identification, collection, characterization, evaluation and conservation of Noni (*Morinda* spp.) of western India (Gujarat and M.P.)

PI: Dr. A. K. Singh

Co-PI: Dr. Sanjay Singh, Sh. H. K. Joshi

*In-situ* evaluation and characterization of different genotypes of noni (Gujarat and M.P.).

### Vegetative characters

Results of study on the vegetative characters of different *M. tomentosa* genotypes varieties exhibited wide variations in their morphological characters viz., plant height, stem girth, plant spread and number of primary and secondary branches under rainfed conditions of western India.

### Growth

The differences in plant height stem girth, plant spread, and number of primary and secondary branches varied between 03.10-4.70 m, 19.10-36.08 cm, 2.32-3.82 m, 6.32-13.45 and 12.15-26.00, respectively. The vegetative characters like plant height (4.70m), stem girth (36.08cm) and plant spread (E-W-3.82 m and N-S-3.822m) were recorded the maximum in CHESN-13, CHESN-5 and CHESN-16, respectively, while the characters like number of primary branches and secondary branch were observed maximum in CHESN-12 (13.45) and CHESN-26 (26.00), respectively whereas the same were minimum in CHESN-38 (6.28) and CHESN-34 (12.12).

## Yield

The fruit yield/tree was conspicuously maximum in CHESN-1 (9.41kg) followed by CHESN-27 (9.12kg), whereas minimum in CHESN-21 (3.50kg). The fruit weight was observed the maximum in CHESN-1 (47.10g), whereas it was found minimum in CHESN-15 (18.99g).

## Fruit characters

Fruit length (4.80 cm) was measured conspicuously highest in CHESN-1 and same was the lowest in CHESN-22 (2.49 cm) followed by CHESN-12 and CHESN-34. Fruit breadth was recorded the maximum in CHESN-16 and CHESN-35 (3.92 cm) and the least breadth was observed in CHESN-22 (2.34 cm) followed by CHESN-12 (2.43 cm). The number of pyrines/fruit were maximum in CHESN-1 (23.95) followed by CHESN-16 (23.20) and the minimum was observed in the genotype CHESN-22 (10.95) followed by CISHN-13 (12.18). Total number of seed per fruit was counted the maximum in CHESN-36 (50.65) followed by CHESN-35 (50.12) and CHESN-19 (41.89), whereas minimum seeds recorded in CHESN-12 (25.17). Total fresh seed weight was recorded maximum in CHESN-12 and CHESN-26 (0.11 g) and minimum in CHESN-2, CHESN-4 and CHESN-29 (6.00 g). Fruit acidity was estimated maximum in CHESN-23 (1.51%) followed by CHESN-8 (1.48%) and CHESN-33 (1.31%) and it was minimum in CHESN-39 (1.16%) followed by CHESN-22 (1.18%) and CHESN-16 (1.47%). Vitamin 'C' content was found the maximum in CHESN-1 (40.15mg/100g) followed by CHESN-16 (38.84 mg/100 gm) and the same was recorded the minimum in CHESN-22 (21.15 mg/100gm) followed by CHESN-23(22.00mg/100gm). $P^H$ of the fruit juice was estimated highest in CHESN-9 (7.00) followed by CHESN-21 (5.50) and the lowest was recorded in CHESN-7 (3.50) followed by CHESN-27 (3.52). The total soluble solids in pulp were recorded maximum in CHESN-1, CHESN-12, CHESN-33 (12.00° Brix) and minimum in CHESN-15 (6.00° Brix).

## Biochemical characters

The biochemical composition of *Morinda* fruit consisted of protein, Ca, K, Na, Zn, Vitamin-C, tannin and phenol varied between 0.09-0.29g, 90.10-102.00 mg, 36.12-49.92mg, 80.16-93.90mg, 0.10-0.29, 0.29-0.92mg, 0.25-0.46g and 11.12-19.01 mg respectively in different genotypes of *Morinda*. The highest content of protein were found in CHESN-1 and CHESN-35 (0.29g) followed by CHESN-23 (0.27g) whereas minimum in CHESN-32.The minimum calcium content was observed in CHESN-33 (90.10mg) and maximum in CHESN-31 (102.00mg) while the maximum potassium was recorded in CHESN-1 (49.92mg) followed by CHESN-16 (46.84mg) whereas the minimum of the same was recorded in CHESN-26 (36.12). The Na content was recorded maximum and minimum in CHESN-24 (93.90mg) and CHESN-31 (80.16mg), respectively. The highest content of Zn was found in CHESN-1 (0.29mg) followed by CHESN-29 (0.28mg), whereas the minimum in CHESN-14 (0.10 mg). The maximum tannin content f was found in CHESN-20 (0.46g) followed by CHESN-13 (0.44g) whereas minimum was observed in CHESN-1 (0.25). Similarly, phenols was recorded the maximum in CHESN-28 (19.01mg) and minimum in CHESN-2 (11.12mg).

Based on the observations, it may be inferred that the *M. tomentosa* can successfully be grown commercially without irrigation under rainfed conditions of western India. Among the evaluated varieties, the varieties CHESN-1, CHESN-16 and CHESN-31 for were found to be superior among the genotypes evaluated under rainfed conditions of western India.

## Multiplication and conservation of collected genotypes of noni (*Morinda spp.*)

Seeds of all the established genotypes were collected and sown in nursery. Seed shown during monsoon recorded 40.17% germination in *M. tomentosa (Aledi)*.More than 90 per cent success

has been achieved by air layering in the month of July. All the genotypes are growing well under rainfed condition of hot semi-arid ecosystem.

## Identification of pests and diseases and their management

*Morinda tomentosa is* known to grow wild in Gujarat region and locally known as '*Aledi'*. It is known to be a hardy plant and is almost free of major severe diseases. During past few years, it has been found infected with some diseases which are of moderate severity in nature but sometimes thought to pose limitation in its cultivation. These include anthracnose or shot holes, *Alternaria* and *Helminthosporium* blights and fungal fruit rots.

This is frequently seen in the foliage of *M .tomentosa.* It is characterized by brown, irregular spots on leaves which gradually increase in size up to 2 cm or more and the central portion of the spot shows necrosis and ultimately dries up and blows away with wind current leading to formation of the shot holes. The necrosed portion shows small dark /dots which are fungal structures. *Noni* is found relatively free of its incidence.

### Causal organism

Its causal organism was identified as *Colletotrichum gloeosporiodes*.

### Disease severity

The disease severity (measured as per cent disease Index, PDI) was categorized as mild (PDI =2.2-4.1).

### Management

The Pathogen is a common soil/seed borne fungus having diverse host range, hence management practices for common anthracnose were found to be applicable as follows.

1. Spraying the plant with Bavistin (Carbendazin, 50WP@1g/l) twice at fortnightly interval commencing from onset of disease during monsoon season (July/August) showed 65-70 per cent disease reduction.
2. Removal /plucking of affected leaves and destruction.
3. Removal of host weeds which harbor the disease.
4. Several other fungicides viz. mancozeb (0.2%), Copper oxychloride 50 wp (0.3%) and Contaf (hexaconzole) (0.1%) also controlled the disease effectively.

## 2. Alternaria leaf blight

It is characterized by appearance of small, round to irregular, light brown or straw colored spots on leaves which show zonations on enlargement. The centre of spots shows a dark point. When 2-3 adjacent spots enlarge to about 10-15 mm size, they coalasce and cover large area giving an appearance of blight on leaves.

### Disease severity

The average severity was 4.2-6.5(PDI)

### Causal Organism

The causal organism is *Alternaria alternata*, which is a common soil and seed borne fungus of a large number of crops and weed plants.

### Management

1. Spray with Chlorothalonil 50wp or mancozeb 75wp @ 2g/l twice in rainy season as stated in case of anthracnose.
2. Removal of affected weeds from the vicinity of orchards.

## 3. White leaf spots

This is commonly seen in the orchard although with very less severity. It is characterized by appearance of several discrete, small (1-4 mm size), round, white spots on leaf lamina. The spots show a distinct but thin dark colored margin.

## Disease severity

The disease severity was categorized as mild (PDI=0.5-1.5).

## Causal organism

The causal organism was identified as *Helminthosporium* spp. Its incidence was very low; hence no control measures were applied.

### 4. Rhizopus fruit rot

The fruit rot mainly affected the fruits during storage period and it was rated as major disease with incidence 15-20 per cent. The affected fruits showed soft straw colored discoloration on their surface, (mostly pyrines near the round ends), which gradually increased, and soon (with in 2-3 days) covered entire fruit .The disease often started from injury. The affected fruit emitted a characteristic bad odour on putrification, and on microscopic examination profuse fungal growth can be seen. Even with naked eyes, several affected fruits showed greyish brown fungal threads. It also affected *Noni*.

**Diseases severity:** The disease severity was **(**PDI=15- 20 )

## Causal organism

The causal organism was identified as *Rhizopus arrhizus*.

## Management

Although perfect disease control was not achieved but avoidance of injury, spraying the fruits with copper oxychloride and culling away of the infected fruits were found reducing the disease severity.

### 4. Sclerotium leaf blights

It was characterized by formation of large, irregular zonate, greyish brown spots on leaves with characteristic dark centre having light brown concentric encircling .The spots showed low average severity.

## Disease severity

The Disease severity was mild (PDI = 1.5-2.5).

## Causal organism

*Sclerotium* sp. was found associated with disease.

## Management

Spray with Bavistin (0.1) or copper oxychloride (0.3%) during rainy season helped in managing the disease.

### 5. Fusarium leaf blight

The spots were round, measured about 0.7-1.2 cm in diameter, generally bound by veins and were having more dark color than the sclerotial blight. An average incidence was very low (0.5-0.7 %)

## Causal organism

The causal organism resembled *Fusarium moniliformae* in morphology.

### 6. Aspergillus on leaves

The dark, zonate spots were also found infected with *Aspergillus* spp; the conidiophore of the fungus was found anchoring epidermal tissue. The exact nature of this disease as also of the nature of the pathogen needs to be well understood.

### 7. New malady (hairy vein banding)

The Noni plants were found affected with a new, uncharacterized malady from this region. The affected plants showed leaves with abnormal curling and deformities in lamina. The veins were unusually thickened and a red color hairy growth was seen. On microscopic examination, a microscopic arthropod was found associated with it. The

organism was white to slightly pale in color and moved very fast. However, compared to the high intensity of the disease and low population of the organism, more investigations are needed to work out the disease.

## 8. Leaf eating Caterpillar

An unidentified leaf eating caterpillar known as hairy caterpillar was also found feeding on leaves and cutting the leaves.

## Performance of *Morinda citrifolia* L. under rainfed condition

The plant height, stem girth and plant spread varied between 2.45-2.78 m, 16.00 cm to 20.00 cm and 2.15 m -2.05 m, respectively. Leaf length varied in a range of 24.35 cm to 37.50 cm and leaf breadth from 16.50 cm to 21.19cm. Fruit quality attributes of *Morinda citrifolia* in terms of fruit girth, fruit length, fruit breadth, total number of fruits, fruit weight, number of seed/ fruit, seed weight, total seed weight /fruit, pulp weight, juice(%) and fruit yield per plant ranged between 10.10-13.50 cm 5.60 - 8.70 cm, 3.15 to 5.00 cm, 140 to 250, 0.04-0.06g, 5.50-8.85g, 32.12- and 47g, 40.00-45 per cent, 50 kg to 6.30 kg, respectively during 3$^{rd}$ year of orchard life purely under rainfed conditions of hot semi-arid ecosystem. The TSS, acidity, vitamin C and pH of juice varied from 6.5-9.50$^{0}$ brix, 0.22-0.30, 98-110 mg/100ml juice and 5.00-6.00, respectively. The colour of fruit turned greenish white to whitish brown in colour during ripening. Cessation in growth of plant, curling, twisting and shrinking of leaves was observed during summer (May- June), but plants regained their normal growth during monsoon. It may be one of the reasons to endure against dry climate particularly during summer.

# 8. PUBLICATION

## RESEARCH PAPERS


Bagle, B. G., Singh, A. K., Singh, Sanjay, Joshi, H.K., and Singh, R. S. 2012. Response of plant density on growth, yield and quality of pomegranate cv. Ganesh. *Indian Journal of Arid Horticulture*, 7 (1-2): 57-59.

Chander Bhan, Singh, D., Sivalingam, P.N. and Sharma M.K. (2013) Studies on in-vitro shoot tip establishment and organogenesis in date palm (*Phoenix dactylifera* L.) *Indian Journal of Horticulture* 70: 475-479

Choudhary, B.R. and Suresh Kumar. 2011. Genetic analysis in ridge gourd [*Luffa acutangula* (Roxb.)L.] under hot arid conditions. *Indian Journal of Arid Horticulture*, 6(1-2): 55-58.

Das B., Krishna H., Ahmed N., Attri B.L., Ranjan J.K. and Pragya. 2013. Protected strawberry culture at high altitude temperate climate as influenced by planting time, mulching and soil moisture. *Indian Journal of Horticulture*, 70(4): 506-511.

Haldhar, S. M. and Singh, R. S. 2014. Report of *Dictyla cheriani* Drake (Hemiptera: Tingidae) on Indian Cherry (*Cordia myxa L.*) in Rajasthan, India: incidence and morphometric analysis. *Indian Journal of Agricultural Sciences* (84 (1): 128–130

Haldhar, S. M., Choudhary, B. R., Bhargava, R. and Sharma, S. K. 2014. Development of an organic integrated pest management (IPM) module against insect-pests of muskmelon in arid region of Rajasthan, India. *Journal of Experimental Biology and Agricultural Sciences*, 2(1): 19-24.

Haldhar, S. M., Bhargava, R., Choudhary, B. R., Garima Pal and Suresh Kumar. 2013. Allelochemical resistance traits of muskmelon (*Cucumis melo* L.) against fruit fly (*Bactrocera cucurbitae* (Coquillett)) in hot arid region of India. (*Phytoparasitica*, DOI: 10.1007/s12600-013-0325-x)

Hare Krishna, Bhargava, R., Sharma, S. K., Sharma, B. D. and Chauhan, Nitesh 2014. Assessment of morphological diversity in ber (*Ziziphus mauritiana* Lamk). In: *Agrotechnol.*, 2(4): 302.

Jatav, M. K. and Sharma, B. D. 2014. Quantification of contribution of Azotobacter for reducing the requirement of nitrogen fertilizer in potato production in mid hills of Himachal Pradesh. In: *Agrotechnol.*, 2(4): 206.

Karuppaiah, V. and Nadarajan, L. 2013. Host plant resistance against sesame leaf webber and capsule borer, *Antigastra catalaunalis* Duponchel (Pyraustidae: Lepidoptera). *African Journal of Agricultural Research*, 8(37): 4674-4680.

Karuppaiah, V. and Srivastava, Chitra. 2013. Relative toxicity of newer group insecticides to *Spodoptera litura*. *Annals of Plant Protection Sciences*, 21(2): 305-309.

Khan, Hanif and Samadia, D. K. 2012. Variability and association studies in tomato germplasm under high temperature arid region. *Journal of Horticulture Sciences*, 7 (2): 194 – 198.

Krishna Rolania, Bhargava M.C. and Haldhar. S. M. 2013. Quantitive analysis of temperature and relative humidity on growth and development of *Lasioderma serricorne* Fab. in fennel seed. *Journal of Insect Science*, 21 (1): 98-104.

Krishna, Hare, Attri B.L. and Kumar A. 2011. Effectiveness of postharvest treatment with salicylic acid and mineral nutrient in the control of gray mould rot of strawberry. *Indian Journal of Arid Horticulture*, 6 (1-2):84-86. (Published in 2013).

Krishna, Hare and Singh D. 2013. Micropropagation of *lasora* (*Cordia myxa* Roxb.). *Indian Journal of Horticulture*, 70(3): 323-327.

Maheshwari, S. K. and Singh, D. 2011. Field evaluation of bottle gourd genotypes for resistance against Alternaria leaf blight in western Rajasthan. *Indian Journal of Arid Horticulture*, 6: 73-74. (published in the year 2013)

Maheshwari, S. K., Choudhary, B. R. and Singh, D. 2013. Occurrence of fungal diseases of bottle gourd in Rajasthan. *Progressive Horticulture*, 45 (1): 206-208.

Maheshwari, Sushil, Chaudhary, B. R., Singh, D. and Sharma, B. D. and Sharma, S. K. 2014. Field reaction of watermelon genotypes for resistance against *Alternaria* leaf blight disease under hot arid conditions of Rajasthan. In: *Agrotechnol*., 2(4): 61.

Meena, Ramkesh, Yadav, P.K. and Singh, R. S. 2013. Response of date palm cultivars to varying concentration of Ethephon on yield and yield attributing characters.. *Progessive Agriculture*,13(1): 1-3.

Raja, S., Bagle, B.G. and More, T.A. 2011. Screening of Amaranth genotypes for yield and quality under summer condition of semiarid ecosystem of western India. *Indian Journal of Arid Horticulture*, 6(1-2):41-45.

Raja, S., Joshi, H.K., Bagle, B.G. and Sharma, S.K. 2012. Genetic variability and heritability for quantitative characters in bottle gourd(*Lagernaria siceraria* (Mol.) Standl.) for rainfed system. *Indian Journal of Arid Horticulture*, 7(1-2):12-15.

Raja, S., Joshi, H.K., Bagle, B.G. and Sharma, S.K. 2012. Prediction of biophysical attributes for high yielding genotypes of bitter gourd (*Momardica charantia* L.) for rainfed condition. *Indian Journal of Arid Horticulture*. 7 (1-2):28-33.

Raja. S., Bagle, B. G., More, T. A. 2013. Drumstick improvement for semi arid ecosystem: Analysis of environmental stability (*Moringa oleifera* Lamk). *Journal of Plant Breeding and Crop Science*, 5(1): xx-xx, 2013.

Rathore, P. S., Haldhar, S. M. and Swaminathan, R. 2013. Biology and morphomatric variation within local species of Kharif grasshopper, *Hieroglyphus nigrorepletus* Bolivar in South-western Rajasthan. *Journal of Entomological Research*, 37 (2): 153-162.

Samadia, D. K. 2011. Genetic variability studies for improvement in bottle gourd under hot arid

agro-climate. *Indian Journal of Arid Horticulture*, 6 (1 – 2): 15 – 18.

Singh, A. K., Singh, Sanjay, Appa Rao, V. V., Hiwale, S. S., Joshi, H. K., and Sharma, S.K. 2012. Effect of organic manure and biofertilizers on soil properties and growth of aonla under rainfed condition of hot semi-arid environment. *Indian Journal of Arid Horticulture*, 7 (1-2): 45-48.

Singh, C., Yadav, P. K. , Samadia, D. K. and Bairwa, S. 2012. Response of nitrogen and row spacing on quality and economics of onion cv. N-53 under arid environment. *Indian Journal of Arid Horticulture*, 7 (1 – 2): 26 – 27.

Singh, R. S. , Hare Krishna and Bhargava, R. 2012. Conservation and management of plant genetic resources of arid fruits- A review, *Indian Journal of Arid Hort.*, 7(1&2),1-11. (Published in 2013).

Singh, S. K., Singh, R.S and Awasthi, O.P. 2013. Influence of pre-and post harvest treatment on shelf –life and quality attributes of ber fruits. *Indian Journal of Horticulture*, 70(4),610-613.

## ABSTRACT OF PAPER PUBLISHED IN PROCEEDINGS OF SEMINAR/ SYMPOSIUM

Choudhary B. R., Bhargava R., Haldhar S. M., Mahesawari S. K., Kumar S. and Sharma S. K. 2013. Developing monoecious line of muskmelon (*Cucumis melo* L.) in National Symposium on "Abiotic and Biotic Stress Management in Vegetable Crops" organised by IIVR, Varanasi during 12-14, April, 2013.

Gupta,V., Pandey, C. D., Kak, A., Arya L., Ramya, K.N. and Singh, A. K. 2013. Morphological variations in fruit and seeds of *Morinda tinctoria* collected from Madhya Pradesh. Proceeding of Noni Search, 2013, National Symposium on Noni for Sustainable Wellness held at GKVK, Bengaluru, 29-30 October, pp.30-35.

Haldhar S. M., Choudhary B. R., Bhargava R. and Sharma S. K. 2013. Effect of abiotic factors on the incidence of hadda beetle, (*Henosepilachna vigintioctopunctata*) in arid region of Rajasthan in national symposium on "*National Symposium On Abiotic And Biotic Stress Management In Vegetable Crops*" organised by IIVR, Varanasi during 12-14, April, 2013.

Haldhar S. M., Choudhary B. R., Bhargava R. and Sharma S. K. 2014. Morphological and biochemical resistance traits of muskmelon against fruit fly (*Bactrocera cucurbitae* (Coquillett)) in hot arid region of Rajasthan. International Conference on "Entomology" organized by PU, Patiala during 21-23, February, 2014.

Hiwale, S. S. 2013. "Horticulture based cropping systems for the semiarid rain fed areas" at National Seminar on Tropical and Subtropical fruits, held at NAU, Navsari, Gujarat, pp 178-191.

Hiwale, S. S. 2013. An overview of citrus in semiarid regions of Gujarat. Paper published in Souvenir of National citrus meet held at NRC, Citrus, Nagpur from 12-13 August, 2013 on Pp 263-269.

Joshi, H. N. and Hiwale, S. S. 2013. Studies on physico-chemical characters of Jamun (*Sizygium cuminii* Skeels). Abstract of paper published in proceedings of National seminar on Tropical and subtropical fruits No. IX-P-14 pp. 155.

Karuppaiah, V., Singh, R. S., Sharma, B. D. and Sharma, S. K. 2014. Factors influencing stone weevil, *Aubeus himalayanus* voss (Curculioniodae: Coleoptera) infestation in ber (*Ziziphus mauritiana* Lamk.) under hot arid ecosystem. In: International Conference on Entomology, held at Punjabi University, Patiala, Feb., 2014 pp.95.

Maheshwari, S. K., Singh, D and Choudhary, B. R. 2013. Screening of different genotypes of bottle gourd for resistance against *Cercospora* leaf spot under hot arid conditions. Presented poster paper in National Symposium on "Abiotic and Biotic Stress Management in Vegetable Crops" held on April 12-14, 2013 at Indian Institute of Vegetable Research, Varanasi, Abs. p. 46- 47.

Singh, A. K., Singh, Sanjay, and Joshi, H. K. 2013. Assessment of *Morinda tomentosa* genotypes for morphological and qualitative characters under rain fed semi-arid conditions of western India. Proceeding of Noni Search National Symposium on Noni for Sustainable Wellness held at GKVK, Bengaluru, 29-30 October, pp.10-17.

Singh, Sanjay, Singh, A. K. and Sharma, S. K. 2013. Trends and issues in Horticulture based farming systems. Reference manual of winter school on Current Trends in Commercial Horticulture during 1-21 Dec., 2013 at COA & Forestry, NAU, Navsari, Gujarat pp.247-253.

Singh, Sanjay, Singh, A. K. and Sharma, S. K. 2013. Importance of underutilized fruit crop for high density plantation under rainfed conditions of western India. Canopy management and high density planting in subtropical fruit crops, pp. 131-139.

Singh, Sanjay, Singh, A. K. and Sharma, S. K. 2013. Recent Advance in Fruit Production. Reference manual of winter school on Current Trends in Commercial Horticulture, during 1-21 Dec., 2013 at COA & Forestry, NAU, Navsari, Gujarat, pp. 292-299.

Singh, Sanjay., Singh, A. K. and Sharma, S. K. 2013. Genetic resource management of underutilized fruit crops (Jamum, Tamarind, Karonda, Khirni, Mahua and Bael). National Seminar on Tropical and Subtropical Fruits, January 9-11, NAU, Gujarat pp. 8-9.

Rajkumar and Singh Dhurendra 2014. Innovative packaging of horticultural produce for better shelf life and marketing in manual of National workshop cum seminar on "Recent plasticulture approaches towards precision horticulture during February 22-24 2014, G. B. Pant University of Agriculture & Technology, Pantnagar.

## POPULAR ARTICLES

Choudhary, B. R. and Birbal. 2014. Vegetable production in arid regions. In: Modern cultivation of fruits, vegetables and seed spices of arid regions published by CAZRI RSS, Bikaner. pp. 47-74.

Choudhary, B. R., Haldhar, S. M., Bhargava, R., Maheshwari, S. K. and Sharma, S. K. 2013. Monoecious line of muskmelon developed. *ICAR News* (July-Sept.), 19(3): 9-10.

Haldhar, S. M. and Choudhary, B. R. 2014. Integrated pest management of important insects of arid horticulture. In: Modern cultivation of fruits, vegetables and seed spices of arid regions published by CAZRI RSS, Bikaner. Pp: 85-105.

Krishna, Hare, Singh, R. S. and Sharma S. K. 2013. Bioactive- compound-rich squash from mulberry. ICAR News, 22, 2013.

Samadia, D. K. 2012. Maintenance and conservation of snap melon germplasm. CIAH Newsletter, 12 (2): 2.

Samadia, D. K. 2013. Agro-techniques developed for mateera cultivation. CIAH Newsletter, 13 (1): 1-2.

Singh, A. K., Singh, Sanjay and Joshi, H. K. 2013. Improving socio-economic through rainfed bael. *Indian Horticulture, July- August,* pp-14-17.

Singh, A. K., Singh, Sanjay, Joshi, H. K. 2013. More aonla in lesser area. Indian Horticulture, March-April, pp. 17-18.

Singh, A. K., Singh, Sanjay, Joshi, H. K., Bagle, B. G. and Sisodia, P. S. 2014. *Amla na Pak Man Achhadan (Mulching) ni asar. Krishi Govidya*, March, 2014, pp. 24-25.

Singh, A. K., Singh, Sanjay, Singh, R.S. Joshi, H. K and Contractor, K. 2014. Exploring biodiversity in bael for healthy and wealthy life. Indian Horticulture, January and February, pp. 24-26

Singh, Sanjay and Singh, A K. 2013. Goma Prateek enriching tamarind wealth. Indian Horticulture. September- October, pp9-11.

Sivalingam, P. N., Singh, D. and Samadia, D. K. 2013. Molecular markers specific to Thar Shoba, a variety of Khejri (*Prosopis cineraria*). CIAH Newsletter, 13 (1): 2.

flg] ,- d-] flg lt;] tk'kh ,- d- vkj edokuk 2013- 'k"d {k= e ujUn vkoyk&7 dh l?ku ckxokuh] Qy&Qy] flrEcj&vDVcj] it 3&5

ehuk] ,l- vkj-] tkVo] ,e- d-] pk/kjh] ch- vkj- vkj ekg'ojh] ,l- d- 2013- Fkkj jfxLrku dh dYio{k eku tku okyh [ktMh dk mUur dju dh rduhd http://www.krishisewa.com/cms/articles/production-technology/362-khejri.html.

ehuk] ,l- vkj-] tkVo] ,e- d-] pk/kjh] ch- vkj- vkj ekg'ojh] ,l- d- 2013- jktLFkku d e:LFky {k=k e [ktMh d ie[k dhV ,o chekfj;k rFkk mudh jkdFkke d mik; http://www.krishisewa.com/cms/disease-management/364-khejri-disease.html.

tkVo] ,e- d-] dekj] ,l-] /keUn] ehuk] ,l- vkj- 2013- vf/kd vky mRiknu d fy, ik'kd rRok dk mfpr ic/kuA [kkn if=dk ¼10½33&37

ekg'ojh] ,l- d-] d".k] gj] ehuk] ,l- vkj- ,o pk/kjh ch- vkj- 2012- ikni lxjk/k ¼lykV dojVhu½ ifjp; ,o egRoA e:ckxok.kh 7: 39-42.

ehuk] ,l- vkj-] lekfn;k] Mh- d- ,o ekg'ojh] ,l- d- 2012- [ktMh 'k"d {k=k dk dYio{k e:ckxok.kh 7: 43-47.

Maheshwari, S. K., Choudhary, B. R. and Meena, S. R. 2013. Diseases of cucurbits: Symptoms and control (Hindi). http://www.krishisewa.com/cms/disease-management/338-cucurbit-disease.html

Ñ".k ,p-] ikjk'kj] ,- ,o eg'ojh] ,l- d- 2012- ckxokuh e ekbdkjkbtk dod‰ mi;kx ,o lHkkouk,¡ e: ckxok.kh] 7‰ 20&23-

jke] lr] ekg'ojh] ,l- d- ,o 'kek] xxjkt 2012- ckxokuh Qlyk e ik/k of) fu;kedk dk mi;kxA e# ckxok.kh] 7‰ 36&38-

lekfn;k] fnyhi dekj 2012- 'k"d {k= e erhjk vul/kku ,o fodklA e: ckxok.kh] 7‰ 8&15-

gy/kj] ,l- ,e- vkj pk/kjh] ch- vkj- 2013- dl dj 'k"d {k= e dnnoxh; lfCTk;k dk lefdr dhV icU/ku- Qy&Qy] ,Q,vkb] ub fnYyh i"B- 25&31-

## BOOKS AND BOOK CHAPTERS

Maheshwari, S. K. and Krishna, H. 2013. Biotechnology in plant disease management: Dawn of a new era. *In:* Biotechnology Approaches in Crop Protection (Eds. Prasad, D. and Ray, D. P.). Biotech Books, New Delhi. pp. 71-79.

More. T. A., Singh, R. S. and Sharma, S. K. 2014. Date palm (*Phoenix dactylifera* L.) In: Palms (ed. Singh, *et al,*.), Westville Publishing House, New Delhi. pp 168-194.

Singh, Sanjay, Singh, A. K. and Sharma, S. K. 2013. Genetic resource management of underutilized fruit and their conservation in semi-arid ecosystem of western India, Horticulture for Prosperity and Nutritional Security in 21st Century (Eds T. K. Hazarika and B. P. Nautiyal), pp. 25-38.

'kek] ,l- d-] flg] vkj- ,l- vkj 'kek] ch- Mh- 2014- ik/k fdLe dk itUu rFkk itud dk vf/kdkj- ik/kk fdLe vkj d"kd vf/kdkj lj{k.k vfèkfu;e] if'k{k.k ,o tkx:drk dk;de] d'kckl chdkuj it- 12&18-

ekg'ojh] ,l- d-] flg] vkj- ,l-] Hkkxo] vkj- vkj 'kek] ch- Mh- 2014- ckf}d lEi}k d vf/kdkj‰ ifjHkk"kk] lj{kk d lk/ku- ik/kk fdLe vkj d"kd vf/kdkj lj{k.k vf/kfu;e] if'k{k.k ,o tkx:drk dk;de] d'kckl chdkuj i"B 41&43-

ekg'ojh] ,l- d- ,o —".k] gj 2014- 'k"d {k=h; Qyk] lfCt;k ,o elkyk e ,dh—r 0;kf/k çcU/kuA 'k"d {k=k e Qyk] lfCt;k ,o chth; elkyk dh vk/kfud [krh dh fdrkc e ¼fgUnh½A ¼lkind chjcy vkfn ½] eæd roj dEi;Vj vkV] chdkuj] i"B l[;k 104&106

## BULLETIN/ LEAFLETS

Choudhary, B. R., Haldhar, S. M., Maheshwari, S. K. and Meena, S. R. 2013. Development of production technology of ridge gourd (*Luffa acutangula*) in arid region of Rajasthan. CIAH/ Tech. Folder/ pp 1-4.

Choudhary, B. R., Sharma, B. D. and Sharma, S. K. 2013. Micronutrients in vegetable crops CIAH/Tech./Pub.No. 55 pp 1-25.

Haldhar, S. M., Sharma, S. K., Choudhary, B. R., Bhargava, R., Samadia, D. K. and Meena S. R., 2013. Insect Pests of Arid Vegetable Crops: Practical Manual for Field Identification and Damage Symptoms. CIAH/ Tech./ Pub. No. 43 pp 1-54.

Haldhar, S. M., Sharma, S. K., Bhargava, R., Singh, R. S., Sharma, B. D. and Dhurendra Singh. 2013. Insect Pests of Arid Fruit Crops: Practical Manual for Field Identification and

Damage Symptoms. CIAH/ Tech./ Pub. No. 42 pp 1-53.

Meena, S.R., Singh, D., Singh, R. S., Sharma, B. D. and Bhargava. R. 2013.Training: A manual of Concepts and Methodologies, Tech. Bull.-47, CIAH, Bikaner,34p

Singh, D., Sivalingam, P. N., Maheshwari, S. K., Bhargava, R., Meena, S. R., Haldhar, S. M. and Sharma, S. K. 2013. Biotechnological aspects of plant microbe interaction. CIAH/ Tech./ Pub. No. 48 pp 1-33.

ekg'ojh] ,l- d-] flg] ,l- vkj- vkj ,o —".k] gj 2013- 'k"d {k=h; Qyk dh ie[k chekfj;k ,o mudk mipkj- QkYMj] d'kckl] chdkujA

ekg'ojh] ,l- d-] pk/kjh] ch- vkj- vkj ehuk] ,l- vkj- 2013- dnnoxh; lfCt;k dh ie[k chekfj;k ,o mudk icU/ku] QkYMj] d'kckl] chdkujA

pk/kjh] ch- vkj-] gy/kj] ,l- ,e-] ekg'ojh] ,l- d- vkj ehuk] ,l- vkj- 2013- rkjb dh oKkfud [krh] QkYMj] d'kckl] chdkujA

flg] vkj- ,l-] Hkkxo] vkj- vkj 'kek] ch- Mh- 2014- ik/k fdLe lj{k.k vkj fdlku vf/kdkj vfèkfu;e] if'k{k.k ,o tkx:drk dk;Øe] cyfVu] d'kckl] it 47-

flg] ,- d-] flg] lt;] fgoky] ,l- ,l-] vlikjko] oh- oh- vkj tk'kh] ,p- d- 2014- v/k 'k"d {k= e vkoyk dh ckjkuh [krhA

flg] ,- d-] flg] lt;] flg] vkj- ,l- vkj tk'kh] ,p- d- 2014- v/k 'k"d {k= e cy dh o"kk vk/kkfjr [krhA

## REPORTS/COMPENDIUM

Samadia, D. K. 2014. Arid zone vegetable production technology under climate change. Chapter in compendium on Refresher course for Assistant Professors / Scientists. Directorate of Human Resource Development, SKRAU, Bikaner, February 18 to March 10, 2014.

Sharma, B. D. (2014) Nutrient management in citrus crops in hot arid region. In: Proceedings of State Level Workshop on Precision Farming Technologies for Citrus from 23-24 January 2014 at SKRAU, Bikaner. Pp 114-126.

Sharma, S. K. and Sharma, B. D. 2012-13. Annual Report All India Coordinated Project on Arid Zone Fruits.

Sharma, S. K. and Sharma, B. D. 2013. Proceedings of XVII Research Workers Group Meeting of All India Coordinated Project on Arid Zone Fruits. CIAH, Bikaner. 58p.

Sharma, S. K. and Sharma, B. D. 2013. Report of XVIII Group Workers Meeting of All India Coordinated Project on Arid Zone Fruits.

Sharma, S. K. Bhargava, R., Singh, R. S. Sharma, B. D., Hare Krishna and Meena, S. R. 2012-13. Annual Report Central Institute for Arid Horticulture, Bikaner.

Singh, D. and Sivalingam, P. N. 2013. Hi-tech propagation of fruit crops. In Training Manual of Fruit Crop Production Technology State Institute of Agriculture Management, Jaipur pp.1-16

Singh, D. and Sivalingam, P. N. 2013. Tissue culture of fruit crops. In Training Manual of Fruit Crop Production Technology State Institute of Agriculture Management, Jaipur, pp30-42

pk/kjh] ch- vkj- vkj 'kek] ,l- d- 2014- fdlku vfèkdkj ,o ik/k fdLe mi;kfxrk- if'k{k.k ,o tkx:drk dk;de dnkjku] if'k{k.k vk;kt d d'kckl] chdkuj fnukd 17-02-2014] ihihoh,Qvkj, ,DV if'k{k.k ifLrdk d it u- 35&28-

Ñ".k] ,p-] Hkkxo] vkj- ,o flg] vkj- ,l- 2013- Ñ"kd vkf/kdkj d ifji{; e Mh-;-,l- if'k{k.k] if'k{k.k ifLrdkA ik/kk fdLe vkj Ñ"kd vkf/kdkj lj{k.k ikf/kdj.k Ñf"k e=ky;] Hkkjr ljdkj] ub fnYyh }kjk ik;kftr ik/kk fdLe vkj Ñ"kd vkf/kdkj lj{k.k vf/kfu;e if'k{k.k ,o tkx:drk dk;ØeA i"B 39&40A

## RADIO TALK

**Dr. Sanjay Singh**

Delivered a radio talk on the topic “Role of farmers before onset of rain at Godhra" Radio Station on 5-6-13.

Delivered radio talk on Establishment and management of mango cultivation. 23-10-13 at Godhra Radio Station.

Delivered a radio talk on dry land fruit culture at Baroda17-1-14

**Dr. S. S. Hiwale**

Delivered a radio talk on pomegranate cultivation in semiarid dry lands on 11/11/13 at All India Radio, Godhra

**Sh. H. K. Joshi**

Delivered a radio talk on IPM practices for tomato, chilli and brinjal on 11/03/14.

# 9. RESEARCH PROJECTS

| Code | Title | Investigators |
|---|---|---|
| **CIAH: 1** | **Introduction, collection, characterization, conservation and evaluation of germplasm of arid and semi-arid fruit and vegetable crops.** | **Dr. S. K. Sharma (Project Leader)** |
| | (a) *Ber* | Dr. Hare Krishna |
| | (b) Pomegranate | Dr. R. S. Singh<br>Dr. S. S. Hiwale<br>Dr. S. K. Maheshwari |
| | (c) Date palm | Dr. R. S. Singh<br>Dr. R. Bhargava<br>Dr. B. D. Sharma |
| | (d) *Aonla* | Dr. A. K. Singh<br>Dr. R. S. Singh |
| | (e) Indigenous and exotic underutilized fruit crops (Lasora, ker, pilu, karonda, phalsa, cactus pear, fig and mulberry). | Dr. Hare Krishna<br>Dr. R. S. Singh<br>Dr. Dhurendra Singh |
| | (f) *Bael* | Dr. R. S. Singh<br>Dr. A. K. Singh<br>Dr. Sanjay Singh |
| | (g) Wood apple, mango, sapota and custard apple. | Dr. S. S. Hiwale |
| | (h) Cucurbitaceous vegetable crops: Bottle gourd, round gourd, snap melon and kachri. | Dr. D. K. Samadia |
| | (i) Cucurbitaceous crops: Muskmelon, watermelon, sponge gourd and long melon. | Dr. B. R. Choudhary<br>Dr. R. Bhargava<br>Dr. S. K. Maheshwari<br>Dr. S. M. Haldhar |
| | (j) Jamun, tamarind, mahua, chiraunji, karonda, phalsa and khirni. | Dr. Sanjay Singh<br>Dr. A. K. Singh<br>Dr. R. Bhargava<br>Dr. V. V. Appa Rao |

| Code | Title | Investigators |
|---|---|---|
| **CIAH: 2** | **Improvement of arid and semi arid fruit and vegetable crops including biotechnological interventions.** | **Dr. S. K. Sharma (Project Leader)** |
| | (a) Improvement in vegetable crops | Dr. D. K. Samadia |
| | (b) Genetic improvement of ridge gourd (*Luffa acutangula*) under arid environment. | Dr. B. R. Choudhary<br>Dr. S. K. Maheshwari<br>Dr. S. M. Haldhar |
| | (c) Breeding for yield, quality, biotic and drought resistance in cucurbitaceous crops. | Dr. Raja Shankar<br>Shri H. K. Joshi |
| | (d) Identification of Institute germplasm through biotechnological interventions : | |
| | (i) Development of phyto-chemical markers in arid horticultural crops for varietal identification and assessment of phylogenetic relationship. | Dr. R. Bhargava<br>Dr. R. S. Singh<br>Dr. B. D. Sharma<br>Dr. Dhurendra. Singh |
| **CIAH: 3** | **Standardization of arid and semi-arid fruits and vegetables production technology.** | **Dr. S. K. Sharma (Project Leader)** |
| | (a) Evaluation of fruit based diversified cropping models for arid region. | Dr. Hare Krishna<br>Dr. R. Bhargava<br>Dr. S. R. Meena |
| | (b) Standardization and commercialization of micro-propagation techniques of horticultural crops under arid agro eco-system : Date palm | |
| | **(i)** Date palm varieties: Halawy & Medjool | Dr. Dhurendra Singh |
| | **(ii)** Date palm varieties: Khalas & Khunezi | Dr. P. N. Sivalingam |
| | (c) Physiological and biochemical investigations in arid horticultural crops under abiotic stresses. | Dr. R. Bhargava<br>Dr. R. S. Singh<br>Dr. B. D. Sharma |
| | (d) Technological interventions for arid horticulture development and its impact assessment. | Dr. S. R. Meena<br>Dr. D. K. Samadia<br>Dr. Dhurendra Singh<br>Dr. R. S. Singh |
| | (e) Standardization of integrated nutrient management in arid horticultural crops. | Dr. B. D. Sharma<br>Dr. R. Bhargava<br>Dr. R. S. Singh<br>Dr. S. K. Maheshwari |

| Code | | Title | Investigators |
|---|---|---|---|
| | (f) | Standardization of production technology of mango and sweet orange. | Dr. Sanjay Singh<br>Dr. A. K. Singh<br>Dr. V. V. Appa Rao<br>Shri H. K. Joshi<br>Dr. S. S. Hiwale |
| | (g) | Organic farming studies in vegetables under semi-arid conditions. | Dr. V. V. Appa Rao<br>Shri H. K. Joshi<br>Dr. Raja Shankar |
| | (h) | Augmentation of vegetable cultivation by tribal farmers of Panchmahals district of Gujarat: An extention action research. | Dr. V. Lenin<br>Dr. Raja Shankar |
| | (i) | Value addition in semi-arid fruit crops. | Dr. S. S. Hiwale<br>Dr. V.V. Appa Rao |
| | (j) | Development of *khejri* based cropping models under rainfed conditions. | Dr. D. K. Samadia<br>Dr. B. D. Sharma<br>Dr. S. R. Meena |
| | (k) | A study on rural wisdom and resources of arid horticultural importance. | Dr. S. R. Meena<br>Dr. B. D. Sharma<br>Dr. S. K. Maheshwari |
| **CIAH: 4** | **Plant health management studies in arid and semi-arid fruit and vegetable crops.** | | **Dr. S. K. Sharma (Project Leader)** |
| | (a) | Integrated disease management in cucurbits (watermelon and bottle gourd) and fruit (pomegranate) under arid zone of Rajasthan. | Dr. S. K. Maheshwari<br>Dr. Dhurendra Singh<br>Dr. B. R. Choudhary |
| | (b) | Survey of insect-pests, their natural enemies and pest management strategies for cucurbits in arid region of Rajasthan. | Dr. S. M. Haldhar<br>Dr. B. R. Choudhary<br>Dr. R. Bhargava |
| | (c) | Management of major fungal diseases of semi-arid fruits and vegetables using foliar sprays with inorganic salts and organic compounds. | Shri H. K. Joshi<br>Dr. V.V. Appa Rao<br>Dr. Sanjay Singh |
| | (d) | Biology and management strategies for major insect pests of fruit crops in hot–arid region with special reference to *ber, bael*, date palm and *lasora*. | Dr. S M Haldhar<br>Dr. R. Bhargava<br>Dr. R. S. Singh<br>Dr. Hare Krishna |
| | (k) | A study on rural wisdom and resources of arid horticultural importance. | Dr. S. R. Meena<br>Dr. B. D. Sharma<br>Dr. S. K. Maheshwari |

| Code | Title | Investigators |
|---|---|---|
| | **Externally funded projects** | |
| **EF 1** | Bioprospecting of genes and allele mining for abiotic stress tolerance. | Dr. P. N. Sivalingam<br>Dr. Dhurendra Singh |
| **EF 2** | Identification, collection, characterization, evaluation and conservation of Noni (*Morinda* spp. L.) of western India (Gujarat and M. P.). | Dr. A. K. Singh |
| **EF 3** | Validation of DUS testing guidelines for cucurbits i.e. watermelon and muskmelon. | Dr. B. R. Choudhary |
| **EF 4** | Validation of DUS descriptor for *ber* (*Ziziphus* sp.). | Dr. Hare Krishna<br>Dr. R. Bhargava |
| **EF 5** | DUS centre for date palm horticultural crop. | Dr. R. S. Singh<br>Dr. R. Bhargava |
| **EF 6** | Enhancement of livelihood of tribal farm households of Panchmahals district in Gujarat State through agricultural diversification. | Dr. V. Lenin |
| **EF 7** | Validation of DUS descriptor for *bael*. | Dr. A. K. Singh |
| **EF 8** | Characterization of *aonla* varieties for developing DUS test guidelines. | Dr. A. K. Singh<br>(Co-Nodal Centre : CHES, Godhra) |
| **EF 9** | Development of morphological descriptor and DUS test guidelines for jamun. | Dr. Sanjay Singh<br>(Co-Nodal Centre : CHES, Godhra**)** |
| **EF 10** | Validation of DUS descriptors for chironji and tamarind | Dr. Sanjay Singh<br>(Nodal Centre : CHES, Godhra**)** |

# 10. RAC, IRC, IMC

## RAC
## (upto 6th September 2013)

**Chairman**
Dr. S. P. Ghosh
Former DDG (Hort.)
ICAR, New Delhi

**Members**
Dr. K. K. Jindal
Ex-ADG
ICAR, New Delhi

Dr. J. P. Gupta
Former Head
CAZRI, Jodhpur

Dr. V. Ponnuswamy
Dean
College of Horticulture & Research Institute
Periyakulam (Tamil Nadu)

Dr. R. D. Rawal
Former Head
IIHR, Bangaluru

Dr. S. K. Sharma
Director
CIAH, Bikaner

ADG (Hort.-I)
ICAR, KAB-II
New Delhi

**Member Secretary**
Dr. R. Bhargava
Principal Scientist
CIAH, Bikaner

## (w.e.f. 7.9.2013 to 6.9.2016)

**Chairman**
Dr. S. L. Mehta
Ex-Vice Chancellor
MPUA&T, Udaipur

**Members**
Dr. B. B. Vashishtha
Ex-Director
NRC on Seed Spices, Ajmer

Dr. Y. N. Reddy
Ex-Principal Scientist & Head
IIHR, Bangaluru

Dr. S. Lingappa
Ex-Director of Research
UAS, Dharwad

Dr. A. R. Mishra
Principal Scientist
Director of Water Management
Bhubaneswar

Dr. S. K. Sharma
Director
CIAH, Bikaner

ADG (Hort.-I)
ICAR, KAB-II
New Delhi

**Member Secretary**
Dr. B. D. Sharma
Principal Scientist (Soil)
CIAH, Bikaner

The meeting of RAC was held on 27.04.2013

## INSTITUTE RESEARCH COMMITTEE (IRC)

**Chairman**
Dr. S. K. Sharma
Director
CIAH, Bikaner

**Members**
All Scientists of the Institute

**Member Secretary**
Dr. S. K. Maheshwari
Sr. Scientist (Plant Pathology)

IRC meeting was held on 21-22 May, 2013

## INSTITUTE MANAGEMENT COMMITTEE

**Chairman:**

Dr. S. K. Sharma, Director, CIAH, Bikaner

| Sr. No. | Name of Members | Term | |
|---|---|---|---|
| 1 | ADG (H-1), ICAR, New Delhi | 28.7.2011 | 27.7.2014 |
| 2. | Director (Horticulture) Government of Rajasthan, Jaipur (Rajasthan) | 15.3.2012 | 14.3.2015 |
| 3. | Director of Horticulture Gujarat State, Krishi Bhavan, Sector No.10-A, Gandhinagar (Gujarat) | 15.3.2012 | 14.3.2015 |
| 4. | Director of Research, Rajasthan Agricultural University, Bikaner | 15.3.2012 | 14.3.2015 |
| 5. | Shri Sher Singh Nehra, Chirawa, Jhunjhunu | 17.9.2013 | 16.9.2016 |
| 6. | Shri Nihal Singh, Chirawa, Jhunjhunu | 17.9.2013 | 16.9.2016 |
| 7. | Finance & Accounts Officer, Directorate of Rapeseed Mustard Research, Bharatpur | 15.3.2012 | 14.3.2015 |
| 8. | Dr. Sanjay Singh, Principal Scientist & Head, CHES, Vejalpur, Godhra | 28.7.2011 | 27.7.2014 |
| 9. | Dr. B. D. Sharma, Principal Scientist, CIAH, Bikaner | 28.7.2011 | 27.7.2014 |
| 10. | Dr. C. K. Narayana, Principal Scientist, IIHR, Bengaluru | 28.7.2011 | 27.7.2014 |
| 11. | Dr. V. K. Singh, Principal Scientist, CISH, Lucknow | 28.7.2011 | 27.7.2014 |
| 12 | Administrative Officer & Member Secretary | Ex-officio whole time | |

IMC meeting was held on 15.06.2013 and 21.03.2014.

# 11. MEETING, CONFERENCE, TRAINING, LECTURE ETC.

## Meeting

### Dr. S. K. Sharma

Participated in the XXXIth Group Meeting of All India Coordinated Research Project (VC) during 2nd to 5th May, 2013 at CSK HPKV, Palampur and act as Co-chairman in the Technical Session on "Seed Production".

Attended the first meeting on 12th Plan of the ICAR-Bioversity International Work Plan 2012-16 held on 14th May, 2013 at NASC, New Delhi.

Attended the meeting with Hon'ble Vice-Chancellor and visited AICRP on Arid Zone Fruits Centre S.K.Nagar on 17.06.2013 and Mundra on 18.06.2013

Attended meeting with Hon'ble Vice-Chancellor and inspected Date Palm Tissue Culture Project at AAU, Anand on 19.06.2013.

Participated in the SAC Meeting of KVK Panchmahal and inspected KVK and of CHES, Vejalpur on 20.06.2013.

Attended the Task Force 01/2011 meeting for finalization of the DUS test guideline for Ber on 07.08.2013 at PPV&FRA, NASC Complex, New Delhi

Participated in the National Meet on Citrus at NRC on Citrus, Nagpur during 12-13 August, 2013.

Participated in the meeting of all the Project Coordinators of AICRPs/AINPs and the Leaders of the CRPs convened under the Chairmanship of Secretary DARE & DG, ICAR, New Delhi during 29-31 August, 2013.

Participated in the Inception Meeting of the ICAR-Bioversity proposal entitled "Mainstreaming agrobiodiversity conservation and utilization in agriculture sector to ensure ecosystem services and reduce vulnerability" at New Delhi on 03 to 04 September, 2013.

Participated in the Working Group of Agriculture meeting under Chairmanship of Dr. R.S. Paroda, Ex- Director General, ICAR, at Jaipur on 07.10.2013.

Participated in the meeting of the Editorial Board of the Indian Horticulture, ICAR, New Delhi on 08.11.2013.

Attended the meeting to review the progress of Date palm Tissue Culture Project on 27th November, 2013 at CAZRI, Jodhpur.

Attended the the SFC presentation meeting with DDG (Hort.),ICAR, New Delhi on 10th December, 2013.

Attended the SFC meeting, ICAR, New Delhi on 11-12th December, 2013 under the Chairmship of Secretary DARE and DG, ICAR, New Delhi.

Attended Mid Term Review Meeting of AICRP on Vegetable Crops as Chairman of Session on seed production at New Delhi on 17 Dec., 2013.

Attended Mid Term Review Meeting ICAR Regional Committee No. 06 at CAZRI, Jodhpur on 18th December, 2013.

Attended & conducted the Annual Group Meeting of AICRP on AZF at Rahuri during 26-28 December, 2013.

Attended review meeting at NRCG, Pune on 17.01.2014 regarding ICAR-Bioversity international work Plan 2012-2016 under Chairmanship of Hon'ble DDG (Hort.), ICAR, New Delhi.

Attended the Directors Conference at Baramati and Pune (Maharashtra) on 19-20 January, 2014.

Attended the RAC meeting of IIVR, Varanasi as Member on 22—23 January, 2014.

Attend DUS Review Meeting at UAS Dharwad w.e.f. 28th February to 1st March, 2014.

Attended the first meeting of the Task Force for validation of DUS test guidelines for Watermelon and Muskmelon on 12th March, 2014 at New Delhi.

## Dr. Sanjay Singh

Attended IJSC meeting at CIAH, Bikaner on 14-6-13.

Attended Institute Management Committee meeting at CIAH, Bikaner on 15-6-13.

Acted as member in PMC meeting for identification of variety on 19-12-13 at CIAH, Bikaner

## Dr. S. S. Hiwale

Attended Institute Management Committee meeting of Directorate of Medicinal an Aromatic Plants Research, Boriavi, Anand, Gujarat, as a member on 7/2/2014.

Nominated by Director General I.C.A.R, New Delhi to act as Member Career Advancement committee of scientist at Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand, Gujarat on 24th November 2013.

Nominated by Vice Chancellor, Sardarkrushinagar, Datiwada Agriculture University to act as selection committee member for direct recruitment for the post of Associate Professor (Horticulture) held on 12/2/2014

## Dr. R. S. Singh

Visited with team of scientists to see the performance of Olive cultivation in Rajasthan at ATC, Lunkaransar on 29.7.2013.

Attended as Member of Institute Management Committee meeting of Zonal Project Directorate (Zone VI) at Jodhpur on 10th March, 2014.

Attended XII Plan/SFC meeting at ICAR, Krishi Bhawan, New Delhi on 11th December 2013.

Attended Annual Group Meet of AICRP on Arid Zone Fruits at MPKV, Rahuri from 26-28 December, 2013.

Attended one day National Workshop on Managing Arid Agriculture in Changing Climate held at CAZRI, Jodhpur on 4th February, 2014.

## Dr. S. K. Maheshwari

Attended PMC Meeting of CIAH, Bikaner as invitee member on 03-12-2013 and 06-03-2014.

## Dr. Hare Krishna

Attended the third meeting of sub task force on special characteristics identification in *ber* held at NAAS Complex, New Delhi on 07.08.2013 and being the Nodal Officer presented and submitted the 'Draft Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) on Indian Jujube (*Ber*) (*Ziziphus mauritiana* Lamk.)'.

## Dr. B. R. Choudhary

Attended Review meeting of ICAR Seed Project (XII Plan)-Horticulture Component held at IIHR, Bengaluru on 22-02-2014.

Attended 8th Review meeting of DUS centres held at UAS, Dharwad from 28-02-2014 to 01-03-2014.

Attended first task force meeting of DUS test guidelines for watermelon and muskmelon held at PPV&FR Authority, New Delhi on 12-03-2014.

Attended XXXIth Group meeting of AICRP on Vegetable Crops at CSK HPKV, Palampur held from 02-05 May, 2013.

Participated in a 'Germplasm field day on vegetable crops (brinjal and bottlegourd)' at Issapur farm, NBPGR, New Delhi on 30-10-2013.

## Conference/Semimar-Symposium/ Workshop/etc

### Dr. S. K. Sharma

Attended the National Seminar on Abiotic and Biotic Stress Management on Vegetable Crops at IIVR, Varanasi and acted as Convener of the Session "Plant Genetic Resource

Participated in National Horticulture Conference as Resource Speaker at Constitution Club, New Delhi on 17th July, 2013.

### Dr. Sanjay Singh

Participated in International Conference on "Water Quality and Management for Climate Resilient Agriculture" from 28 to 31 May, 2013 at Jain Hills, Jalgaon.

Participated in Brain Storming Session on 5/ 08/13 and 6/08/13 at Navsari. On this occasion, had interaction with the chairman, scientists and members regarding the potential of Horticulture in semi arid and arid regions of western India.

Participated in the Annual Group Workers Meeting from 26-12-2013 to 28-12-2013 at M.P.K.V., Rahuri, Ahmed Nagar, Maharastra.

Participated in National symposium on " Noni for sustainable wellness at G. K. V. K. campus, Bangalore (UAS, Bangalore) from 29-30/9/2014.

### Dr. S. S. Hiwale

Attended National Seminar on Tropical and Subtropical fruits in 6th session on cropping systems research "Horticulture based cropping systems for the semiarid rain fed areas on January 9-11, 2013 at NAU, Navsari, Gujarat.

Participated in International conference of ISTS-IUFRO conference on "sustainable resource management for climate for climate change mitigation and social security at Entrepreneur development center, IT park, Chandigarh from 13-15 March 2014. "Increasing production potential of marginal lands through fruit crop under semiarid rain fed conditions."

Participated in National citrus meet held at NRC, Citrus, Nagpur from 12-13 August, 2013 on "An overview of citrus in semiarid regions of Gujarat".

### Dr. R. Bhargava

Participated in a workshop on 'Water use and water use efficiency- Phenotyping and their relevance in improving adaptation of crops under water limited condition' held at UAS, GKVK, Bengaluru from 02-12-2013 to 04-12-2013.

### Dr. Dhurendra Singh

Participated in National Seminar on Horticultural Biotechnology on 14.06.2013 held at IIHR, Bangalore

Participated in National Conference on Bioactive compound and functional foods in health and disease management organized by NIFTEM, Kundli, Sonepat, on 15-16 Nov. 2013

Participated in workshop on "Precision Farming Technologies For Citrus" held on 23- 24 January 2014 at PFDC , ARS-SKRAU, Bikaner

### Dr. A. K. Singh

Participated in National Symposium on Noni for Sustainable Wellness held at GKVK, Bengaluru, 29th and 30th October, 2013.

### Dr. S. K. Maheshwari

Participated in National Symposium on "Abiotic and biotic stress management in vegetable crops" held on April 12-14, 2013 at Indian Institute of Vegetable Research, Varanasi (U.P.).

Attended 2nd International Conference on Agricultural and Horticultural Sciences on February 03-05, 2014 at Banjara Hills, Hyderabad (A.P.).

### Dr. M. K. Jatav

Participated in 2nd International Conference on Agricultural and Horticultural Sciences on February 03-05, 2014 at Banjara Hills, Hyderabad (A.P.).

### Dr. Pinaki Acharyya

Participated in National Workshop on "Cactus pear" on 21.03.2014 at CAZRI, Jodhpur.

### Dr. B. R. Choudhary

Attended National Symposium on 'Abiotic & biotic stress management in vegetable crops' held at IIVR, Varanasi from 12-14 April, 2013.

Participated in a workshop on 'Water use and water use efficiency- Phenotyping and their relevance in improving adaptation of crops under water limited condition' held at UAS, GKVK, Bengaluru from 02-12-2013 to 04-12-2013.

### Dr. S. R. Meena

Attended a Braining Storming Session on "Extension Research Issues" held at ZPD, Jodhpur on 26.04.2013.

Participated in International conference and workshop on " Emerging food safety/quality risk: Challenges for developing countries" to organized by department of basic and applied sciences, National Institute of Food Technology Entrepreneurship and Management( NIFTEM) at Kundali, Sonepat, Haryana, India from 09 – 11 January, 2014 and presented a research paper orally on Traditional concepts and methodologies of processing and value addition of arid fruits and vegetables grown in western Rajasthan.

### Dr. S. M. Haldhar

Attended "National Symposium on Abiotic and Biotic Stress Management in Vegetable Crops" organised by IIVR, Varanasi during 12-14, April, 2013.

Attended International Conference on Entomology organized by PU, Patiala during 21-23, February, 2014.

### Dr. Rajkumar

Participated in the state level workshop on "Precision farming technologies for citrus" organized by Agriculture Research Station, Beechwal, SKRAU, Bikaner during 23-24 January, 2014.

Participated in Annual Workshop on AICRP on AZF held at MPKV, Rahuri from 26-28 December, 2013.

## Training attended

### Dr. S. K.Sharma

Participated in the training of EDP on Leadership Development at NAARM, Hyderabad during 25-29 June, 2013.

### Dr. Sanjay Singh

Participated in training programme on "Management Development Programme on Leadership Development (Pre-RMP Cadre) from 26/08/13 to 06/09/13 at NAARM, HYDERABAD.

### Dr. Dhurendra Singh

Attended 15 days training programme on Date palm Tissue culture from 29.04.2013 to 13.05.2013 at Anand Agricultural University, Anand, Gujarat

### Dr. Rajkumar

Attended 97th FOCARS (Foundation Course for Agricultural Research Services) training from 1st January, 2013 to 1st April 2013 at NAARM, Hyderabad.

Attended three month professional attachment training from 14th May 2013 to 13th August, 2013 at IIHR, Bengaluru

Attended one month orientation training programme from 12.4.2013 to 10.05.2013 at CIAH, Bikaner

## Training imparted

### Dr. Sanjay Singh

RAWE training was given on semi arid horticulture to the 34 students of 8th semester of SDAU, S K Nagar, Gujarat on 18-4-13.

### Dr. S. S. Hiwale

Training imparted to the farmers of ATMA project Dahod on different dates.

### Dr. R. S. Singh

Organized Agricultural Education Day programme at CIAH, Bikaner on 20.7.2013 for college students.

Organized one day training-cum -awareness programme sponsored by PPV& FRA, GOI, New Delhi for farmers/extension workers/students on 17.2.2014 at CIAH, Bikaner and more than 100 participants attended the training programme.

## Lecture

### Dr. Sanjay Singh

Lecture delivered on 19.4.2013 to the farmers of ATMA Dahod on cultivation of mango and sweet orange.

Lecture was delivered in NGO Sathguru Foundation, Dahod on Potential of underutilized fruit crops on 28-6-13.

Lecture was delivered to the farmers of ATMA Garbada, Dahod on potential of under utilized fruits on 19-7-13.

Lecture was delivered on the topic 'Medicinal value of under utilized fruits' to the farmers in the training programme on promotion of medicinal plants cultivation in tribal areas of Gujarat for livelihood and health security organized by Directorate of Medicinal Plant Research, Anand and KVK, Panchmahal on 31-7-13.

Lecture was delivered to the farmers of ATMA , Fatepura, Dahod on potential of under utilized fruits on 23-7-13.

Lecture was delivered to the farmers of ATMA Dahod on cultivation of mango and sweet orange on 7-8-13.

Delivered lecture post watershed management organized by NABARD,Godhra.

### Dr. B. D. Sharma

Delivered lecture on Shusk bagwani faslon mein mitti, pani tatha poshak tatva prabhandhan. In: Farmers Innovative day on 9th October 2013.

Delivered lecture on Agriculture disasters and its management. In: Refresher Course organised by DHRD, SKRAU, Bikaner on 19th February 2014.

Delivered lecture on Importance and Possibilities of Arid Fruit, Vegetable and Spices on 16-01-2014 In: Training organized by CAZRI, RRS, Bikaner on Phalon, Sabjion evam Masalon ki Kheti.

Delivered lecture on Drip Fertigation in fruit crops on 17-10-2013. In: Training programme on Cultivation of fruit and vegetable crops in arid region organized by CAZRI RRS, Bikaner.

### Dr. R. Bhargava

Delivered lecture on Documentation and report writing in "Refresher Course" organized by DHRD, SKRAU, Bikaner on 25.09.2013.

Delivered lecture on Intellectual Property Right at College of Agriculture, SKRAU, Bikaner on 27.03.2014.

### Dr. R. S. Singh

Delivered lecture on Importance of Horticulture & Improved Techniques of Fruits

production in Agriculture Education day programme on 20.7.2013 at CIAH, Bikaner.

Delivered lecture on Improved Technology for Fruits Cultivation in Arid region in Farmers Innovation Day programme on 9.10.2013 at CIAH, Bikaner

Delivered lecture on cultivation of fruit and vegetable crops in training programme for women at CAZRI, RRS, Bikaner 17.1.2014.

Importance of Horticulture development and biodiversity conservation in arid region in Training cum Awareness programme on PPV&FRA, held at CIAH, Bikaner on 17.2.2014.

## Dr. D. K. Samadia

xe 'k"d {k=k e lCth mRiknu dh mUur rduhfd;k ij Á{k= uokUo"ku fnol] dUnh; 'k"d ckxokuh lLFkku] chdkuj e fnukd 09@10@2013 dk 0;k[;ku fn;k x;kA

Delivered lecture as resource person - Arid zone vegetable production technology under climate change. In: Refresher course for Assistant Professors / Scientists. Organized by Directorate of Human Resource Development, SKRAU, Bikaner, February 18 to March 10, 2014 (06/03/2014).

Delivered lecture and method demonstrations In: Off-campus farmer's training programme on improved agro-techniques for vegetable production during kharif season. Organized by CIAH on 07/08/2013 at village Husansar, Bikaner.

Delivered lecture and method demonstrations In: Off-campus farmer's training programme on development of khejri based cropping system through *in-situ* budding technique. Organized by CIAH on 23/08/2013 at village Husansar, Bikaner.

Delivered lecture and method demonstrations In: Off-campus farmer's training programme on khejri based cropping systems. Organized by CIAH on 13/09/2013 at village 489 RDL (Khara), Bikaner.

Delivered lecture and method demonstrations on improved agro-techniques In: Front-line demonstration of improved varieties of arid vegetables. Organized by CIAH on 14/03/2014 at village Sherekunjiya (Chak-493 RDL), Bikaner.

Delivered lecture and method demonstrations In: Off-campus training on arid vegetable production technologies during summer season. Organized by CIAH on 15/03/2014 at village Sherekunjiya (Chak-493 RDL), Bikaner.

Delivered lecture and method demonstrations on improved agro-techniques In: Front-line demonstration of improved varieties of arid vegetables. Organized by CIAH on 19/03/2014 at village Khinchiya (Chak-05 SKHM), Bikaner.

Delivered lecture and method demonstrations In: Off-campus training on arid vegetable production technologies during summer season. Organized by CIAH on 20/03/2014 at village Khinchiya (Chak-05 SKHM), Bikaner.

## Dr. Dhurendra Singh

Presented Action Taken Report of CIAH, Bikaner in National Seminar on Horticultural Biotechnology held at IIHR on 14/6/2013 chaired by DDG(H).

Presented lecture on Hi-tech propagation of fruit crops. In Training programme on Fruit Crop Production Technology State Institute of Agriculture Management, Jaipur on 21.08.2013

Presented lecture on Tissue culture of fruit crops. In Training programme on Fruit Crop Production Technology State Institute of Agriculture Management, Jaipur on 21.08.2013

Presented a lecture on Hi-tech propagation of citrus and crop regulation in arid environment in workshop on "Precision Farming Technologies For Citrus" held on 23- 24 January 2014 at PFDC, ARS-SKRAU, Bikaner. pp 47-63

## Dr. A. K. Singh

Lectures delivered to BRS students during the training entitled ''Semi-arid horticulture for livelihood and nutritional security'' from 6-12-13 to14-1-14 CHES, Vejalpur on Mulching in aonla (17-12-2013), Drip irrigation in aonla (17-12-2013 ), Planting cum high density in aonla( 17-12-2013), Production technology of bael (20-12-2014), Value added products of bael (20-12-2014), Crop improvement in bael (21-12-2014), Medicinal value of bael (23-12-2013), Water use efficiency in horticultural crops (8-1-2014).

## Dr. Hare Krishna

Delivered lecture on 'Ñ"kd vf/kdkj d ifji{; e Mh-;-, l- ijh{k.k' during PPV&FRA sponsored training cum awareness programme at CIAH, Bikaner on February17, 2014.

## Dr. S. K. Maheshwari

Delivered a lecture on "Improved agro-techniques for vegetable production" during *kharif* season" in off-campus farmer's training programme held at Husansa ( 2, 3 NGM) village of Bikaner district on 07th August, 2013.

Delivered a lecture on "*shushk kshetriya phalo wa sabjiyon mein vyadhi prabandhan*" on Farm Innovation Day' held on 09th October, 2013 at this Institute.

Delivered lectures on "Integrated disease management in arid fruits, vegetables and spices" in training on 'Phalon, Sabjion evam Masalon ki Kheti' during 16-20th and 25-29th January, 2014 at RRS, CAZRI, Bikaner.

Delivered lectures regarding diseases of arid vegetables on "Arid vegetable production technologies during summer season" in off-campus farmer's training held at Sherekunjiya and Khinchiya villages of Bikaner district on 15-03-2014 and 20-03-2014, respectively.

## Dr. M. K. Jatav

Delivered a lecture on Quantification of contribution of Azotobactor in reducing the requirement of nitrogen fertilizer in potato production in mid hill of Himachal Pradesh in 2nd International Conference on Agricultural & Horticultural Sciences held on 3 to 5 February, 2014 at Hyderabad (Andhra Pradesh).

Delivered a lecture on nutrient management for arid fruits and vegetable on 27.01.2014 in a farmers training on Phalon, Sabjion evan masalon ki kheti during 25-29th January, 2014 at RRS, CAZRI, Bikaner

## Sh. H. K. Joshi

Lecture delivered to ATMA Trainees on IPM in semi-arid fruits and vegetables.

6 lectures delivered to BRS trainees from NAU, Navsari (Sept-Oct.,13)

## Dr. B. R. Choudhary

Delivered lecture on 'Role of PPV&FRA' and 'Improved varieties of vegetables and their cultivation for high production' in a training programme on 05-09-2013 organized by SIAM, Jaipur.

Delivered lecture on 'Production technology of cucurbits in hot arid region' in a Farm Innovation Day on 09-10-2013 organized by CIAH, Bikaner.

Delivered lecture on 'Cultivation of fruits, vegetable and spices' in a training programme on 16-01-2014 organized by CAZRI RSS, Bikaner.

Delivered lecture on 'Cultivation of fruits, vegetable and spices' in a training programme on 28-01-2014 organized by CAZRI RSS, Bikaner.

Delivered lecture on 'Vegetable production in dry land' and 'Innovative technologies in dry land horticulture crop production' in a training programme on 04-02-2014 organized by SIAM, Jaipur.

Delivered lecture on 'Protection of plant varieties and farmer's right act' in a training cum awareness programme on 17-02-2014 organized by CIAH, Bikaner.

### Dr. S. M. Haldhar

Delivered lecture to farmers on 'Integrated Pest Management (IPM) in fruit, vegetable & spices' in training "Phalon, Sabjion evam Masalon ki kheti" organized by CAZRI, RS, Bikaner during 25-29 January, 2014.

Delivered lecture to farmers on 'Insect-pests and disease management of arid fruits and vegetable crops' in "Farm Innovation Day" organized by CIAH, Bikaner during 09 October, 2013.

### Dr. P. N. Sivalingam

Presented a lecture on Advances in Citrus Improvement through Biotechnological Approaches in workshop on "Precision Farming Technologies For Citrus" held on 23- 24 january 2014 at PFDC , ARS-SKRAU, Bikaner.

### Dr. V. Karuppaiah

Delivered lecture on Factors influencing stone weevil, *Aubeus himalayanus* Voss (Curculionidae: Coleoptera) infestation in ber (*Ziziphus mauritiana* Lamark) under hot-arid ecosystem. In proceedings of International Conference on Entomology, during 21-23 February 2014 at Punjabi University, Patiala.

### Dr. Raja Shankar

Delivered lecture on improved production technology in Moringa and Cucurbitaceous vegetables. In Training and Skill development program under Tribal Sub Plan (TSP), at CHES, Vejalpur on 24/3/2014.

Delivered lecture on "Crop production and pest management in moringa" on 18.12.13 to BRS students under RAWE program

Delivered lecture on "Farm Field School" on 19.12.13 to BRS students under RAWE program

Delivered lecture on "Crop production in tomato" on 28.12.13 to BRS students under RAWE program

Delivered lecture on "Breeding techniques of vegetable crops" on 31.12.13 to BRS students under RAWE program

Delivered lecture on "Crop production in Cucurbits" on 03.1.14 to BRS students under RAWE program

Delivered lecture on "Post harvest technology in vegetable crops" on 08.1.14. to BRS students under RAWE program

Delivered lecture on "Extension methods for dissemination of horticultural technologies" on 10.1.14 to BRS students under RAWE program

Delivered lecture on "Front line Horticultural Extension by ICAR institutes" on 13.1.14 to BRS students under RAWE program

## Important Events

Institute Joint Staff Committee Meeting was on 14.06.2013.

## Celebration of Week/day

The Institute's Foundation day was celebrated on 1.4.2013 in the campus of the Institute. The Chief Guest of the programme was Dr. A. K. Dahama, Vice Chancellor, SKRAU, Bikaner.

Anti-terrorism day was celebrated in the Institute on 21.05.2013 and 09-09-2013

Celebrated Agriculture Education Day on 20.07.2013.

Celebrated National Science Day on 28$^{th}$ February, 2014.

Celebrated Farmers Innovators Day on 9.10.2013.

Celebrated ICAR-Industry Meet on 18.12.2013

# 12. DISTINGUISHED VISITORS

Dr. S. P. Ghosh, Former DDG (Hort), ICAR New Delhi visited CIAH on 27.04.2013.

Dr. K. K. Jindal, Former ADG (Hort.), ICAR, New Delhi visited CIAH on 27.04.2013.

Dr. J. P. Gupta, Former Head, CAZRI, Jodhour visited CIAH on 27.04.2013.

Dr. V. Ponnuswamy, Dean, College of Horticulture & Research Institute, Periyakulam (T N.) visited CIAH on 27.04.2013.

Dr. R. D. Rawal, Former Head, IIHR, Bangaluru visited CIAH on 27.04.2013.

Dr. A. K. Dahama, Vice-Chancellor, SKRAU, Bikaner visited the Institute on 02.09.2013 and 17.02.2014

Dr. M. P. Singh, Principal Scientist and Head Farming System, Directorate on Farming System Research, Modipuram (UP) visited the Institute on 02.09.2013

Dr. P. N. Kalla, Director of Extension, SKRAU, Bikaner visited the Institute on 02.09.2013

Dr. Gulsan Lal, Retd. Prof. and Head, Vegetable Crops, GB PUAT, Pant nagar visited the Institute on 02.09.2013.

Dr. T. R. Sharma, Principal Scientist, NRC, Plant Biotechnology, New Delhi visited the Institute on 02.09.2013.

Dr. K. V. Bhatt, Principal Scientist, NBPG, New Delhi visited the Institute on 2.09.2013

Dr. L. K. Dashora, Dean, Collage of Horticulture and Forestry, Jhalawar visited the Institute on 10.12.2013

Dr. K. R. Solanki, Ex. ADG (Agro-Forestry), ICAR, New Delhi visited the Institute on 15.12.2013

Dr. A. K. Patel, Head, Regional Station of CSWRI, Bikaner visited the Institute on 13.01.2014

Dr. Rabi Prakash, Registrar, PPV & FRA, Ministry of Agriculture, New Delhi visited the Institute on 16.01.2014

Dr. O. P. Jangir, Ex. Director of Research, SKRAU, Bikaner visited the Institute on 29.11.2013

Dr. Sanghavi K. N. U.C. Retd. Prof. College of Agriculture, Dhule (Maharashtra) visited the Institute on19.02.2014

Dr. C. B. Upadhyay, Director, Central State Farms Suratgarh visited the Institute on 19.03.2014

# 13. RAJBHASHA

## jkt Hkk"kk dk;kUo;u lfefr dh cBd

lLFkku jkt Hkk"kk dk;kUo;u lfefr dh frekgh cBdk e çFke frekgh dh cBd dk vk;ktu fnukd fnukd 14 tu] 2013 dk fd;k x;k FkkA blh Øe e f}rh; cBd dk vk;ktu fnukd 09 flrEcj 2013 dk fd;k x;k FkkA rhljh frekgh dh cBd dk vk;ktu fnukd 03 fnlEcj] 2013 dk rFkk pkFkh frekgh dh cBd dk vk;ktu fnukd 15 ekp] 2014 dk fd;k x;k FkkA

## fgUnh dk;Z'kkykvksa dk vk;ktu

lLFkku e fnukd 29 tu] 2013 dk çFke frekgh dh dk;Z'kkyk dk vk;ktu fd;k x;kA bl volj ij Hkkjrh; —f"k vuqla/kku ifj"kn] ub fnYyh d fgUnh foHkkx d lgk;d e[; rduhdh vf/kdkjh Jh eukt dekj u ^jkt Hkk"kk fu;ek ,o vf/kfu;ek dh tkudkjh rFkk fVI.kh ,oa çk:i y[ku* fo"k; ij viuk 0;k[;ku ndj vf/kdkfj;k ,o depkfj;k e fgnh e dk; dju dh çj.kk tkxr dhA f}rh;

fgUnh dk;Z'kkyk e 0;k[;ku nr g, Hkk—vuqi] ub fnYyh d jkt Hkk"kk foHkkx d lgk;d e[; rduhdh vf/kdkjh Jh eukt dekj

frekgh dh dk;Z'kkyk dk vk;ktu fnukd 27 flrEcj] 2013 dk fd;k x;k FkkA ftle lLFkku d ofj"B rduhdh vf/kdkjh Jh çe çdk'k ikjhd u ^oruh dh 'k)rk* fo"k; ij viuk 0;k[;ku fn;kA

rhljh frekgh dh dk;Z'kkyk dk vk;ktu fnukd 16 fnlEcj] 2013 dk fd;k x;k FkkA ftle fgUnh lkfgR;dkj ,o io fgUnh 0;k[;krk M,- ¼Jherh½ m"kk fdj.k lkuh u **fo'o Hkk"kk dh vkj c<r fgUnh d dne vkj ge^^ fo"k; ij 0;k[;ku fn;kA blh Øe e pkFkh frekgh dh dk;Z'kkyk dk vk;ktu fnukd 19 ekp] 2014 dk fd;k x;k FkkA ftle e.My jy dk;ky; d jkt Hkk"kk vf/kdkjh ,o ujkdkl d lnL; lfpo Jh vfuy dekj 'kekl u **jkt Hkk"kk fgUnh D;k vko';d g vkj bld ç;kx dk dl c<k, fo"k; ij 0;k[;ku fn;k A

## fgUnh i[kokM dk vk;ktu

dUæh; 'k"d ckxokuh lLFkku] chdkuj e fnukd 16 flrEcj] 2013 l 30 flrEcj] 2013 rd fgUnh i[kokM dk vk;ktu fd;k x;kA i[kokM d nkjku fofHkUu çfr;kfxrk, vk;kftr dh x;h ,o çfrHkkfx;k dk ijLdkj fn, x;A

mn?kkVu lekjkg d volj ij jktokl] chdkuj d io çk/;kid ,o lkfgR;dkj M,- cEgk jke pk/kjh e[; vfrfFk Fk ogh lekiu lekjkg e chdkuj d ofj"B vf/koDrk ,o lkfgR;dkj Jh mi/;ku pæ dkpj e[; vfrfFk FkA

lekjkg e fof'k"V vfrfFk dUæh; HkM o Åu vuqla/kku lLFkku] chdkuj d v/;{k M,- ,- d- iVy FkA lLFkku d fun'kd M,- lrh'k dekj 'kekl u mifLFkr oKkfudk] vf/kdkfj;k ,o depkfj;k l fgUnh e vf/kdkf/kd dk; dju dk vkxg fd;kA

i[kokM d nkjku vk;kftr çfr;kfxrkvk e fgUnh fVli.k y[ku e Jh dynhi ikUM çFke] Jh Hkkt jkt [k=h f}rh; rFkk Jh Lo:i pn jkBkM u rrh; LFkku çkIr fd;kA fgUnh 'kCn y[ku e lJh itk tk'kh çFke] Jh Hkkt jkt [k=h f}rh; rFkk Jh Lo:i pn jkBkj rrh; LFkku ij jgA blh çdkj vk'kHkk"k.k çfr;kfxrk e Jh dynhi ikUM çFke rFkk M,- f'kojke ehuk u f}rh; LFkku çkIr fd;kA oKkfud 'kk/k y[ku çfr;kfxrk e M,- f'kojke ehuk rFkk M,- ,l- ,e- gy/kj dk ç;kl ljkguh; jgkA e[; vfFkfr ,o lLFkku d fun'kd u fot rkvk dk Lefr fpUg çnku fd,A vk;ktu lfefr d v/;{k M,- jek 'kdj flg u i[kokM d nkjku vk;kftr dk;Øek dk fooj.k çLrr fd;kA ç'kklfud vf/kdkjh Jh jkenhu u /kU;okn Kkfir fd;k rFkk jkt Hkk"kk vfèkdkjh Jh çe çdk'k ikjhd u fot rkvk dh ?kk"k.kk ,o dk;Øe dk lpkyu fd;kA

## fgUnh çdk'ku

çfronu vof/k d nkjku lLFkku }kjk fuEufyf[kr fgUnh çdk'ku çdkf'kr fd, x;A

1- okf"kd çfronu 2012&13 ¼lLFkku½
2- okf"kd çfronu 2012&13 ¼,fØi½
3- N ekgh lekpkj i=
4- jkt Hkk"kk if=dk *e# ckxok.kh 2012*




fgUnh i[kokM dh nkjku epkIhu vfrfFk ,oa ijLdkj xg.k djrs gq, lLFkku dh vf/kdkjhA

# 14. PERSONNEL

## CIAH (INCLUDING CHES) (as on 31.03.2014)

| Sr. No. | Designation | Sanctioned Posts | Posts filled | Posts vacant |
|---|---|---|---|---|
| 1. | Director (RMP) | 01 | 01 | 00 |
| 2. | Scientific | 35 | 22 | 13 |
| 3. | Technical | 43 | 40 | 03 |
| 4. | Administrative | 23 | 19 | 04 |
| 5. | Skilled Support Staff | 33 | 29 | 04 |
| | Total | 135 | 108 | 27 |

## Krishi Vigyan Kendra

| Category | Sanctioned Strength | In position |
|---|---|---|
| Programme Coordinator | 01 | 01 |
| Administrative | 02 | 02 |
| Technical | 11 | 10 |
| Supporting | 02 | 02 |
| Total | 16 | 15 |

## A. CIAH, Bikaner – Headquarter

| S. No. | Name | Designation/Discipline |
|---|---|---|
| **I. RESEARCH MANAGEMENT POSITION** | | |
| 1. | Dr. S. K. Sharma | Director |
| **II. SCIENTIFIC** | | |
| 1. | Dr. B.D. Sharma | Principal Scientist & I/c Head, Division of Crop Production |
| 2. | Dr. R. Bhargava | Principal Scientist & I/c Head, Division of Crop Improvement |
| 3. | Dr. R.S. Singh | Principal Scientist & I/c PME Cell |
| 4. | Dr. D.K. Samadia | Principal Scientist |
| 5. | Dr. Dhurendra Singh | Principal Scientist |
| 6. | Dr. S. K. Maheshwari | Senior Scientist |
| 7. | Dr. Hare Krishna | Senior Scientist |
| 8. | Dr. S.R. Meena | Senior Scientist |
| 9. | Dr.M.K.Jatav | Senior Scientist |
| 10. | Dr.P.P.Singh | Senior Scientist |
| 11. | Dr.Pinaki Acharya | Senior Scientist |
| 12. | Dr. B. R. Chaudhary | Scientist |
| 13. | Dr. P. N. Sivalingam | Scientist |
| 14. | Sh. Karuppaiah V. | Scientist |
| 15. | Dr. S. M. Haldhar | Scientist |
| 16. | Dr. Rajkumar | Scientist |
| **III. ADMINISTRATIVE** | | |
| 1. | Shri Ramdeen | Administrative Officer |
| 2. | Shri Raj Kumar | Finance & Accounts Officer |
| **IV. TECHNICAL** | | |
| 1. | Dr. U. V. Singh | Sr. Technical Officer - Field |
| 2. | Shri P.P. Pareek | Sr. Technical Officer - O.L. |
| 3. | Shri Sanjay Patil | Sr. Technical Officer - Photography |
| 4. | Shri C. L. Meena | Sr. Technical Officer |
| 5. | Shri M. K. Jain | Technical Officer - Computer |
| 6. | Shri R. D. Rathva | Technical Officer - Lab |
| 7. | Shri K. K. Vankar | Technical Officer-Field |

## B. CHES, GODHRA – REGIONAL STATION

| Sr. No. | Name | Designation/Discipline |
|---|---|---|
| **I.** | **SCIENTIFIC** | |
| 1. | Dr. Sanjay Singh | Principal Scientist & Head |
| 2. | Dr. S.S. Hiwale | Principal Scientist |
| 3. | Sh. H.K. Joshi | Scientist |
| 4. | Dr. V.V. Appa Rao | Senior Scientist |
| 5. | Dr. A.K. Singh | Senior Scientist |
| 6. | Dr.Raja Shankar | Scientist |
| **II.** | **ADMINISTRATIVE** | |
| 1. | Smt. R. K. Shah | Assistant Administrative Officer |
| **III.** | **TECHNICAL** | |
| 1 | Sh.D.K.Saraswat | Chief Technical Officer - Field |
| 2. | Sh. Nihal Singh | Chief Technical Officer - Field |
| 3 | Sh. G.U. Trivedi | Sr. Technical Officer - Library |
| 4 | Sh. M.N. Makwana | Sr. Technical Officer - O.L. |
| 5 | Sh. A.V. Dhobi | Sr. Technical Officer - Civil |
| 6 | Shri G. R. Baria | Technical Officer-Field |
| 7 | Shri B.J. Patel | Technical Officer-Field |
| 8 | Shri B. H. Patel | Technical Officer - Photography |
| 9 | Sh.R.B.Baria | Technical Officer-Field |
| 10 | Sh.K.V.Parmar | Technical Officer - Lab |

## KVK, VEJALPUR

| S. No. | Name | Designation/Discipline |
|---|---|---|
| **I. PROGRAMME COORDINATOR** | | |
| 1 | Dr. (Mrs). Kanak Lata | Programme Coordinator |
| **II. TECHNICAL** | | |
| 1 | Sh. J.K.Jadav | Sr.Technical Officer - (Edu. Extn.) |
| 2 | Sh.Balbir Singh | Sr.Technical Officer - (Animal Hus.) |
| 3 | Dr. Ajay Kr. Rai | Sr.Technical Officer - (Soil Sci.) |
| 4 | Dr. Raj Kumar | Sr.Technical Officer - (Hort.) |
| 5 | Dr. Shakti Khajuria | Sr.Technical Officer - (Plant Prot.) |

## NEW ENTRANTS

1. Dr. Rajkumar, Scientist (Fruit Science) joined the Institute on 12.4.2013.
2. Sh. Ramdeen, Administrative Officer joined the Institute on 1.8.2013.
3. Dr. M.K.Jatav, Sr.Scientist (Soil Science) joined the Institute on 1.8.2013.
4. Dr. P.P.Singh, Sr.Scientist (Vegetable Science) joined the Institute on 7.8.2013.
5. Dr.Pinaki Acharya, Sr.Scientist (Vegetable Science) joined the Institute on 17.1.2014.

## PROMOTION

### Scientists

| Sr. No. | Name/Designation | Grade to which promoted and pay scale | Date of Promotion |
|---|---|---|---|
| 1. | Dr. S.R. Meena, Scientist (Agricultural Extension) | Rs.15600-39100+RGP Rs.8000/- with designation of Sr. Scientist | 14.09.2009 |
| 2. | Dr. Balu Ram Choudhary, Scientist (Vegetable Science) | Rs.15600-39100+RGP Rs.7000/- | 27.06.2009 |
| 3. | Dr. P.N. Sivalingam, Scientist (Plant Bio-technology) | Rs.15600-39100+RGP Rs.7000/- | 07.01.2012 |

### Administrative

| Sl. No. | Name and Present Grade/ Designation | Promoted to Grade/Scale | Date of merit Promotion | Present Place of Posting |
|---|---|---|---|---|
| 1. | Sh. N.A. Patel, Assistant | Asstt. Adm. OfficerPay Band-2/ Rs. 9300-34800 with Grade Pay of Rs. 4600 | 28.5.2013 | CIAH, Bikaner |

### Technical

| Sl. No. | Name and Present Grade/ Designation | Promoted to Grade/Scale | Date of merit Promotion | Present Place of Posting |
|---|---|---|---|---|
| 1. | Sh. A.V. Dhobi Technical Officer – Overseer (T-5) | Sr. Technical Officer – Overseer (T-6) PB-3 Rs 15600-39100 + GP 5400.00 | 05.12.2012 | CHES, Godhra |
| 2. | Sh. K.V. Parmar Sr.Tech. Assistant - Lab (T-4) | Technical Officer – Lab (T-5) PB-2/Rs.9300-34800 + GP 4600.00 | 12.11.2012 | CHES, Godhra |
| 3. | Sh. I.P. Thakor Sr.Technician – Elect. (T-2) | Technical Assistant – Electrician (T-3) PB-1/Rs.5200-20200 + GP Rs.2800 | 08.08.2012 | CHES, Godhra |
| 4. | Sh. R.V. Rathva Sr.Technician – Lab (T-2) | Technical Assistant – Lab (T-3) PB-1/Rs.5200-20200 + GP Rs.2800 | 17.7.2012 | CHES, Godhra |
| 5. | Sh. Chhuttan Lal Meena, Technical Officer – Field (T-5) | Sr. Technical Officer – Field (T-6) PB-3 Rs 15600-39100 with GP 5400.00 | 13.7.2013 | CIAH, Bikaner |
| 6. | Sh. B.F. Patelia, Technical Assistant – Field (T-3) | Sr. Tech. Assistant – Field (T-4) PB-2 Rs 9300-34800 with GP Rs 4200.00 | 16.12.2012 | CHES, Godhra |

### Supporting

Nil

**MODIFIED ASSURED CAREER PROGRESSION SCHEME (MACPS)**

| Sl. No. | Name of Official with designation | Existing pay band and grade pay | Date of grant of 3rd Financial Up-gradation and Pay Band + Grade Pay |
|---|---|---|---|
| 1. | Sh. M.J. Parmar, SSS | PB-1 Rs 5200-20200+GP 2000 | 01.03.2013PB-1 Rs 5200-20200+GP 2400 |
| 2. | Sh. A.D.Vankar, SSS | PB-1 Rs 5200-20200+GP 2000 | 1.12.2012PB-1 Rs 5200-20200+GP 2400 |
| 3. | Sh. S.J. Patel, SSS | PB-1 Rs 5200-20200+GP 2000 | 10.5.2013PB-1 Rs 5200-20200+GP 2400 |

| Sl. No. | Name of Official with designation | Existing pay band and grade pay | Date of grant of 2nd Financial Up-gradation and Pay Band + Grade Pay |
|---|---|---|---|
| 1. | Sh. G.S. Rathva, SSS | PB-1 Rs 5200-20200 + GP Rs 1900 | PB-1 / Rs 5200-20200 GP Rs 2000/- |

## PROBATION CLEARANCE & CONFIRMATION

### Scientist

| Sr. No. | Name of the Scientist | Date from which probation cleared |
|---|---|---|
| 1. | Dr. Sushil Kumar Maheshwari, Sr.Scientist (Plant Pathology) | 28.07.2011 |

### Technical

| Sr. No. | Name | Designation/Grade | Date of clearance of Probation |
|---|---|---|---|
| 1. | Sh. Jadav Jay Palsinh Kalyansinh | T-6 (SMS) Education Extension PB-3/ Rs 15600-39100 + GP Rs 5400.00 | 25.05.2011 |
| 2. | Dr. Ajay Kumar Rai | T- 6 (SMS) Agronomy / Soil Science PB-3/ Rs 15600-39100 + GP Rs 5400.00 | 31.5.2011 |
| 3. | Sh. Sua Lal Choudhary, T-1 (Driver) | Pay Band-1/Rs.5200 to 20200 with Grade Pay of Rs.2000 | 27.7.2011 |
| 4. | Sh.B.C.Meena, T-1 (Driver) | Pay Band-1/Rs.5200 to 20200 with Grade Pay of Rs.2000 | 27.7.2011 |
| 5. | Sh.N.B.Varia, T-1 (Driver), CHES, Godhra | Pay Band-1/Rs.5200 to 20200 with Grade Pay of Rs.2000 | 28.7.2011 |

### Administrative

| Sr. No. | Name and Designation | Grade | Date of clearance of Probation |
|---|---|---|---|
| 1. | Sh. Rajesh Daiya, Assistant | Pay Band-2/Rs.9300-34800 with Grade Pay of Rs.4200/- | 06.01.2012 |
| 2. | Sh. Kuldeep Pandey, Assistant | Pay Band-2/Rs.9300-34800 with Grade Pay of Rs.4200/- | 07.01.2012 |

## JOINING ON TRANSFER

| Sl. No. | Name/Designation | Date of joining |
|---|---|---|
| 1. | Sh. Rakesh Kumar Swami, Assistant | 23.10.2013 |
| 2. | Sh.B.K.Panchal, LDC | 3.10.2013 |

## RELIEVING ON PROMOTION/TRANSFER

1. Sh. S.N. Patel, UDC transferred to CHES, Godhra and relieved from the Institute on 11.4.2013.
2. Sh. P.V. Nayak, UDC transferred to CHES, Godhra and relieved from the Institute on 6.9.2013..
3. Sh. H.S. Patel, UDC transferred to CHES, Godhra and relieved from the Institute on 19.10.2013.

# 15. BUDGET

## Plan expenditure 2013-14

| Head | Bikaner | Godhra | Total |
|---|---|---|---|
| **A. Grand in aid-Salary** | | | |
| a. Salary | 0 | 0 | 0 |
| b. Wages | | | 0 |
| Total (A) | 0 | 0 | 0 |
| **B. Grant in aid – Capital** | | | |
| a. Equipment | 0 | | 0 |
| b. Works | 4398000 | | 4398000 |
| c. Library | 670008 | 129992 | 800000 |
| d. Furniture & Fixture | 4677000 | | 4677000 |
| Total (B) | 9745008 | 129992 | 9875000 |
| **C. Grant in aid - General** | | | |
| a. O.T.A. | | | 0 |
| b. T.A. | 554938 | 245000 | 799938 |
| c. H.R.D. | 150062 | 50000 | 200062 |
| **D. Contingency** | | | |
| Res. & Operation | 2106460 | 525452 | 2631912 |
| Administrative Exp. | 7097670 | 1438296 | 8535966 |
| Misc. Exp. | 3092605 | 236222 | 3328827 |
| Total (d) | 12296735 | 2199970 | 14496705 |
| Total (C) | 13001735 | 2494970 | 15496705 |
| Grand Total (A+B+C) | 22746743 | 2624962 | 25371705 |

## Non-Plan expenditure 2013-14

| Head | Bikaner | Godhra | Total |
|---|---|---|---|
| **A. Grand in aid-Salary** | | | |
| a. Salary | 31907220 | 31098462 | 63005682 |
| b. Wages | 0 | 16668876 | 16668876 |
| Total (A) | 31907220 | 47767338 | 79674558 |
| B. Grant in aid - Capital | | | |
| a. Equipment | 249981 | 0 | 249981 |
| b. Works | | | 0 |
| c. Library | | | 0 |
| d. Furniture & Fixture | | | 0 |
| Total (B) | 249981 | 0 | 249981 |
| C. Grant in aid - General | | | |
| a. O.T.A. | 22223 | 0 | 22223 |
| b. T.A. | 206084 | 136830 | 342914 |
| c. H.R.D. | | | 0 |
| D. Contingency | | | 0 |
| Res. & Operation | 1066803 | 999999 | 2066802 |
| Administrative Exp. | 3527930 | 1131113 | 4659043 |
| Misc. Exp. | 62919 | 88724 | 151643 |
| Total (d) | 4657652 | 2219836 | 6877488 |
| Total (C) | 4885959 | 2356666 | 7242625 |
| D. Others | | | |
| a. Pension | 50355 | 2445527 | 2495882 |
| b. P-Loan | 246000 | 401250 | 647250 |
| Grand Total (A+B+C) | 37339515 | 52970781 | 90310296 |

## Revenue receipt 2013-14

| Receipt | CIAH | CHES | KVK | Seed Project | Total |
|---|---|---|---|---|---|
| Sale of Farm Produce | 172376 | 1094191 | 13109 | 594743 | 1874419 |
| Interest on STD | 1470550 | 0 | | 59080 | 1529630 |
| Misc. | 192888 | 6396 | | | 199284 |
| Licence Fee | 81706 | 4700 | | | 86406 |
| Water Charge | 1860 | 480 | | | 2340 |
| Tender Fee | 203491 | 0 | | | 203491 |
| Interest on P-Loans | 145964 | 21348 | | | 167312 |
| LS & PC | 0 | | | | 0 |
| Guest House | 27500 | 0 | | | 27500 |
| Sale of Condemned Items | 101000 | | | | 101000 |
| Total | 2397335 | 1127115 | 13109 | 653823 | 4191382 |

# 16. METEOROLOGICAL DATA

## BIKANER

### Meteorological Data for the year 2013-14

| S. No. | Month | Temperature | | RH% | Rainfall (mm) | Rainy days | Wind speed (km) | Evop. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | | | | | | |
| 1. | April, 2013 | 37.2 | 17.6 | 45.23 | 1.4 | 01 | 5.9 | 7.25 | |
| 2. | May, 2013 | 43.4 | 23.7 | 36.6 | - | - | 6.8 | 10.4 | |
| 3. | June, 2013 | 41.3 | 27.0 | 46.6 | 16.0 | 02 | 13.8 | 11.3 | |
| 4. | July, 2013 | 38.1 | 23.8 | - | 53.9 | 04 | 9.3 | 4.0 | |
| 4. | August, 2013 | 37.9 | 25.6 | - | 100.2 | 07 | 8.5 | - | |
| 5. | September, 2013 | 37.4 | 24.7 | - | 6.5 | 01 | 7.3 | - | |
| 7. | October, 2013 | 34.3 | 19.8 | 53.0 | - | - | 4.4 | - | |
| 8. | November, 2013 | 28.4 | 12.6 | - | - | - | 2.19 | - | |
| 9. | December, 2013 | 23.7 | 6.8 | - | - | - | 2.34 | - | |
| 10. | January, 2014 | 20.28 | 5.87 | - | - | - | 6.00 | - | |
| 11. | February, 2014 | 23.47 | 4.07 | - | - | - | 3.94 | - | |
| 12. | March, 2014 | 29.50 | 16.33 | - | 13.5 | 2 | 5.27 | - | |

## GODHRA

### Meteorological Data for the year 2013-14

| Sl. No. | Month | Temperature ($^0$C) | | RH (%) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|---|
| | | Max | Min | | | |
| 1 | April, 2013 | 38.56 | 22.14 | 48.96 | | |
| 2 | May, 2013 | 40.68 | 24.59 | 47.68 | | |
| 3 | June, 2013 | 41.86 | 25.98 | 45.35 | 74.59 | 9 |
| 4 | July, 2013 | 38.62 | 25.99 | 75.24 | 317.42 | 11 |
| 5 | August, 2013 | 38.48 | 25.33 | 81.78 | 528.48 | 19 |
| 6 | September, 2013 | 32.46 | 24.66 | 81.44 | 130.8 | 15 |
| 7 | October, 2013 | 36.28 | 22.19 | 80.15 | 2.25 | 4 |
| 8 | November, 2013 | 35.18 | 20.17 | 75.15 | | |
| 9 | December, 2013 | 32.88 | 13.56 | 62.28 | | |
| 10 | January, 2014 | 27.66 | 10.24 | 60.48 | | |
| 11 | February, 2014 | 29.38 | 11.18 | 59.68 | | |
| 12 | March, 2014 | 33.86 | 15.28 | 56.35 | | |

# NOTES

# NOTES




हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch