# Annual Report

## 2014-15


**ICAR-Central Institute for Arid Horticulture**

(Indian Council of Agricultural Research)

Bikaner- 334006 (Rajasthan)

# Annual Report
# 2014-15



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

**Published by**

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# PREFACE

It gives me immense pleasure in bringing out the Annual Report 2014-2015 of the ICAR-Central Institute for Arid Horticulture, Bikaner. Owing to their strength such as vast area, ample solar radiation, low incidence of diseases and pests 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 ICAR-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 8 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 organizations 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 Director General, 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 (Horticultural Science) for his ciritcal remarks and valuable suggestions and to Dr. T. Janakiram, ADG (Hort.-1) for his 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.

Bikaner
Dated: May 2015,

**(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.

A promising chance seedling of ber was identified at the Institute and christered as CIAH-Ber-S-15. A physiological disorder "brown tip"was noted in ber cv. Chhuhara for fourth consecutive year.

A survey was undertaken to evaluate the biodiversity of bael in Alwar, Chomu and Sikar area. Some promising types were identifed in Alwar and Chomu area.

An intensive survey was undertaken in North-Eastern region of India with a viw to identify frost tolerant aonla. A total of 39 accessions were collected and are being budded for evaluation at Bikaner and Godhra.

9 exotic eollections of watermelon and 4 each of ridge gourd and sponge gourd from USDA, ARS, Griffin, Georgia, USA were collected in collaboration with ICAR-NBPGR, New Delhi

A total of 26 genotypes of jamun, 24 of tamarind, 30 of mahua, 40 of karonda and 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

The sponge gourd germplasm maintained as generated material (22) at the institute were studied for storage behaviour and maintenance cycle for seed multiplication. These were evaluated for trait specific characterization and sufficient quantity of seed was produced during rainy season of 2014-15 for conservation. Based on quality fruit yield potentials and over all performance, the progeny from germplasm line AHSG–4 and white seeded progeny of cross combination [($P_5$ x $P_4$) x $P_4$] were found to be most potential for utilization in trait specific crop improvement.

During summer season of 2014, nineteen advanced breeding material of round melon were evaluated and wide range of variation were recorded for characters under study, potential individuals were identified for the advancement of generation.

Advanced progenies of long fruited bottle gourd developed with a breeding objective for high temperature tolerance were evaluated (11) during rainy season of 2014–15. Similarly, two advanced lines of bottle gourd were tested as summer season crop trial for performance study.

During 2014–15, forty three snap melon genotypes consisted of generated breeding material from germplasm, advanced lines and varieties were studied for screening against melon fruit fly.

Developed breeding line of tomato (AHSL–02) and brinjal (CIAH–01) were tested during spring–summer of 2014 as replicated trials for uniformity, stability and marketable fruit yield potential under high temperature conditions.

In khejri, 14 elite genotypes were maintained for *ex situ* conservation with good management practices and three additional types were studied for horticultural characters, and Khejri Selection–2 is potential and characterized for growth and flowering traits. The variety Thar Shobha out yielded for tender pod, loong and total bio-mass production.

Varietal maintenance and crop production studies on snap melon, kachri and beans were conducted for quality and high yield potentials in arid vegetables under ICAR funded revolving fund project during 2014–15. About 180.00 kg TFL / breeder seeds of potential arid vegetable crop

varieties was produced and distributed to the farmers, NGO's, KVK's and state and private agencies for initial spread of the institute varieties and further seed multiplication.

## Crop Management and Agrotechniques

The growth, yield, physiological and fruit quality parameters were recorded in nine 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-khejri (46.2 kg per plant) system followed by aonla- ber (44.7 kg/plant), aonla-kinnow (43.4 kg/plant) and aonla- mulbery (42.5 kg/plant), while the lowest was recorded in aonla- moringa (40.6 kg/plant).

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

Khejri based cropping models were studied during 2014–15 and no significant differences were observed in growth characters of khejri variety Thar Shobha under varying planting models. The intercrop studies on cluster bean, kachari and grasses were successful under rainfed conditions and observations were recorded on yield and biomass products.

Systematic studies on jharber plantation were undertaken for growth, fruiting and bio-mass production as inter-crop with wide spacing khejri planting models. The developed jharber plantation was also studied as seed generated germplasm progenies from wide spectrum of variability collected and established *ex situ* for exploitation of native crop diversity.

Likewise, growth studies were conducted in native crop-plant species such as khejri, rohida and lasora as seedling plantation around the production site. In addition, studies on naturally perpetuated shrubs of phog and khimp were undertaken in the production site.

For monsoon supported harvest, inter-crops of cluster bean, kachri and grasses (sewan, dhaman and bharut) were studied for bio-mass production under rainfed situation of year 2014.

## 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, neem, *Pithecellobium 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 RAPD profile of 60 pomegranate accessions available at ICAR-CIAH, Bikaner farm were developed to identify varieties and assess the phylogenetic relationships. The impact of water stress on accumulation of secondary metabolities was also evalauted.

The activities of catalase, peroxidase, polyphenol oxidase, amylase, invertase and protease were assessed in primed seeds.

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 was 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.

Attempt was made to extract the natural color of karonda and use it as a natural colourant cum nutraceutical supplement.

## Crop Protection

Integrated disease management of powdery mildew in ber and leaf spot of pomegrate, 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 small salmon arab, *Colotis amata* is a small butterfly that is yellow and white in color, eggs are laid singly on leaves or young shoots. The length of male and female antenna is 4.63 mm and 5.46 mm. The significant differences were found in percentage bug infestation and bug per leaf among the tested germplasm of lasora during screening. AHCM-34, AHCM-22, AHCM-25 and AHCM-23 were found to the resistant. The per cent infestation was highest in AHCM-01 (69.49 %) and lowest in AHCM-22 (12.01 %) followed by AHCM-25 (13.97 %). The leaf infestations ranged from 12.01 to 69.49 % and significantly lower in resistant germplasm and higher in susceptible germplasm. Tannins, phenols, total alkaloid and flavonoid contents were significantly higher in resistant germplasm and lower in susceptible germplasm. Free amino acid of different germplasm was significantly lower in resistant germplasm and higher in susceptible germplasm. Free amino acid of leaf had a significant positive correlation whereas, tannins, phenols, alkaloids and flavonoid contents had significant negative correlations with the percentage leaf infestation and the bug per leaf. The average incidence of flower beetles on watermelon ranged between 1.27 to 5.33 per plant of *M. macilenta*, 3.53 to 7.73 per plant of *A. crinitus* and 2.80 to 8.53 per plant of *A. subclaviger*.

## 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

At CIAH, Bikaner and its regional Station CHES, Vejalpur (Godhra), a total of nine externally funded projects were in operation.

Under the DUS project on ber, the DUS descriptor of ber was accepted by PPV& FRA and the same have been notified.

Under the project “Validation of DUS testing guidelines for cucurbits i.e. watermelon and muskmelon”, the draft DUS descriptors have been published.

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.

One elite type of ber has been identified during survey at Chomu. Five wood apple lines were evaluated in arid region.

# 1. INTRODUCTION

The SWOT analysis of arid ecosystem reveals that it has ample strengths, such as ample sunshine, vast land, human labour, biodiversity harbouring important genes, low humidity and low incedence 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 production 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, Bengaluru) was merged with it as its Regional Station on 1st October, 2000. Subsequently, two divisions i.e. Division of Crop Production and Division of Crop Improvement were created in the Institute w.e.f. 1st August, 2013.

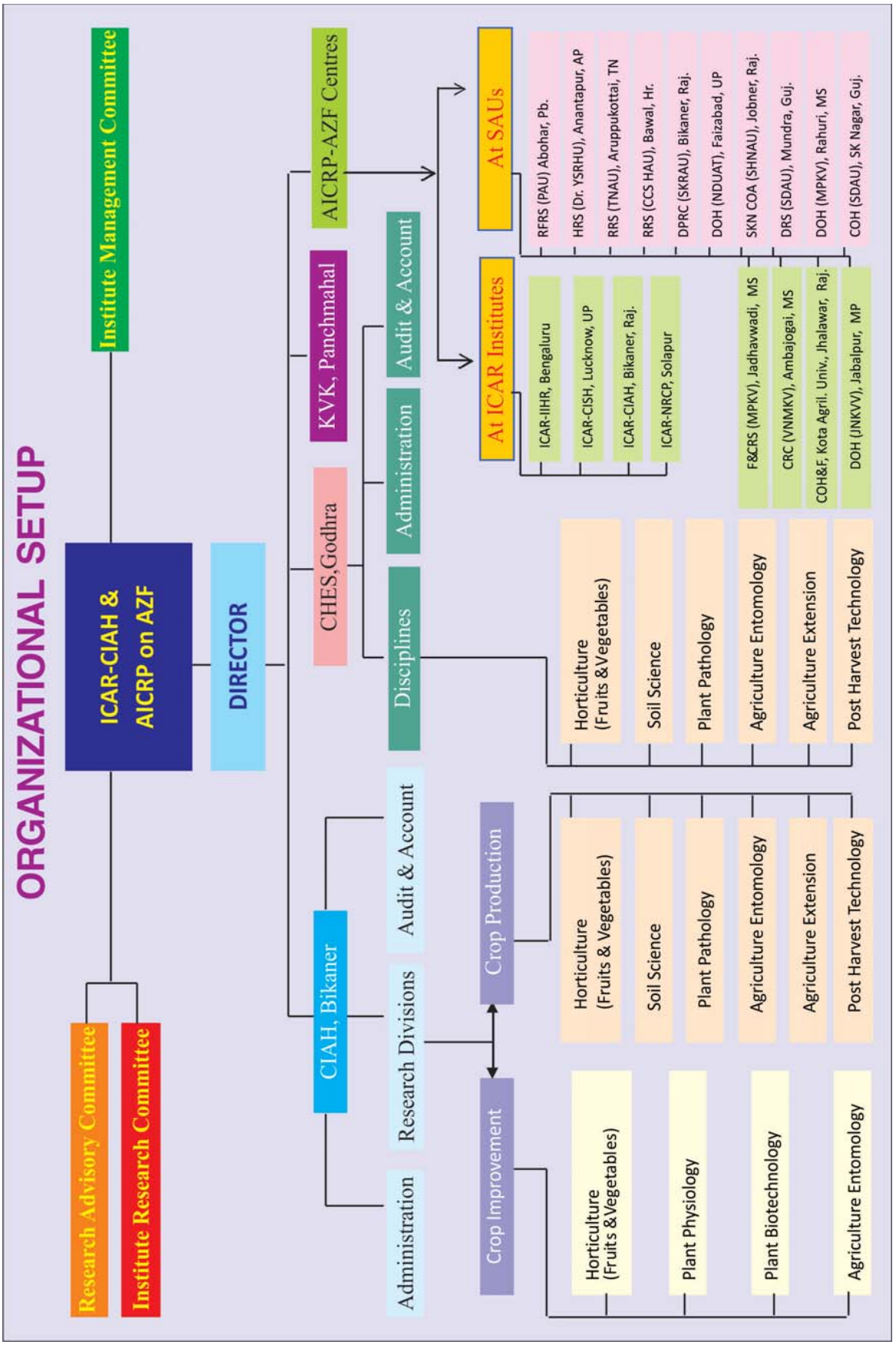
## Mandate

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, 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 2014-15 and the significant results obtained in different projects are presented hereunder.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# 2. RESEARCH ACHIEVEMENT

## GENETIC RESOURCES

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

### FRUIT

### At Bikaner

### Ber (*Ziziphus mauritiana*)

#### Identification and evaluation of a promising ber selection

A promising chance seedling of *ber* was identified at the institute and christened as CIAH *Ber* S-15. It is a semi-erect, late maturing, free from pests (infestation under field conditions) and a potentially high yielding genotype (~65 kg/tree) (Fig. 1).

#### Observations on stylar end browning of *ber* cv. 'Chhuhara'

Like previous years, a physiological disorder 'brown tip' was noted in *ber* cv. Chhuhara for the fourth consecutive year (Fig. 2). During this fruiting season too, the disorder has been found to aggravate with the progress in the maturity. Further, this disorder appears during late harvesting period, when atmospheric temperature is well above 20 $^0$C i.e. last week of February to first fortnight of March.

A bearing tree of CIAH *Ber* S-15

A view of fruiting in CIAH *Ber* S-15

Foliage characteristics

Fruit characteristics

**Fig. 1: Promising chance seedling selection CIAH *Ber* S-15**

Fig. 2: Stylar end browning in cv. Chhuhara

### Observations on infection of *Alternaria* sp. in *ber*

Infection of *Alternaria* sp. in *ber* was noted during the fruiting season. Infection was manifested as dark greyish-black colonies of the fungus on leaves of all the major *ber* varieties. The major site of infection was ventral side of leaves. However, some infection was also noted on dorsal side too (Fig. 3). Infection was quite prominent during foggy days. Initially, there were no leaf spots; however, at later stages, the infected surface turns grey; probably due to interruption in photosynthesis at the site of infection by the fungus growth. Although, there was apparently no reduction in yield or plant growth performance, a monitoring is needed to be kept on its occurrences so as to prevent any potential havoc wreaked by this fungus in future.

Fig. 3: Infection of *Alternaria* sp. on *ber* leaves on ventral and dorsal surface. Inset: Microscopic view of branched acropetal chains (blastocatenate) of multicelled conidia (dictyoconidia) of *Alternaria* sp.

## Date palm (*Phoenix dactylifera*)

### 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 flowering/fruiting was noted first time in cv. Amhat after four years of planting. The offshoots of a late maturing red colour fruit type was planted in repository block for evaluation.

### Evaluation of germplasm

The maximum palm height and spread was observed in cv. Muscat followed by cv. Halawy. The spathe emergence started from third week of February and completed in the month of March. About 10-12 days delay in emergence of spathe was noticed among germplsam, during the year, due to climatic conditions. Out of 61 germplasm the spathe emergence/opening and fruiting were observed in 30 genotypes. However, fruit drop was observed in cvs. Saidy, Tayer, Muscat and Sayer. Early emergence of spathe/flowering and fruit maturity was observed in cv. Muscat.

The maximum bunch length was in cv. Sewi (113cm) followed by Chip Chap (109cm), Muscat and Saidy (105cm). The number of bunches varied from 2 - 11 per plant and fruit yield was recorded from 0.500 to 69.00 kg/plant among the germplasm. Similarly, number of strands/ bunch ranged from 1-70; number of berries/strand varied from 13-30. The maximum number of bunches/ plant were observed

in Sabiah, Seddami, Migraf (11) followed by Sewi and Chip-Chap (10.). The maximum number of berries (30 per strand) was observed in cv. Zahidi followed by Sewi, Hayani and Shamran (25) while minimum was in Nagal (8). The bigger size and fruit weight (23.0 g) was observed in cv. Medjool followed by Sewi, Hayani, Nagal Hillali (13.5 to 16.7g) and Braim (11.0g) and minimum fruit weight (4.90g) was in cv. Gulchati. Fruiting in a local genotype Javantri was also observed but taste of *doka* fruit was astringent. The weight of stone varied from 0.5 -2.20 g. The early *doka* stage was observed in cv. Muscat and fruits were harvested in last week of June, 2014. The maturity of fruits (*doka* stage) recorded in maximum cultivars in the second week of July. However, cvs. Medjool, Dayari and Sewi were harvested late in August. Maximum fruit yield at *doka* stage was observed in cv. Khalas (69.0 kg/tree) and Halawy (65.0kg),) followed by Zahidi (42.0kg), Shamran (41kg/tree) and Chip Chap (40kg/tree). However, minimum fruit yield (0.500kg/plant) was observed in cv. Amhat possibly due to young plant. During the year, pind (tamer) stage was not observed in any genotype.

### Varietal evaluation

A varietal trial consisting of cvs. Halawy, Khalas, Zahidi, Medjool and Khadrawy was 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 5.00 x 4.90m spread followed by height (3.00m) 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 some plants and 5-8 bunches/palm were recorded and others are in vegetative stage. The maximum fruit yield/tree was observed in cv. Khalas (69.0 kg/tree) and Halawy (61.5kg.) followed by Zahidi (45kg). The lowest per plant fruit yield was observed in cvs. Khadrawy (31kg) and Medjool (22kg), which may possibly be due to young plants.

### Evaluation of Tissue culture plants

Tissue culture plants of cv. Barhee and KCS-143 were evaluated for growth, flowering/fruiting. The vegetative growth of Barhee (2.40m) was better than KCS-143 plant (1.40m). The vegetative growth in respect of height (2.40m), spread (2.50 x 2.70m) and number of leaves (16) was noted after five years of planting. The spathe emergence/fruiting was observed in cv. Barhee. During second year of fruiting 6.00kg *doka* stage fruit was harvested on 24$^{th}$ July, 2014. However, fruits were damaged due to low plant's height. The light yellow colour, berry size and taste was good at *doka* stage.

### Performance of seedlings

During the year, seeds of two elite type was collected from Mundra and also fruits from Qatar. The seeds were sown in the nursery during September month to see the germination performance. About 30 to 80% seeds germinated after 50-55 days of sowing and seedlings will further be planted for evaluation.

Flowering and fruiting was observed in seedlings after 7-8 years and the sex ratio of male and female plants was 50%. The morphological characters of berry of seedling type were noted however, the taste of fruit was astringent at *doka* stage.

## Pomegranate (*Punica granatum*)

Maintained 154 germplasm in field repository at CIAH, Bikaner and 45 at CHES, Vejalpur, Godhra during the year. The effect of low temperature/frost was not severe on pomegranate plants during the month of January, 2015. Sprouting and growth in plants started after employing cultural practices, irrigation, manuring which were varied among germplasm. It was observed that flowering and fruit set was better in Ambe bahar than Mrig bahar under arid conditions. However, proper colour development in arils was not observed.

The oil was extracted from seeds of pomegranate varieties. Variation in oil content was observed from 12.3 -18.4 % and highest oil content was noted in cv. Jalore Seedless (18.4%) while low oil content was in the seeds of cv. Jodhpur Collection (13.6%).

Plants of 05 germplasm (NRCP- 2014- 1. 2, 3, 4, 5) were procured from ICAR-NRC on Pomegranate, Solapur and planted during August

month for evaluation under arid conditions. Fifty plants of one fruit cracking tolerance (IC- 318712) germplasm was planted in the field for evaluation. The plants are growing well.

### Evaluation of Anardana type

Flowering/fruiting was observed in anardana types. The fruits were small in size ranging from 60 to 100g weight and number of fruits/plant varied from 20 to 50. The aril was small and hard in all anardana types

## Bael (*Aegle marmelos*)

### At Bikaner

Bael germplasm (18) were maintained in the field repository at CIAH, Bikaner and evaluated for growth, flowering, fruiting and effect of frost/low temperature. The vegetative growth of plants varied from 2.00m to 4.75m under arid conditions. The maximum germplasm are of seedling types. The maximum height of plant 4.70 m and spread (4.00m N-S and 3.80 m E-W) was recorded in a seedling type after 12 years of planting. Fruiting was noted in nine germplasm during 2014. Further, flowers and immature fruit drop were also observed possibly due to poor soil moisture conditions during summer. During the year-2015, effect of frost/low temperature was not observed. Variation in number of fruits per plant was from 01 to 29 at maturity stage in February-March. Fruiting in two genotypes was found better with respect to fruit weight (800-1000g) and fruiting 26-29 per plant. Fruit cracking was not observed in any genotype.

A survey was undertaken at Chomu, Alwar and Sariska forest area to identify promising type of bael during April-May, 2014. Some promising type was marked in Alwar and Chomu area which are seedling and growing on field's boundary and having better fruit quality traits. In Sairska forest area wild bael fruit trees are available having very small size fruits. The fruit samples from elite tree were collected for morphological and quality characters study. Variability in bael fruit was observed in fruit shape, size *viz.* length x width (10.71 x 12.40cm to 15.9x13.8cm), weight (0.585 to 1.86 kg), number of seeds/fruit (50-130) and TSS $^{0}$ brix (22.4 -.40.6).

Development of a varietal block of bael NB-5, NB-9, CISH Bael-1, CISH Bael-2, Pant Sujata, CIAH Bael Sel-2, Bael Sel. -1 and Goma Yashi was carried out. *In-situ* budding was done but success percentage was low. However, initial growth in young plants was slow in all varieties.

Bael rootstocks were planted at four spacings *i.e.* 8x8, 4x4, 6x4 and 6x6m and survival rate varied from 50-60% among spacing's during 2014. Rootstocks could not attain proper thickness for *in situ* budding.

### At Godhra

Apart from the 12 varieties, 110 germplasm of bael have been established and evaluated for growth, flowering and fruiting characters which were established through *in-situ* patch budding. All the genotypes showed wide variation in growth characters in terms of growth habit, leaf morphology, and spine and bark morphology. Flowering and fruiting was noticed in 35 genotypes during the year 2014-15. Annual growth extension in terms of plant height was recorded maximum in CHESB-5 (43.25cm) and minimum in CHESB-27 (27.95.10cm), whereas girth of stem (2.72cm) was recorded maximum in CHESB-31 and it was the minimum in CHESB-19 (2.12cm) 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-16, CHESB-21, CHESB-29 and CHESB-31 were found to be superior for various qualitative and morphological characters among the genotypes evaluated under rainfed semi-arid ecosystem.

Salient features of identified promising genotypes of bael

### CHESB-5

Plant height, stem girth, plant spread was recorded 5.98 m, 46.62cm and 5.61 m, respectively during 8$^{th}$year of orchard life. Average yield 70.50 kg in 8$^{th}$ year, fruit weight 1.51 kg, fruit size 20.60 cm x 14.87 cm, fruit girth 44.80 cm, shell thickness 1.8 mm, total number of seeds 120, seed weight

0.13g, total seed weight 32.00g, fibre weight 61g, shell weight 235g, locules in cross section 13-15, pulp 70.50%, TSS pulp 37$^0$B, TSS mucilage 49.50$^0$B, acidity (0.30%) and vitamin C 19.80 mg / 100 g pulp were recorded. It is an early maturing variety (2$^{nd}$ fortnight of February).The fruits of this genotype is less affected (40% less than other varieties) by sun scald owing to compact and luxuriant growth of plant under rainfed semi-arid ecosystem of western India.

### CHESB-8

Plant height, stem girth and plant spread were recorded 4.65 m, 37.92 cm and 4.47 m, respectively during 6$^{th}$year of orchard life. Average yield per plant 44.93 kg in 6$^{th}$ year, fruit weight 1.75 kg, fruit size 16.10 cm x 16.00 cm, fruit girth 48.30 cm, shell thickness 0.18cm, total number of seed 73, seed weight 0.22g, total seed weight 15.46g, fibre weight 110.17 g, shell weight 285.00g, locules in cross section 13-16, pulp 71.30%, TSS pulp 38.50$^0$B, TSS mucilage 50.15$^0$B, acidity (0.30%) and vitamin C 19.90 mg / 100 g pulp were recorded. It is an early maturing variety (2 $^{nd}$ week of March).The fruits of this genotype is having good flavour and aroma. It is highly suitable for sherbet, powder and squash making having excellent aroma.

### CHESB-11

Vegetative growth in terms of plant height, stem girth, plant spread was recorded 4.00 m, 34.35cm and 3.80 m, respectively during 2014-15. Average yield per plant 34.15 kg in 5$^{th}$ year, fruit weight 1.48 kg, fruit size 14.10 cm x 15.20 cm, fruit girth 44.21 cm, shell thickness 0.21cm, total number of seeds 85, seed weight 0.21g, total seed weight 17.58g, fibre weight 1125.60 g, shell weight 200.20g, locules in cross section 14-17, TSS pulp 38.13$^0$B, TSS mucilage 49.80$^0$B, acidity (0.29%) and vitamin C 22.83 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 powder making.

## Wood apple (*Feronia limonia*)

### At Godhra

Five wood apple genotypes were evaluated for survival and growth under arid conditions. The initial growth of plant was slow in all genotypes.

Growth parameters of wood apple were recorded in different lines indicated that the there were significant differences in respect of plant height,the maximum in line CHESW-8 (7.31 m) stock and scion diameter were maximum in CHESW-1. Plant spread in North South and East and West directions for the year revealed significant differences between the lines. Number of fruit per plant ranged from 92 to 230, resulting the yield per plant of 24.11 to 120.28 kg/plant. The highest number of fruits per plant harvested in line CHESW -2 (248 no.), followed by CHESW-3 (115.05 kg). Yield per plant was maximum in CHESW-2.

The physico chemical characters of fruits along with TSS, acidity, reducing and total sugar, showed significant variation among the lines. Data on fruit weight varied from 250 g to 590 g with the maximum in line CHESW-3 (590.0 g). Pulp weight per fruit was maximum in line CHESW-3 (272 g). Skull weight per fruit was highest in CHESW-4. The highest TSS was recorded in line-6 (14.4$^o$ Brix) and was least in line-4 (8.2$^0$ Brix). Total sugar was highest in line-4 (28.84%). Reducing sugar content was recorded highest in line CHESW-2. Acidity was the highest in line CHESW-8 (2.76%). Seed number per fruit was maximum in Line CHESW-9; however seed per fruit was highest in CHESW-1.

## Argan (*Argania spinosa*)

### At Bikaner

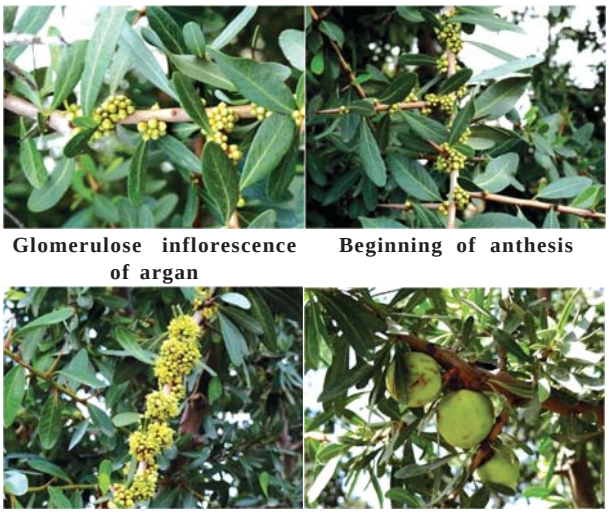
The stem cuttings treated with 1000 and 2000ppm IBA, cow dung alongwith control were planted in nursery during August for multiplication of Argan plants, which is very hardy to root. IBA treatment was responsive for sprouting in cuttings after planting however, due to lack of proper root development, cuttings dried after sprouting.

The flowering and fruiting was observed in seedling Argan (*Argania spinosa*) plant first time at an age of 10 years introduced from Israel (EC-497195). Fruiting was observed during November-December. The fruit weight was 8-10g and 30-40 green colour fruits were noted on a plant during

February month. Further, bumper flowering in clusters was also observed during March month.

### Flowering and fruiting in argan

Argan (*Argania spinosa*, also known as *A. sideroxylon*, Sapotaceae), an exotic tree species, is a medium, thorny, evergreen tree. Argan tree, introduced from Israel, as a seed material, has come into flowering for the first time after ten years of juvenility at germplasm block of underutilized fruits, ICAR-CIAH, Bikaner. Flowering was noticed in March, 2015 on last-year shoot (main ligneous shoot) and on first-year growth shoots (lateral shoots). At the same time fruiting was also noticed on older growth in which flowering took place in September, 2014. Monoecicous flowers are grouped in a glomerulose inflorescence in the axils of the leaves or around nodes and even around thorns in clusters; however, only 2-3 fruits are retained till maturity. It is a glomerule of up to 30 pentamerous flowers, grouped in cymose clusters, where the inner flower blooms first followed progressively by lower (Fig. 4). There were five hairy green sepals, a pale green corolla with five lobes, five stamens alternating with five staminodes, and one pistil in a actinomorphic, hypogynous flower.



Glomerulose inflorescence of argan | Beginning of anthesis

Flowering in argan | Fruiting in argan

**Fig. 4: Flowering and fruiting in argan**

## Karonda (*Carisa carandus*)

### At Bikaner

Five genotypes were maintained and evaluated for growth, flowering and fruiting under arid conditions. Flowering was observed but fruit set was very less due to poor moisture conditions.

### At Godhra

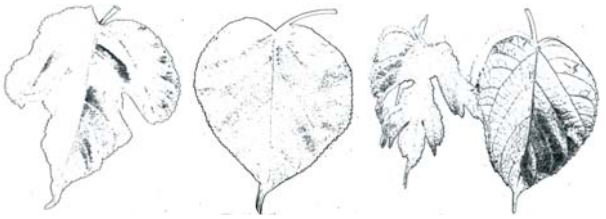
Total 40 genotypes were evaluated. Konkan Bold recorded maximum fruit weight (14.10g) and TSS (11.20$^0$ Brix) but fruit yield was 5.20 kg per plant only. Minimum acidity (0.42 %) was recorded in Konkan Bold during ripening. Maximum fruit yield (13.00 kg/ plant), fruit weight (5.0 g) and TSS ( 9.56$^0$ Brix) was recorded in CHESK-2, closely followed by CHESK-3. Pant Manohar recorded 3.60 g fruit weight, 9.10 kg yield/ plant. CHESK-2 was identified as variety Thar Kamal.

## Mulberry

### At Bikaner

### Morphological characterization of mulberry

Mulberry (*Morus* sp.) genotypes *viz.*, CIAH-1, CIAH-2, CIAH-3, Delhi Local, Gurgaon Local, SL-1, SL-2, Ajmer, MI-315and MI-380, available at Germplasm Block were characterized morphologically for qualitative and quantitative characters. Distinct variations have been noted in leaf lobes and leaf size. However, shape of leaf and leaf base were found to be cordate in all the studied varieties. Similarly, leaf arrangement, petiole attachment and second order vein was noted to be alternate, marginal and brochidodromous, respectively. Nature of leaf base varied from acute to acuminate. Likewise, leaf margin found to be coarse or fine serrated (Fig, 5). Fruit colour varied from green-white to red. Highest average fruit weight was recorded in Delhi Local followed by Gurgaon Local and CIAH-1.



Lobed leaf | Unlobed leaf | Heterophylly

**Fig. 5: Variations in leaf morphology of mulberry genotypes**

### Bearing in mulberry genotypes

03 mulberry accessions out of 05, obtained (as bud sticks) from Central Sericulture Germplasm Resource Centre, Hosur came in to fruiting for the first time at CIAH, Bikaner. Three accessions belonged *to Morus laevigata* such as MI-572, MI-315 and MI-363, while other two accessions were of *M. indica viz*., MI-775 and MI-781. These accessions were subjected to regeneration either through budding on rootstocks or by rooting of stem cuttings under greenhouse conditions. The stem cuttings of *M. indica* were treated with IBA @50mg/L, while those of *M. laevigata* were treated with IBA@50mg/L + NAA 50mg/L. Four accessions successfully propagated through stem cuttings and later planted under field conditions. Three accessions came into fruiting during March, 2015. Some fruit characters are presented here under;

**MI-363:** White colour fruits, 3-4 cm long; MI-572: Red fruited, 5-7 cm long fruits;

**MI-775:** Small 1-2 cm long, white colour fruits.

## 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 cultured plant of vegetable type were evaluated for survival and growth. The clone-1308 sprouted early than other clones. The field performance of tissue culture raised plants was comparatively not better than cladodes planted through cuttings in clone 1308 under field conditions after a year. The performance of clone 1269 was better in respect of cladode's production per plant than other clones.

## Manila tamarind (*Pithecelobium dulce*)

### At Bikaner

Three germplasm of *Pithecelobium dulce* were evaluated for growth under field conditions and the plants are growing well.

## 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. The maximum panicle length and fruit set per panicle were recorded in GJ-2, closely followed by GJ-8. Time taken for complete development of flower bud ranged between 22.50-26.60 days in different genotypes. Peak period of ripening was recorded in the month of June. The maximum fruit yield per plant was recorded (60.10 kg) in Goma Priyanka. Fruit weight (19.00 g), pulp weight (16.60 g), pulp percent (87.68 %) and TSS (16.10 $^{0}$ Brix) were also recorded maximum in Goma Priyanka, closely followed by GJ-8.

Further, 40 genotypes including Konkan Bahadoli, CISHJ-37,Gokak 1, Gokak 2, Gokak 3, Seedless and Seeded Jamun have been evaluated for growth, flowering, fruiting and fruit quality attributes. Two promising genotypes GJ-67 and GJ-68 were collected from Por village of Vadodara district. GJ-67 had earliness, spreading type growth pattern with 21.20 g fruit weight, 87.10 per cent pulp and 17. 10 $^{0}$ Brix TSS.

### Brief characters of promising genotype of jamun- GJ-8

It was collected from Ode village of Anand district of Gujarat. Peak period of flowering was recorded in the month of March. It ripens in the second week of June and recorded 19.40 g fruit weight, pulp weight 16.80g, 86.59 % pulp, 15.50 $^{0}$ Brix TSS, 0.38 % acidity, 10.50 % total sugar and 46.00 mg/100g vitamin C.

## 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 were recorded in Pratisthan (4.20), closely

followed by Goma Prateek (3.90) and T-263 (3.40). Peak period of ripening time in majority of genotypes was March. The maximum fruit yield per plant (75.00 kg) was recorded in Goma Prateek during 13 years of orchard life under rainfed conditions of hot semi-arid ecosystem, closely followed by T-10 (40.00 kg/plant), while minimum was recorded in PKM-1 (10.00kg/plant). Goma Prateek also recorded maximum pod weight (26.10 g), pulp percent (52.00 %) and TSS (71.20°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 Aruppukotai, Tamil Nadu have been established in the field. They are growing well.

## 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 3.70 m-5.90m, plant spread i.e. N-S 1.80m – 5.70 m and E-W 1.90 m – 5.80 and stem girth 25.70 cm- 55.80 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 (26.20cm) and fruit set per panicle were recorded in Thar Priya, closely followed by CHESC-2. After evaluation, CHESC-2 was found promising.

#### CHESC-2

It is having up right growth habit. Peak period of ripening time was May. It recorded 1.20 g fruit weight, 23.00°Brix TSS, 12.00 % total sugar and 49.30 mg/100g vitamin C. Kernel protein was recorded 32.23 %.

#### CHEST-10

It has semi-spreading growth habit, thick trunk and drooping branches. Peak period of ripening time was first week of April. It recorded 40 kg fruit yield per plant, pulp percent (52.80 %) and TSS (72.10°Brix).

#### CHEST-11

It has semi-spreading growth habit, thick trunk and drooping branches. Peak period of ripening time was last week of March. It recorded 20 kg fruit yield per plant, pulp percent (53.00 %) and TSS (72.00°Brix).

## 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 (30.00 g) and seed weight (12.30 g) was found in MH-10., while MH-14 recorded 27.50g fruit weight and 11.20 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 3.10-5.20 in different genotypes being highest in CHESK-10. Fruit set per cluster ranged from 2.50 to 4.20 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 (5.40 g) and TSS (24.00°Brix) was recorded in CHESK-10, closely followed by CHESK-1, CHESK-6, CHESK-11, CHESK-12 and CHESK-16.

#### CHESK-10

It was collected from Parwadi village of Panchamahal district, Gujarat. It has spreading growth habit, thick trunk, dense foliage and drooping branches The peak period of flowering was recorded in the month of December. Fruit set per cluster was noted 4.20 It ripens in third week of May and recorded 5.40g fruit weight, 24.00°Brix TSS, 29.00mg/100 vitamin C.

## Phalsa (*Grewia subineaqualis*)

Total 19 genotypes have been collected. During period under report 6 genotypes from Chiraigaon,

Rustampur, Bariyasanpur and Chunadih villages of Varanasi and 2 genotypes from Lawarpur, Gandhinagar, Gujarat were collected. Maximum fruit weight was recorded in CHESP-13 (2.00 g), closely followed by CHESP-14 and CHESP-15. Maximum TSS was also recorded in CHESP-13 (20.10 Degree Brix). Vitamin C was also noted highest in CHESP-13. Plants have been established in the field.

## Sapota (*Manilkara zapota*)

### At Godhra

Vegetative growth parameters recorded during the year indicated that the plant height and plant spread was maximum in PKM-1. However, stock diameter and scion diameter were highest in PKM-2 (128.8 mm and 84.00 mm, respectively). Data recorded on fruiting indicated that the maximum number of fruit set per shoot was in PKM-1 (45). The maximum number of fruits set per plant was recorded in cv. 689. Fruit weight, fruit length and diameter were highest in PKM-3 (128.75 g, 84.13 and 53.62 mm, respectively). Fruit yield per plant was highest in PKM-2 (25.64 kg.)

## Mango (*Mangifera indica*)

### At Godhra

Efforts were made to collect the variability in mango cv. Kesar to identify superior types particularly in respect of yield, fruit set, fruit size and color. Total five collections were established in the field and were evaluated for growth and quality parameters. There were significant differences in respect of plant height, stock and scion diameter of the collections. The maximum plant height and stock diameter was observed in CHESM-1 (2.85 m and 90.3 mm, respectively). Scion diameter and plant spread was however in CHESM-2 (77.83mm, 2.2 NS and 16m EW, respectively). Data on number of fruit set per plant indicated that it was highest in CHESM-4 (205.75), fruit retention was maximum in CHESM-2 (146.25). Selection-4 has maximum fruit weight, length and diameter (291.00g 88.66 mm and 41.16mm respectively). Yield per plant was maximum in CHESM-4 (35.08 kg/plant).Chemical analysis of the fruit indicated that pulp weight was highest in CHESM-4(225.06 g). Skin weight per fruit was in CHESM-3 (45.66 g). Stone weight was highest in CHESM-4(21.66). Pulp skin ration and pulp stone ratio were maximum in CHESM-3.

## Aonla (*Emblica officinalis*)

### At Godhra

#### Evaluation of germplasm

The varieties of aonla (Chakaiya, Banarsi, Francis, Krishna, Kanchan NA-10, Anand-1 and Anand-2) were studied for their growth, qualitative and quantitative characters of fruits during the year 2014-15.

#### Growth attributing characters

Results of study revealed that the aonla varieties had considerable difference in tree habit which was observed upright spreading in Banarasi, Krishna, Chakaiya, tall upright in Anand-1 and Aanad-2; tall spreading in NA-7, drooping in Francis and tall semi-spreading in Kanchan under rainfed conditions of western India. The foliage in Banarasi, Chakaiya, Krishna, Kanchan, Anand-1 and Anand-2 had sparse whereas in Francis, NA-7 and NA-10 had dense foliage. The tree trunk colour of different varieties were grey in Banarasi, Krishna, Francis, Chakaiya, Anand-1 and Anand-2 and whitish grey in Kanchan, NA-7 and NA-10 . The inflorescence colour was deep pink in Banarasi and Krishna; yellowish green in Francis; pinkish green in Chakaiya and Kanchan; green to light pink in NA-7, NA-10 and Anand-1 while light green to pinkish colour of inflorescence was observed in Anand-2.

The leaf shape was oblong in Banarasi, Krishna, Chakaiya, NA-10, Anand-1 and Anand-2; oval oblong in Francis and Kanchan, and elliptical in NA-7. The leaf apex was mainly of 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 Francis (1.47 cm) followed by Banarasi (1.44cm) and NA-7 (1.40cm) and the value for same trait was minimum in Chakaiya (1.24cm) followed by Anand-2(1.25 cm), Anand-1 (1.26cm) NA-10 (1.27cm) and Krishna (1.28 cm). The leaf width was measured the maximum in Banarasi (0.37 cm) followed by Kanchan (0.32 cm), whereas same was recorded

the minimum in Anand -2 (0.22 cm) followed by Anand-1 (0.27 cm).

## Physical characters of fruit

Results of study clearly divulged that the fruit shape had great variations among the aonla varieties. The fruit shape was triangular in Banarasi and Krishna, flattened round in Francis, NA-7, Chakaiya, Kanchan and NA-10 and flattened oval in Anand -1 and Anand-2. Fruit colour of Banarasi and Kanchan was whitish green; light green in Krishna, Francis and Chakaiya; yellowish green in NA-7, NA-10 and Anand-2 and greenish yellow in Anand-2. Fruit stalk was observed short and thick in Banarasi, Krishna, NA-7 and NA-10 and short and thin was observed in Francis, Chakaiya, Kanchan, Anand-1 and Anand-2. Fruit stem end cavity was noticed shallow and deep, it was observed shallow in Banarasi, Francis, Chakaiya, Kanchan, Anand-1 and Anand-2 whereas it was deep in Krishna, NA-7 and NA-10. Styler end was leveled in Banarasi, Francis, Chakaiya, Kanchan, and NA-10; prominent in Krishna and less prominent in NA-7, Anand-1 and Anand-2. Number of segments in all the varieties had six but in few varieties like Krishna and Kanchan 6-8 segments may also be seen. Most of the varieties showed whitish green coloured flesh excluding Krishna which had yellowish green colour under rainfed semi arid environment of western India. The highest fruit set was recorded in the NA-7 (52.92%) followed by Krishna (48.51%), NA-10 (41.82%), NA-10 (40.28%) and Kanchan (39.77%) and it was the lowest in Banarasi (22.80%) followed by Chakaiya (27.25%). The time of fruit set was noticed during the 1$^{st}$ fortnight of March in Krishna, Francis, Chakaiya, Kanchan and 2$^{nd}$ fortnight of February in Banarasi, NA-7 and NA-10 whereas it was recorded 2$^{nd}$ fortnight of March in Anand-1 and Anand-2. The time of fruit maturity was observed during last week of October in Banarasi, Francis, NA-10 and the same was observed during last week of November in Krishna, Chakaiya, Kanchan, Anand-1 and Anand-2. Days of maturity of different varieties ranged between 208 -220 days.

## Quantitative characters

Physical attributes of fruit in terms of weight ranged between 25.15-34.70gm, being maximum in Banarasi (34.70 gm) followed by NA-7 (33.97 gm) and it was measured the minimum in Kanchan (25.15 gm).The fruit length ranged between 3.06-3.75cm whereas it was observed the maximum in Banarasi (3.75 cm) followed by Krishna(3.70 cm) and NA-7(3.62 cm) and the same was observed the minimum in Francis (3.06 cm) followed by Anand-1(3.10 cm) and Anand -2 (3.11 cm). Among the varieties, fruit breadth varied between 3.41-4.39cm and the maximum breadth was observed in Banarasi (4.39 cm) followed by NA-7 and Chakaiya (4.00 cm) whereas it was minimum in Francis (3.41 cm) followed by Anand-2 (3.42 cm) and Anand -1 (3.44 cm). The percentage of fruit set (52.85 %) and fruit retention (27.42%) were recorded maximum in NA-7 followed by Krishna for 48.50 % fruit set and 21.73% fruit retention, and the minimum fruit set and fruit retention were recorded 35.25% and 18.70%, respectively in Banarasi followed by Francis (36.59%) for fruit set and Anand-2 (18.89%) for fruit retention under hot semi arid ecosystem.

## Qualitative characters

Results of study on the qualitative attributes of different cultivars exhibited wide range of variability. Among the varieties, the juice content was recorded the maximum in NA-7 (69.40 %) followed by Anand-1(67.28%), however Chakaiya had the minimum juice content (41.20%) followed by Banarasi (41.57%). The astringency level was highest in Krishna, Chakaiya, and NA-10, and it was least in NA-7, whereas the rest of the varieties had medium astringency. The acidity ranged between 2.05-2.22 % being the maximum in Banarasi (2.22%) followed by Krishna (2.16 %) whereas it was observed 2.05 % in Kanchan and Anand-1. The pulp content ranged between 22.93-32.61g and it was recorded the maximum in Banarasi (32.61 g) followed by NA-7 (31.67g) and Krishna (31.21g ) whereas the minimum pulp content was in Kanchan (22.93 g) followed by Anand-2 (23.54g), Anand-1 (25.47 g) and Kanchan (28.60 g) .The estimated

vitamin C content among all the varieties ranged between 335.10- 459.00 mg /100gm. It was observed the maximum in NA-7 (459.00 mg/100gm) followed by Kanchan (427.27 mg/100g) and the same was found to be the minimum in Banarasi (335.10mg/100gm) followed by Francis (345.34 mg/100gm) and Krishna (352.45 mg/100gm). The total soluble solids were recorded the maximum in NA-7 (10.50% Brix) followed by Anand-1 ($10.31^0$ Brix) and Anand-2 ($10.25^0$ Brix) while Banarasi had the minimum value ($8.52^0$ Brix) followed by NA-10 ($8.55^0$ Brix). The value of specific gravity ranged between 1.06-1.45 being the highest in Banarasi (1.45) followed by Anand-1 (1.35) while it was least in Francis (1.06) followed by NA-7 (1.12). TSS/Acid ratio ranged between 3.65-6.79 where in it was maximum in Krishna (6.79) followed by NA-7(5.60) and Anand-1(5.53).

### Seed characters

All the varieties showed wide variability on account of quantitative and qualitative seed characters in different varieties. Stone shape was observed triangular in Banarasi and Krishna; round in Chakaiya, Kanchan, Anand-1 and Anand-2; oval in Francis and NA-10; oval round in NA-7. Banarasi followed by Krishna and NA-7 enunciated large stone and seed size, whereas it was small into Chakaiya, Kanchan, Anand-1 and Anand-2 while the rest of the varieties had medium stone size. The weight of the stone was exhibited the maximum in Francis (2.10 gm) followed by Krishna and Anand-1(2.09 gm) and it was minimum in NA-7(1.97 gm) followed by Kanchan and NA-10 (1.98 gm) under rainfed hot semi-arid environment.

## Exploring biodiversity of aonla from North-Eastern Region of India (Assam, Nagaland, Manipur and Meghalaya States)

### Vegetative characters

The range of growth habit included tree with tall, spreading, semi- spreading and drooping and foliage with dense and sparse type among all the characterized genotypes. Tree shapes of different genotypes were irregular, semi circular, broad vase and elliptical types in north eastern region of India. The leaf shape was oblong, oval oblong and elliptical, however the leaf apex was mainly of two kinds i.e., acute and obtuse.

### Fruit characters

The morphological variability in the fruits of the different genotypes varied in shape i.e., round flattened, round spherical and round while fruit colour was observed as light green, pale yellowish green, yellowish green, dark green. Variability with respect to fruit styler end and fruit stem end cavity were observed *i.e.*, sunken, deeply sunken, smooth, slightly depressed, and depressed. The stone shape was observed round triangular at apex, flattened triangular, flattened round, spherical round, and spherical round triangular at apex in all the genotypes

### Fruit physical attributes

The fruits of different genotypes considerably varied with respect to size, weight, specific gravity and stone weight. The fruit weight ranged between 1.39 – 10.59 g, fruit length (1.26-2.53 cm), fruit breadth (1.27 cm -2.57 cm), fruit girth (4.16 cm-8.10 cm), specific gravity ranged between 1.01- 1.62, stone weight per fruit ranged between the 0.28 - 1.50 g (Table 1 & 2).

### Fruit chemical attributes

The TSS ranged between 10-22.8°Brix and pH among all the genotypes varied between 2.48 - 3.41. Fruit acidity (1.80-5.84%), total sugar (7.50-13.68%) ,vitamin C content (375.00 -1428.50 mg/100 ml of juice ), phenol content (944.85-4969.50 mg/100 ml juice) and TSS /acid ratio (2.64-9.72) also varied considerably among the 39 genotypes studied for quality attributes. (Table 1& 2).

## VEGETABLE

### Germplasm collection

During 2014 introduced 9 exotic collections of watermelon and 4 each of ridge gourd and sponge gourd from USDA, ARS, Griffin, Georgia, United States through ICAR-NBPGR, New Delhi.

**Table 1. Physico-chemical attributes in fruits of Indian gooseberry genotypes from Nagaland**

| Sr. No. | Name of Area from where Genotypes collected | Fruit length (cm) | Fruit width (cm) | Fruit girth (cm) | Fruit weight (gm | Specific gravity | Stone weight/ fruit (gm) | TSS % | PH of fruit juice |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Pungilong(Mon distt) | 2.10 | 2.19 | 6.8 | 5.88 | 1.11 | 0.65 | 11 | 3.0 |
| 2 | Tanshiqui( Mon) | 1.69 | 1.86 | 5.78 | 3.12 | 1.28 | 0.60 | 10 | 2.9 |
| 3 | Jharnapani (Dimapur) | 1.87 | 2.04 | 6.24 | 4.72 | 1.06 | 0.53 | 18 | 2.8 |
| 4 | Photok(Longleng) | 1.39 | 1.53 | 4.97 | 2.11 | 1.08 | 0.41 | 21.3 | 2.5 |
| 5 | Udalguri (Golaghat) | 1.41 | 1.51 | 5.04 | 2.04 | 1.30 | 0.63 | 11 | 3.0 |
| 6 | Tsemenyu (Kohima) | 1.27 | 1.38 | 4.38 | 1.50 | 1.00 | 0.51 | 12 | 2.8 |
| 7 | Lunghar I (Manipur) | 1.94 | 2.32 | 7.22 | 6.78 | 1.21 | 0.79 | 14 | 2.7 |
| 8 | Longleng | 1.83 | 1.87 | 6.08 | 3.69 | 1.20 | 0.51 | 16 | 3.1 |
| 9 | Kachai(Manipur) | 1.54 | 1.64 | 5.22 | 2.51 | 1.45 | 0.36 | 13 | 2.7 |
| 10 | Mokokchung | 1.89 | 2.17 | 6.5 | 5.04 | 1.16 | 0.51 | 14.5 | 2.8 |
| 11 | Lunghar- II(Manipur) | 1.56 | 2.08 | 5.94 | 3.78 | 1.07 | 0.52 | 13.5 | 2.8 |
| 12 | Chikilong (Wokha ) | 1.91 | 2.23 | 6.68 | 5.69 | 1.19 | 0.84 | 11.5 | 2.6 |
| 13 | Longsachung Wokha | 2.28 | 2.44 | 6.80 | 6.37 | 1.11 | 0.85 | 12.3 | 3.0 |
| 14 | Lungar-III (Manipur) | 1.80 | 1.88 | 5.94 | 4.03 | 1.13 | 0.95 | 17 | 2.8 |
| 15 | Cachinmolong Mon (Nagaland) | 1.55 | 2.03 | 6.06 | 3.74 | 3.10 | 0.47 | 16.3 | 2.6 |
| 16 | Marshall Kirki (Kohima) | 1.67 | 2.12 | 6.34 | 4.56 | 1.18 | 0.51 | 17.5 | 2.8 |
| 17 | Hundung (Manipur) | 1.82 | 2.31 | 7.12 | 5.71 | 1.22 | 0.46 | 14.7 | 2.5 |
| 18 | Santipur (Jorhat, Assam) | 1.36 | 1.27 | 4.16 | 1.39 | 1.33 | 0.28 | 13.1 | 2.9 |
| 19 | Nirayo( Wokha) | 1.73 | 2.29 | 6.6 | 5.02 | 1.22 | 0.69 | 12.2 | 2.8 |
| 20 | Aboi(Longleng) | 1.44 | 1.51 | 4.72 | 2.12 | 1.02 | 0.29 | 15 | 3.2 |
| 21 | Totak ( Mon) | 1.67 | 2.10 | 6.34 | 4.28 | 1.09 | 0.43 | 12 | 3.0 |
| 22 | Kotok (Longleng) | 1.83 | 1.86 | 6.1 | 3.96 | 1.09 | 0.47 | 16 | 2.7 |
| 23 | Alayong Mokokchung | 1.64 | 2.36 | 6.55 | 4.87 | 1.50 | 0.71 | 14 | 3.3 |

## Germplasm supplied

Germplasm maintained at the institute were supplied to various organizations for research purposes. A total of 8 germplasm of muskmelon to Post Harvest Technology Centre, TNAU, Coimbatore, 2 of watermelon to PAU, Ludhiana and 20 of Faba bean to ICAR-NBPGR, New Delhi have been supplied.

## Germplasm registered

A muskmelon line (AHMM/BR-8; IC0599709) has been registered at ICAR-NBPGR, New Delhi under INGR14043 for its monoecious sex trait (Fig 6.)

## Germplasm deposited to National Gene Bank

Seed of AHRG-57 has been deposited to national gene bank at ICAR-NBPGR, New Delhi with national identity of IC-0599708 for long term storage. The plants of this line produce only hermaphrodite flowers in clusters (8-14 flower/ cluster). Fruits are round and small in size weighing 20-25g/ fruit.

**Table 2. Physico-chemical attributes in fruits of Indian gooseberry genotypes from Meghalaya**

| No. | Genotype collected from the Place | Fruit weight (gm) | Fruit length (cm) | Fruit breadth (cm) | Fruit girth (cm) | Specific gravity (cm) | TSS % | PH of juice | Acidity (gm/100ml juice) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mookhan Jaintia hills | 3.13 | 1.57 | 1.72 | 5.6 | 1.08 | 16.10 | 3.0 | 4.34 |
| 2 | Rybai district Mawokhona-1 | 8.67 | 2.53 | 2.48 | 7.78 | 1.24 | 14.75 | 3.0 | 5.18 |
| 3 | Rybai district Mawokhona-1 | 10.59 | 2.30 | 2.57 | 8.10 | 1.03 | 16.20 | 3.0 | 5.32 |
| 4 | Monthari-3 Jaintia hills | 5.03 | 1.60 | 2.15 | 6.88 | 1.09 | 11.30 | 2.8 | 4.34 |
| 5 | Nongthymmu Jaintia hills | 2.73 | 1.41 | 1.49 | 5.42 | 1.01 | 17.00 | 2.9 | 4.4 |
| 6 | Myngdnoot Jaintia hills | 3.72 | 1.58 | 1.81 | 5.70 | 1.06 | 15.23 | 3.1 | 4.34 |
| 7 | Nogspoin, Khasi hills | 5.23 | 1.93 | 2.07 | 6.48 | 1.32 | 15.30 | 3.1 | 4.20 |
| 8 | Kunrud, Khasi hills | 2.83 | 1.47 | 1.63 | 5.04 | 1.30 | 14.20 | 3.1 | 5.84 |
| 9 | Mawkarsh, Khasi hills | 5.22 | 1.81 | 2.21 | 6.60 | 1.35 | 17.10 | 3.0 | 5.60 |
| 10 | Mairang, Khasi hills | 4.28 | 1.72 | 1.90 | 6.12 | 1.03 | 15.30 | 2.8 | 6.84 |
| 11 | Monthani-2 Jaintia hills | 4.15 | 1.64 | 2.06 | 6.14 | 1.19 | 20.30 | 3.2 | 6.30 |
| 12 | Jowai-1 Jaintia hills | 3.43 | 1.57 | 1.89 | 5.50 | 1.62 | 17.10 | 3.0 | 4.97 |
| 13 | Mynrod-2 Jaintia hills | 1.88 | 1.26 | 1.42 | 4.76 | 1.15 | 22.80 | 3.1 | 6.08 |
| 14 | Mynrod-1 Jaintia hills | 4.02 | 1.61 | 1.87 | 5.94 | 1.14 | 18.00 | 3.1 | 5.08 |
| 15 | Kayanshi, Khasi hills | 3.72 | 1.58 | 1.79 | 5.74 | 1.02 | 18.21 | 3.3 | 5.04 |
| 16 | NonthaimuJaintia hills | 2.86 | 1.49 | 1.65 | 5.24 | 1.14 | 17.8 | 3.0 | 5.32 |

**Fig. 6: View of muskmelon (IC0599709; INGR14043)**

## Generation advancement

A total of 20 segregating populations ($F_2$) were advanced to create genetic variability in watermelon. Among the segregating populations identified a genotype having non-lobed leaves (entire leaf) (Fig. 7) which took 51-54 days to produce 50% female flowering and 80-84 days for first fruit harvesting having red flesh. The fruit weight, fruit diameter, rind thickness and TSS of this line were 2.2-2.5 kg, 14-17 cm, 0.70-0.90 cm and 9-10%, respectively.

Fig. 7: Non-lobed leaf (entire leaf) line of watermelon

## Maintenance, conservation evaluation of germplasm and advance lines

### Mateera (*Citrullus lanatus*)

Twenty germplasm lines were evaluated for flowering, fruit, and quality attributes in red flesh segment. AHW/BR-7 was found to be earliest and took 47.33 days to produce 50% female flowering followed by AHW/BR-15 (48.00 days). Average fruit weight varied from 2.03 kg (AHW/BR-18) to 2.60 kg (AHW/BR-19) while fruit diameter 13.00 cm (AHW/BR-12) to 16.10 cm (AHW/BR-1). Maximum rind thickness was observed in AHW/BR-16 (1.31 cm) followed by AHW/BR-7 (1.17 cm). TSS content ranged from 8.47% (AHW/BR-17) to 11.17% (AHW/BR-16). A line having andromonoecious sex form was identified as AHW/BR-5 which produced round, red fleshed fruits having grey rind in 80-85 days after sowing weighing 2.0-2.5 kg with 10.8-11.3% TSS and thick rind (0.8-1.2 cm). On the basis of fruit size, rind thickness, flesh colour, TSS and attractiveness of fruits, AHW/BR-5 and AHW/BR-16 were found promising and selected for further validation. Seed of selected promising lines and released varieties from different institutes were maintained through inbreeding.

### Muskmelon (*Cucumis melo*)

Twenty diverse germplasm were evaluated for different horticultural traits and observed considerable variation. Days taken to produce 50% female flowers, flesh thickness, rind thickness, total soluble solids, fruit weight and number of marketable fruits/ plant ranged from 46.00-52.33, 1.87-3.60 cm, 0.13-0.50 cm, 8.07-11.17%, 0.32-1.77 kg and 2.67-5.33, respectively. Maximum total soluble solids recorded in AHMM/BR-1 (11.17%). Maximum number of marketable fruits/ plant was harvested from AHMM/BR-35 (5.33) followed by AHMM/BR-28 (4.67). The flesh colour was observed as white, green and salmon orange. The fruit infestation of fruit fly ranged from 12.61 to 79.49% in different genotypes. Maintained the seed of selected promising lines and released varieties from different sources through inbreeding (Fig. 8)

### Longmelon

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.

During rainy season of 2014 evaluated the available advance lines of longmelon for growth and yield attributes. Among the evaluated lines, AHLM-2 was found early to produce 50% female flowering (40-45 days after sowing) on lower nodes. The fruits at marketable stage were tender, non-bitter, light green, 25-30 cm long and 1.8-2.2 cm in diameter weighing 60-80 g. The plants of this genotype were vigorous and profusely branched (Fig. 9). Seed of AHLM-2 was multiplied for further validation.

### Sponge gourd (*Luffa cylindrica*)

A total of 16 diverse lines were evaluated for horticultural traits. Among the evaluated genotypes, AHSG-28 was earliest and took 46.67 days for 50% female flowering on lower nodes (11.20). Maximum number of marketable fruits/ plant was harvested from AHSG-28 (36.60) followed by AHSG-29 (34.40) while maximum fruit weight was recorded in AHSG-23. The depth of leaf cut at terminal lob varied from 3.6-5.8 cm being the maximum in AHSG 28 (Fig. 10). Multiplied the seed of a white seeded line (AHSG-23). The seed of promising lines was maintained through inbreeding as active collection.

## Ridge gourd (*Luffa acutangula*)

### Performance evaluation of advance lines

Twenty genotypes of ridge gourd were evaluated for flowering, yield and yield related

Fig. 8: Variability in fruit traits of muskmelon

Fig. 9: View of longmelon (AHLM-2)

attributes. Among the evaluated genotypes, AHRG-29 was earliest to produce 50% female flowering (50 days) on lower nodes (12) and performed best at high temperature. Maximum number of marketable fruits/ plant was produced by AHRG-29 (19.67) followed by AHRG-31 (18.43). On the basis of earliness, fruit traits and total yield, AHRG-29 was found promising and stable (Fig.11) The per cent infestation of fruit fly ranged from 17.65% (AHRG-29) to 79.63% (AHRG-31) under open field conditions.

Fig. 10: Variation in leaf traits of sponge gourd

Fig. 11: View of ridge gourd (AHRG-29)

### Varietal Trial AVT I

Five entries of ridge gourd along with two checks were evaluated during summer season of 2014. Maximum fruit length (24.20 cm), fruit weight (115.40 g), fruit diameter (3.09 cm) and fruits/ plant (15.53) were recorded in RGVAR-2.

## CROP IMPROVEMENT

### Vegetable

### Hybridization and generation advancement

The parents from available germplasm were selected on the basis of earliness, yield and yield attributing traits. A total of 15 $F_1$, were made during summer season of 2014 by crossing 6 diverse parents in a diallel fashion excluding reciprocals and collected the seeds for evaluation. Evaluated 12 $F_1$, during summer season of 2014 for earliness, yield and yield attributing traits which have been developed during 2013. Among the evaluated hybrids, AHRG-29 x AHRG-28 was found promising with respect to days taken to produce 50% female flowering (48.33), fruit length (22.20 cm), fruit weight (100.76 g) and number of marketable fruits/ plant (21.67).

**$F_2$:** Twenty families were raised and single plant selections were made on the basis of flowering and yield traits.

**$F_3$:** Fifteen single plant selections were made and selfed for further advancement to obtain desirable recombinants.

### Sponge gourd (*Luffa cylindrica*)

Sponge gourd is a popular cucurbit vegetable but not much exploited for developing varieties suited to the prevailing abiotic and high temperature conditions in the hot arid region. Realizing the significance of vegetable diversification, systematic germplasm and varietal evaluation trials were undertaken from 1997–2005 and up to 2010 a good number of lines were generated, purified and developed from the evaluated germplasm for utilization in improvement programme at CIAH, Bikaner. During 2014, the generated breeding material (22) was studied for seed storage and germination behaviour, trait specific characterization and identification of promising lines under abiotic and biotic stresses, and also seed enhancement was done for conservation and maintenance under hot arid agro-climate.

The generated sponge gourd material (fourth generation) exhibited wide range of variations for days to appearance of first male flower (36.4–67.2 DAS), node number to first male flower (4.8–21.4), days to appearance of first female flower (43.3–71.7 DAS), node number to first female flower (9.8–32.5), days to first harvesting of tender fruits (51.6–88.5 DAS), tender fruit length (12.2–32.7 cm),

tender fruit diameter (2.2–4.3 cm), tender fruit weight (58.4–169.6 g), number of tender fruits/plant (14.8–32.4), marketable fruit yield/plant (1.23–3.12 kg), vine length (2.15–3.65 m), mature fruit length (27.2–48.4 cm), mature fruit diameter (5.4–8.6 cm), number of seeds/fruit (79.4–353.5), weight of seeds/fruit (11.22-37.52 g), seed length (1.02–1.23 cm), seed width (0.52–0.91 cm), weight of 100 seeds (8.72–12.56 g) and seed colour (black, white & mottled). These lines were categorized for flowering and fruit setting behaviour, and plant growth characters at 30 and 90 days after sowing to understand the field tolerance towards high temperature and aridity conditions. (Fig. 12)

**Fig. 12: Field view of generated material of sponge gourd crop for evaluation in rainy season 2014**

The material was also studied for fruit quality characters at tender stages such as shape (straight, straight-necked, curved) and colour (green, dark green, light green, whitish green) and intensity of fruit fly infestation (18.2–76.5 %) under abiotic stresses of hot arid agro-climate (Fig. 13). Based on earliness, quality fruit yield potentials and over all performance, the progeny from germplasm line AHSG–4 and white seeded progeny of cross combination [($P_5$ x $P_4$) x $P_4$] were found to be most potential for utilization in trait specific crop improvement. Sufficient quantity of seeds of 22 lines was produced under maintenance and enhancement work during rainy season of 2014–15 for safe conservation both at CIAH and NBPGR, RS, Jodhpur.

**Fig. 13: Fruit variability in generated material of sponge gourd evaluated during rainy season 2014**

## Round melon (*Praecitrullus fistulosus*)

### Breeding for high temperature tolerance and fruit quality

During the summer season of 2014, nineteen advanced breeding material of round melon developed through hybridization between the lines of AHRM–1 and AHRM–2 were evaluated for growth, flowering and fruiting characters (Fig. 14). A good amount of variations were observed in the developed progenies with respect to the characters such as days to appearance of first male flower (36.2–55.5 DAS), node number to appearance of first male flower (1.9–3.8), days to appearance of first female flower (42.4–59.8 DAS), node number to appearance of first female flower (3.9–5.6), days to first harvesting of tender fruits (52.5–69.8 DAS).

Most of the evaluated progenies were severely affected at fruiting stage due to high temperature and aridity conditions during the May month and studied for heat tolerance based on field performance. Maximum progenies recorded high level of fruit fly infestation and susceptibility towards high temperature conditions (above $42^0$C), and thus rejected from selection cycle in $F_4$ generation. The advanced progenies from AHRM–2b x AHRM–1b, AHRM–2a x AHRM–1a and AHRM–1a x AHRM–2a exhibited maximum variations and superiority for fruit and other desirable characters. Therefore, potential individuals were identified for purification, advancement of generation and further

Fig. 14: Fruit variability identified from the progenies of round melon evaluated during 2014-15

selection breeding based on better fruit quality and marketable yield under high temperature conditions and abiotic and biotic stresses of arid agro-climate. Similarly, three breeding lines were studied during rainy season of 2014-15 and individual were identified for advancement of generation.

## Bottle gourd (*Lagenaria siceraria*)

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

During the rainy–winter season of 2014–15, eleven advanced breeding material ($F_6$ 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 of hot arid agro-climate, and also advancement of generation and selection breeding based on field performance. The performance of $F_6$ generation progenies of cross combination of AHLS–24 x BOGVAR–3 is summarized as range for the characters under study. A good variations were observed between the progenies and recorded for days to appearance of first male flower (42.4–52.8 DAS), node number to appearance of first male flower (2.5–4.4), days to appearance of first female flower (48.3–59.2 DAS), node number to appearance of first female flower (3.4–9.8), days to first harvesting of tender fruits (58.9–70.4 DAS), fruit weight (0.548–0.884 kg), fruit length (24.4–30.2 cm) and fruit diameter (5.48– 7.12 cm) at marketable stages. The variations were also recorded for fruit colour (green, light green and whitish green), shape (straight, straight with neck, necked) and quality at marketable stages (Fig. 15). Based on *per se* performance and field superiority, three lines were identified for fruit and other desirable characters. These were identified for purification, advancement of generation and further selection breeding based on better fruit quality and marketable yield potential under high temperature conditions and abiotic stresses of arid agro-climate.

During the spring–summer season of 2014–15, two potential lines ($F_5$/1 and $F_5$/9) identified based on field performance were studied under replicated performance trial for growth, flowering and fruiting behaviour, marketable fruit quality and yield component characters, and comparative data is presented in table 3.

Fig. 15: Fruit shape, size and quality at marketable stages in evaluated bottle gourd lines

**Table 3. Performance study of advanced bottle gourd lines during summer season of 2014**

| Characters Pedigree | 2012/$F_5$/01 | 2012/$F_5$/09 |
|---|---|---|
| Days to appearance of first male flower (DAS) | 49.55 | 50.25 |
| Node number to first male flower | 4.48 | 3.59 |
| Days to appearance of first female flower (DAS) | 53.45 | 56.64 |
| Node number to first female flower | 8.65 | 8.89 |
| Days to first harvesting of tender fruits (DAS) | 64.85 | 65.62 |
| Fruit weight (kg) at marketable stages | 0.635 | 0.715 |
| Fruit length (cm) at marketable stages | 27.28 | 28.45 |
| Fruit diameter (cm) at marketable stages | 6.24 | 6.35 |
| Number of fruits/ plant | 8.96 | 9.75 |
| Fruit yield/ plant (kg) | 5.695 | 6.971 |
| Fruit yield potential (q/ha) | 246.37 | 294.14 |
| Fruit colour | Light green | Light green |
| Fruit shape | Uniform, straight and slightly necked | Uniform, straight and slightly necked |
| Remarks | The plants of both the lines are medium in growth and produces uniform and good marketable quality fruits with regular harvesting under temperature range form 40–44$^0$C and is up to middle of May month as summer season crop. The increased temperature range from 45–48$^0$C and high aridity conditions during middle of May month affected marketable fruit quality and about 50 % were with necked. | |

## Snap melon (*Cucumis melo* var. momordica)

### Screening of snap melon lines against biotic stresses

Forty three snap melon genotypes consisted of generated breeding material from germplasm, advanced lines and varieties were taken for screening against melon fruit fly during the year 2014. The significant differences were recorded in percentage fruit infestation and larval density/fruit among the tested genotypes. The larval density/fruit exhibited significant and positive correlations with fruit infestation. The line IC-430176, IC-430190, DKS-AHS-2011/3, DKS-AHS-2011/4 were found to be resistant whereas IC-430160, IC-430162, IC-430163, IC-430165, IC-430166, IC-430167, IC-430173, IC-430174, IC-430175, IC-430179, IC-430180, IC-430181, IC-430185, IC-430188, IC-430189, IC-369788, DKS-AHS-2011/2, DKS-AHS-2011/5 were moderately resistant and IC-430154, IC-430155, IC-430156, IC-430157, IC-430158, IC-430159, IC-430161, IC-430164, IC-430168, IC-430169, IC-430170, IC-430171, IC-430172, IC-430177, IC-430178, IC-430182, IC-430183, IC-430184, IC-430186, IC-430187, DKS-AHS-2011/1 were susceptible. The larval densities ranged from 8.33 to 19.43 larvae/fruit and significantly lower in resistant than the susceptible lines. The larval density/fruit was the highest in IC-430182 (19.43) followed by IC-430187 (18.97). The minimum larval density was found in IC-430190 (8.33) followed by DKS-AHS-2011/3-(8.63 larvae). The per cent fruit infestation was the highest in IC-430182 (73.13 %) and lowest in IC-430190 (10.79 %) followed by DKS-AHS-2011/4 (14.43 %). The fruit infestation ranged from 10.79 to 73.13 % and significantly lowers in resistant and higher in susceptible genotypes.

## Brinjal (*Solanum melongena*)

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

During the spring-summer season of 2014–15, the developed brinjal genotype CIAH–01 was studied under replicated performance trial.

**Performance studies on brinjal genotype CIAH–1:** The result of intensive germplasm evaluation followed by selection and hybridization breeding work from the year 2000–2010 at ICAR-CIAH for developing genotype suited to the prevailing hot arid agro-climate and the developed brinjal genotype CIAH–1 (Fig. 16 & 17) is found potential for commercial exploitation. The genotype CIAH–1 (a derivative of AHB–04xPPC) was studied for field performance over the seasons and years from 2010–2014 and is stabilized for uniform fruit quality, yield and morphological traits. It is most potential for earliness (first harvest at 45 days after transplanting) and high quality marketable fruit yield (58–73 tonnes/ha) under high temperature and abiotic stresses of hot arid environment. The plant of the genotype are short stature and semi-erect with purple hairy leaves. The fruits are small, oblong and dark purple in colour. It is heavy bearer (79.5–92.3 fruits/plant) with prolong period of harvesting. Attractive and excellent quality tender fruits at marketable stages are 39.8–46.2 g in weight, 4.9–5.8 cm in length and 4.2–4.7 cm in diameter. Based on *per se* performance over the seasons, it is most suitable both for rainy-winter and spring-summer crop cultivation with fruit yield of 3.16–4.35 kg/plant (Table 4).

## Tomato (*Solanum lycopersicum*)

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

During summer season of 2014, the tomato breeding line AHSL-2 (developed through combination breeding and fourth generation of selection) was evaluated and studied for growth,

Fig. 16: Field evaluation of brinjal genotype CIAH-1 under replicated trials during 2014

Fig. 17: Mature fruits of brinjal genotype CIAH-1 for seed crop studies

**Table 4. Performance of brinjal genotype CIAH–1 under large scale trials over the seasons and years (2010–2014) at CIAH, Bikaner**

| Character | 2010 | 2011 | 2012 | 2014 | Range | Mean |
|---|---|---|---|---|---|---|
| Days to flowering (DAT) | 23.5 | 28.3 | 23.7 | 30.4 | 23.5 – 30.4 | 26.1 |
| Days to first harvest of marketable fruits (DAT) | 44.6 | 46.4 | 44.7 | 45.4 | 44.6 – 46.4 | 45.2 |
| Average fruit weight at marketable stages (g) | 46.2 | 39.8 | 42.5 | 43.4 | 39.8 – 46.2 | 42.8 |
| Number of fruits/plant | 92.3 | 79.5 | 84.6 | 81.4 | 79.5 – 92.3 | 85.4 |
| Fruit yield/plant (kg) | 4.35 | 3.16 | 4.25 | 3.29 | 3.16 – 4.35 | 3.92 |
| Fruit yield (q/ha) | 730.2 | 580.5 | 605.7 | 582.2 | 580.5 – 730.2 | 638.8 |

Fig. 18: Field performance study and ripen fruits of tomato line AHSL-2 during summer season 2014

flowering, fruit set, yield and quality characters. The line was also studied for fruit ripening, uniformity, stability and response to environmental stresses of hot arid agro-climate. Based on field performance over the seasons, the line AHSL-2 is characterized for important traits such as leaf length (5.3–7.5 cm), leaf width (2.6–4.5 cm), days to flowering (32.8–35.4 DAT), days to first harvest (61.5–65.4 DAT), number of flowers/cluster (3.5–7.2), number of fruits/cluster (2.6–4.3), number of fruits/plant (55.6–

**Table 5. Characterization and performance trial of tomato genotype AHSL-2 (developed through hybridization and selection breeding) at CIAH, Bikaner**

| Characters | Range | Mean |
|---|---|---|
| Leaf length (cm) | 5.3 – 7.5 | 6.04 |
| Leaf width (cm) | 2.6 – 4.5 | 3.12 |
| Days to flowering (DAT) | 32.8 – 35.4 | 34.32 |
| Days to first harvest (DAT) | 61.5 – 65.4 | 63.75 |
| Number of flowers/ cluster | 3.5 – 7.2 | 4.46 |
| Number of fruits/ cluster | 2.6 – 4.3 | 3.17 |
| Number of fruits/ plant | 55.6 – 72.4 | 64.78 |
| Fruit yield/ plant (kg) | 2.25 – 3.18 | 2.78 |
| Fruit yield (q/ha) | 405.1 – 567.2 | 493.34 |
| Plant height at 90 days (cm) | 64.2 – 71.4 | 68.53 |
| Number of branches/ plant | 5.4 – 8.2 | 6.61 |
| Fruit weight (g) | 41.2 – 58.6 | 48.92 |
| Fruit length (cm) | 3.8 – 4.1 | 3.95 |
| Fruit diameter (cm) | 4.2 – 4.8 | 4.52 |
| TSS ($^0$ Brix) | 5.5 – 7.2 | 6.54 |
| Number of seeds/ fruit | 104.5 – 117.8 | 115.52 |
| Fruit shape | Roundish-flat | |
| Fruit size | Medium | |
| Fruit colour | Reddish | |
| Fruit taste | Slightly sweet and good sugar-acid blend | |
| Fruit firmness | Medium-juicy-firm | |
| Seediness of fruit | Less seeded | |
| Plant type | Determinate, straight, compact with green foliage | |

72.4), fruit yield/plant (2.25–3.18 kg), plant height at 90 days (64.2–71.4 cm), number of branches/plant (5.4–8.2), fruit weight (41.2–58.6 g), fruit length (3.8–4.1cm), fruit diameter (4.2–4.8 cm), TSS (5.5–7.2$^0$Brix) and number of seeds/fruit (104.5–117.8) (Table 5). The medium sized fruits are roundish-flat in shape and reddish in colour (Fig. 18). The ripen fruits are medium firm, juicy, less-seeded and slightly sweet taste with good sugar-acid blend. The plants are determinate, straight and compact having green foliage. The fruit setting, maturity and ripening is highly affected both as summer and winter season crops from extremeness of high and low temperature conditions in the arid region. It recorded shorter duration of harvesting and thereby low yield potential for quality marketable fruits at Bikaner condition. However, more number of fruit/plant was of unripe stages and recorded as non-marketable quality fruits.

## Khejri (*Prosopis cineraria*)

### 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 studied for generation of information on phenological and horticultural characters over the seasons and years. In addition, the newly identified genotype Khejri Selection–2 was characterized (Fig. 19-22).

Fig. 19: Growth behavior in four year age old plant of Khejri Selection – 2

Fig. 20: Flowering behavior in Khejri Selection – 2

Fig. 21: Flowering behavior in Khejri Selection – 2

Fig. 22: Leaf growth behavior in Khejri Selection – 2

## CROP MANAGEMENT AND AGRO-TECHNIQUES

### Planting models

### Khejri based cropping models

#### a) Growth and development studies

To study khejri based cropping models adopting Horticulture Based Crop Production Site Management Approaches (HBCPSMA), an area of two hectare was developed through *in situ* establishment by planting the seedling in 2007 and budding of variety Thar Shobha in 2009 under absolute rainfed situation. During 2014–15, the plant growth and development observations were recorded periodically and no significant differences were observed in growth parameters in variety Thar Shobha plantations under varying planting models.

The production site was maintained adopting good management practices as technological recommendations for crop production studies. The summer ploughing practices in the inter plantation field areas by cross harrowing was done with the end of June after assessing the weather forecasting for monsoon rains. A four days rainy spell (±45mm) during second–third week of May was recorded in summer months followed by extremes of hot weather conditions till middle of July. This year, the start of monsoon rain in the region was in time and pre-monsoon rains were scattered, localized and started from second week of July 2014, and rainfed crop sowing was done after good rains from 26-07-2014 in the production site. The kharif season was very normal with a long dry–spell of 24 days in middle of August, and later on good rainy days were recorded with the end of August to first week of September. Total 12 rainy days for kharif season crops and about 385 mm rain was recorded in the production site. The inter–crop studies on cluster bean, kachri and grasses were successful under the rainfed situations, and the performance was very normal for the consecutive third year owing to good rains during the crop period. During 2014–15, the inter-crops of cluster bean, kachri and grasses (sewan, dhaman and bharut) were studied for monsoon supported harvest and observations were compiled for yield and bio–mass production from rainfed sites. Similarly, jharber and ker exhibited normal growth and development, and periodical observations were recorded for the compilation of data as khejri based inter-crops.

After harvesting of monsoon supported crops in November, the area between the planting models were ploughed by cross harrowing in December as post-monsoon recommended practice for conserving soil moisture and also buried-out of monsoon supported weeds and crop residues for improving fertility of sandy soils in the fields. This year, the winter season was abnormal, uneven and longer in the arid region. The low temperature, fog, frost and cloudy conditions were observed from December to February months, and rains and hail storms was also recorded from end of February to Middle of March, 2015, and the wide–spread western disturbances in India resulted in winter rains (±50mm) on the production site of CIAH. The crop-genotype-environment interaction observations were recorded on main and inter–crops for the compilation of experimental results.

During November–December, intensive training and pruning operations were performed to develop better frame-work in the budded khejri and also in seedling plantations of native crop species. Pinching or removal of un-desirable new sprouts and removal of wild suckers and sprouts was done in the month of February–March. These are essential operations for removal of unwanted sprouts, better frame-work and growth in the plants and should be practiced as recommendation.

#### b) Studies on Jharber- a native fruit species

Intensive studies on jharber plantation was undertaken periodically to understand the growth, foliage and fruiting behaviour and bio-mass production as established inter-crop (4$^{th}$ year) with khejri planting models (Fig. 23-27). The jharber plantation was also studied as seed generated progenies develop from wide spectrum of germplasm variability collected and established *ex situ* at CIAH for exploitation and commercialization of native crop under rainfed situations of hot arid agro-climate.

The seed generated jharber progenies were in 4th year of its establishment and with uniform growth and fruiting pattern for characterization. Based on passport information and observations on population from the year 2010 at CIAH, a total 37 variable individuals have been identified from the diversity and wide range of observations were recorded with developed descriptor to generate scientific information on jharber during 2014-15.

### c) Studies on boundary plantation and native species

Studies on growth parameters in khejri, rohida and lasora seedling was undertaken as boundary plantations under production site management approach. Similarly, observations in response to training and pruning were recorded on native plant species such as phog and khimp to understand growth, development and bio-mass production in the

**Fig. 23: Plant growth behavior and forms studies in jharber diversity established *ex situ* at CIAH (plantation of fourth year age group and first year of bio-mass harvest)**

**Fig. 24: Variability studied in leaf, fruit and seed characters in wide spectrum jharber seedling population established at CIAH for exploitation of native crop**

**Fig. 25: Fruit bearing studies in identified jharber genotype**

**Fig. 26: Studies on training and pruning for bio-mass harvest in jharber plantation**

**Fig. 27: Studies on leaf fodder harvest in jharber plantation**

naturally perpetuated shrubs of desert eco-system in the khejri based production site.

### d) Studies on plant establishment and growth behaviour

During the period, studies on ker and khejri were undertaken for germination and growth characters under nursery conditions and also field establishment and growth characters under wide spacing khejri planting model as gap-filling for inter-crop and scattered gap filling plants of khejri seedling, respectively.

### e) Studies on nursery, *in situ* establishment and demonstration

During the period, about 400 poly-bags filled with 1:1:1 mixture of sandy soil, sheep manure and vermi-compost, and 2-3 healthy seeds sown in each bag as per technological advancement standardized for production of seedlings in nursery were studied for khejri, ker and kumat. 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 seedling growth in nursery, and plant establishment and growth under field conditions. In addition, seedling plants were also studied to understand the growth and development up to two years for *in situ* budding both at the institute farm and farmer's field. The nursery raising, field planting, establishment and *in situ* budding and after care techniques were demonstrated regularly to the farmers.

## Evaluation of fruit Based Diversified cropping Models for Arid Region

The experiment comprises of eight different cropping models *viz*., *Aonla-Ber*-Cluster bean-Fennel (M-1), *Aonla-Bael*-Cluster bean-Coriander (M-2), *Aonla-Khejri*-Cluster bean-Ajowain (M-3), *Aonla*-Drumstick-Cluster bean-Dill (M-4), *Aonla-Khejri*-Grass (*L. sindicus*) (M-5), *Aonla*-Mosambi-Cluster bean-Mateera (M-6), *Aonla*-Kinnow-Cluster bean-Chick pea (M-7) and *Aonla*-Mulberry-Kachari-Mustard (M-8). Observations on growth and development was recorded in already 10 year old established plants of *Aonla*, *Ber*, *bael*, *Khejri* and drumstick grown in association with *Aonla* in the different cropping models. Ground storey crops were sown as per the treatments during *kharif* and *rabi* season (Fig. 28).

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

The average yield of *aonla* varied considerably in different cropping model systems

**Fruit development in *aonla* in *aonla-ber*-Cluster bean-Fennel (M-1) cropping model**

**Fruiting in *karonda* in *Aonla-Bael*-Cluster bean-Fennel cropping model**

**Bearing in *ber* in *aonla-ber*-Cluster bean-Fennel (M-1) cropping model**

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

**Intercropping with seed spices in different cropping models**

**Intercropping with *mateera* in *Aonla*-Mosambi-Cluster bean-*Mateera* (M-6) cropping model**

**Fig: 28: Intercropping in different fruit based cropping systems**

with highest being recorded in *aonla-khejri* (46.2 kg per plant), *aonla-ber* (44.7) followed by *aonla*-Kinnow (43.4 kg/plant) and *aonla*-mulberry (42.5), while the lowest was recorded in *aonla*-moringa (40.6 kg/plant). The higher yield in *aonla* involving *ber* and *khejri* could be due to synergistic crop interaction. The higher yield of *aonla* in models involving Kinnow and mulberry could be attributed to less competition, for natural resources, exerted by these crops as Kinnow and mulberry plants in the respective cropping models are in young stage. The average yield of *bael* was recorded to be 20-25 kg per tree, while a single fruit weighed around 1.36 kg with maximum and minimum fruit weights recorded to be 2.7 and 0.7 kg, respectively. The average yield of *karonda* was recorded up to 13.4 kg/plant planted in between *aonla* plants. Likewise, the yield of *ber* cv. Seb was recorded to be 50.6 kg/plant in model M-1. The yield of sewan grass was recorded to be an average of 2.03 kg/m$^2$ on dry weight basis.

### Eco-physiological interaction studies

The trend of eco-physiological parameter like canopy interception of light for different fruit crops over the seasons is being presented hereunder;

April: *Karonda*> Moringa >*Bael* > *Aonla* > *Ber*>*Khejri* .

May: *Karonda* >*Bael*> Moringa> *Ber*> *Aonla* > *Khejri*.

June: *Karonda* > *Ber* > Moringa> *Aonla* > *Bael* > *Khejri*.

July: *Ber* > *Karonda* > Moringa > *Bael* > *Khejri* >*Aonla*.

August: *Karonda* > Moringa > *Bael* >*Ber* > *Aonla* >*Khejri*.

September: *Karonda*> *Bael* > Moringa > *Ber* >*Khejri*> *Aonla* .

October: *Karonda* > Moringa> *Bael* > *Aonla* > *Ber*> *Khejri*.

November: *Karonda* >Moringa > *Bael* > *Aonla* > *Ber* >*Khejri*.

December: *Karonda* >Moringa >*Khejri* >*Bael* >*Ber* >*Aonla*.

January: Moringa> *Khejri* >*Karonda* > *Bael* > *Aonla* > *Ber*.

February: *Karonda* >*Khejri* >*Bael* >*Aonla* > Moringa > *Ber*.

March: *Karonda* > *Aonla* > *Bael* > *Khejri* > Moringa > *Ber*.

The canopy interception of light was recorded to be the maximum with *karonda* followed by moringa and *bael* during extreme summer season. However, least was noted in *ber* and *khejri* for most of the period under study.

## Physiological Studies

### Monthly Relative Water Contents (%) of Fruit Trees

April: *Karonda* (91.31)>Moringa (82.84)>*Khejri* (80.90)>*Aonla* (74.11)> *Bael* (70.34) >*Ber* (62.99).

May: *Aonla* (93.49)>*Karonda* (88.15)> *Khejri* (85.02)>*Bael* (73.98)> *Ber* (60.37)>Moringa (57.63).

June: *Khejri*(88.97) >*Karonda* (85.65) >*Aonla* (85.65)>*Bael* (76.47)>Moringa (75.88).

July: *Bael* (92.77)> *Aonla* (88.71)> *Karonda* (87.52) > *Khejri* (81.59) > Moringa (71.12) > *Ber* (56.49)

August: *Aonla* (93.49)>*Ber* (93.49)>*Karonda* (93.49)>*Bael* (93.49)>Moringa (93.49) >*Khejri* (46.36).

September:*Ber(87.26)*>*Bael(87.01)*>Moringa *(85.37)*> *Aonla(85.19)*>*Khejri(84.38)*>*Karonda (81.38)*.

October: *Karonda* (96.29)>*Bael* (92.71)> Moringa (89.89)>*Khejri* (83.68)>*Aonla* (81.35)> *Ber* (77.41).

November: *Bael* (92.86)>Moringa (89.89)> *Khejri* (83.82)>*Aonla* (83.2)>*Ber* (76.6)>*Karonda* (69.96).

December: *Bael* (96.88)>*Karonda* (95.45)>Moringa (88.72)>*Khejri* (85.8)>*Aonla* (80.35)>*Ber* (77.0).

January: *Khejri* (95.17)>*Karonda* (92.27)>*Bael* (91.82)>moringa (83.33)>*Aonla* (70.14)>*Ber* (59.34).

February: *Karonda* (93.1)>*Khejri* (91.68)>*Bael* (89.05)>*Aonla* (83.21)> Moringa (82.9)> *Ber* (57.8).

March: *Karonda* (91.07)> *Bael* (88.47)> *Aonla* (88.24)> *Khejri* (86.12)> Moringa (83.2)> *Ber* (54.3).

*Karonda* and *Bael* leaves were observed to maintain the comparatively higher relative water content throughout the period under study followed by *aonla*, *khejri* and moringa while the lowest was noticed with *Ber*. Likewise, with regards to the leaf water content, drumstick tree was observed to be highest while *ber* tree the lowest.

### Leaf Water Contents (%) Pattern of Fruit Trees

April: Moringa (76.06) > *Karonda* (66.24) > *Khejri* (62.13)> *Bael* (59.17) > *Aonla* (57.1) > *Ber* (55.19)

May: Moringa (73.26) > *Khejri* (65.37) > *Aonla* (63.04)> *Karonda* (66.22)> *Bael* (62.36)> *Ber* (56.11)

June: Moringa (75.44) > *Bael* (65.41) > *Khejri* (61.75) > *Aonla* (59.32) > *Karonda* (57.61)

July: *Bael* (72.37) > Moringa (68.67) > *Karonda* (64.51) >*Aonla* (63.77) > *Khejri* (57.82) > *Ber* (48.36).

August: Moringa(73.86)> *Karonda* (71.84)> *Bael* (69.95)> *Ber* (56.41)> *Khejri* (56.32)> *Aonla* (48.92)

September: Moringa (74.18)> *Bael* (70.69)> *Khejri* (64.57)> *Ber* (62.88)> *Aonla* (59.55)> *Karonda* (54.79)

October: Moringa (78.59) > *Karonda* (69.38) > *Ber* (62.12) > *Bael* (62.07) > *Khejri* (59.40) > *Aonla* (56.72)

November: Moringa (73.64) > *Aonla* (58.37) > *Khejri* (59.44) > *Karonda* (57.61) > *Bael* (50.94) > *Ber* (48.35)

December: Moringa (73.01) > *Khejri* (69.02) > *Bael* (59.74)> *Karonda* (57.26) > *Ber* (57.02) > *Aonla* (51.72)

January: *Khejri* (73.57) > Moringa (73.31) > *Ber* (60.15) > *Bael* (56.24) )> *Aonla* (51.27)> *Karonda* (49.66)

February: Moringa (78.39) > *Khejri* (69.94) > *Karonda* (64.61) > *Bael* (56.59) > *Ber* (54.83) > *Aonla* (50.65);

March: *Karonda* (69.56) > Moringa (63.28) > *Ber* (54.17) > *Aonla* (51.62) > *Khejri* (45.83) > *Bael* (45.47).

### Available soil nutrient status

Upon nutrient analysis from the soil samples collected from the 0-15 cm soil depth, the maximum organic matter, available soil nitrogen and micronutrient contents were found to be in *Aonla-Khejri* system, which was statistically at par with the *Aonla-Ber* cropping system (Fig. 29).

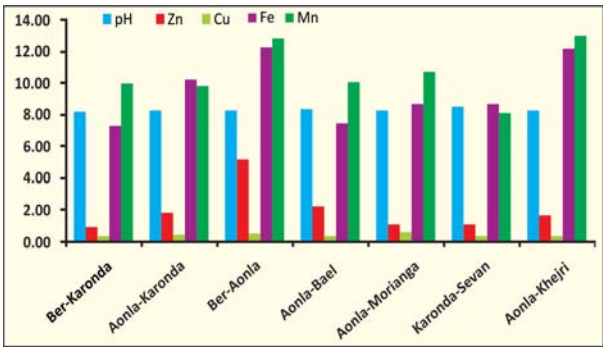



**Fig. 29: Available soil micronutrient status in different cropping systems**

## Intensification of research on tissue cultured date palm in hot arid region

### A. Standardization of planting time

This experiment was conducted with following approved technical programme and observations were also recorded as given below.

Treatments : February, July, October

Cultivars: Barhee, Khalas, Khuneizi and Medjool

Replication: Five

Design: RBD

Observations: Survival (%), Plant height (m), Plant spread (m x m), emergence of new leaves.

The results of the said experiment are given here:

- Maximum survival (95%) of tissue culture plants was recorded in July planting followed in February month planting and minimum survival (85%) was recorded in October planting.
- In respect of cultivars maximum survival (95%) was recorded in Khalas, Barhee

followed in Medjool (90%) and minimum(85%) survival was recorded in Khuneizi cultivar

- Maximum plant height (95 cm) was recorded in Barhee followed by Khalas (90 cm) and minimum in Khuneizi cultivar.
- Maximum plant spread (N-S) and (E-W) was recorded in Barhee (1.00 m and 1.05 m) and minimum in Khuneizi cultivar.
- In cultivars Khalas and Barhee 3-4 new leaves emerged while in Medjool it was 2-3 and minimum leave emerged in Khuneizi cultivar (i.e.1-2).

### B. Standardization of pit size for planting

This experiment was conducted with following approved technical programme and observations were also recorded as given below.

Pit size: 2 (1 x1 x 1m and 0.5 x 0.5 x 0.5m)

Cultivar: Barhee, Khalas, Khuneizi and Medjool

Replications: 5

Design: RBD

Observations: Survival (%), Plant height (m), Plant spread (m x m), emergence of new leaves

The results of the said experiment are given here:

- Irrespective of cultivar, maximum survival (95%) was recorded in 1x 1 x 1 m pit size while it was 85% in 0.5 x 0.5 x 0.5m size of pit.
- No significant effect of pit size was observed on plant height and emergence of new leaves.

### C. Standardization of crop geometry (plant to plant and row to row spacing)

This experiment was conducted with following approved technical programme and observations were also recorded as given below.

Spacing: 02 (6 x 6m and 8 x 8m)

Cultivars: Barhee, Khalas, Khuneizi and Medzool

Replications: 05

Design: RBD

The results of the said experiment are given here:

In all cultivars i.e. Khuneizi, Khalas, Barhee and Medjool, impact of spacing (row to row and plant to plant) i.e. 6 x 6m and 8 x8m was not seen and survival, plant height and spread were not significantly different between the treatments.

## At Godhra

### Organic and biodynamic farming

### Mulching (Mango)

### 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 lowered significantly with paddy straw followed by grasses.

### Soil moisture

Among the organic mulches, soil moisture content was recorded maximum with paddy straw mulch at both the depths of soil (0-15 cm and 15-30 cm). Amongst the organic mulches evaluated, soil moisture ranged 19.70-14.90, 20.50-16.60% in paddy straw and it was recorded 14.90-12.12, 16.50-13.60 % in control at both the depths from soil surface after mulching.

### Vegetative growth

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

### Fruit yield and quality attributes

Plants treated with paddy straw mulch recorded highest yield (48.10 kg/ plant), followed by grasses (44.20 kg/ plant) and black polythene mulch (41.50 kg/plant) and it was recorded minimum in control (36.80 kg/plant). Maximum TSS (20.90 $^{0}$

Brix) was noted in paddy straw mulch followed by grasses (20.70 $^0$ Brix) and polythene mulch(20.50 $^0$ Brix), it was recorded least in control (19.80 $^0$ Brix).

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

Experiment was set in randomized block design which were 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 (2.90 m), plant spread East- West (2.30 m), north-south (2.20m) and scion girth (35.20 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 (20.80 $^0$ Brix) was also recorded in T-6, closely followed by T-8(20.60 $^0$ Brix).

### Pruning trial in mango

For conducting the pruning trial in mango, planting of 200 plants of Kesar mango under high density (5x5 m ) has been done in 0.5 ha area. Plants are growing well.

## Sweet orange

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

Maximum fruit yield per plant (35.20kg) was recorded in paddy straw mulch followed by grasses (33.20 kg/ plant), black polythene mulch (29.10 kg). Minimum fruit yield (22.00 kg/ plant) was recorded under control. Maximum fruit weight (235.12) and TSS (13.40$^o$Brix) was also recorded in paddy straw mulch, followed by grasses and black polythene mulch.

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

Experiment was set on in randomized block design which were 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 mx5 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 (2.20 m), plant spread East- West (1.90 m), north-south (2.10m) and scion girth (21.12 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.

### Effect of rootstocks on growth, yield and fruit quality attributes of sweet orange cv Sathgudi.

Experiment has been conducted on 4 root stocks i.e. Rangpur lime, Rough lemon, Cleopatra mandarin, Carizzo citrange. Sathgudi was used as scion variety. Plants are growing well.

## Bael

### Effect of age of scion shoot and time of budding (*in-situ*) on success and survival of the bael plant

### Detopping and promotion of scion wood

For getting vigorous and healthy scion shoots, the branches have been detopped on the 10th day of the month in April and May when the plants were in leafless condition. The multiple axillary shoots

arised below the cut portion attained the length of 45 cm to 60 cm in two months, vigorous and healthy in growth, were used as scion shoots for budding.

### Selection of bud wood

Bud wood becomes available during the active growth from May onwards. The bud stick, 1 and 2 months old having 15- 25 mm girth of current growth and recently matured buds (but still not open) were collected. The active growth period is indicated by easy and clear separation of the scion shoot from the wood of scion sticks. After collection, the bud wood stored for a while and budding was performed in every month right from May, 2014.

It was observed that the plants grafted in May took the least time (8 days) to sprout closely followed by that done in June (12 days) and July (18days); however maximum time (22 days) was taken to sprout when grafting was performed in August. The highest percentage of graft success (97.10) was recorded when grafting was done in May closely followed by June (93.20), July (68.10) and August (68.00) with one month old shoots. The maximum mean length of sprout *i.e.* 61.00 cm was recorded when patch budding was done in May closely followed by June (59.50 cm) and July (54.10 cm) whereas least length of sprout was recorded in August (45.00cm). The maximum number of trifoliate leaves (35.17) per plant was recorded from the plants when the budding was done in May followed by June (28.65) and in July (24.50) and the minimum was recorded in August i.*e.* 20.32 leaves.

## 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 2014-15 was carried out in bael and kinnow field experiments of integrated nutrient management. The bacterial population in different treatments ranged from 5 to 30 x$10^5$ cfu $g^{-1}$ soil, fungal from 1 to 2 x$10^5$ cfu $g^{-1}$ soil and actinomycetes from 10-20 x $10^5$ 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 6). Total population as well as individual population of different micro-organism increased with involvement of 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 of 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* + 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 showed 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 7 revealed that status total microbial population was less in bael orchard in all INM treatments in comparison to kinnow orchard. The bael orchard was only 6 year old and added only small amount of FYM and biofertilizers. In different treatment of INM in bael, bacterial population ranged from 8 to 30x $10^5$ cfu $g^{-1}$ soil, fungal 1 to 2 x $10^5$ cfu $g^{-1}$ soil and actinomycetes 10 to 20x $10^5$ 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 parameters of kinnow

The data presented in table 8 revealed that significantly maximum plant height (3.70 m) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatment and minimum was in control (2.65 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

**Table 6. Effect of different INM treatments on microbial population in kinnow orchard (14year old plants)**

| Treatments | 0-15 cm depth | | | | 15-30 cm depth | | | |
|---|---|---|---|---|---|---|---|---|
| | Bacteria Cfug$^{-1}$ x $10^5$ | Fungal Cfug$^{-1}$ x $10^5$ | Actinomycetes Cfug$^{-1}$ x $10^5$ | Total | Bacterial Cfug$^{-1}$ x $10^5$ | Fungal Cfug$^{-1}$ x $10^5$ | Actinomycetes Cfug$^{-1}$ x $10^5$ | Total Cfug$^{-1}$ x $10^5$ |
| Control | 5 | 1 | 10 | 16 | 5 | 1.5 | 10 | 16.5 |
| RDF | 12 | 1.2 | 12 | 25.2 | 10 | 1.2 | 12 | 23.2 |
| RDF + FYM | 25 | 1.8 | 20 | 46.8 | 20 | 1.5 | 20 | 41.5 |
| RDF +Azotobactor | 28 | 1.2 | 10 | 39.2 | 25 | 1.2 | 10 | 36.2 |
| RDF + PSB | 30 | 1.5 | 15 | 46.5 | 25 | 1 | 10 | 36 |
| RDF + VAM | 8 | 2 | 12 | 22 | 5 | 2 | 10 | 17 |
| RDF+FYM + AZB | 30 | 1.5 | 15 | 46.5 | 25 | 1.2 | 15 | 41.2 |
| RDF + FYM + PSB | 30 | 1.5 | 15 | 46.5 | 25 | 1 | 12 | 38 |
| RDF + FYM + VAM | 28 | 2 | 18 | 48 | 25 | 2 | 15 | 42 |
| RDF +FYM + PSB + AZB | 30 | 1.8 | 20 | 51.8 | 25 | 1.5 | 18 | 44.5 |
| RDF + FYM + PSB + AZB + VAM | 30 | 2 | 18 | 50 | 28 | 2 | 15 | 45 |
| SE± | 3.2 | 0.11 | 3.25 | - | 2.63 | 0.13 | 3.1 | - |
| CD 5% | 8.65 | 0.33 | 9.25 | - | 7.32 | 0.31 | 8.9 | - |

**Table 7. 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 Cfug$^{-1}$ x $10^5$ | Fungal Cfug$^{-1}$ x $10^5$ | Actinomycetes Cfug$^{-1}$ x $10^5$ | Total | Bacterial Cfug$^{-1}$ x $10^5$ | Fungal Cfug$^{-1}$ x $10^5$ | Actinomycetes Cfug$^{-1}$ x $10^5$ | Total Cfug$^{-1}$ x $10^5$ |
| Control | 8 | 1 | 15 | 24 | 5 | 1 | 10 | 16 |
| RDF | 12 | 1.0 | 15 | 28 | 10 | 1.0 | 10 | 21 |
| RDF + FYM | 20 | 2.0 | 20 | 42 | 20 | 1.0 | 20 | 41 |
| RDF +Azotobactor | 25 | 1.0 | 10 | 36 | 20 | 1.0 | 10 | 31 |
| RDF + PSB | 30 | 1.0 | 10 | 41 | 25 | 1.0 | 10 | 36 |
| RDF + VAM | 5 | 2 | 12 | 19 | 5 | 2 | 10 | 17 |
| RDF+FYM + AZB | 30 | 1.0 | 15 | 46 | 20 | 1.0 | 15 | 36 |
| RDF + FYM + PSB | 30 | 1.0 | 20 | 51 | 20 | 1.0 | 18 | 39 |
| RDF + FYM + VAM | 20 | 2.0 | 15 | 37 | 15 | 2.0 | 10 | 27 |
| RDF +FYM + PSB + AZB | 25 | 1.0 | 18 | 44 | 20 | 1.0 | 15 | 36 |
| RDF + FYM + PSB + AZB + VAM | 20 | 2.0 | 15 | 37 | 20 | 2.0 | 15 | 37 |
| SE± | 2.58 | 0.10 | 2.50 | - | 2.55 | 0.10 | 2.52 | - |
| CD 5% | 7.25 | 0.26 | 6.89 | - | 6.58 | 0.25 | 6.85 | - |

**Table 8. Effect of different INM treatments on morphological parameter of kinnow orchard (Average age of plant: 14 years)**

| Treatment | Tree height (m) | Tree Spread | | Stem diameter |
|---|---|---|---|---|
| | | N-S (m) | E-W (m) | (cm) |
| Control | 2.65 | 2.50 | 2.45 | 60 |
| RDF | 2.85 | 2.55 | 2.45 | 70 |
| RDF + FYM | 3.50 | 2.85 | 2.85 | 70 |
| RDF +Azotobactor | 2.85 | 2.55 | 2.60 | 70 |
| RDF + PSB | 2.85 | 2.60 | 2.65 | 70 |
| RDF + VAM | 2.80 | 2.60 | 2.60 | 70 |
| RDF+FYM + AZB | 3.60 | 2.75 | 2.75 | 80 |
| RDF + FYM + PSB | 3.60 | 2.85 | 2.85 | 80 |
| RDF + FYM + VAM | 3.60 | 2.80 | 2.80 | 85 |
| RDF +FYM + PSB + AZB | 3.65 | 2.90 | 2.85 | 85 |
| RDF + FYM + PSB + AZB + VAM | 3.70 | 2.90 | 2.80 | 85 |
| SE± | 0.18 | 0.12 | 0.15 | 5.50 |
| CD 5% | 0.32 | 0.30 | 0.38 | 12.56 |

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.

## 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 9 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 (19.50 t/ha) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatment and minimum (8.0 t/ha) yield was estimated in control treatment. The TSS was measured in mature fruits from all treatment and recorded in the range of 12.50 to 15.00 ° 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 ranged from 40 to 55 percent and maximum juice (55 %)was recorded in those treatments where FYM was the component of the treatment.

## Evaluation of benefit cost ratio of different INM treatments in Kinnow fruit crop

The benefit cost ratio of different INM treatments was evaluated for 14 year old kinnow fruit crop. The fixed cost was worked out taking into account the cost of all type of activities carried out in each treatment except the defined treatment. Simultaneously, cost of each treatment was also worked and then both fixed and treatment cost were added for each treatment. The yield was also estimated on hectare basis. The gross income of each treatment was worked out by taking cost of the produce @ Rs. 8000 /t. After that net income was evaluated after deducting the total cost from the gross income of each treatment. Finally benefit cost ratio was worked out of each treatment. The maximum benefit cost ratio (2.50) was recorded in treatment $T_{10}$ and minimum (1.56) was in control treatment. The data revealed that adding of FYM

**Table 9. Effect of different INM treatments on yield and fruit quality parameters of kinnow orchard (Average age of plant: 14 years)**

| Treatment | Fruit weight (g) | Fruit yield (t/ha) | TSS (° Brix) | Acidity (%) | Juice (%) |
|---|---|---|---|---|---|
| Control | 120 | 8.00 | 12.50 | 0.85 | 40.00 |
| RDF | 160 | 11.00 | 12.00 | 0.70 | 50.00 |
| RDF + FYM | 225 | 16.50 | 12.50 | 0.60 | 55.00 |
| RDF +Azotobactor | 170 | 11.00 | 12.50 | 0.60 | 50.00 |
| RDF + PSB | 165 | 11.00 | 12.50 | 0.70 | 55.00 |
| RDF + VAM | 165 | 11.00 | 12.50 | 0.70 | 50.00 |
| RDF+FYM + AZB | 190 | 17.00 | 15.00 | 0.70 | 55.00 |
| RDF + FYM + PSB | 195 | 17.50 | 15.00 | 0.70 | 55.00 |
| RDF + FYM + VAM | 185 | 16.50 | 15.00 | 0.70 | 55.00 |
| RDF +FYM + PSB + AZB | 225 | 19.25 | 15.00 | 0.65 | 55.00 |
| RDF + FYM + PSB + AZB + VAM | 230 | 19.25 | 15.00 | 0.65 | 55.00 |
| SE± | 15.25 | 1.80 | 0.65 | 0.26 | 1.20 |
| CD 5% | 45.90 | 5.20 | 1.78 | NS | 3.50 |

with recommended dose of NPK increased the benefit cost ratio while adding of AMF did not the benefit in the income (Table 10).

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

The parameters on plant height, tree spread and stem diameter were measured and data presented in table 11. The data revealed that maximum plant height (1.20 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.

**Table 10. Evaluation of benefit cost ratio of different INM treatments in Kinnow fruit crop (14 years old)**

| Treatments | Fixed cost ('000) | Treat Cost ('000) | Total cost ('000) | Yield (t/ha) | Gross income ('000) | Net income ('000) | B:C ratio |
|---|---|---|---|---|---|---|---|
| Control | 25 | - | 25 | 8.00 | 64 | 39 | 1.56 |
| RDF of N, P and K | 25 | 10 | 35 | 11.00 | 88 | 53 | 1.52 |
| RDF + FYM | 25 | 15 | 40 | 16.50 | 132 | 92 | 2.30 |
| RDF +AZB | 25 | 12 | 37 | 11.00 | 88 | 51 | 1.38 |
| RDF + PSB | 25 | 12 | 37 | 11.00 | 88 | 51 | 1.38 |
| RDF + AMF | 25 | 12 | 37 | 11.00 | 88 | 51 | 1.38 |
| RDF+FYM +AZB | 25 | 17 | 42 | 17.00 | 136 | 94 | 2.24 |
| RDF + FYM + PSB | 25 | 17 | 42 | 17.50 | 140 | 98 | 2.33 |
| RDF + FYM + AMF | 25 | 17 | 42 | 16.50 | 132 | 90 | 2.14 |
| RDF +FYM +PSB + AZB | 25 | 19 | 44 | 19.25 | 154 | 110 | 2.50 |
| RDF+FYM+ PSB + AZB + AMF | 25 | 21 | 46 | 19.25 | 154 | 108 | 2.34 |

**Table 11. Effect of different INM treatments on morphological parameter of bael orchard (Average age of plant: 6 years)**

| Treatment | Tree height (m) | Tree Spread | | Stem diameter |
|---|---|---|---|---|
| | | N-S (m) | E-W (m) | (cm) |
| Control | 0.80 | 0.25 | 0.30 | 20 |
| RDF | 1.05 | 0.30 | 0.30 | 20 |
| RDF + FYM | 1.15 | 0.30 | 0.30 | 28 |
| RDF +Azotobactor | 1.00 | 0.30 | 0.30 | 28 |
| RDF + PSB | 1.15 | 0.30 | 0.30 | 25 |
| RDF + VAM | 1.00 | 0.30 | 0.25 | 25 |
| RDF+FYM + AZB | 1.20 | 0.35 | 0.35 | 25 |
| RDF + FYM + PSB | 1.15 | 0.40 | 0.35 | 30 |
| RDF + FYM + VAM | 1.15 | 0.40 | 0.35 | 30 |
| RDF +FYM + PSB + AZB | 1.20 | 0.35 | 0.40 | 30 |
| RDF + FYM + PSB + AZB + VAM | 1.20 | 0.40 | 0.40 | 30 |
| SE± | 0.18 | 0.15 | 0.14 | 4.25 |
| CD 5% | 0.52 | NS | NS | NS |

The physico-chemical properties of the soil under different INM treatments were measured periodically and data presented in table 12 depicts the changes in the different properties over the year. The data revealed that pH of the soil did not change much when only chemical fertilizers were applied

**Table 12. 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 | 0.10 | 08.50 | 175.00 | 0.50 | 3.50 |
| RDF | 8.20 | 0.12 | 13.50 | 210.00 | 0.50 | 3.50 |
| RDF + FYM | 7.50 | 0.20 | 14.50 | 215.00 | 0.60 | 4.25 |
| RDF +Azotobactor | 8.00 | 0.12 | 14.00 | 200.00 | 0.60 | 3.80 |
| RDF + PSB | 8.00 | 0.15 | 16.00 | 200.00 | 0.60 | 3.80 |
| RDF + VAM | 8.00 | 0.12 | 16.50 | 200.00 | 0.60 | 3.80 |
| RDF+FYM + AZB | 7.60 | 0.20 | 14.50 | 210.00 | 0.65 | 4.80 |
| RDF + FYM + PSB | 7.60 | 0.20 | 18.50 | 210.00 | 0.65 | 4.80 |
| RDF + FYM + VAM | 7.60 | 0.20 | 18.50 | 220.00 | 0.65 | 4.80 |
| RDF +FYM + PSB + AZB | 7.60 | 0.20 | 18.50 | 220.00 | 0.65 | 5.00 |
| RDF + FYM + PSB + AZB + VAM | 7.50 | 0.20 | 18.50 | 220.00 | 0.65 | 5.00 |
| Initial level | 8.20 | 0.08 | 08.00 | 180.50 | 0.50 | 3.50 |

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 inorganic fertilizers along with FYM. Likewise, availability of zinc and iron content in the soil has also been increased over the application of FYM.

The soil moisture status 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 13). Application of biofertilizers alone did not improve the soil moisture status of the soil.

**Table 13. 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 |

## Nutrient Management in Vegetable

### Role of organic and inorganic source of nutrient on performance of Kachri

Field experiments were conducted at CIAH research farm with popular kachari cultivars AHK119 during 2014 in the kharif season to investigate the role of application of inorganic and FYM source of nutrient on kachari performance. The kachari crop received differential doses of NPK from inorganic fertilizers or FYM as per schedule of treatments. The six manurial treatments consisting of control, 100% NPK from inorganic fertilizers, 75% (I)+7.5 t/ha FYM, 50%(I)+ 15 t/ha FYM, 25%(I)+ 22.5 t/ha FYM and 30 t/ha FYM were replicated 3 times in a randomized block design. Nitrogen dose was applied in three splits *i.e.* 1/3$^{rd}$ at planting, 1/3$^{rd}$ at 25 DAP and rest 1/3$^{rd}$ 50 DAP from fertilizers and FYM as per treatment was applied in furrows at the planting time.

Application of organic and inorganic sources of nutrients significantly increased yield of kachri as compared to control (Table 14). Integration of organic and inorganic sources at equal proportion (application of 50% NPK from inorganic fertilizers and 15 t/ha FYM) gave the highest kachri yield (113.08 q/ha) which was significantly higher than all other treatments. The increase in total yield was 26.77% higher over recommended NPK through fertilizers. Application of 100% NPK through FYM also increased yield significantly by 32.71% compared to control. Whereas, this treatment gave only 5.12% more kachri yield as compared to recommended dose of fertilizers. Other treatments,

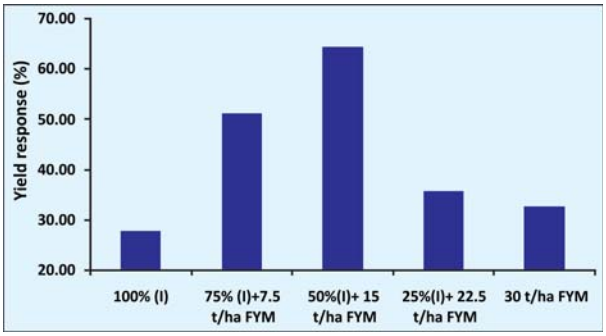



**Fig. 30: Role of organic and inorganic source of nutrient on yield response (%) of Kachri**

**Table 14. Role of organic and inorganic source of nutrients on performance of Kachri**

| Treatments | Yield (q/ha) | Average fruit weight (kg) | Dry matter (%) | Dry matter yield (q/ha) |
|---|---|---|---|---|
| Control | 68.71 | 0.26 | 8.16 | 5.60 |
| 100% (I) | 87.89 | 0.34 | 8.69 | 7.64 |
| 75% (I)+7.5 t/ha FYM | 104.00 | 0.36 | 8.79 | 9.15 |
| 50%(I)+ 15 t/ha FYM | 113.08 | 0.38 | 9.81 | 11.09 |
| 25%(I)+ 22.5 t/ha FYM | 93.27 | 0.37 | 9.98 | 9.31 |
| 30 t/ha FYM | 91.19 | 0.34 | 8.99 | 8.19 |

where 25, 75 or 100% of NPK were applied through organic sources were better than control, but were inferior to 50% replacement and at par among treatments.

Maximum per cent yield response was observed where 50%(I)+ 15 t/ha FYM was applied (64.57%) followed by 75% (I)+7.5 t/ha FYM (54.37%) as compared to control (Fig. 30).

This may be due to more partitioning of dry matter to fruits of kachri as a result of balance nutrition in the treatment receiving FYM application.

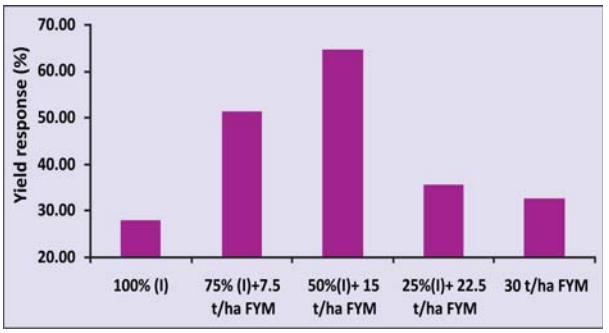



**Fig 31: Percent yield response of kachri using omission plot technique**

## Determination of fertilizer requirement in kachri

Field experiments were conducted at CIAH research farm with popular kachari cultivars AHK119 during 2014 in the kharif season to investigate nutrient requirement of kachari. The kachari crop received differential doses of NPK from inorganic fertilizers as per schedule of treatments. The seven manurial treatments involving NPK through inorganic fertilizer *viz*., 40, 20 and 20 kg/ha of NPK, 80, 40 and 40 kg/ha of NPK , 120, 60 and 60 kg/ha of NPK, 40 and 40 kg/ha of PK, 80 and 40 kg/ha of NK, 80 and 40 kg/ha of NP and without NPK (Absolute control) were replicated 3 times in a randomized block design. Nitrogen dose was applied in three splits *i.e.* 1/3$^{rd}$ at planting, 1/3$^{rd}$ at 25 DAP and rest 1/3$^{rd}$ 50 DAP from fertilizers . PK fertilizers was applied in furrows at the planting time as per treatment.

**Table 15. Requirements of N, P and K fertilizers in kachri using omission plot technique**

| Treatments | Yield (q/ha) | Average of 10 fruit (kg) | DM % | Dry matter yield (q/ha) |
|---|---|---|---|---|
| 40, 20 and 20 kg/ha of NPK | 82.65 | 0.37 | 9.19 | 7.59 |
| 80, 40 and 40 kg/ha of NPK | 100.95 | 0.40 | 9.30 | 9.38 |
| 120, 60 and 60 kg/ha of NPK | 108.87 | 0.42 | 10.37 | 11.29 |
| 40 and 40 kg/ha of PK | 71.25 | 0.38 | 9.50 | 6.77 |
| 80 and 40 kg/ha of NK | 80.45 | 0.40 | 10.55 | 8.49 |
| 80 and 40 kg/ha of NP | 98.87 | 0.33 | 9.69 | 9.58 |
| Without NPK (Absolute control) | 55.58 | 0.29 | 8.62 | 4.79 |

Maximum yield was obtained when 120, 60 and 60 kg/ha of NPK followed by 80, 40 and 40 kg/ha of NPK and 80 and 40 kg/ha of NP and 40, 20 and 20 kg/ha of NPK. Same trend was observed for percent yield response of different treatments (Fig. 31) (Table 15).

## Micronutrient application in mateera under arid conditions

Field experiments were conducted at CIAH research farm with popular mateera cultivar, Thar Manak, during 2014 in the kharif season to investigate the role of application of micronutrient on performance of mateera. The mateera crop received differential doses of different micronutrient as per schedule of treatments. The seven treatments consisting of control (full recommended NPK through chemical fertilizer), NPK+Zinc Sulphate @ 15 kg/ha at the of planting, NPK+ Iron Sulphate @ 15 kg/ha at the of planting, NPK+ Managaenese Sulphate @ 15 kg/ha at the time of planting,NPK+ Cupper Sulphate @ 15 kg/ha at planting, NPK+ Zn, Fe, Mn and Cu Sulphate @ 15 kg/ha each at planting and NPK +Zn+Fe Sulphate @ 15 kg/ha each at planting were replicated 3 times in a randomized block design. micronutrients were applied as per treatments.

Application of Zn, Fe, Mn and Cu Sulphate @ 15 kg/ha each at the time of planting was found superier and gave maximum yield followed by Zn+Fe Sulphate @ 15 kg/ha each at planting and application of Zn Sulphate @ 15 kg/ha each at planting as compared to other treatments. Same trend was observed for percent yield response of different treatments.

This may be due to zinc and iron deficient soil and more partitioning of carbohydrate to mateera as a result of balance nutrition in the treatment receiving zinc application (Table 16 & Fig. 32).

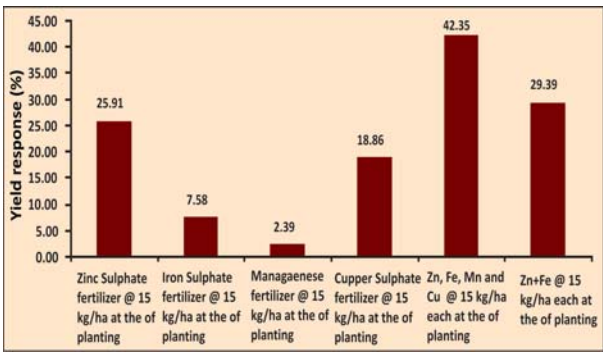



**Fig. 32: Percent yield response of mateera under different micronutrient levels**

## Effect of boron application on performance of mateera in the arid region

Field experiments were conducted at CIAH research farm with popular mateera cultivar, Thar Manak, during 2014 in the kharif season to investigate the role of boron application on mateera performance. The six treatments consisting of control, 50 ppm boron foliar application at 25, 35 and 45 days, 100 ppm boron foliar application at 25, 35 and 45 days, 2 kg/ha Borax soil application at the

**Table 16. Micronutrient application in mateera under arid conditions**

| Treatments | Yield (q/ha) | TSS | DM (%) | DM yield (q/ha) | Av fruit wt | No. of fruit/ ha |
|---|---|---|---|---|---|---|
| Full recommended NPK through chemical fertilizer | 236.66 | 7.83 | 6.26 | 14.81 | 1.73 | 13648 |
| T1 +Zinc Sulphate fertilizer @ 15 kg/ha at the of planting | 297.98 | 9.23 | 6.01 | 17.91 | 2.05 | 14535 |
| T1+ Iron Sulphate fertilizer @ 15 kg/ha at the of planting | 254.61 | 8.15 | 5.14 | 13.09 | 1.75 | 14549 |
| T1+ Managaenese fertilizer @ 15 kg/ha at the of planting | 242.33 | 8.24 | 5.4 | 13.09 | 1.41 | 17186 |
| T1+ Cupper Sulphate fertilizer @ 15 kg/ha at the of planting | 281.29 | 8.55 | 5.86 | 16.48 | 1.56 | 18031 |
| T1+Zn, Fe, Mn and Cu @ 15 kg/ha each at the of planting | 336.89 | 8.82 | 5.96 | 20.08 | 1.89 | 17825 |
| T1+Zn+Fe @ 15 kg/ha each at the of planting | 306.21 | 8.92 | 6.06 | 18.56 | 2.01 | 15234 |
| CD | 48.20 | 0.96 | 0.52 | 1.65 | 0.30 | 2577 |

time of planting, 4 kg/ha Borax soil application at time of planting and 6 kg/ha Borax soil application at time of planting. Application of 100 ppm boron foliar application at 25, 35 and 45 gave higher yield, number of fruits and average fruit size (Table 17) followed by 50 ppm boron foliar application at 25, 35 and 45 days and 6 kg/ha Borax soil application at the time of planting as compared to control. Same trend was observed for percent yield response of different treatments (Fig. 33).

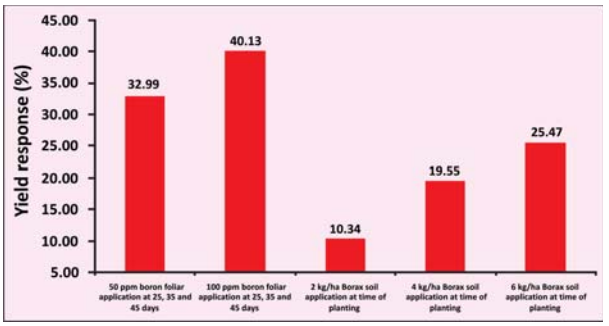



**Fig. 33: Per cent yield response of mateera under different boron application**

**Table 17. Effect of boron application on performance of mateera**

| Treatmants | Yield (q/ha) | TSS | % DM | DM yield (q/ha) | Av fruit wt (kg) | No. fruits/ ha |
|---|---|---|---|---|---|---|
| Control | 223 | 8.33 | 6.00 | 13.38 | 1.55 | 14388 |
| 50 ppm boron foliar application at 25, 35 and 45 days | 297 | 9.73 | 5.20 | 15.42 | 1.73 | 17143 |
| 100 ppm boron foliar application at 25, 35 and 45 days | 312 | 8.65 | 5.14 | 16.06 | 1.76 | 17755 |
| 2 kg/ha Borax soil application at time of planting | 246 | 8.74 | 5.40 | 13.29 | 1.56 | 15772 |
| 4 kg/ha Borax soil application at time of planting | 267 | 9.05 | 5.86 | 15.62 | 1.71 | 16362 |
| 6 kg/ha Borax soil application at time of planting | 280 | 9.32 | 5.96 | 16.68 | 1.54 | 17311 |

## Organic farming in vegetables in semi arid conditions

Leaf sampling of chironji, custard apple, jamun and tamarind was done from May-2014 to March-2015 to standardise leaf sampling technique in chironj, custard apple, jamun and tamarind. Samples were analysed for nutrient contents like nitrogen, phosphorous, potassium, calcium, magnesium and sulphur.

### Chironji

Leaves are simple, thick and leathery which are broadly oblong with blunt tip and rounded base. Number of leaves generally range from 6 to 14 in matured twigs. Leaves are deciduous and leaf fall starts from March and continues upto April. After leaf falls, young leaves appear on the stem. Flowers appear in January to March and fruits ripen from April to May. However, a little variation can be seen from plant to plant in these events. Samples were collected at monthly interval and in June month, in twigs of 14 leaves, the weight of fresh leaves reached maximum up to 5.53 g, which was in 5$^{th}$ leaf. The phosphorous content of leaves ranged from 705 to 1084 ppm. The potassium percent of leaves ranged from 0.704 to 0.964. The calcium content ranged from 1.28% to 1.6%. The magnesium content ranged from 0.34 % to 0.58%.

### Jamun

Leaves are oblong, opposite, smooth and glossy. The leaves are in pairs on the twigs ranging from single to 5 pairs for each twig. Leaf fall starts from February and continues upto March. Simultaneously, new leaves replace old leaves. Nutrient content of jamun leaves is less in the month of June compared to the samples collected in the month of March. It is due to diversion of nutrients to development of jamun fruits. Nutrient content of the collected leaves varied from month to month and position of the leaf on the stem. The nitrogen content, phosphorous %, potassium % calcium %, magnesium % and sulphur % in April month ranged 1.58 to 2.54 , 0.04 to 0.313, 0.406 to 0.794, 0.76 to 0.92, 0.9 to 1.34 and 0.089 to 0.111, respectively.

## CROP PHYSIOLOGY AND BIOTECHNOLOGY

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

#### Impact of water stress on growth and development

An experiment was laid out in the field using kachari and musk melon as the material under investigation. The plants were grown at normal spacing with drip irrigation. At 35 days after sowing, the water stress was imposed on the plants and maintained for long duration. The observations on the plant dry matter distribution was estimated at 60 days after sowing.

The data revealed that imposition of water stress in kachari had little effect on reducing the dry matter content of different plant parts. For instance, the stem dry matter decreased from 9.0g to 8.6 g under water stress. Similarly, the leaves dry matter decreased from 11.56 to 9.8g and that of root increased from 0.37 to 0.58g. This illustrates that under water stress the dry matter allocation to root enhanced in Kachari.

Perusal of data for muskmelon revealed that there was drastic decrease in dry matter in all plant parts. For instance, the stem dry matter decreased from 14.48 to 3.42 g leaves from 19.1 to 7.65 g and root from 1.02 to 0.63 g. The results demonstrate that under water stress kachari is able to maintain the growth and development but in musk melon the growth and development is highly hampered.

#### Impact of water stress on photosynthetic activity

An experiment was laid out in the field using kachari and musk melon as the material under investigation. The plants were grown at normal spacing with drip irrigation. At 35 days after sowing, the water stress was imposed on the plants and maintained for long duration. The observations on photosynthetic activity and carboxylation efficiency was measured at 45 and 60 days after sowing.

Perusal of data revealed that at 45 DAS the photosynthetic activity in kachari was to the tune of 22.06 $\mu molm^{-2}s^{-1}$ under irrigated condition which dropped slightly to 19.85 $\mu molm^{-2}s^{-1}$ under water stress. Similarly at 60 DAS the Pn was 25.30 $\mu molm^{-2}s^{-1}$ under irrigated condition which dropped to 21.25 $\mu molm^{-2}s^{-1}$ under stress condition. However, in musk melon the magnitude of Pn at 45 days was 19.99 $\mu molm^{-2}s^{-1}$ under irrigated condition which drastically dropped to 12.45 $\mu molm^{-2}s^{-1}$ and at 60 DAS the respective values were 20.45 $\mu molm^{-2}s^{-1}$ and 8.45 $\mu molm^{-2}s^{-1}$ .

The data on carboxylation efficiency also reveals that it was maintained high in kachari under water stress condition being 0.132 and 0.083 at 45DAS and 60 DAS, respectively. However, in musk melon, the magnitude was 0.056 and 0.063 at 45 DAS and 60 DAS, respectively.

#### Impact of water stress on soluble sugar and starch content

An experiment was laid out in the field using kachari and musk melon as the material under investigation. The plants were grown at normal spacing with drip irrigation. At 35 days after sowing, the water stress was imposed on the plants and maintained for long duration. The observations on soluble sugar and starch content was estimated after giving water stress treatment for at least 20 days. Perusal of data revealed that the magnitude of soluble sugars accumulated in root are more in kachari as compared to that in musk melon. This is illustrated by the fact that the sugar levels were 65, 74 and 86 $mgg^{-1}$ fr. wt. at 20, 23 and 26 days after imposition of stress whereas in musk melon the respective values were 38, 40 and 44 $mgg^{-1}$fr. wt. The data further reveals that in shoot the level of sugars were nearly same in both the materials.

The data on starch content reveals that the magnitude of starch content in the roots of kachari was 40.44, 36.32 and 16.28 mg $g^{-1}$ fr. wt. at 20, 23 and 26 days after imposition of stress. The values in musk melon at respective stage were 44.32, 40.57 and 25.60 mg $g^{-1}$ fr. wt. The results revealed that there is no marked difference at starch content in roots of two species under water stress. Similar results were also observed in shoots.

## Impact of water stress on phenolics

An experiment was laid out in the field using kachari and musk melon as the material under investigation. The plants were grown at normal spacing with drip irrigation. At 35 days after sowing, the water stress was imposed on the plants and maintained for long duration. The observations on phenolics content was estimated after giving water stress treatment for at least 20 days.

Perusal of data revealed that in kachari root the magnitude at day of stress was 922.93 µg $g^{-1}$ fr. wt. which remained upto 1152.10 µg $g^{-1}$ fr. wt. under control condition, but the imposition of water stress drastically increased the phenolics and ther magnitidue went up to 2530.81 µg $g^{-1}$ fr. wt. by 26 days after imposition of stress.

Similarly in shoot, in the control samples, the magnitude was 2455.90 µg $g^{-1}$ fr. wt. at day of imposition of stress which remained nearly same at all stages in control but under water stress, it drastically incrassed and went up to 3482.97, 3863.00 and 3852.71 µg $g^{-1}$ fr. wt. at 20, 23 and 26 days after imposition of stress.

The results in musk melon also shows an increase in phenolics content in the samples. This is illustrated by the fact that in root, the magnitude was 1418.30, 1435.39, 1609.06 and 1594.20 µg $g^{-1}$ fr. wt. at day of imposition of stress, 20, 23 and 26 days after imposition of stress respectively under controls. However, under stress treatment, the magnitude was 3135.99, 2759.19 and 2722.15 µg $g^{-1}$ fr. wt. at 20, 23 and 26 days after imposition of water stress. Similar results were also obtained for shoot also.

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

Sixty cultivars of *P. granatum* were procured from core collection maintained at ICAR-Central Institute for Arid Horticulture, Bikaner, Rajashan (Table 18). Young emerging leaves were collected from single plant of each accession for DNA isolation.

**Table 18. Pomegranate genotypes used for RAPD profiling.**

| S.No. | Cultivar names | S.No | Cultivar names | S.No | Cultivar names | S.No | Cultivar names |
|---|---|---|---|---|---|---|---|
| 1 | Jallore Seedless | 17 | Jodhpur Red | 33 | Spin Sakaharin | 49 | Jobner-A |
| 2 | Ganesh | 18 | Jodhpur Collection | 34 | Utkal | 50 | Banaras Cell-I |
| 3 | G-137 | 19 | P-23 | 35 | Siah Siri | 51 | IIHR/19/10 |
| 4 | Bedana Suri | 20 | Jyoti | 36 | Kandhari | 52 | AHPG-C-I |
| 5 | Kabul IIHR | 21 | Surkh Anar | 37 | Agah | 53 | AHPG-C-3 |
| 6 | Khog | 22 | Dorsata Malus | 38 | Tajetis EC-4347 | 54 | AHPG-C-4 |
| 7 | Yercaud HRS | 23 | Kabul | 39 | P. Granatum | 55 | Ruby |
| 8 | A. K. Anar | 24 | Dholka | 40 | Kuravi 2 IC-24685 | 56 | Bedana Thiskin |
| 9 | P-26 | 25 | Coimbatore White | 41 | Spendanedar | 57 | Kabul Kohinoor |
| 10 | Mridula | 26 | Jodhpur Collection-I | 42 | Kajaki Anar | 58 | Gul-e-Shah Red |
| 11 | Baseeha Link | 27 | Crenedo Deleiche | 43 | Saharanpur | 59 | Gul-e-Shah Rose |
| 12 | Gul-e-Shah | 28 | Tesest | 44 | Bassein Seedless | 60 | Bhagwa |
| 13 | Siri Anar | 29 | Surat Anar | 45 | MR-599 | — | — |
| 14 | Achikdona | 30 | P-13 | 46 | Nasha | — | — |
| 15 | GKVK-1 | 31 | Damini Poona | 47 | EC-62812 | — | — |
| 16 | Muscat | 32 | Alah | 48 | EC-126113 | — | — |

## Genomic DNA isolation

The total genomic DNA, for RAPD analysis, was extracted following Qiagen kit method with some modification. The plant leaves were fixed in alcohol for 24 hrs. before grinding in AP1 buffer (provided by kit) making liquid nitrogen unnecessary. The DNAs were isolated from each accession and were collected in separate labeled tubes. To remove RNA, DNA was treated with 40 micro-grams RNAse-A at 37°C for 1 hour and samples were stored at -20° C. Extracted DNA was quantified by visual comparison on ethidim bromide stained 0.8% (w/v) agarose gels.

## RAPD-PCR conditions

To use in Polymerase Chain Reaction (PCR) a 1:4 dilution of DNA was made in doubled distilled, deionized and autoclaved water. Thirty Operon® RAPD's 10mer oligonucleotide primers were evaluated among kit D (OPD-01, OPD-02, OPD-03, OPD-04, OPD-05, OPD-06, OPD-07, OPD-08, OPD-09 and OPD-10) and kit F (OPF-01, OPF-02, OPF-03, OPF-04, OPF-05, OPF-06, OPF-07, OPF-08, OPF-09, OPF-10, OPF-11, OPF-12, OPF-13, OPF-14, OPF-15, OPF-16, OPF-17, OPF-18, OPF-19 and OPF-20), for DNA amplification and 13 of them were selected based on clear and reproducible banding patterns (Table 19). The PCR reactions were performed in a total reaction volume of 25 µl of 2 x Toptaq PCR Master Mix (Qiagen; USA) containing 10 pmol of each 13 different arbitrary 10-mer primers and 25 to 50 ng of genomic DNA. Amplification was performed in a preheated PCR machine (Genemate Series, Analytica Biotech, Corp. UK). PCR was initiated by a denaturation step at 94°C for 3 min and then the reaction was subjected to 35 cycles of 94°C for 30 sec, 36°C for 1 min, 72°C for 2.5 min with a final elongation step of 5 min at 72°C. In order to select the optimal conditions of the RAPD-PCR, different optimization experiments were carried out.

**Table 19. Details of thirteen selected 10-mer primers and corresponding primer code, their sequences, band sizes range (bp), total no. of loci scored, no. of polymorphic loci, % polymorphism of genetic instability and Polymorphic information content (PIC).**

| Sl. No. | Primer code | Sequence (5' to 3') | Band size range (bp) | Loci scored | No. of polymorphic loci | % Polymorphism | PIC |
|---|---|---|---|---|---|---|---|
| 1 | OPD-01 | ACCGCGAAGG | 700-3000 | 5 | 1 | 20.00 | 0.013 |
| 2 | OPD-02 | GGACCCAACC | 500-2300 | 8 | 4 | 50.00 | 0.299 |
| 3 | OPD-05 | TGAGCGGACA | 500-2400 | 11 | 5 | 45.45 | 0.190 |
| 4 | OPD-06 | ACCTGAACGG | 1100-3200 | 4 | 4 | 100.00 | 0.500 |
| 5 | OPD-10 | GGTCTACACC | 300-1500 | 4 | 3 | 75.00 | 0.402 |
| 6 | OPF-01 | ACGGATCCTG | 600-1800 | 7 | 5 | 71.43 | 0.317 |
| 7 | OPF-04 | GGTGATCAGG | 400-1300 | 5 | 2 | 40.00 | 0.320 |
| 8 | OPF-06 | GGGAATTCGG | 400-1800 | 7 | 5 | 71.43 | 0.064 |
| 9 | OPF-07 | CCGATATCCC | 400-1600 | 6 | 5 | 83.33 | 0.184 |
| 10 | OPF-08 | GGGATATCGG | 100-1000 | 6 | 2 | 33.33 | 0.059 |
| 11 | OPF-10 | GGAAGCTTGG | 400-1800 | 6 | 3 | 50.00 | 0.367 |
| 12 | OPF-16 | GGAGTACTGG | 300-800 | 4 | 1 | 25.00 | 0.349 |
| 13 | OPF-18 | TTCCCGGGTT | 400-1600 | 6 | 4 | 66.67 | 0.378 |
| | Total | - | - | 79 | 45 | - | - |
| | Average | - | 100-3200 | - | 45 | 57.24 | 0.265 |

## Visualization and analysis of RAPD-PCR products

Amplified products from each sample were separated electrophoretically on 1.4% agarose gel containing ethidium bromide in 1X TAE buffer at 120 V for 1½ h. To determine molecular weight of DNA marker (1kbDNA ladder) was electrophoresed along side RAPD products. DNA bands were observed on UV-transilluminator and photographed by a comprehensive and fully-automated gel documentation system GeneGenius (SYNGENE Cambridge, UK).

The presence and absence of bands between samples was scored and data were transcribed into binary format (1, 0, respectively). Only reproducible and clear bands in the replications were considered as potential polymorphic markers. An unweighted pair group arithmetic mean method (UPGMA) cluster analysis was performed, based on Jaccard's coefficient of similarity, as available in NTSYSpc software package version 2.11a (Rohlf, 2000). Dendrogram was drawn using SAHN clustering method and generated by using TREE display option.

A marker index was calculated for the RAPD markers to characterize the capacity of each primer to detect polymorphic loci among the cultivars. As such, the marker index was the sum of the polymorphism information content (PIC) values for all the selected markers produced by a particular primer. The PIC value was calculated using the formula PIC=1-Ópi$^2$, where Pi is the frequency of the *i* allele (Smith et al., 1997).

## Polymorphism and identity

All tested RAPD primers generated 44 polymorhic, stable and reproducible bands in all samples. The thirteen RAPD primers (Table 19) used in this study produced 79 amplified fragments in the whole data set. The amplified DNA polymorphic fragments were scored as binary matrix for presence (1) and absence (0), and data matrix of RAPD phenotypes was assembled for further analysis.

The all RAPD primers amplified 45 (56.96%) polymorhic, stable and reproducible bands out of 79 and 34 (43.04%) monomrphic banding sites. The highest percentages of polymorphism belonged to four primers OPD-6 (100%), OPF-7 (83.33%), OPF-01 (75.00%) and OPF-06 (71.43%) and the lowest percentages of polymorphism belonged to two primers with OPD-1 and OPF-16 (20.00%, 25.00%) respectively. The largest fragment amplified was in the range of 1500 to 3200 bp while the smallest but easily recognizable fragment was approximately of 100 bp. Most bands were concentrated between average ranges of 300 to 2500 bp. The number of bands scored for each primer varied from 4 to 11. Operon primers OPD-05 (11), OPD-02 (8), OPF-1 (7) and OPF-6 (7) generated the largest number of bands compared to the others. The highest number of bands was achieved with primer OPD-05 (11 bands), while the amplifications with three primers viz. OPD-06, OPD-10, OPF-16 resulted in only four bands.

Banding patterns of different cultivars in respect of three primers showed that primer OPF-10, OPD-10 produced maximum polymorphic bands (Fig 34 and Fig 35). Present study also indicated the effectiveness of RAPD in detecting polymorphism among different cultivars of *P. granatum*. RAPD marker profiles produced by the primer OPF-4 had only two polymorphic bands and out of those one loci is only present in *cv*. Banaras Cell-I and was absent in left over all 60 genotypes (Fig. 36).

PIC provides an estimate of discriminatory power of a marker by taking into account not only the number of alleles at a locus, but also their relative frequencies. The PIC values, a reflection of allele diversity and frequency among the varieties, were not uniformly higher for all the RAPD loci tested. The PIC value ranged from 0.013 (OPD-01) to 0.500 (OPD-06) with a mean of 0.265. However, a similar PIC range 0.317, 0.320, 0.349 and 0.367 observe in primers OPF-1, OPF-4, OPF-16 and OPF-10 respectively. The most informative primer was OPD-06 with PIC value of 0.500.

## Genetic Relatedness

In the present study, genetic similarity was calculated from Jaccard's coefficient value for the 60 pomegranate, considering data set for RAPD methods. Similarity coefficients varied from 0.69 (Jallore Seedless and EC126113, Khog and Kabul

Kohinoor) to 0.99 (Yercaud-HRS and Kabul, P-13 and A. K. Anar, Siah Siri and A. K. Anar). The derived UPGMA dendrogram illustrated in Fig. 37 has clustered the 60 cultivars into Five main groups. The first, second, third and four groups labelled I, II, III and IV are monophyletic branches including Kabul Kohinoor, Coimbatore White and Gul-e-Shah Rose pink cultivars, respectively. The fifth major group V exhibited two sub-clusters labeled V-A and V-B. The sub-cluster labeled V-B is further divided into two sub-clusters V-B(I) and V-B(II). The sub-cluster of V-A contains three *cvs*. (Jallore Seedless, Ganesh and Tebest). The sub-cluster of V-B (I) and V-B (II) are further grouped into two (a1 and a2) and three (b1, b2 and b3). The sub-sub-group b3 is monophyletic branch including *cv*. Banaras Cell-I. The b1 and b2 sub-sub-clusters comprises three (Saharanpur, Kajaki Anar and Bhagwa) three (Gul-e-Shah, EC-126113 and Siri Anar). The sub-cluster a in itself divided into sub-sub-clusters (a1 and a2) formed in different groups (Fig. 37). The sub-sub-cluster a1 and a2 contains 31 and 15 cvs. of pomegranates respectively .

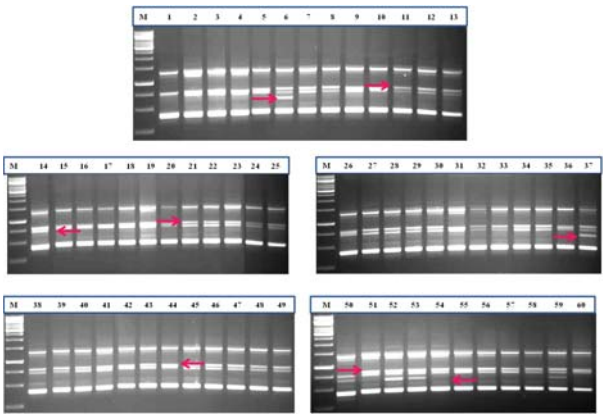


**Fig. 34: RAPD banding patterns of 60 pomegranate genotypes obtained with the primer OPF-10. Lane numbers correspond to the cultivar codes in Table 18. *Lane M* = GeneRuler 1kb DNA Ladder (Fermentas)**

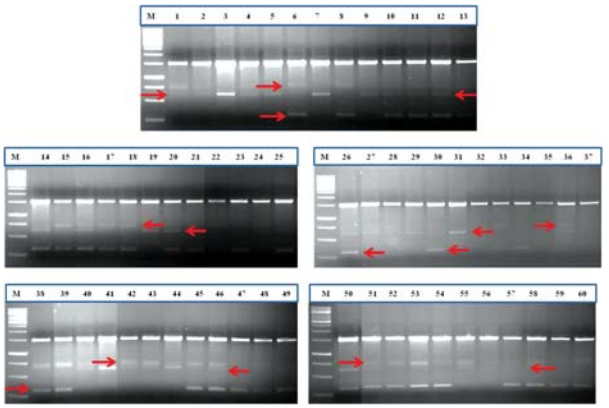


**Fig. 35: RAPD banding patterns of 60 pomegranate genotypes obtained with the primer OPD-10. Lane numbers correspond to the cultivar codes in Table 18. *Lane M* = GeneRuler 1kb DNA Ladder (Fermentas)**

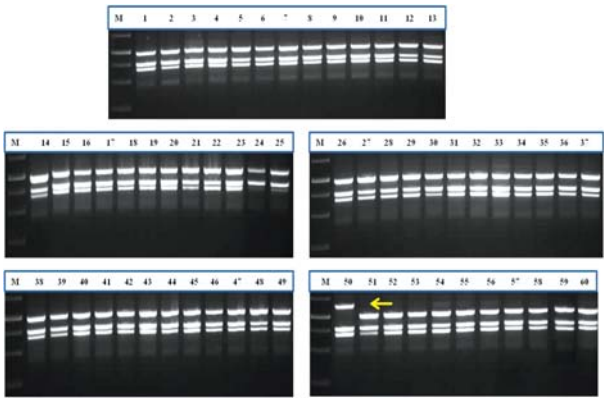


**Fig. 36: RAPD banding patterns of 60 pomegranate genotypes obtained with the primer OPF-4. Lane numbers correspond to the cultivar codes in Table 18. *Lane M* = GeneRuler 1kb DNA Ladder (Fermentas)**

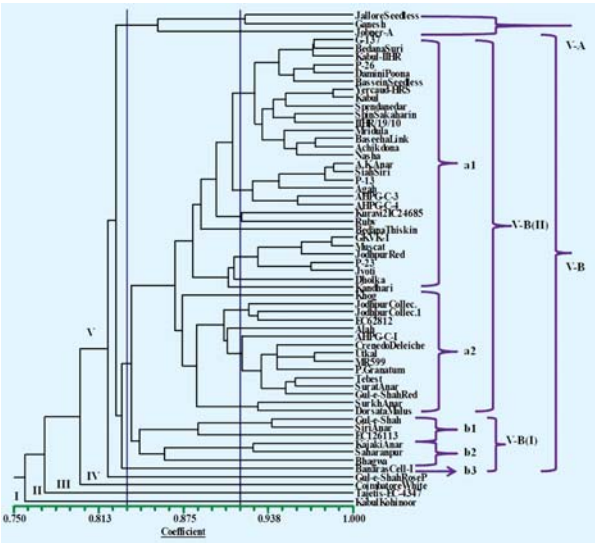



**Fig. 37: Dendrogram constructed using UPGMA based on Jaccard's similarity matrix data generated by RAPD analysis, revealing genetic relationship among sixty *P. granatum* accessions**

## Alleviation of climatic constraints on growth of vegetable crops under hot arid regions with an understanding on its seed physiology

### Osmopriming and germination parameters in cucurbits

Six sets of osmopriming treatments viz. Thiourea-1%($T_1$), $KH_2PO_4$ -$10^{-1}$M($T_2$), Salicyclic acid -50 ppm($T_3$), $KNO_3$ -1% ($T_4$), PEG6000-30% having osmotic potential of -1.5MPa($T_5$) and control-distilled water($T_6$) were utilized. The duration of soaking ranged from 24 to 48 hours. The ratio of the seed weight to solution volume was maintained at 1:5($gmL^{-1}$). Experimental units were arranged in a completely randomized design(CRD) with three replicates. Observations pertaining to germination percentage, mean germination time, germination index, time to reach 50% germination and seed vigour of osmoprimed seeds were recorded.

The data pertaining to germination parameters revealed that $T_2$ treated seeds of snapmelon cv. Phoot kakri and watermelon cv. Sugar Baby was having the highest germination percentage. Both snapmelon and watermelon shared similar results with respect to mean germination time was least in $T_2$ and time to reach 50% germination was fastest in $T_1$. However, they differed with respect to germination index and seed vigour index. Similarly, the seeds of ridge gourd cv. Twelve leaves excelled under $T_3$ with respect to germination percentage, the mean germination time and seed vigour index .The same trend was observed in bittergourd cv. Pusa Do Mausami seeds but under $T_5$, however they showed solidarity with respect to germination index under $T_3$.

## Enzymatic assay of osmo primed seeds

### Catalase

Most of the cucurbits under study showed higher catalase activity when compared to control. Both snapmelon and watermelon was having the highest catalase activity under $T_2$ followed by $T_4$ and $T_5$ (Fig. 38).All the above treatments elicited the activity of catalase over control by 200%. However, in ridge gourd, $T_3$ exhibited the highest activity followed by $T_4$ and $T_5$. Bittergourd seeds showed higher activity in $T_5$ followed by $T_2$ and $T_4$.

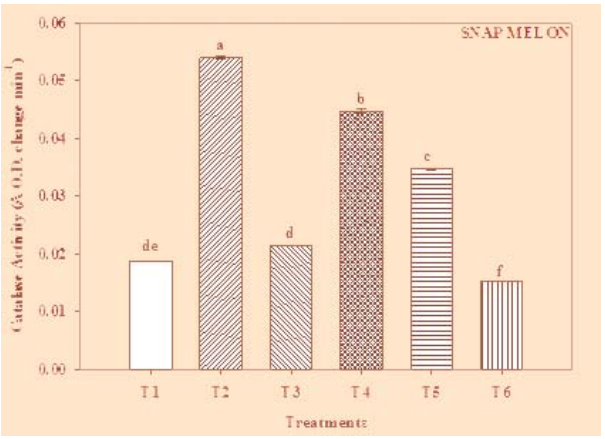



Fig. 38: Catalase activity of snapmelon

Significant low catalase activity as compared to control was observed in $T_1$ in ridge gourd as well as in bittergourd (Fig. 39). Similar results were also obtained in better gourd and watermelon (Fig. 40-41).

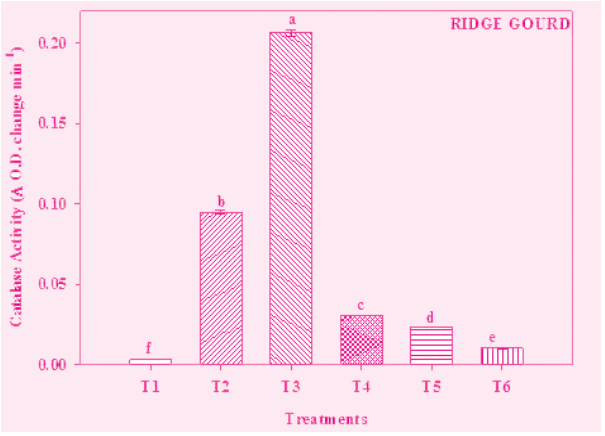



Fig. 39: Catalase activity of ridge gourd seeds cv. Twelve leaves


Fig. 40: Catalase activity of bittergourd seeds cv. Pusa Do Mausami

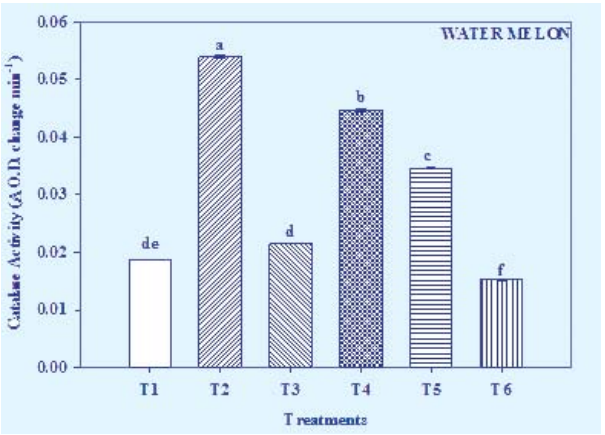



**Fig. 41: Catalase activity of watermelon seeds cv. Sugar Baby**

## Peroxidase

Peroxidase activity showed significant (p d" 0.05) differences among the different primed seedlings of cucurbits. In snapmelon and watermelon, $T_3$ exhibited low activity with respect to control , higher activity being observed in $T_2$ (129 %) and $T_4$ (130 %) which also co related with germination data. Primed ridge gourd and bitter gourd seeds baring $T_1$ showed an increase in enzyme activity in the range of 110-140% over control (Table 20).

## Polyphenol oxidase

Polyphenol oxidase activity showed significant (p d" 0.05) differences among primed seedlings of snapmelon and watermelon when allowed to grow under conditions of pot culture. The highest activity of the enzyme was recorded for $T_5$ (< 200 %) in snap melon as well as in watermelon and bittergourd, however the lowest activity was recorded for $T_3$ (53 %) in snapmelon , $T_6$ in watermelon and bittergourd in comparison to control. In ridge gourd, the highest activity was recorded in treatment $T_3$ (47 %).,treatment $T_1$ showed no appreciable increase in activity over control and was at par with it.

## Esterase activity

Esterase activity of $T_2$ snapmelon and watermelon seeds showed the highest enzymatic activity followed by $T_5$ and $T_4$, however, $T_1$ showed a 30 % decline in activity in comparison to control. Similar trend was observed for ridge gourd. In bittergourd, the highest percent increase in the esterase activity was observed in $T_5$ (271 %) followed by $T_4$ (238 %) and $T_2$ (226 %), the lowest increase in the enzyme activity was seen for treatment $T_3$ (61 %).

## Amylase activity

Amylase provides the simple carbohydrate as substrate to respiration. All the treatments in watermelon and snapmelon showed a hike in the amylase activity of the seeds, the highest being noted in $T_2$(>200%), $T_5$,$T_4$ and $T_3$ too exhibited similar results. Usually those treatments that had higher germination was found to have higher amylase activity to meet the germination requirement. The lowest activity of the amylase enzyme was recorded for $T_1$ over control in most of the cucurbits. In ridge gourd, $T_3$ showed higher activity while in bittergourd it was $T_5$., however the increment in the gourds was not synonymous with the melons.

**Table 20. Changes in peroxidase activity of treated and untreated seeds of the cucurbitaceous crops under study.**

| Treatment | Snapmelon Δ O.D. change $min^{-1}$ | Ridge gourd Δ O.D. change $min^{-1}$ | Bitter gourd Δ O.D. change $min^{-1}$ | Watermelon Δ O.D. change $min^{-1}$ |
|---|---|---|---|---|
| $T_1$ | 0.02143 ± 0.00122$^{c}$ | 0.01094 ± 0.000063$^{f}$ | 0.038023 ± 0.00042$^{d}$ | 0.02114 ± 0.00120$^{c}$ |
| $T_2$ | 0.04084 ± 0.00233$^{a}$ | 0.01747 ± 0.000010$^{b}$ | 0.023723 ± 0.00029$^{e}$ | 0.04056 ± 0.00217$^{a}$ |
| $T_3$ | 0.01146 ± 0.00066$^{e}$ | 0.02766 ± 0.000158$^{a}$ | 0.055220 ± 0.00049$^{b}$ | 0.01123 ± 0.00064$^{e}$ |
| $T_4$ | 0.04101 ± 0.00234$^{a}$ | 0.01698 ± 0.000097$^{c}$ | 0.064687 ± 0.00130$^{a}$ | 0.04093 ± 0.00220$^{a}$ |
| $T_5$ | 0.03091 ± 0.00177$^{b}$ | 0.01246 ± 0.000071$^{d}$ | 0.049531 ± 0.00073$^{c}$ | 0.03072 ± 0.00165$^{b}$ |
| $T_6$ | 0.01781 ± 0.00101$^{d}$ | 0.01155 ± 0.000066$^{e}$ | 0.023255 ± 0.00034$^{e}$ | 0.01760 ± 0.00091$^{d}$ |

Values followed by similar letters are not significantly different at p d" 0.05.

### Invertase

The highest activity in the enzyme was recorded for $T_4$ (133 %), and the lowest was recorded for $T_2$ (46 %) over control in snapmelon. The observations are synonymous to that of watermelon. However, certain treatments namely $T_3$ and $T_1$ showed a lower enzyme activity than control, as both had significantly higher amylase activity which may have resulted to the suppression of the invertase activity. In ridge gourd and bittergourd $T_5$ showed a more heightened enzyme activity.

### Protease

In watermelon and snapmelon , with the exception of $T_1$ all the treatment sets showed significant rise in the protease activity of the seeds over control, however $T_1$ showed a 15 % lower protease activity in comparison to control. In ridgegourd, $T_3$ with 39 % and in watermelon $T_2$ (68 %) showed the highest enzyme activity. In ridgegourd , all the seed treatments showed significant rise in the protease activity in comparison to control while in bittergourd 39 % increase in protease activity was noted in $T_5$ which was the highest among all the treatments.

## BIOTECHNOLOGY

### At Bikaner

### Standardisation and commercialization of micro- propagation techniques of horticultural crops under hot arid agro-eco system: Date palm cv. Halawy and Khalas

### Somatic embryo germination

The media optimized for embryo formation and multiplication was also tried for embryo germination with some additional media composition for date palm cv. Halawy and Khalas. It is revealed from the study that the rate of embryo germination was higher with media composition MS + NAA + BA whereas the germination on without hormone was poor. Further the combination of NAA and BA was also found to affect shoot and root formation greatly. The higher concentration of BA was tended to form only shoot where as higher concentration of NAA suppressed the shoot formation. However, root elongation was higher. The higher concentration of NAA could not be found suitable for healthy root and shoot formation. Although better shoot growth obtained in MS media with BA were used for further shoot elongation with other media composition (Fig. 42). In both the cultivars two media compositions containing various concentrations of NAA and BA were found suitable for germination of somatic embryos. However, the maximum shoot length in germinated embryos was recorded with media having activated charcoal devoid of hormones.

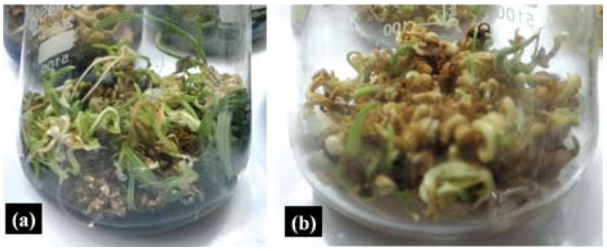



**Fig. 42: Somatic embryo germination of date palm cv. Halawy (a) and Khalas (b)**

### Shoot elongation

The germinated embryos having minimum shoot length of 20 mm were further subjected for elongation of the microshoots for better root formation and survival. Under this experiment eight media composition consisting of basal media of MS media with or without activated charcoal (Fig. 43) were used for shoot elongation of date palm cv Halawy and Khalas. In this stage the micro shoots were sub-cultured on same media for three times (once in four week). The observations recorded after completion of third sub-culture. Better elongation of shoot in terms of survival percentage and length of shoot were noticed on MS media + without or with activated charcoal with higher concentration of sucrose devoid of hormone.

### Rooting

The micro shoots of minimum 5 cm shoot length were taken for induction of roots. Under this study initially 10 media composition were tried for root formation in the developed micro shoots. Although all concentration of NAA was found to induce roots in the micro shoots from 80 to 90 per cent, however, quality roots were produced in media composition of higher concentration of NAA. At lower concentration of NAA the root quality was


Fig 43: Shoot elongation of date palm cv. Halawy (a & c) and Khalas (b & d)

thin and longer which could not support plant survival under primary hardening. Long, sturdy root with normal shoot growth was noticed with high concentration NAA (Fig. 44). This media composition was tried three times for its reproducibility of the media. The total period of 100-120 days were taken in obtaining quality root formation with normal shoot which are suitable for primary hardening of both cultivars of date palm (Halawy & Khalas)

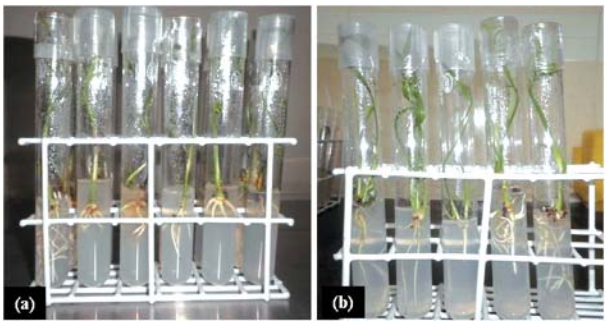



Fig 44: Rooting in micro shoots of date palm cv Halawy (a) and Khalas (b) with MS media + high concentration NAA

## Primary hardening

The plants having 2-3 leaves and 15-20 cm long were selected for primary hardening under culture room with environmental regime of 27± 2°C temperature and 3000 lux light intensity. The plants were transferred in different potting mixture of vermiculite, perlite, sand and cocopeat in different ratio. All the plants were covered by polythene bag making four holes of 4 mm for increasing humidity around the plants. The plants were kept for two months under same hardening condition. Thereafter the survived plants were transferred in green house under 30± 2°C temperature, 60-80 % RH and 8000-10000 lux light intensity. The survival percentage of date palm cv. Halawy and Khalas was maximum (70%) in potting mixture containing vermiculite+cocopeat+sand (Fig. 45).

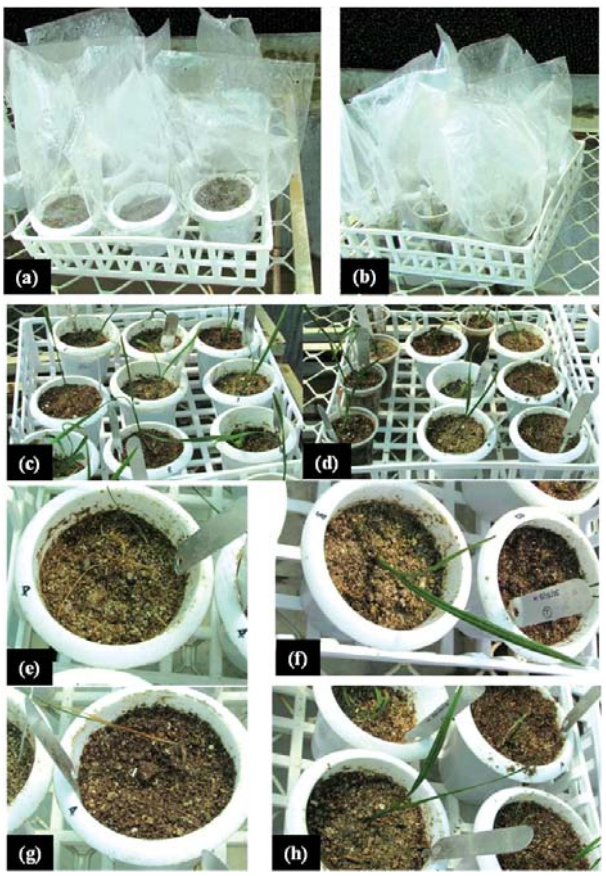



Fig. 45: Primary hardening of tissue culture date palm plants covered with polythene bag to avoid desiccation after transferring from test tubes (a &b), established date palm plants (c & d), dead plants during hardening (e &g) and survived date palm plants (f &h). a, c, e & f – date palm cv Halawy; b, d, g & h – date palm cv Khalas

## CROP PROTECTION

### At Bikaner

### Disease management

#### Management of different diseases of watermelon/*mateera* through botanicals, bio-agents and chemicals

A field trial was conducted for management of watermelon/*mateera* diseases during summer season of 2014 at Pathology Block. Eleven treatments were taken for above study (Table 21). After seed treatment by imidacloprid (0.05%), one foliar spray each of the treatments was also given separately on the crop. Out of them, imidacloprid (0.05%) was the most effective as seed treatment + one foliar spray for management of mosaic disease and shoe string with minimum disease incidence (20.0 and 15.0%), followed by acephate (0.06%) with disease incidence of 23.50 and 17.60%, respectively. Maximum disease incidence (31.30 and 26.30%) of both the diseases was recorded in onion leaf extract (5%) followed by *Trichoderma viride* CIAH- Non-Resistant (5%) under field conditions. Mancozeb (0.25%) was the best treatment against *Alternaria* leaf blight with minimum disease severity of 9.50%. Next best treatments were found *Trichoderma viride* CIAH-240 (5%) and *Trichoderma viride* Non-Resistant (5%) having disease severity (11.80 and 14.10%) (Table 21).

#### Management of *Alternaria* leaf blight and *Cercospora* leaf spot of bottle gourd through botanicals, bio-agents and fungicides

Bottle gourd variety 'Thar Samridhi' was sown on 27th July, 2014 at Pathology Block. Seventeen treatments with 01 botanical, 01 bio-agent, 02 fungicides and their combinations were taken for this study (Table 22). Foliar sprays (FS) in different combinations of treatments were done after seed treatment (ST). Minimum disease severity (7.65%) was found in combined treatment of carbendazim (ST) + mancozeb (FS) + *Pseudomonas fluorescens* (FS) + neem leaf extract (FS) which was most effective for integrated management of *Alternaria* leaf blight. Combination of mancozeb (ST) + carbendazim (FS) + *Pseudomonas fluorescens* CIAH-196 (FS) + neem leaf extract (FS) was noticed most efficient treatment with minimum disease severity (8.15%) against *Cercospora* leaf spot. Maximum disease severity (29.20 and 30.40%) was found in *Pseudomonas fluorescens* CIAH-196 (seed treatment only) against *Alternaria* leaf blight and *Cercospora* leaf spot, followed by neem leaf extract (ST) with disease severity of 26.80 and 27.10%, respectively (Table 22).

**Table 21. Field efficacy of chemicals, bio-agents and botanical on mosaic, shoe-string and *Alternaria* leaf blight of *mateera***

| S. No. | Name of treatments with dose | Incidence of mosaic disease (%) | Incidence of shoe-string disease (%) | Disease severity *of Alternaria* leaf blight (%) |
|---|---|---|---|---|
| 1. | Copper oxychloride (0.25%) | 25.0* (29.96) | 20.0 (26.54) | 22.50 *(28.28) |
| 2. | Carbendazim (0.1%) | 27.80.0 (31.80) | 22.20 (28.07) | 15.70 (23.29) |
| 3. | Mancozeb (0.25%) | 25.0 (29.98) | 20.0 (26.55) | 9.50 (17.97) |
| 4 | Imidacloprid (0.05%) | 20.0 (26.54) | 15.0 (22.75) | 27.60 (31.56) |
| 5 | Acephate (0.06%) | 23.50 (28.97) | 17.60 (24.75) | 29.60 (32.90) |
| 6 | *Aspergillus niger* (5%) | 29.40 (32.80) | 23.50 (28.97) | 20.40 (26.73) |
| 7 | *Pseudomonas fluorescens* CIAH-196 (5%) | 26.30 (30.78) | 21.10 (27.31) | 24.80 (29.83) |
| 8 | *Trichoderma viride* CIAH-240 (5%) | 27.80.0 (31.80) | 22.20 (28.02) | 11.80 (20.07) |
| 9 | *Trichoderma viride* CIAH-NR (5%) | 30.0 (33.19) | 25 (29.96) | 14.10 (22.04) |
| 10. | Onion leaf extract (5%) | 31.30 (33.95) | 26.30 (30.85) | 25.90 (30.54) |
| 11. | Control | 35.0 (36.25) | 35.0 (36.25) | 31.30 (33.92) |
| | CD | 3.44 | 3.07 | 3.49 |

*Figures in parenthesis are angular transformed value

**Table 22. Response of fungicides, bio-agent, botanical and their combinations on disease severity of *Alternaria* leaf blight and *Cercospora* leaf spot of bottle gourd (2014).**

| Sl. No. | Name of treatments with dose | Disease severity of *Alternaria* leaf blight (%) | Disease severity of *Cercospora* leaf spot (%) |
|---|---|---|---|
| 1. | Carbendazim (0.1%) ST | 24.70 *(29.77) | 25.50 *(30.21) |
| 2. | Mancozeb (0.25%) ST | 25.40 (30.25) | 25.20 (30.08) |
| 3. | *Pseudomonas fluorescens* CIAH-196 (5%) ST | 29.20 (32.73) | 30.40 (33.43) |
| 4 | Neem leaf extract (5%) ST | 26.80 (30.93) | 27.10 (31.33) |
| 5 | Carbendazim (ST) + Mancozeb (FS) | 18.50 (25.30) | 16.70 (23.98) |
| 6 | Carbendazim (ST) + *Ps. fluorescens* CIAH-196 FS | 19.50 (26.15) | 20.60 (26.97) |
| 7 | Carbendazim ST + Neem leaf extract | 21.70 (27.69) | 18.50 (25.19) |
| 8 | Mancozeb ST + Carbendazim (FS) | 20.60 (26.92) | 22.40 (28.22) |
| 9 | Mancozeb (0.25%) ST + *Ps. fluorescens* CIAH-196 (5%) FS | 22.50 (28.30) | 24.20 (29.43) |
| 10 | Mancozeb (0.25%) ST + Neem leaf extract (5%) FS | 20.30 (26.76) | 21.30 (27.46) |
| 11. | Carbendazim (ST) + Mancozeb (FS) + *Ps. fluorescens* CIAH-196 (5%) FS | 11.70 (19.78) | 12.50 (20.53) |
| 12. | Carbendazim (ST) + Mancozeb (FS) + Neem leaf extract (FS) | 12.10 (20.28) | 13.40 (21.09) |
| 13 | Carbendazim (ST) + Mancozeb (FS) + *Ps. fluorescens* (FS) + Neem leaf extract (FS) | 7.65 (15.96) | 10.70 (18.93) |
| 14 | Mancozeb (ST) + Carbendazim (FS) + *Ps. fluorescens* CIAH-196 (5%) FS | 16.20 (23.65) | 17.10 (24.36) |
| 15 | Mancozeb (ST) + Carbendazim (FS) + Neem leaf extract | 18.60 (25.41) | 20.50 (26.75) |
| 16. | Mancozeb (ST) + Carbendazim (FS) + *Ps. fluorescens* CIAH-196 FS + Neem leaf extract FS | 9.70 (18.13) | 8.15 (16.51) |
| 17. | Control | 36.20 (36.96) | 33.33 (35.23) |
| | CD | 3.59 | 3.97 |

*Figures in parenthesis are angular transformed value

### Screening of different genotypes of sponge gourd for resistance against diseases under field conditions

Fourteen genotypes (Pusa Sneha, AHSG-16, AHSG-17, AHSG-18, AHSG-20, AHSG-21, AHSG-22, AHSG-24, AHSG-27, AHSG-28, AHSG-29, AHSG-30, AHSG-32 and AHSG-34) of sponge gourd were screened for resistance against diseases during rainy season of 2014 at Vegetable Block of the Institute. Only *Alternaria* leaf blight was observed in the genotypes. Disease severity of *Alternaria* leaf blight was recorded from 4.70 to 34.30% in different genotypes of this crop. Minimum disease severity (up to 10%) was noticed in the 01 variety 'Pusa Sneha' and 03 genotypes *viz*., AHSG-16, AHSG-28 and AHSG-29 while maximum disease severity was found in 02 genotypes such as AHSG-18 and AHSG-20.

## Pest management

### At Bikaner

The periodical observation on major insect pests of arid fruits and vegetables has been carried out at fortnight intervals. The screening of ridge gourd, watermelon and lasora varieties/ genotypes was done against fruit fly resistance. The fruit fly incidence ranged from 29 to 59 % in cucurbits Incidence of pests like, bottle gourd bug,

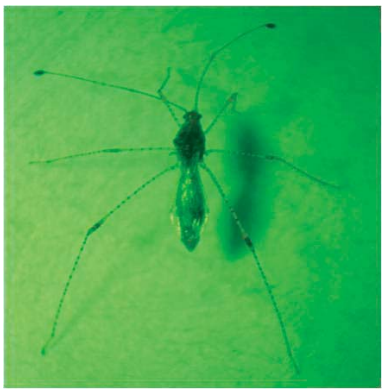
*Metacanthus pulchellus* and natural enemies like, coccinellids like *Coccinella septempunctata*, *Scymnus coccivora*, *Chrysoperla*, *Cyrtorhinus lividipennis* and hadda beetle parasitoid, *Pediobius foveolatus* were recorded. The incidence of beetles, *Mylabris macilenta*, *Anthicus crinitus* and *Anthrenus subclaviger* on cucurbits flowers were also recorded during survey (Fig. 46).

## Phenotypic fruit traits of the ridge gourd varieties/ genotypes response to resistance to fruit fly

The length of ovary pubescence, rind hardness, fibre content and rind thickness ranged from 0.17 to 0.50 mm, 2.37 to 6.68 kg/ $cm^2$, 1.17 to 2.28 g/ 100g edible fruit and 0.56 to 1.07 mm, respectively, being significantly high in resistant and low in susceptible varieties/ genotypes. However, the fruit length (3.67 to 29.70 cm) and fruit diameter (3.35 to 6.53 cm) being significantly low in resistant and high in susceptible varieties/ genotypes. The length of ovary pubescence, rind hardness, fibre content and rind thickness had significant negative correlations whereas; fruit length and fruit diameter had significant positive correlations with the percentage fruit infestation and the larval density per fruit (Table 23-25).

## Screening of different variety/ genotypes of watermelon against fruit fly

The length of ovary pubescence, rind hardness and rind thickness ranged from 6.20 to 3.82 mm, 12.99 to 8.37 kg/ $cm^2$ and 1.58 to 0.80 cm, respectively, being significantly high in resistant and low in susceptible varieties/ genotypes. However, the days to first fruit harvest (70.67 to 80.67 days), fruit length (12.23 to 25.60 cm) and fruit diameter (12.05 to 20.59 cm) being significantly low in resistant and high in susceptible varieties/ genotypes. The length of ovary pubescence, rind hardness and rind thickness had significant negative correlations whereas; days to first fruit harvest, fruit length and fruit diameter had significant positive correlations with the percentage fruit infestation and the larval density per fruit (Table 26-28).



**Bottle gourd bug, *Metacanthus pulchellus***

**Predator, *Cyrtorhinus lividipennis***

**Beetle (*Anthicus crinitus* Laferte)**
**Family: Anthicidae**

**Beetle (*Anthrenus subclaviger* Reitter)**
**Family: Dermestidae**

**Fig. 46. Pests and natural enemies of cucurbits in arid region of Rajasthan**

**Table 23. Antixenotic fruit traits of different varieties/ genotypes of ridge gourd**

| Varieties/ genotypes | Length of ovary pubescence (mm) | Rind hardness (Kg/cm$^2$) | Fibre content (g/100g edible fruit) | Fruit length (cm) | Rind thickness (mm) | Fruit diameter (cm) |
|---|---|---|---|---|---|---|
| AHRG-49 | 0.19$^{ab}$ | 2.56$^{a}$ | 1.24$^{ab}$ | 29.70$^{h}$ | 0.61$^{a}$ | 6.53$^{d}$ |
| Arka Sujata | 0.32$^{f}$ | 3.59$^{c}$ | 1.69$^{de}$ | 18.57$^{cd}$ | 0.76$^{de}$ | 3.93$^{a}$ |
| AHRG-29 | 0.42$^{hi}$ | 3.55$^{bc}$ | 1.49$^{bcd}$ | 21.40$^{de}$ | 0.87$^{f}$ | 4.14$^{a}$ |
| AHRG-36 | 0.30$^{ef}$ | 3.71$^{c}$ | 1.47$^{bcd}$ | 18.13$^{c}$ | 0.72$^{cd}$ | 6.43$^{d}$ |
| AHRG-47 | 0.17$^{a}$ | 3.72$^{c}$ | 1.62$^{de}$ | 22.23$^{ef}$ | 0.69$^{bcd}$ | 3.53$^{a}$ |
| AHRG-41 | 0.39$^{gh}$ | 4.18$^{c}$ | 1.38$^{abc}$ | 19.80$^{cde}$ | 0.83$^{ef}$ | 4.15$^{ab}$ |
| S. Manjari | 0.30$^{ef}$ | 3.46$^{b}$ | 1.53$^{cde}$ | 19.17$^{cd}$ | 0.72$^{cd}$ | 3.88$^{a}$ |
| AHRG-31 | 0.18$^{a}$ | 3.64$^{c}$ | 1.51$^{bcde}$ | 22.10$^{ef}$ | 0.56$^{a}$ | 5.30$^{bcd}$ |
| AHRG-33 | 0.22$^{bc}$ | 3.72$^{c}$ | 1.41$^{abc}$ | 23.47$^{fg}$ | 0.62$^{ab}$ | 4.91$^{abc}$ |
| AHRG-42 | 0.25$^{cd}$ | 2.45$^{a}$ | 1.17$^{a}$ | 20.33$^{cde}$ | 0.66$^{bc}$ | 5.80$^{cd}$ |
| AHRG-30 | 0.28$^{de}$ | 2.37$^{a}$ | 1.32$^{abc}$ | 24.40$^{fg}$ | 0.67$^{bc}$ | 6.57$^{d}$ |
| AHRG-57 | 0.49$^{ij}$ | 6.68$^{e}$ | 2.28$^{f}$ | 3.67$^{a}$ | 1.07$^{g}$ | 3.35$^{a}$ |
| S. Uphal | 0.28$^{de}$ | 2.90$^{ab}$ | 1.38$^{abc}$ | 25.67$^{g}$ | 0.70$^{cd}$ | 4.43$^{ab}$ |
| Pusa Nasdar | 0.50$^{j}$ | 5.23$^{d}$ | 2.14$^{f}$ | 18.43$^{c}$ | 0.89$^{f}$ | 3.57$^{a}$ |
| AHRG-35 | 0.36$^{fg}$ | 4.07$^{c}$ | 1.74$^{e}$ | 12.20$^{b}$ | 0.80$^{e}$ | 4.20$^{ab}$ |

**Table 24. Correlation coefficient (r) between percent fruit infestation and larval density per fruit with different antixenotic fruit traits of ridge gourd varieties/ genotypes**

| | Percent damage | Larva density | Length of ovary pubescence (mm) | Rind hardness (kg/cm$^2$) | Fibre content (g/100g edible fruit) | Fruit length (cm) | Rind thickness (mm) |
|---|---|---|---|---|---|---|---|
| Larval density | 0.958$^{**}$ | | | | | | |
| Length of ovary pubescence | -0.936$^{**}$ | -0.894$^{**}$ | | | | | |
| Rind hardness | -0.559$^{*}$ | -0.529$^{*}$ | 0.710$^{**}$ | | | | |
| Fibre content | -0.530$^{*}$ | -0.507$^{*}$ | 0.687$^{**}$ | 0.906$^{**}$ | | | |
| Fruit length | 0.619$^{**}$ | 0.561$^{*}$ | -0.664$^{**}$ | -0.819$^{**}$ | -0.766$^{**}$ | | |
| Rind thickness | -0.859$^{**}$ | -0.834$^{**}$ | 0.925$^{**}$ | 0.813$^{**}$ | 0.763$^{**}$ | -0.784$^{**}$ | |
| Fruit diameter | 0.480$^{NS}$ | 0.356$^{NS}$ | -0.522$^{*}$ | -0.662$^{**}$ | -0.677$^{**}$ | 0.520$^{*}$ | -0.634$^{**}$ |

## Morphomatrics study of small salmon arab

The data on linear measurements of the small salmon arab, *Colotis amata* have been presented (Table 29) and it is a small butterfly that is yellows or whites in colour. Eggs are laid singly on leaves or young shoots. They are 0.58 mm to 0.72 mm in length; 0.38 mm to 0.43 mm width and white when first laid, later developing red blotches. First larval instar is greenish yellow with black head. The length of I$^{st}$ instar larvae is 1.98 mm to 2.29 mm and width

**Table 25. Backward stepwise regression models showing effect of different antixenotic fruit traits of ridge gourd on larvae per fruit and percentage fruit infestation**

| Percent fruit infestation | $R^2$ | Role of individual traits (%) |
|---|---|---|
| $Y= -7.38- 242.49X_1- 7.63X_2+ 17.35X_3-124.53X_4+ 0.52X_5+ 4.52X_6$ | 91.60 | 03.40 |
| $Y= 81.84- 216.09X_1- 6.53X_2+ 11.25X_3+ 46.54X_4- 0.01X_5$ | 88.20 | 00.00 |
| $Y= 81.28- 216.50X_1- 6.50X_2+ 11.27X_3+ 46.98X_4$ | 88.20 | 00.40 |
| $Y= 98.90- 214.52X_1- 3.12X_2+ 14.60X_3$ | 87.80 | 00.20 |
| $Y= 107.06- 187.91X_1- 1.33X_2$ | 87.60 | 00.10 |
| $Y= 107.52- 204.09X_1$ | 87.50 | 87.50 |
| Larval density per fruit | | |
| $Y= 10.18- 34.37X_1- 4.81X_2+5.29X_3+ 35.51X_4- 0.06X_5+0.76X_6$ | 89.70 | 02.30 |
| $Y= 25.16- 29.94X_1- 4.63X_2+4.28X_3+22.41X_4- 0.15X_5$ | 87.40 | 01.20 |
| $Y= 18.33- 34.96X_1- 4.34X_2+ 4.58X_3+ 27.74X_4$ | 86.20 | 02.90 |
| $Y= 28.74- 33.79X_1- 2.34X_2+ 6.54X_3$ | 83.30 | 00.80 |
| $Y= 32.40- 21.89X_1-1.54X_2$ | 82.50 | 02.60 |
| $Y= 32.92- 40.58X_1$ | 79.90 | 79.90 |

$X_1$- length of ovary pubescence, $X_2$- rind hardness, $X_3$- fibre content, $X_4$- rind thickness, $X_5$- fruit length, $X_6$- fruit diameter, $R^2$- coefficient of determination

**Table 26. Antixenotic fruit traits of different genotypes of watermelon**

| Genotypes | Length of ovary pubescence (mm) | Rind hardness ($Kg/cm^2$) | Rind thickness (cm) | Days to first fruit harvest | Fruit length (cm) | Fruit diameter (cm) |
|---|---|---|---|---|---|---|
| Thar Manak | $5.44^{gh}$ | $11.23^{fg}$ | $1.17^{cd}$ | $70.33\ (8.45)^{*a}$ | $17.65^{c}$ | $15.54^{cd}$ |
| AHW/BR-12 | $5.31^{g}$ | $10.77^{ef}$ | $1.13^{bcd}$ | $73.00\ (8.60)^{abcd}$ | $12.23^{a}$ | $12.05^{a}$ |
| AHW/BR-60 | $4.70^{cde}$ | $9.20^{ab}$ | $0.80^{a}$ | $80.67\ (9.04)^{e}$ | $20.13^{d}$ | $17.84^{e}$ |
| Arka Manik | $5.21^{fg}$ | $9.97^{bcde}$ | $1.58^{e}$ | $79.67\ (8.98)^{de}$ | $17.83^{c}$ | $20.18^{h}$ |
| Asahi Yamato | $6.20^{i}$ | $12.00^{g}$ | $1.57^{e}$ | $70.67\ (8.47)^{ab}$ | $17.57^{c}$ | $19.90^{gh}$ |
| Charleston Grey | $5.09^{efg}$ | $10.70^{def}$ | $1.04^{bc}$ | $74.00\ (8.66)^{abcde}$ | $21.23^{d}$ | $14.39^{bc}$ |
| AHW/BR-16 | $5.75^{h}$ | $12.99^{h}$ | $1.46^{e}$ | $71.00\ (8.48)^{abc}$ | $17.94^{c}$ | $13.80^{b}$ |
| BSM-1 | $4.41^{bc}$ | $9.40^{abc}$ | $1.07^{bc}$ | $74.67\ (8.70)^{abcde}$ | $25.60^{g}$ | $20.59^{h}$ |
| IC 582909 | $4.61^{cd}$ | $9.87^{bcde}$ | $0.80^{a}$ | $77.00\ (8.83)^{bcde}$ | $15.03^{b}$ | $14.90^{bc}$ |
| AHW-19 | $4.83^{def}$ | $10.07^{bcde}$ | $1.16^{cd}$ | $75.33\ (8.73)^{abcde}$ | $22.13^{f}$ | $19.39^{fg}$ |
| AHW-65 | $4.88^{def}$ | $9.67^{bcd}$ | $1.49^{e}$ | $77.33\ (8.85)^{bcde}$ | $18.58^{c}$ | $17.99^{e}$ |
| Sugar Baby | $5.03^{efg}$ | $10.57^{def}$ | $1.20^{cd}$ | $75.33\ (8.73)^{abcde}$ | $17.75^{c}$ | $16.47^{d}$ |
| AHW/BR-9 | $3.82^{a}$ | $8.37^{a}$ | $0.80^{a}$ | $77.67\ (8.87)^{cde}$ | $21.70^{ef}$ | $15.54^{cd}$ |
| Durgapura Lal | $4.88^{def}$ | $10.36^{cdef}$ | $1.33^{de}$ | $72.00\ (8.54)^{abc}$ | $15.21^{b}$ | $15.41^{cd}$ |
| AHW/BR-137 | $4.14^{ab}$ | $9.77^{bcde}$ | $0.90^{ab}$ | $79.67\ (8.98)^{de}$ | $20.43^{de}$ | $18.27^{ef}$ |

**Table 27. Correlation coefficient (r) between percent fruit infestation and larval density per fruit with different antixenotic fruit traits of watermelon genotypes**

| | Percent damage | Larva density | Length of ovary pubescence (mm) | Rind hardness (kg/cm$^2$) | Rind thickness (cm) | Days to first fruit harvest | Fruit length (mm) |
|---|---|---|---|---|---|---|---|
| Larval density | 0.991** | | | | | | |
| Length of ovary pubescence | -0.908** | -0.914** | | | | | |
| Fruit toughness | -0.856** | -0.872** | 0.880** | | | | |
| Rind thickness | -0.770** | -0.746** | 0.728** | 0.591* | | | |
| Days to first harvest | 0.746** | 0.763** | -0.669** | -0.763** | -0.423$^{NS}$ | | |
| Fruit length | 0.568* | 0.545* | -0.453$^{NS}$ | -0.395$^{NS}$ | -0.253$^{NS}$ | 0.284$^{NS}$ | |
| Fruit diameter | 0.241$^{NS}$ | 0.206$^{NS}$ | -0.095$^{NS}$ | -0.289$^{NS}$ | 0.242$^{NS}$ | 0.359$^{NS}$ | 0.581* |

**Table 28. Backward stepwise regression models showing effect of different antixenotic fruit traits of watermelon on larvae per fruit and percentage fruit infestation**

| Percent fruit infestation | $R^2$ | Role of individual traits (%) |
|---|---|---|
| $Y= 10.68- 10.06X_1- 1.21X_2- 23.33X_3-1.18X_4+ 0.96X_5+ 0.62X_6$ | 94.00 | 00.10 |
| $Y= 1.29- 8.49X_1- 2.01X_2- 20.70X_3+ 1.34X_4+ 1.27X_5$ | 93.90 | 04.30 |
| $Y= 47.49- 12.84X_1- 1.95X_2- 18.07X_3+ 1.28X_4$ | 89.60 | 02.50 |
| $Y= 173.75- 13.11X_1- 4.86X_2- 17.21X_3$ | 87.10 | 03.20 |
| $Y= 179.98- 20.33X_1- 3.94X_2$ | 83.90 | 01.40 |
| $Y= 171.77- 26.89X_1$ | 82.50 | 82.50 |
| *Larval density per fruit* | | |
| $Y= 9.04- 1.35X_1- 0.47X_2- 2.32X_3+ 0.23X_4+ 0.19X_5- 0.06X_6$ | 93.30 | 00.10 |
| $Y= 9.97- 1.51X_1- 0.39X_2- 2.58X_3+0.21X_4+ 0.17X_5$ | 93.20 | 03.00 |
| $Y= 15.96- 2.07X_1- 0.38X_2- 2.24X_3+ 0.20X_4$ | 90.20 | 02.60 |
| $Y= 36.16- 2.12X_1- 0.84X_2- 2.10X_3$ | 87.60 | 02.00 |
| $Y= 36.92- 2.99X_1-0.73X_2$ | 85.60 | 02.00 |
| $Y= 35.39- 4.22X_1$ | 83.60 | 83.60 |

$X_1$- length of ovary pubescence, $X_2$- rind hardness, $X_3$- rind thickness, $X_4$- days to first fruit harvest, $X_5$- fruit length, $X_6$- fruit diameter, $R^2$- coefficient of determination

is 0.36 mm to 0.48. The fifth instar larva is 19.30 mm length and 3.33 mm width. Pupa is 14.10 mm length and 5.73 mm width with laterally compressed, strongly keeled and moderately high dorso-thoracic keel; pointed but short cephalic projection, slightly up curved distally. Adult has a salmon-pink ground colour with female body length 9.71 mm and width 33.62 with wing expansion. The male body length is 7.59 mm and width 25.67 mm with wing expansion.

**Table 29. Mean linear morphometric measurements of different life stages of the small salmon arab**

| Sl. No. | Different stages (mm) | Length | Width |
|---|---|---|---|
| 1. | Egg | 0.62 | 0.41 |
| 2. | I$^{st}$ instar | 2.15 | 0.42 |
| 3. | II$^{nd}$ instar | 5.04 | 1.15 |
| 4. | III$^{rd}$ instar | 9.77 | 1.96 |
| 5. | IV$^{th}$ instar | 14.27 | 2.27 |
| 6. | V$^{th}$ instar | 19.30 | 3.33 |
| 7. | Pupa | 14.10 | 5.73 |
| 8. | Adult female with wing expansion | 9.71 | 33.62 |
| 9. | Adult male with wing expansion | 7.59 | 25.67 |
| 10. | Female antenna | 5.46 | - |
| 11. | Male antenna | 4.63 | - |

*Mean of ten specimens.

## Incidence of lasora bug in different germplasm of lasora

The significant differences were found in percentage bug infestation and bug per leaf among the tested germplasm during preliminary screening. The bug per leaf had a significant positive correlation with percentage infestation. AHCM-34, AHCM-22, AHCM-25 and AHCM-23 were found to the resistant; AHCM-14, AHCM-30, AHCM-31, AHCM-03 and AHCM-11 moderately resistant; AHCM-16, AHCM-09, AHCM-29 and AHCM-04 moderately susceptible; AHCM-33, AHCM-08, AHCM-07 and AHCM-06 susceptible and AHCM-01, AHCM-26, AHCM-24, AHCM-02 and AHCM-32 highly susceptible germplasm. The leaf infestations ranged from 12.01 to 69.49 % and significantly lower in resistant germplasm and higher in susceptible germplasm (Table 30).

Tannins, phenols, total alkaloid and flavonoid contents was significantly higher in resistant germplasm and lower in susceptible germplasm (Table 31). Free amino acid of different germplasm leaf was significantly lower in resistant germplasm and higher in susceptible germplasm. Free amino acid of leaf had a significant positive correlation whereas, tannins, phenols, alkaloids and flavonoid contents had significant negative correlations with the percentage leaf infestation and the bug per leaf (Table 32).

**Table 30. Lasora bug density and per cent infestation on different germplasm of lasora**

| Germplasm | Bug/ leaf | Bug infestation (%) | Resistance category |
|---|---|---|---|
| AHCM-14 | 15.25 | 27.80 | MR |
| AHCM-16 | 14.73 | 34.26 | MS |
| AHCM-09 | 17.39 | 37.20 | MS |
| AHCM-01 | 25.56 | 67.49 | HS |
| AHCM-30 | 13.27 | 25.15 | MR |
| AHCM-34 | 5.24 | 17.35 | R |
| AHCM-22 | 3.96 | 12.01 | R |
| AHCM-26 | 24.44 | 56.41 | HS |
| AHCM-33 | 22.80 | 46.15 | S |
| AHCM-31 | 10.36 | 23.30 | MR |
| AHCM-24 | 23.47 | 53.27 | HS |
| AHCM-08 | 20.54 | 43.06 | S |
| AHCM-25 | 4.17 | 13.97 | R |
| AHCM-23 | 6.25 | 18.15 | R |
| AHCM-02 | 22.33 | 65.94 | HS |
| AHCM-07 | 19.21 | 43.56 | S |
| AHCM-29 | 17.25 | 33.23 | MS |
| AHCM-03 | 14.68 | 27.67 | MR |
| AHCM-32 | 23.82 | 68.30 | HS |
| AHCM-04 | 16.59 | 38.80 | MS |
| AHCM-11 | 14.25 | 25.81 | MR |
| AHCM-06 | 20.78 | 44.95 | S |

## Pest of ber

The damage level of ber butterfly (*Tarucus theophrastus*), a major leaf feeder pest of ber has been recorded in different ber cultivars. Besides, negligible level infestation of leaf feeder viz., leaf webber (*Synclera univocolis*) and ash weevil (*Myllocerus* sp) also been recorded. No incidence of stone weevil, fruit fly, bark eating caterpillar and

**Table 31. Allelochemical fruit traits of different germplasm of lasora**

| Germplasm | Flavinoid content** (mg/g) | Tannins content** (mg/g) | Phenols Content** (mg/g) | Total alkaloids** (%) | Free Amino Acid (mg/g) ** |
|---|---|---|---|---|---|
| AHCM-14 | 4.20 | 17.15 | 13.44 | 0.29 | 1.44 |
| AHCM-16 | 3.94 | 17.37 | 13.85 | 0.27 | 1.56 |
| AHCM-09 | 3.74 | 16.36 | 13.48 | 0.24 | 1.48 |
| AHCM-01 | 2.38 | 14.49 | 11.31 | 0.14 | 2.02 |
| AHCM-30 | 4.70 | 18.47 | 13.41 | 0.34 | 1.15 |
| AHCM-34 | 5.14 | 20.03 | 17.62 | 0.36 | 1.01 |
| AHCM-22 | 5.43 | 22.38 | 18.44 | 0.43 | 0.87 |
| AHCM-26 | 2.74 | 14.78 | 12.41 | 0.16 | 1.89 |
| AHCM-33 | 3.29 | 15.68 | 12.78 | 0.19 | 1.45 |
| AHCM-31 | 4.66 | 19.18 | 16.70 | 0.34 | 1.14 |
| AHCM-24 | 3.34 | 15.51 | 11.99 | 0.19 | 1.73 |
| AHCM-08 | 3.45 | 16.39 | 15.26 | 0.23 | 1.76 |
| AHCM-25 | 5.59 | 20.40 | 18.27 | 0.37 | 0.97 |

**Analysis on dry weight (DW) basis

**Table 32. Correlation coefficient (r) between percent infestation and bug per leaf with different allelochemical leaf traits of lasora germplasm**

| | Percent Infestation | Bug/Leaf | FC | TC | PC | TAC |
|---|---|---|---|---|---|---|
| Bug/ Leaf | 0.963** | | | | | |
| FC | -0.982** | -0.977** | | | | |
| TC | -0.941** | -0.972** | 0.961** | | | |
| PC | -0.863** | -0.915** | 0.877** | 0.919** | | |
| TAC | -0.975** | -0.971** | 0.979** | 0.982** | 0.873** | |
| FAA | 0.954** | 0.937** | -0.965** | -0.940** | -0.835** | -0.948** |

**Significant at P = 0.01 (two-tailed)
* Significant at P = 0.05 (two-tailed)
FAA- Free amino acid (mg/g), TC- tannins content (mg/g), PC- phenols content (mg/g), TAC- total alkaloid content (%) & FC- flavinoid content (mg/g)

termite observed during this period. In addition, relative damage of ber butterfly, *Tarucus theophrastus* on nine popular cultivars was studied from July to September 2014. The observation has been made from three randomly selected branches from three trees, in each branch 25 leaves were examined for the damaged as well as healthy leaves and percent damage was worked out. Among the cultivars examined cv. Dandan recorded least (8%) number of leaves damage followed by cv. Katha

(20%). The cultivar Gola and Seb recorded the percent leaves damage of 38.67 and 44, respectively. Other genotypes were recorded an average of 50% leaves damage by the caterpillar (Fig 47).

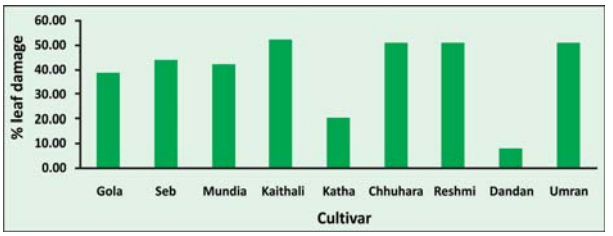



**Fig. 47: Relative damage of ber butterfly,*Tarucus theophrastus* on different ber cultivars**

## POST HARVEST MANAGEMENT AND VALUE ADDITION IN ARID HORTICULTURAL CROPS

### At Bikaner

Various value added products like bael squash, bael biscuits, dates barfi/laddu, date biscuits, date chuhara, karonda jam, kinnow-carrot blended RTS, kinnow-ginger-mint blended RTS, kinnow squash, watermelon squash & RTS, ber nectar, ber pickle and ber pulp were prepared in the post harvest technology laboratory. Various experiments like estimation of antioxidants, total phenols and flavonoids was done in kinnow-Ginger-Mint mixed RTS beverages, storage studies on ber fruits and drying of ber fruits etc. were also conducted during the year 2014-15.

### At Godhra

#### Watermelon candy

In consumption of fruits 20-30 per cent waste is generated which can be converted into edible products through value addition, which can provide additional income to the growers. In watermelon (*Citrullus vulgaris*) 78 per cent portion is edible with 22per cent waste. This waste can be converted to a colourful candy which is sweet in taste (T.S.S. 50 $^0$Brix), high in total sugar (32.82%). The waste material is cut in to pieces of suitable size in square, shape, which is mixed with sugar (50% of the weight of the pieces) and kept overnight. The pieces were remaned and solar dried till constant moisture recorded. The per kg expenditure for making one kg product is around Rs. 145/-. The product does not need cold storage and can be kept in ambient condition in polythene bags for one year.

#### Ber slices

The matured uniformly ripened fruits of cv. Goma Kirti were washed and sliced with the help of potato slicer and dried them on paper under fan for an hour, add 50 per cent sugar to the slices and keep them steeped for 24 hrs. Remove slices and dry them in sun in stainless steel trays for two days and for one day in oven at 80 $^0$C temperature to make them crisp. The slices can be stored in polythene bags under ambient conditions for a year.

#### Ber Chips

The matured uniformly ripened fruits of cv. Goma Kirti were washed and sliced with the help of potato slicer and add 10 per cent salt to the chips. Keep them steeped for 12 hrs. The water excreted from chips is removed. Add cardamom, pepper, turmeric, chilli powder and black salt 5 g each after grinding them in dry mixture. Mix the slices thoroughly so that each piece is coated with the masala. Dry slices should be exposed to sun in stainless steel trays for two days and for one day in oven at 80 $^0$C to make them crisp. The chips can be stored in polythene bags under ambient conditions for a year.

## Diversified uses of *Karonda*

### *Karonda* (cv. CIAH Selection-1) as a source of natural dye

In order to diversify the use of crop produce from the plants being grown under fruit based diversified cropping system and keeping in view the fact that a renewed interest has arisen among the end users for natural dyes due to increased awareness of the environmental and health hazards associated with the use of synthetic dyes, use of *karonda* fruits was explored as a source of natural dye. *Karonda* is hitherto remained a neglected crop and is mostly used as a bio-fence. To some extent, it is also used for processing. However, *karonda* genotype, CIAH Selection-1, grown under cropping system, turns dark red upon maturity; thereby, indicating its alternative use, other than consumption, as a source of natural dye for its potential industrial

**Fig. 48: Cotton fabric dyed with colour obtained from *karonda* and premordant with (a) tannic acid (b) ferrous sulphate. Inset: Dark fruited ripe *karonda* fruits.**

application. Dye was extracted either with water or ethanol. However, dyestuff extracted through ethanol yielded better results. Premordanting with mordants such as PEG, tannic acid, ferrous sulphate and cupric sulphate followed by natural dyeing gave various shades like grey, yellow and red to cotton fabrics (Fig. 48).

### A natural colourant cum nutraceuticals-supplement derived from *karonda*

A natural 'food colourant cum nutraceuticals-supplement' was prepared from the ripe *karonda* fruits. For colour extraction, after washing and cleaning ripe fruits were cut into halves. Seeds were removed before subjecting fruits to dehydration. The dehydrated fruits were later grounded into powder. Powdered fruit pulp was extracted with ethanol, filtered and later air dried. The dried concentrated 'colour pigments' which predominantly contained anthocyanin and phenolics were then dissolved in water to get ready-to-use 'food colourant cum nutraceuticals-supplement'. The formulation had been christened as 'Lalima'.

To make it user-friendly, the formulation was packed in 10 ml plastic dropping bottles. This packed bottle had pigments extracted from the 10g dried fruits. 01 ml of this pigment suspension formulation is sufficient to give pleasing red colour to one serving (100 ml) of any colourless beverage such as lemon based beverages (Fig. 49). One serve of such supplemented beverage may additionally contain 469.2 µg anthocyanin, 14.1 mg phenol with total antioxidant activities to be 390 µM Trolox Equivalent. Lemon sherbet supplemented with 'Lalima' was found to be more acceptable in terms of flavour and appearance among the testers than the plain lemon *sherbet*. The development of technology for value addition of the food items through alternative uses of *karonda* would help regulate the availability of such antioxidant rich sources for nutritional security.

**Fig. 49: Lemon *sherbet* fortified with 'Lalima', a 'natural colourant cum nutraceuticals-supplement' derived from *karonda* genotype CIAH Selection-1**

## AGRICULTURAL EXTENSION

### Collection of information/data, documentation and evaluation of the potential rural resources/ rural wisdom based technologies of arid horticultural importance

**Potential land races/germplasms/wild species of arid fruits and vegetables for the crop improvement and arid horticultural development:** Large land races/germplasm/wild

species of arid fruits and vegetables are available in hot arid regions, which may play a crucial role in crop improvement/introduction of new variety, genotype or new crop in the field of arid horticulture. The information/ data on such kind of land races/ / germplasm/wild species or genotypes were collected through different sources. Some of the important land races/wild species or genotypes of arid vegetables which were identified and documented during the study are *khinp* (*Leptadenia pyrotechnica* ), *tumba* (*Citrullus colocynthis*), wild *kakoda* (*Momordica sp.), Mat kachar* (*Cucumus sp*.), loiya of mateera (*Citrullus sp*.), local green round melon *(Citrullus sp.), phog (Calligonum polygonoides),* cowpea (*Vigna sinensis), local mushroom (Agaricus sp),* spiny local brinjal (*Solanum sp.),* single stemed local clusterbean (*Cyamopsis sp.),* drumstick (*Moringa sp.),* wild kundru (*Coccinia* sp.) *and* leafy vegetable *viz., Cholai (Amaranthus sp.), bathua (Chenopodium album),* fenugreek (*Trigonella foenum-graecum),etc* (Plate 1). The above land races/ wild species or genotypes of arid vegetables may be boon for breeding/crop improvement programme and introduction of new variety, genotype or new crops of vegetable to the part arid horticultural crops of the country. Seeds of the some of above landraces/ wild species were also collected for conservation, use and ready references in future.

Likewise, there are some of the important land races/ wild species or genotypes related to arid fruits crops which were identified and documented. Among these, important one are *Jhar ber* (*Ziziphus ssp.), ker* (*Capparis decidua*), *lasora (Cordia Mixa*), mango (*Mangifera indica*) and pilu (*Salvadora oleiodes* ). The above land races/wild species or genotypes of arid fruit crops may play a vital role in breeding/crop improvement programme and introduction of new variety or genotype of fruit crops suited in hot arid regions of the country.

### Collection, documentation, validation and refinement/standardization of the potential rural wisdom based traditional technologies

**Validation, refinement and standardization of production of value added products, processes /techniques:** Information/data (from respondents, secondary and online sources) on rural wisdom based traditional technologies/ ideas and also self developed ideas to develop innovative processes / techniques and value added products of arid horticultural crops were collected. During the reported period, the following efforts were made in this direction (Fig. 50-51).

In addition to above the value addition of snapmelon like dehydrated plain slice for vegetable purpose, dry sweet slice and spicy *golchha* for direct consumption were also prepared (Fig. 52).

### (3) Development of the compatible extension models, concepts and methodologies

On the basis of traditional/ indigenous knowledge various concepts related to value addition, irrigation water management, plant protection, etc., in arid fruits and vegetables production were generated and developed during the year under this project. The some new concepts of value addition of arid fruits and vegetables are like preparation of pickle of mature pods (*sangari*) of *khejri*, pickle of ber, *sarbat* of ber, toffee of ber, pickle and ice-cream of date palm fruits, pickle and juice of kachri, *sarbat* and sweets of *mateera* fruits, pickle and *shake* of snapmelon, *sarbat*/juice and pickle of karonda, nectar of mulberry, dry RTS of bael, etc., were developed to strengthen the wing of value addition/ post harvest management of the Institute. The concepts for water management/ saving in arid horticultural crops production like mulching of *kheep* (Leptodenia ssp.), *bui*, mulching of fine FYM, etc., were formulated. With the help of traditional/ indigenous knowledge, various concepts of eco-friendly pesticides/bio-pesticides used by the farmers to protect their crops were evolved. Such major developed concepts are spraying of extract of *tumba* fruits and leaves on horticultural crops, mixing of mustard/sesamum oil cake in the soil, spray of extract of leaves of oak, moringa, *khejri*, olive, tobacco; dusting of powder of tobacco leaves, chilli, *tumba* fruits, spraying of cow dung and urine solution, spraying of excreta of blue bull, spraying of goat/sheep excreta, spray of garlic powder solution, wrapping of grease bands around trees, application of kerosene, burning of mustard/sesamum oil in crop fields, smoking +


Cowpea


Bathua


Mat Kachar


Kakoda


Khinpoli of Khinp


Fruits of wild kundaru


Loiya of mateera


Tumba fruits


Local mushroom


Phogale of Phog


Local green roundmelon


Drumstick pods


Fruits of lasora


Ripened fruits of ker


Fruits of Jhar ber


Fruits on local mango tree

**Plate 1. Important arid horticlturral crops in Western Rajasthan**

dusting of ash on fruits and vegetable crops, storage of vegetables seeds with dry *neem* leaves, dry ash/ sand, dry chillies in air tight pots, coating seeds with mustard oil , etc. Some of the photographic flow charts of the processes/techniques and value added products as developed and tested under the some above concepts of value addition of arid fruits and vegetables are being depicted in fig. 53-56.

Various methods and methodologies of data/ information collection related to role of rural wisdom and rural resources in arid horticultural development were designed and developed. Some of the methods /methodologies and processes of production of value added products of arid fruits and vegetables were standardized and developed using self created hypothesizes/innovative ideas. The major methods/ methodologies standardized/developed to produce the unique and neo value added products were: prepare procedure of pickles tumba, local mushroom, giloy, etc. The methodology/procedure of production of dehydrated pods of clusterbean, khinp,

## (i) Validation, refinement, standardization and development of the processes, products and techniques of preparing the pickle *of* tendril *khejri (Prosopis cineraria) sangari (*pods), khakari and *suhali (Papadi)of* khokha *of khejri* pods.

**Process/ technique of preparing the pickle of tendril *khejri sangari* (pods)**

↓

Selection and harvesting of healthy tender *sangari* (pods) of khejri.

↓

Washing pods with clean water

↓

Boiling of pods for 5-7 minutes

↓

Drying (removing excess of water) of boiled pods at shaded place for 5-6 hours (summer)

↓

After drying, pods are fried in pan with hot mustard oil for a movement.

↓

Mix some of the processed immature fruits of *ker* with pods (*sangari)* of *khejri* while frying them to increase the acid taste and nutritional value of the pickle.

↓

Mix salt, spices/ condiments (powder of aesfoitida, red chilli, turmeric, cumin, and seeds of fenugreek, fennel, *kalongi,* etc.) while frying the pods + processed fruits of *ker* with mustard oil in pan.

↓

Leave the product to Cool

↓

After Cooling, fill the material in glassware

↓

Boiled the mustard oil and cool it to room temperature. This is then added to above mixture and kept at room temperature for 3-5 days before serve.

**Process/ technique of preparing the *khakari* of khejri pods' *khokkas***

↓

Selection and collection/harvesting of healthy full mature pods' *khokka* of khejri.

↓

Washing pods' *khokkas* with clean water

↓

Drying/dehydration of pods' khokha at warm shady place or using mild solar energy at neat and clean place.

↓

Crushing the pods' *khokkas* and removing the seeds of the same

↓

Grinding the crushed pods' *khokkas* without seeds and making powder of them. Sieving it through a fine sieve to get a very fine powder of the same.

↓

Rousting/ frying the powder of khokhas with *Deshi Ghee.*

↓

Get down the temperature of rousted/ fried powder of khokhas, mixed powder of sugar, black piper, cardamom, ginger, fine rousted wheat flour, etc. while the powder is still warm.

↓

Thoroughly mixed the whole mass material as prepared above in warm condition.

↓

Made the *khakari* of so prepared mass material giving desirable shape and sizes.

↓

Thus, a unique and nutritive sweet (*khakari*) of khejri pods' khokhas are ready to serve/ consumption.

**Process/ technique of preparing the *suhali (Papadi)* of khejri pods**

↓

Selection and collection/harvesting of healthy full mature pods' *khokka* of khejri.

↓

Washing pods' *khokka* with clean water

↓

Drying/dehydration of pods' khokha at warm shady place or using mild solar energy at neat and clean place.

↓

Crushing the pods' *khokka* and removing the seeds of the same

↓

Grinding the crushed pods' *khokkas* without seeds and making powder of them. Sieving it through a fine sieve to get a very fine powder of them.

↓

Mixed sugar or salt (as per desired taste) *ajwine*, black piper, fine flour of wheat or *maida,* etc.

↓

Made the hard paste of above all constituents/ingredients (sugar or salt (as per desired taste) *ajwine*, black piper, fine flour of wheat or *maida,* etc.) together.

↓

Prepared the roundish thin suhali (*papdi)* of the above paste so prepared

↓

Fried the suhalies (*papdies)* with good quality of refined oil or *Deshi Ghee.*

↓

Thus, a unique and nutritive suhalies (*papdies)* of khejri pods' khokhas are ready to serve/ consumption. They have their long self-life.

**Fig. Pickle of tendril khejri pods (*sangari*)**

**Fig. Khankari of khejri pods' *khokha***

**Fig. Suhali of powder of khejri pods' *khokha***

**Fig. 50: Prodcuts of khejri**

## (ii) Validation, refinement and standardization of processes, products and techniques of dehydration of *kachri*, preparing the quality & self life improved readymade dry chutney and pickle of *kachri*.

**Process/ technique of dehydration of kachri slice with peeling and without seeds**

↓

Selection, collection/harvesting of mature & healthy fruits of *kachri*

↓

Washing the selected fruits of *kachri* with clean water and removing the moisture from the surface of the *kachri* fruits

↓

Peeling/ removing the skin/rind of the washed *kachri* fruits

↓

Cut down the *kachri* fruits in four pieces/ slices vertically

↓

Removing the seeds of each cut downed piece of the *kachri*

↓

Drying/dehydration of so prepared piece of the *kachri* at warm shady place or using mild solar energy.

↓

Thus, dried/dehydrated pieces/slice of kachri can stored for a long time in normal conditions and can be utilized to prepare different products like vegetable, chutney, powder, pickle or to mix in other vegetable, food item/ food stuff as a relish/ condiments to maintained acidic tastes of the same.

**Process/ technique of preparing the quality dry chutney of *kachri***

↓

Selection, collection/harvesting of mature & healthy fruits of *kachri*

↓

Washing the selected fruits with clean water and removing the moisture from the surface of the *kachri* fruits.

↓

Peeling/ removing the skin/rind of the washed *kachri* fruits.

↓

Cut down the *kachri* fruits in four pieces/ slices vertically.

↓

Removing the seeds of each cut downed piece of the *kachri.*

↓

Drying/dehydration of so prepared piece of the *kachri* at warm shady place or using mild solar energy.

↓

Grinding of dried/ dehydrated pieces /slice of kachri in maxi with dried red chilies to get a fine powder of both togather.

↓

Blending/mixing of the semi-grinded powder of cumin, sesame and fine powder of garlic, common salt, *Saindha Namak*, etc. as per need to maintain the taste, nutritional value and self life of the dry *chutney of kachri*.

↓

Thus, a unique, tasty and nutritive readymade dry *chutney* of *kachri* is ready for immediate as well as for the use in long duration without degradation.

**Process/ technique of preparing the pickle of kachri of improved quality**

↓

Selection, collection/harvesting of mature & healthy fruits of *kachri*

↓

Washing the selected fruits with clean water and removing the moisture from the surface of the *kachri* fruits.

↓

Peeling/ removing the skin/rind of the washed *kachri* fruits.

↓

Cut down the *kachri* fruits in two/ four pieces/slices vertically.

↓

Removing the seeds of each cut downed piece of the *kachri.*

↓

Drying piece of the *kachri* at warm shady place or using mild solar energy at neat and clean place (for 24 hours) to reduce the access moisture of the *kachri* pieces.

↓

Frying the piece of the *kachri* so processed with mustard oil in pan and gently, juxtaposes mixing of the salt, spices/ condiments (powder of asafoetida, red chilli, turmeric, cumin, and seeds of fenugreek, fennel, kalongi, etc.) while frying the piece of the *kachri*.

↓

Immediately, switch off the gas chulha and take down the pan of prepared material of pickle as above and cool down the material.

↓

After cooling the prepared material of pickle, fill it in any suitable glassware.

↓

Boiled the mustard oil and get cool it and pour the same in glassware of pickle untill sinking of the prepared material and put at a neat and cool place. It is ready to serve after a week with a long self-life.

↓

Thus, a unique, tasty and nutritive pickle of *kachri* is ready as a daily food item.

**Fig.: Dehydrated *kachri* slices/pieces with peeling and without seeds**

**Fig. : Readymade dry chutney of *kachri***

**Fig. : Quality & self-life improved pickle of *kachri***

**Fig 51. Value added products of kachri**

Dehydrated slice of snapmelon | Dry sweet slice of snapmelon | Spicy golchha of snapmelon

Fig. 52: Value added productes of snap melon

Fig. 53: Flow chart of major steps in preparing pickle of mature fruits of *Gola* variety of *ber*

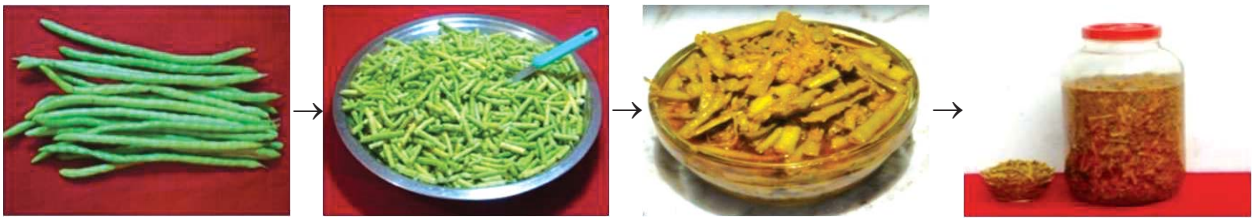


Fig. 54: Flow chart of major steps in preparing pickle of full mature & hard pods (*sangari*) of *khejri*

Fig. 55: Flow chart of major steps in preparing bael *PRASH* from the pulp of bael fruits

Fig. 56: Different samples/models of ice-cream prepared from mature fruits of *Halawy* variety of datepal

round melon, local mushroom, *ber,* etc. were refined and developed. Dehydrating mehtods/procedure of products like dry leaves of gram, fenugreek, bathua, carrot, flower buds of fog (*fogle), etc.* were also developed.

**Socio-economic and personal profile of the respondents/ farmers:** It was observed that there was high heterogeneity in existing social structure and social system. Social contravention (process whereby contending group or individuals strive to prevent each other to achieve some objective/ success) is also enough. There was high inertia in culture and resistance to change. Technology adoption solidarity (cohesiveness and unity) was very poor. The horizontal social groups observed predominant over vertical groups and reference groups. They believe highly in local Gods and Goddesses. Majority of the farmers are laggards and a few are innovators. Absence of "liaisons" (an individual who links two or more cliques/group of farmers in a system, but who is not a member of any clique / group). Scientific orientation – was low and political orientation – was high. Dummy/pseudo farmers more than the real farems. Decisions making system in technology adoption - rejection was mainly hierarchical and male dominated. Monomorphism was observed dominant over polymorphism. In the process o*f monomorphism* an opinion leader acted for only single topics but i*n polymorphism* an opinion leader is act for variety of topics. Mostly, diffusion communication was one-way, linear direction and reciprocal only amongst similar type of groups/ castes. Low fidelity and high distortion in technologies during diffusion process was observed. The –strength-of-weak-Tie (Bridging links) were poor that is low proximity between two Groups. Discontinuance stage was followed by conformation stage and there was a disenchantment type discontinuance of technology rather than replacement Discontinuance due to over all dissatisfaction. Among senior farmers (age of 45 - 60 years) about 44 % were literate and rest of them were illiterate. However, among young farmers (Age group-25 - 45 years) > 60 % are illiterate and remaining were observed illiterate. Majority of the respondents like mixed farming system. 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.

- Psychological characteristics of farmers of the study areas: There was existed only I or II level motivation amongst the respondents as per need hierarchy (Maslow model ). The behaviours were – unstable and unreliable. There was observed high disparity between intrinsic and extrinsic responses of the farmers. The majority of the farmers were "ethnocentric" and arena of attitude of most of them was surrounded by "The Self".The constraints in utilization of rural resources and rural wisdom based knowledge/technologies and arid horticultural development in western Rajasthan were also analysed. in arid horticultural development.

# 3. TRAINING AND CAPACITY BUILDING

## At Bikaner

### B. Extension programmes and activities

**Front line demonstrations/ adaptive trials:** Seven frontline demonstrations of improved varieties of arid vegetable crops *viz- Thar Mank (Mateera)*, AHS-82 (snap melon), AHK- 119 (*Kachri*) and *Thar Shobha* variety of khejri were conducted on farmers' fields at Chak No. 8VDM, *Sarehrupayat* village and *Sinthal* village of Bikaner district dated: 06.08.14, 07.08.14, 05.09.14 and 08.09.14 during the *kharif* season of the year. During the summer season of 2014-15, four frontline demonstrations of improved varieties of arid vegetable crops *viz-* AHK-119 (*Kachri*) and AHS-82 (snap melon) were conducted on farmers' field at Bachhasar village and at Chak No. 4BKM, Kanasar village of Bikaner district dated 07.03.15 and 11.03.15. In addition, 23 method demonstrations about improved agro-techniques of arid fruits and vegetable production, value addition, in-situ budding, etc were given to the Institute visiting farmers/ extension functionaries and on farmers' field during the visits to farmers' fields or interaction.

**Farmer's trainings:** 05 farmer's training programme (on/ off campus were conducted / organised at the Institute and at farmer's fields. Four of campus training conducted at *Sarehrupayat* village and *Sinthal* village of Bikaner district dated: 06.08.14, 07.08.14, 05.09.14 and 08.09.14 on "improved agro-techniques of arid vegetable production" the *kharif* season and "orchard development of improved variety (*Thar Shobha*) through *in-situ* budding technique". One farmers' training (three days) programme was conducted at the Institute during 27.08.2014 to 29.08.2014

**Participation in farmer's fair and arranging technological exhibitions:** Participated and organized 02 exhibitions of arid horticultural technological in farmer's fairs organized by Directorate of Extension, SKRAU, Bikaner on 03.10.2014at Lunkarnsar, Bikaner. The exhibition of the Institute was highly appreciated by the Hon'ble Chief Minister of Rajasthan, Smt. Vasundhara Raje during visiting our exhibition. Another exhibitions of arid horticultural technological was displayed at NDRI, Karnal(Haryana) during the organization of 12th Agricultural Science Congress from 03.02.2015 to 06.02.2015.

**Visit and interaction/ meetings with farmers at the Institute :** More than 800 farmers (both men & women) belonging to 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.

**Lectures :** Delivered 19 lectures related to different arid horticultural improved technologies for the visiting farmers / extension worker/ NGO personnel and during different training programmes

**Visit and interaction with students/young farmers at the Institute:** Besides the farmers, >150 young farmers/students came from different agricultural colleges/ university and schools of the Rajasthan state and other states of the country visited and 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:** Moreover, > 100 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.

## Frontline Demonstrations

**Research-extension-farmers-interface meetings:** 22 Research-Extension-Farmers-interface meetings with 22 groups of farmers 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.

**Development of farmers group:** 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 district (Rajasthan) where front line demonstrations of improved varieties of arid fruits/ vegetables crops and their agro-techniques were conducted. More than 11 Groups of farmers which had interest in propagation/ multiplication and growing of the improved varieties of *khejri* (*Thar Shobha), ber, kachri (*AHK-119), snapmelon (AHS-82) and *mateera* (Thar manak), etc. was also organized. Later on, these groups were follow upped and their visit to the Institute for technological interaction/ discussion was organized.

**Celebration of Farm Innovators Day:** Celebration of Farm Innovators Day was held on 09.10.14 in the Institute in which more than 100 innovative farmers and students were 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.

**Celebration of ICAR Foundation Day:** ICAR Foundation day was observed at *Jalwali* village of Bikaner district on 16.07.14 in collaboration of NRCC, Bikaner, RRS of CSWRI, Bikaner, RRS of CAZRI, Bikaner, RRS Equine, Bikaner to educate the farmers about modern agricultural technologies. In this programme various activities like exhibition, scientists- farmers interaction, question-answering, group discussions, distribution of seed and planting material, & technical literatures (>200 copies), technological method demonstration/exposure to farmers/ clients were also carried out.

**Celebration of ICAR Industry Day:** The ICAR Industry Day was Celebrated at the Institute on 18.12.2014 during which several industrialists and clients participated and discussions were held on industrial aspects of arid horticultural crops.

**Celebration of Agriculture Education Day:** On 23.07.14, Agriculture *Education Day* was celebrated in the Institute in which 60 students and teachers from different school of Bikaner participated. The students and other participants also visited the Museum of the Institute to acquaint them with latest technologies developed by Institute.

**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 CIAH technologies 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.

**Mobile advisory service/ ICT based/ e-extension based activities:** During the reported time, the 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.

**Providing technical literature:** About 150 copies of technical folders and bulletins (technical literature) were provided to the farmers /extension workers/ NGOS, during their visit, farmer's fair, exhibitions, meetings, etc.

**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.

## Technological interventions and impact assessment

The important technologies/processes/ methods and activities used for technological intervention, technological intervening means/methods and impacts indicators responded and observed during the assessment as per feedback of farmers are being presented below.

**(I) Intervened technologies/processes/ methods:** (1) Improved varieties of arid fruits and vegetable crops like *ber (*Gola, Seb, Umran*)*, pomegranate (Jalore Seedless, Ganesh, Bhagwa), *phalsa*, *lasora*, Kachri (AHK-119), Snaplmelon (AHS- 82), Mateera (Thar Manak), Khejri (*Thar Shobha*) (2) Improved/refined/New agro-techniques of arid fruits and vegetable production (3) Seed production techniques of improved varieties of arid vegetables like Kachri (AHK-119), Snaplmelon (AHS- 82), Seed treatment and fruit fly controlling technologies (4) In-situ budding based orchards development of improved varietiy of *khejri*, *ber* and other fruit crops (5) Seeds production technique of

## Farmer's Trainings




improved varieties of arid vegetables like *kachri*, snapmelon, etc. (6) Production of planting materials of improved varieties arid fruits like *ber*, pomegranate, *phalsa*, *lasora*, etc. and management of nurseries of the same (7)Innovative techniques of value addition/post harvest management of arid fruits and vegetables (8) Other technologies.

**(II) Strategic means/methods and processes used for technological interventions:** (1) Frontline demonstrations/method demonstrations (2)Trainings/ visits (3) Research- Extension-Farmers- interface meetings (3) Providing initiator inputs like improved seeds, planting materials, buds of arid fruits and vegetables crops to farmers/ clients with perfect technologies and scientific guidance (4) Providing buds, cuttings of improved varieties and rootstocks of arid fruit crops to farmers/ clients with perfect techniques of orchard development through *in-situ* budding technique (5) Farmer's field visits, meetings and group discussions (6) On line/ personal technical advises and guidance (7) Press publicity of the technologies (8) Technological exhibition & film shows, talks/ lectures (9) Providing technological literature/ written advice to the farmers/ clients, etc.

**(III) Impacts assessment and success indicators observed and responded by farmers/clients:** Following impacts with respect to dissemination, adoption and diffusion of improved technologies, processes, products and methods were observed.

**Impact in terms of increasing area and adopters:** The area under improved varieties of arid fruits crops like *ber (*Gola, Seb, Umran*)*, pomegranate (Jalore Seedless, Ganesh, Bhagwa), datepalm, *phalsa*, *lasora*, and the area under improved varieties of arid vegetable crops like Kachri (AHK-119), Snaplmelon (AHS- 82), Mateera(Thar Manak), Khejri (*Thar Shobha*) has been increased/spread over > 1000 hectares and > 3000 hectares, respectively during recent period in hot arid region of western Rajasthan. Presently, > 600 farmers/ clients are growing above improved varieties of arid fruits crops at large to subsistence level. Likewise, > 5000 farmers/ clients are growing above improved varieties of arid vegetables crops at large to subsistence level in hot arid regions of western Rajasthan as a result of direct or indirect technological interventions of the ICAR- Central Institute of Arid Horticultural Institute, Bikaner.

**Impacts in terms of economical benefits:** Farmers are getting gross income of Rs. 144000-185000 /ha / season by growing improved varieties of arid vegetables like Kachri (AHK-119), Snaplmelon (AHS- 82) and Mateera (Thar Manak). In case of arid fruits farmers' are getting gross income of Rs. 72000 - 102000/ha/year depending on climatic conditions and orchard management.

Some of the farmers (4-5%) have started to produce seeds of the improved varieties of *kachri* (AHK- 119) and snaplmelon (AHS-82 at a small scale scale for their own use and also to earn money by selling the same to fellow farmers, local markets or NGOs, etc.

Some of the farmers/ persons (2 -3%) have started to produce planting material of arid fruits like *ber, bael*, pomegranate, kinnow, lasora, phalsa, lemon,etc., by establishing nusaries at small scale and are earning enough amount of money by selling the same to farmers, institutions/ NGOs.

## Exhibitions organized


Increased the quality and quantity (> 30%) of the arid vegetables and their products in the local markets.

Farmers are very eager to grow and produce the improved varieties of arid vegetables like *kachri* (AHK- 119), snaplmelon (AHS-82), mateera (Thar Manak), clutersbean, at large and commercial scale to make their life economically sound.

**Impacts in terms of success of the innovative/ improved technology/process, methods:** The farmers/clients reported that the improved varieties of arid fruits crops like ber (Gola, Seb, Umran, Tha Sevika)*phalsa, lasora*, and the improved varieties of arid vegetable crops like Kachri (AHK-119), Snaplmelon (AHS- 82), *mateera(Thar Manak)*, Khejri (*Thar Shobha*) and their agro-techniques as developed by the Institute (ICAR-CIAH, Bikaner) are highly successful

**Impact in terms of change in cognitive behavior:** Increased the knowledge, awareness, and interest among > 50% farmers of the areas where FLDs and trainings were of improved varieties of arid fruits and vegetables conducted like *ber (*Gola, Seb, Umran*)*, pomegranate (Jalore Seedless, Ganesh, Bhagwa), *phalsa, lasora*, Kachri (AHK-119), Snaplmelon (AHS- 82), Mateera (Thar Manak), Khejri (*Thar Shobha*) and their agro-techniques.

**Impact in terms of social changes:** Several changes were observed as a result of extension interventional programmes and adoption/ reaching the improved technologies to users fields/clients working places. There were signs of motivation for adoption of horticultural crops and commodities. Close interaction and intimacy among the farmers increased to exchange inputs/ knowledge to each-other in adopting horticultural crops on their field. Increased the commodity interest groups in social system. Increased the cosmopolitism and scientific orientation of the farmers. The windfall profit (advantage earned by first adopter) farmers were also increasing in the field of horticulture in hot arid regions of western Rajasthan.

**Impact in terms of agro-ecological changes:** Farmers/ clients feels that after adoption of arid fruits and vegetables, there is significant reduction in soil erosion and shifting sand dunes/sand in the crop fields. Increased soil fertility of the crops' fields by increasing the organic matter in the soil. Overall, the micro-climate of the area/ crop fields became mild and pleasant.

It was also observed that the farmers are very eager to grow improved variety of kachri (AHK-119), mateera (Thar Manak), Snap melon (AHS-82), *khejri "Thar Shobha"* released by the institute. They expect a lot of benefit from these varieties. It is expected by the farmers that "*Thar Shobha"* will be a boon for socio-economic upliftment of rural people of hot arid regions. The farmers are bound to think that the horticulture crops will be a dominant component of their farming / cropping system in future. Year by year, the farmers of hot arid region are including horticultural crops as one of the essential component of their existing farming / cropping system.

## Farmer's visit to CIAH




## At Godhra

### Visit to Farmer's field

A total of 2187 visitors including 1403 male, 286 female, 331 students and 167 Ex-workers visited the Station. Various experimental blocks were shown to them and technology developed by the CHES center were also demonstrated particularly propagation techniques.

### Farmer's training/ exhibition

Different live samples of fruits and vegetables were exhibited during Global Conference on Technological Challenges and Human Resources for Climatic Smart Horticulture Issues Strategies during 28-31 May, 2014. Charts, photographs, specimens, etc showed and explained the station activities and technology to the visitors and distributed publications of the station to the farmers.

Different live samples of fruits and vegetables were exhibited during Krishi Mahotsav and Exhibition organized by the Department of Agriculture, Government of Gujarat at Chota-Udaipur, Gujarat during 2-3 June, 2014.

## Capacity building

### Dr. Pinaki Acharrya

Attended refresher course on Agricultural Research Management from July 14th to 26th,2014 at National Academy of Agricultural Research Management, Hyderabad.

Attended winter school on " Bioinformatics and its emerging dimensions in Agriculture" from 12th January to ist February,2015. organized by Bioinformatics Centre, College of Horticulture, KAU, Thrissur.

### Dr. S.K. Maheshwari

Attended training on "Management Development Program on PME for Agricultural Research Projects" from 04-08-2014 to 08-08-2014 at National Academy of Agricultural Research Management (NAARM), Hyderabad.

Attended Training on "Nursery Management in citrus" from 07-09th Oct., 2014 at National Research Centre for Citrus, Nagpur.

### Dr. M.K. Jatav

Attended training on "Management Development Program on PME for Agricultural Research Projects" from 04-08-2014 to 08-08-2014 at National Academy of Agricultural Research Management (NAARM), Hyderabad.

### Sh. Jagan Singh Gora

Attended Training on "Nursery Management in citrus" from 07-09th Oct., 2014 at National Research Centre for Citrus, Nagpur.

Attended Professional Attachment training during 11-05-2014 to 10-08-2014 at ICAR-CISH, Lucknow.

Attended Short Course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India" held on September 22 to October 01, 2014 at CIAH, Bikaner, Rajasthan.

### Dr. Raj Kumar

Attended a short term training programme on "Technologies for Processing of Fruits and Vegetables for Commercial Trades" from 1st September, 2014 to 12th September, 2014 at CFTRI, Mysore, Karnataka.

Attended Winter School on "Hi-tech interventions in fruit production for enhancing productivity, nutritional quality and value addition" from 5 to 25th November, 2014 at Central Institute for Arid Horticulture, Bikaner.

### Dr. Sanjay Singh

Imparted training on different aspects of semi-arid fruits to the participants in the training organized

by NABARD, Dahod in association with CHES, Vejalpur during 16.3.2015 to 22.03.2015.

Conducted training to BRS student at CHES, Vejalpur during 1-1-2015 to 20.1.2015.

Conducted training-cum-awarness programme for Tribal Sub Plan on 13-3-2015.

Delivered lectures to farmers under ATMA, Dahod on different dates in October, 2014, November, 2014, February and March 2015 on underutilized fruits.

### Dr. R.S. Singh

Organized Agricultural Education Day programme at CIAH, Bikaner on 23.7.2014 for college students.

Organized as Course co- Director 21days ICAR sponsored winter school programme on "Hi-tech Interventions in enhancing Fruit production , Nutritional and Value addition" at CIAH, Bikaner from 5-25 November, 2014

Organized as Course co- Director 10 days ICAR sponsored short course on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India at CIAH, Bikaner from 22 September to 01October, 2014 .

Acted as In-charge/mentor for ARS Probationer Scientist (Mr. Jagan Singh Gora ) for conducting Orientation training programme at CIAH, Bikaner for four weeks.

Nominated as In charge/ mentor for ARS probationer Scientist (Mr. B.M.Murlidhara Scientist Fruit -Science CISH, Lucknow), for conducting 03months Professional attachment training programme at CIAH, Bikaner from 8.5.3014 to 8.8.2014..

Nominated as In-charge/ mentor for ARS probationer Scientist (Mr. Julius Uchoi, Scientist Fruit Science, CAZRI, Jodhpur), for conducting 03months Professional attachment training programme at CIAH, Bikaner from 13th November, 2014 to 12th February,2015.

Acted as Major advisor of M.Sc. Ag. student (Hort.) for thesis research work of Deptt. of Horticulture, COA, SKRAU, Bikaner at CIAH Bikaner during the year and member of advisory committee of a PG student for thesis research work.

### Dr. M.K. Jatav

In the capacity of Course Co-Director, ICAR sponsored 10 days training programme on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India was conducted during 22 September to 1 October, 2014.

### Sh. Ramdeen (Administrative Officer)

Attended training programme on "Orientation Course in Records Management for Records Officers under provisions of the Public Records Act, 1993" during 15-17 October, 2014 at National Archives of India, Jaipur.

### Sh. Rajesh Daiya (Assistant)

Attended training programme on "Pension and Retirement Benefits" during 6.4.2015 to 9.4.2015 at ISTM, New Delhi.

# 4. WOMEN EMPOWERMENT

## Programmes/activities for empowerment of farm women

About 150 farm women visited to the Institute and had research extension-farmers-interface meetings with them. They were exposed and educated about modern arid horticultural crop production technologies, value addition techniques of arid fruits and vegetables by delivering lectures and visiting them to the Institute. More than 500 farm women were also exposed and educated about modern arid horticultural crop production technologies, value addition techniques of arid fruits and vegetables by displaying the technological exhibitions of the Institute in different farmers' fairs/ science congress and during other occasions. Similarly, many farm women were exposed and taught about modern arid horticultural technologies and how can they reduce the drudgery in crop production and post harvest management during farmers' field visit/ *in-situ* discussion/ delivering lecture in rural areas. Moreover, they were motivated to participate actively in main stream of arid horticultural developmental programmes and activities of the Government and Non- Government organization.

# 5. AWARDS AND RECOGNITIONS

## Award

### Dr. R. S. Singh

Received fellow of Horticulture Society of India for the year 2014.

### Dr. Hare Krishna

केन्द्रीय शुष्क बागवानी संस्थान में सितंबर 8–15, 2014 तक हिन्दी चेतना सप्ताह के दौरान आयोजित 'हिन्दी भाषा ज्ञान' एवं 'वैज्ञानिक शोध लेखन' प्रतियोगिताओं में क्रमशः प्रथम एवं द्वितीय स्थान प्राप्त किया।

राष्ट्रीय उष्ट्र अनुसंधान केंद्र, बीकानेर में हिन्दी पखवाड़ा के दौरान आयोजित 'हिन्दी में सामान्य ज्ञान प्रश्नोत्तरी प्रतियोगिता' में टीम स्पर्धा के आधार पर प्रोत्साहन पुरस्कार प्राप्त किया।

### Dr. B. R. Choudhary

Ranked on second place in Hindi Bhasha Ghyan Competition (Scientist category) during Hindi Awareness Week organized by ICAR-CIAH, Bikaner from 8-15 Sept., 2014.

Received Encouragement prize in Scientist Research Paper Competition during Hindi Awareness Week organized by ICAR-CIAH, Bikaner from 8-15 Sept., 2014.

Received Encouragement prize in Poster Display Competition of Research Paper during Hindi Week organized by ICAR-NRCC, Bikaner from 15-29 Sept., 2014.

### Dr. S. M. Haldhar

Shravan M Haldhar: Awarded first prize in Hindi article writing contest during Hindi week organized by CIAH, Bikaner from 15-21, September, 2014.

Shravan M Haldhar: Awarded third prize in Hindi article writing contest during Hindi Pakhvada organized by NRC on Camel, Bikaner from 15-29, September, 2014.

Shravan M Haldhar: Awarded Protsahan prize in Hindi article writing contest during Hindi Pakhvada organized by NRC on Camel, Bikaner from 15-29, September, 2014.

### Dr. P. N. Sivalingam

Sivalingam P N., Singh D., Gurjar K. and Bhargava R.( 2015) awarded best oral presentation in Second International Conference on Bio-resource and stress management at Hyderabad during 07-10 January 2015 for presenting the paper on "Differential expression of transcripts during low moisture stress in *Ziziphus nummularia*"

### Dr. S. R. Meena

Dr. S.R. Meena, Sr. Scientist,(Agril. Extension),attended the International conference: Changing scenario of pest problems in Agri-horti ecosystem and their management to be organized by Entomological Research Association, Udaipur and Department of Entomology, RCA, Udaipur, MPUAT, Udaipur from 27 -29 November, 2014 and his oral presentation on a research paper entitled "*Traditional eco-friendly pesticides applied to protect the horticultural crops from the attack of insect-pests in hot arid regions of western Rajasthan* "was awarded with *third best* paper award during the above conference.

Dr. S. R. Meena, Sr. Scientist, (Agril. Extension),was awarded with best oral paper presentation entitled as "Rural talent in value addition and expend of underutilized fruits and vegetables in hot arid regions of western Rajasthan: Noble concepts and methods formation during the National Seminar to be organized on "Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity" at ICAR-NRCSS, Ajmer, Rajasthan, from 19- 20 January, 2015.

Dr. S. R. Meena, Sr. Scientist, (Agril. Extension),was awarded with second best poster presentation of the paper entitled as "bio-organic preparations complying to reduce the load of insect-pests on horticultural crops without environmental risk: Conceptual evaluation" during the National Seminar to be organized on "Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity" at ICAR-NRCSS, Ajmer, Rajasthan, from 19- 20 January, 2015.

Dr. S. R. Meena, Sr. Scientist (Agril. Extension) was awarded/honoured by the Indian Society of Seed Spices with S*ociety Fellow Award* for the year 2014-15 on 30.03.2015 at NRCSS, Ajmer, Rajasthan for his outstanding contribution in the field of seed spices and other areas of agricultural research.

### Dr. Sanjay Singh

Received H. S. Mehta Memorial award, 2014 for outstanding work on minor fruits during Global conference on "Technological Challenges and human Resources for climate Smart Horticulture*"* from 28 to 30 May, 2014 at N.A.U., Navsari, Gujarat, organized by ASM foundation.

Received Eminent Scientist Award by Samagra Vikas Welfare Society, Lucknow during International Symposium on Peri Urban Agriculture for Improving Livelihood Opportunities during 25-26 November, 2014, Lucknow, organized by Samagra Vikas Welfare Society, Lucknow.

### Dr. A. K. Singh

Research paper entitled "Evaluation of bael varieties for fruit characters under hot semi-arid environment of Western India" was awarded as best oral/ paper presentation award during Seminar on Global Conference on Technological Challenge and Human Resources for Climate Smart Horticulture-Issue and Strategies during May, 28-31 2014, NAU, Gujarat.

Received Young Scientist Award by High Tech Horticultural Society during International Conference on Technological Intervention in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value Addition, November 11-13, 2014 for outstanding contribution in bael and aonla. at Nagaland University, SASRD, Medziphema, Nagaland.

## Recognition

### Dr. B. D. Sharma

Director, CIAH, Bikaner nominated act as Examination Nodal Officer of the AIEEA-UG-2014 Examination held at Bikaner on 12-04-2014

Acted as Rapporteurs in Action Taken Report and Plenary Sessions in XIX Workshop of AICRP on AZF, held at SKNAU, Jobner during 12-14$^{th}$ December 2014

Delivered the lead presentation on Status of Hi-tech horticulture in arid region of India. In: National Seminar on Hi-tech horticulture for enhancing productivity, quality and rural prosperity held at NRCSS, Ajmer 19-20th January 2015

Acted as Co-Chairman in the Technical Session on Protected cultivation technologies for horticultural crops In: National Seminar on Hi-tech horticulture for enhancing productivity, quality and rural prosperity held at NRCSS, Ajmer 19-20th January 2015

### Dr. S. M. Haldhar

Rapporteur in international conference on "*International Conference on horticulture for nutrition, livelihood & environmental security in hills: opportunity and challenges*" of technical session-IV (Plant health management) organized by UBKV (Hill campus), Kalimpong during 22-24, May, 2014.

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

Recognition as an expert for 'IPM package of practices for Ber' developed by NIPHM, Hyderabad.

### Dr. S. K. Maheshwari

Acted as 'Rapporteur' (Technical session) in National Symposium on "Recent Advances in Diagnosis and Management of Diseases of Field and Horticultural Crops" held on 28th February-1st March, 2015 at N. D. University of Agriculture & Technology, Kumarganj, Faizabad, (U.P.).

Acted as Course Co-Director of ICAR-sponsored 21 days Winter School on "Hi-tech interventions in fruit production for enhancing productivity, nutritional quality and value addition" during 05 to 25th November, 2014 at ICAR-CIAH, Bikaner.

### Dr. Pinaki Acharyya

Member, Scientific and Technical Committee & Editorial Review Board on Medical and Biological Sciences, World Academy of Science, Engineering and Technology, USA.

Selected as a member of the on-line paper reviewing panel of "Journal of Tropical Agriculture" published by Kerala Agricultural University.

### Dr. Sanjay Singh

Acted as Member (DG nominee) on 4-4-2014 in Board of Management meeting at N.A.U., Navsari.

Delivered key note lecture on Improvement in arid and semi arid fruit crops for climate smart horticulture on 29-5-2014 in Global conference on "Technological challenges and human Resources for climate smart horticulture" from 28 to 30 May, 2014 at N.A.U., Navsari, Gujarat, organized by ASM foundation.

Acted as member of organizing committee of Global conference on "Technological Challenges and Human Resources for Climate Smart Horticulture" organized by ASM foundation from 28 to 30 May, 2014 at N.A.U., Navsari, Gujarat.

Acted as co-chariman in the session " Innovation in shelf life enhancement, value addition and marketing on 29-5-2014 in Global conference on "Technological challenges and human Resources for climate smart horticulture" organized by ASM foundation from 28 to 30 May, 2014 at N.A.U., Navsari, Gujarat.

Acted as Rapporteur for the session 'Plant Genetic Resources (Germplasm survey and collection, evaluation and varietal trials)' in Group workers meeting of AICRP Arid Fruits at Jobner, Rajasthan.

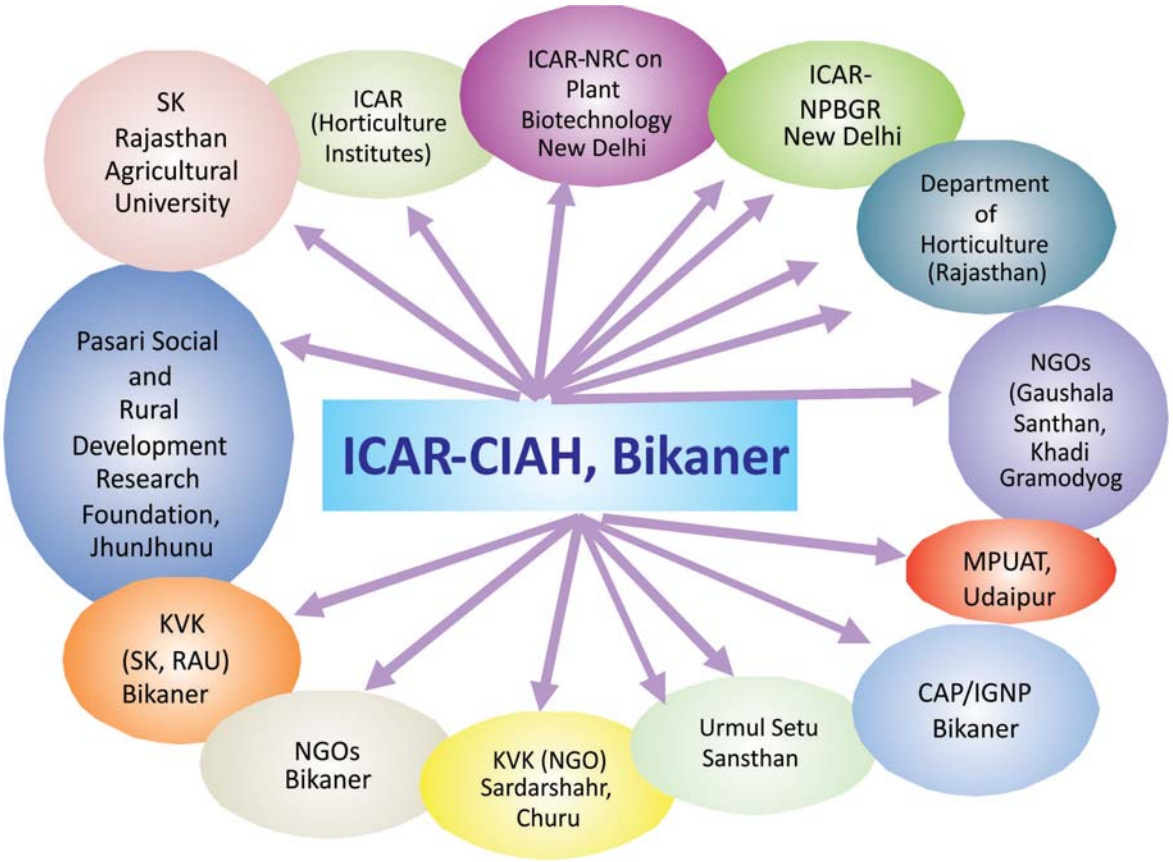
Chairman in the session production technology of mango in national seminar on Sustainable mango production in semi arid ecosystem on 28 January, 2015 organized by N. M. Sadguru Water and Development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

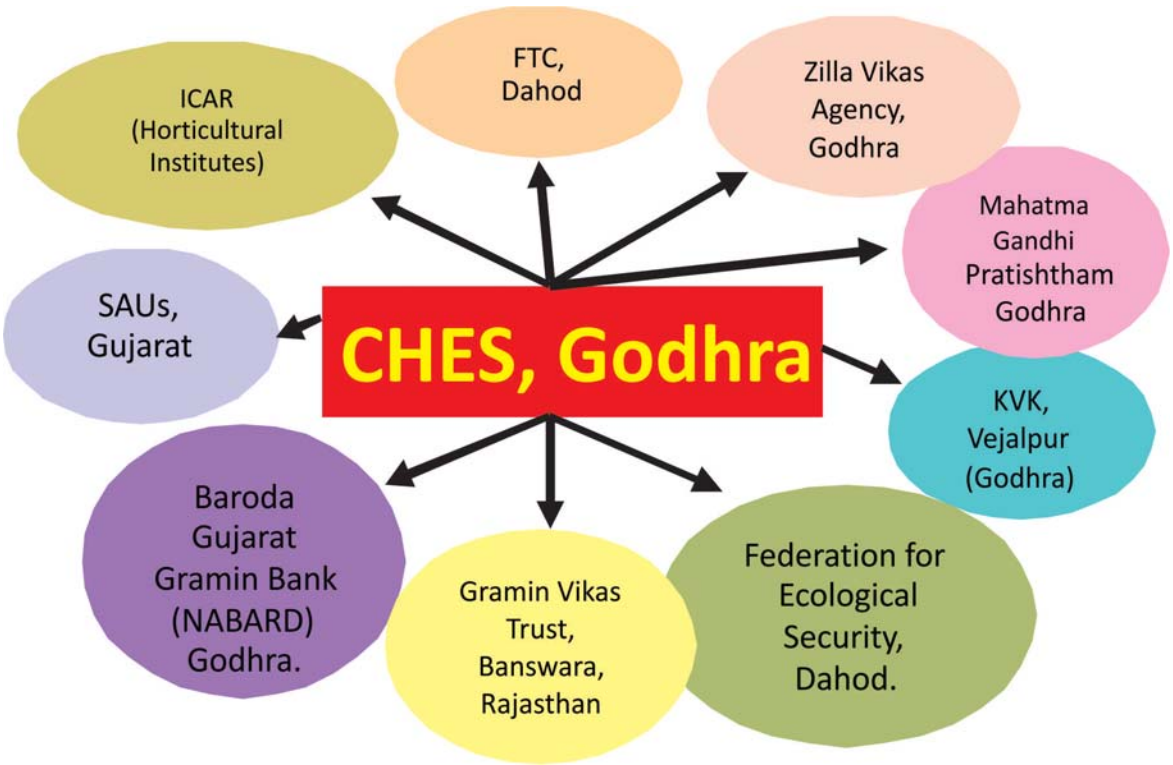
Organizing Secretary in the national seminar on Sustainable Mango Production in semi arid ecosystem on 28 January, 2015 organized by N M Sadguru water and development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

### Dr. S. S. Hiwale

Nominated by Director General I.C.A.R, New Delhi to act as Member Career Advancement Committee of scientist at Directorate of Medicinal an Aromatic plants research, Boriavi, Anand, Gujarat on 24th November 2013.

# 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, Sr. Scientist

During summer season of 2014 maintained the seed of released varieties of watermelon and muskmelon through inbreeding. Developed DUS test guidelines of watermelon and muskmelon. The following grouping traits have been identified to facilitate the assessment of distinctiveness of varieties (Table 33 & 34).

**Table 33. Grouping traits in watermelon**

| Trait | State | Example variety |
|---|---|---|
| Leaf blade: degree of primary lobing | Weak | Durgapura Lal |
| | Medium | Sugar Baby |
| | Strong | Thar Manak |
| Fruit: shape in longitudinal shape | Flat globe | Sugar Baby |
| | Cylindrical (Oblong) | Charleston Grey |
| | Elongated globe | Asahi Yamato, Arka Manik |
| Fruit: colour of rind | Yellow | Kashi Pitamber |
| | Light green | Asahi Yamato, Charleston Grey |
| | Medium green | Durgapura Kesar |
| | Dark green | Sugar Baby |
| Fruit: stripes | Weak | Asahi Yamato. Charleston Grey, Sugar Baby |
| | Diffused | Arka Manik |
| | Clearly defined | Thar Manak |
| Fruit: size (kg) | Small (<3) | Sugar Baby |
| | Medium (3-6) | Arka Manik, Durgapura Lal |
| | Large (>6) | - |
| Fruit: colour of flesh | Yellow | Durgapura Kesar |
| | Dark red | Sugar Baby, Asahi Yamato |
| Seediness: number of seeds/ fruit | Absent or rudimentary (<20) | - |
| | Low (<150) | - |
| | Medium (150-350) | Charleston Grey, Sugar Baby |
| | High (>350) | Durgapura Kesar |
| Seed: colour of coat | White | Durgapura Kesar |
| | Grey | AHW-19, Asahi Yamato |
| | Brown | Durgapura Lal |
| | Black | Sugar Baby |

**Table 34. Grouping traits in muskmelon**

| Trait | State | Example variety |
|---|---|---|
| Sex expression (at full flowering) | Monoecious | - |
| | Andromonoecious | Kashi Madhu, Pusa Madhuras, Hara Madhu, Durgapura Madhu |
| | Others | - |
| Fruit shape at longitudinal section | Ovate | MHY-3 |
| | Elongated globe | Arka Rajhans |
| | Oblate (Flat globe) | GMM-3, Kashi Madhu |
| | Obovate | Durgapura Madhu |
| Fruit: rind colour | Yellow | Kashi Madhu |
| | Yellow Green | Durgapura Madhu |
| | Orange | Arka Jeet |
| Fruit: sutures | Absent | Arka Jeet, MHY-3 |
| | Present | Hara Madhu, Kashi Madhu |
| Fruit: surface netting | Absent | Arka Jeet, MHY-5 |
| | Moderate | RM-50, Punjab Sunehri |
| | Dense | - |
| Fruit: flesh colour | Creamish white | Arka Jeet |
| | Grey orange | GMM-3 |
| | Yellowish green | Durgapura Madhu |
| | Green | Hara Madhu |
| | Orange | Kashi Madhu |

## 2. DUS Centre on *Ber*

PI: Dr. Hare Krishna, Sr. Scientist

Co-PI: Dr. R. Bhargava, Principal Scientist

During the reported period, Indian jujube (*Ber*) had been notified for registration under the Protection of Plant Varieties and Farmer's Right Act, 2001. A new separate block of *Ber* is being developed at ICAR_CIAH, Bikaner for the 26 reference varieties as mentioned in National DUS Test Guidelines for *Ber*. Process has been initiated for registration of promising *ber* varieties developed under AICRP-Arid fruits in consultation with the concerned centers.

## 3. DUS Center on Date palm

PI: Dr. R. S. Singh, Princpal Scientist

Co-PI: Dr. R. Bhargava, Principal Scientist

Under DUS centre on Date palm Horticultural crop, morphological and fruit characters in date palm varieties were recorded. Variation with respect to plant morphological characters viz. thorn size, leaflet size, was observed among the date palm cultivars.

Data on all identified characters could not be undertaken due to non-extension of project in time. However, spathe emergence/opening in date palm varieties was observed. Co-Nodal centre at DRS,

Mundra was approved in August, 2014 for validation of DUS characters. Work was initiated after approval of the Co- nodal centre. During the year-2015, spathe emergence/opening was observed in maximum cultivars during February month and in few cultivars in first week of March. Further, it was observed that spathe emergence, opening/flowering in female palms were earlier than male which may due to change in climatic conditions. Pollination was done at the end of February and during March month. Collection of data on fruiting is in progress.

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

For quality and high seed yield potentials, varietal maintenance and crop production trials in 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 2014–15 (Table 35). About 180.00 kg TFL seed of institute varieties of arid zone vegetables was produced 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.

**Table 35. Seed production in arid vegetable crop varieties at CIAH, Bikaner during 2014-15.**

| Crop – varieties under breeder / TFL seeds | Quantity produced (kg) |
|---|---|
| Kachri (AHK–119) | 63.0 |
| Snap melon (AHS–82) | 92.0 |
| Bottle gourd (Thar Samridhi) | 18.0 |
| Cluster bean (Thar Bhadavi) | 0.5 |
| Sword bean (Thar Mahi)** | 0.05 |
| Indian bean (Thar Kartiki)** | 5.0 |
| Indian bean (Thar Maghi)** | 0.15 |
| Moringa (AHMO–1)** | 0.25 |
| Others (Brinjal and tomato lines) | 1.50 |

**Complete crop damage at pod maturity (prior to seed harvest) due to low temperature and frost conditions on 25/12/2014.

## Godhra

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

PI: Dr. A. K. Singh

Co-PI: Dr. Sanjay Singh

#### Different phonological events

Results of study on various phenological events divulged that the varieties (12) exhibited dissimilar pattern. The inflorescence among all the varieties differed with regards to morphology and phenological characteristics *viz.*, type of inflorescence, number of floral parts and inflorescence etc.

#### Leaf defoliation and initiation

Phenologically, all the varieties had long leaf fall period of 21-25 days, starting from 2nd week of April in variety Pant Aparna, Pant Sujata and Goma Yashi which completes in 3rd, 4th and 2nd week of May, respectively. Variety Pant Shivani had leaffall from 2nd week of April to 3rd week of April, Pant Urvashi had from 3rd week of April to 2 nd week of May, whereas NB-5, NB-7, NB-9 had leaf fall from 3rd, 2 nd, 1st week of May, respectively which completes in the 4th week of May. Variety CISHB-1 had 4 th week of March to 2 nd week of April; CISHB-2 had 1stweek of June to 3rd week of June. NB-16 had from 1st week of June to 2 nd week of May. Leaf initiation started from 4 th week of April in CISHB-1, Pant Shivani; 2 nd week of May in NB-9; 3 rd week of May in Goma Yashi, 4th week of May in NB-16, NB-17 and Pant Urvashi; 1st week of June in NB-5, NB-7, Pant Aparna, Pant Sujata, which proceeded from the top of the tree towards the lower branches.

#### Flowering, anthesis and dehiscence

Inkling of bud emergence in all the varieties started from different time, but it lasted from April to late June. The peak period was observed during 2nd fortnight of May in all the varieties. All the buds are globose, spheroid in shape in each variety and green in colour which commenced to full bloom from 13th May to 26th June among all the varieties. It was observed early blooming in (mid May) in the varieties

CISHB-1, NB-16, Pant Urvashi and in Goma Yashi, the peak period started from 6th June to 11th June whereas rest of the varieties had blooming in between 20th May to 26th June while peak period started from 7th June to 12th June. There were deviation in the time of initiation and termination of the anthesis which was between 5 to 8 A.M. among all the varieties of bael. It was observed early initiation (5.00A.M.) in the variety NB-7, NB-9, Pant Shivani and Pant Sujata. No flowers of any variety opened completely before 5 .00 A.M and followed specific time under semi-arid condition of western India. During anthesis, flowers starts loosening their floral part which later on blooms completely. Some flowers opened all petals at the time while other petals start opening one by one which takes 45 to 60 minutes in complete opening which may vary from flower to flower. In the inflorescence, lower side bud opened earlier as compared to rest of buds localized centrally in all varieties whereas varieties had anthesis vice versa where centrally located buds which were opened first compare to lateral buds. After anthesis within half an hour, the hint of the anthers dehiscence started which continued between 5.45- 8.30 A.M. The pollens were coming outside by bursting the anther centrally by pore. The anthers and floral organs shrunk and turn into brick red after dehiscence as time passed on. The findings regarding anthesis clarified that anthesis and anther dehiscence in bael varieties took place early in the morning (5.30 -8.30 A.M.) where low temperature and high humidity prevailed.

## Pollen viability and stigma receptivity

In newly opened flowers of all the varieties, pollen viability is about 95 % or more in the different varieties. Stigma receptivity after anthesis was recorded highest on same day within hour in all the varieties being the maximum in Pant Urvashi (68.53%) followed by Goma Yashi (65.19%) and it was least in NB-7 (45.27%) whereas similar trait was recorded between 7.95 - 15.52 % and 3.62-14.37% one day before and after the anthesis, respectively, which showed considerable difference in their values which had lesser percentage of stigma receptivity. Pollen viability was more than 95% among all the varieties.

## Pollination

As soon as flower started opening, honey bees (*Apis dorsata*), beetles, houseflies and butterflies visited the flowers for the foraging purpose, and large number of pollens stick to their abdomen and legs. Effective pollination occurred through the honeybees which visited the flower 5-23 times in 1 hour and carried highest number of pollen grains (29.65) than the rest of pollinators.

## Inflorescence morphology

Results of study divulged the considerable variations in their morphological characters of inflorescence among the varieties. Generally, all the varieties have axillary cymose with long peduncle type of inflorescence which was biparous, multiparous and uniparous. It was axillary biparous in CISHB-1, CISHB-2, NB-7, Pant Aparna, and Pant Urvashi; terminally multiparous cyme in NB-5 and NB-16; terminally biparous cyme in Pant Shivani and rest of the varieties had axillary multiparous cyme and differed in their length and number of flowers. Pant Sujata had the highest inflorescence length (10.85 cm) followed by Pant Aparna (10.82 cm), CISHB-2 (10.54 cm), NB-7 (9.37 cm) and NB-5 (8.73 cm) and the same was the lowest in Pant Shivani (5.67 cm) followed by Pant Urvashi (6.52cm) and NB-9 (6.74 cm). The maximum number of flowers per inflorescence was observed in the variety Pant Shivani (24.27) followed by NB-16 (23.22), Pant Sujata (21.18) and it was least in the variety CISHB-1(6.03) followed by NB-7(11.13). Varieties of the bael have a virtually similar ûoral morphology *viz.*, stalked, bracteolate, erect, sweet-scented, complete, actinomorphic, bisexual, slender pedillate, calyx shallow, united at the base short, broad teeth and pubescent outside, petals oblong-oval, dotted with glands, blunt and thick, hypogynous, anthers were long linear cream in colour having white short filaments. Ovary oblong-ovoid, slightly tapering into the thick short style which is again somewhat thicker at upward and capitates stigma. Corolla was also differed in their colour *i.e.* light green (NB-5and NB-17), whitish green (CISHB-1, NB-9, Pant Shivani and Goma Yashi) and greenish white (CISHB-2, NB-6, NB-16, Pant Aparna, Pant Sujata and Pant Urvashi) among the

varieties. The aestivation of sepals and petals also varied among different varieties *i.e.* imbricate to quincuncial. It was observed imbricate aestivation in CISHB-1, NB-5, NB-7, Pant Aparna, Pant Sujata and Pant Urvashi whereas rest of the varieties had quincuncial aestivation observed.

The quantitative characters of the floral parts varied significantly among all the bael varieties. The flowers were mostly tetramerous, but number of sepals and petals varied from 4 to 6 among the varieties. Varieties namely CISHB-1, NB-5, NB-7, NB-17 and Pant Urvashi had two kinds of flowers which were having 4 sepals, 4 or 5 petals and 5 sepals and 4 or 5 petals (tetramerous and pentamerous). NB-9, Pant Shivani had tetramerous flowers, Pant Aparna, Goma Yashi and Pant Sujata had 5 - 6 sepals from it one was unequal in size compare to rest of the sepals. Similarity was also observed in the case of petals where it was 5-6 in number in Pant Sujata. There were variability in the number of anthers which ranged between 36.67-61.23 among all the variety where it was maximum in Pant Urvashi (61.23 ) and least number of anthers were observed in Pant Aparna (36.67 ) followed by CISHB-2 (38.43), NB-5 (38.95) and NB-9 (39.57).

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

Co-Nodal Centre

Co-PI: Dr. A. K. Singh

Nine aonla varieties *viz.*, Banarasi, Krishna, Kanchan, Francis, Chakaiya, NA-7, NA-10, Anand-1 and Anand-2, were studied for the developing DUS-test guidelines at CHES, Vejalpur during the year 2013-2014. Variation in the plant morphological characters was observed among the varieties with respect to vegetative growth behavior, leaf characters, inflorescence colour and different fruit characters *viz.*, time of fruit set, time of fruit maturity and fruit retention percentage, fruit physico - chemical characters and seed characters.

Tree habit was observed upright spreading in Banarasi, Krishna, Chakaiya, tall upright in Anand-1,Aanad-2; tall spreading in NA-7; tall drooping in Francis; tall semi-spreading in Kanchan and NA-10. The foliage was dense and sparse among all the cultivars. The inflorescence colour was deep pink (Banarsi, Krishna and NA-10), yellowish green (Francis), pinkish green (NA-7 and Chakaiya) and green to light pink in Kanchan, Anand-1 and Anand-2.

The fruit set was recorded between the 21.9-47.9% among the varieties. The time of fruit set persisted from 2$^{nd}$ fortnight of February to 2$^{nd}$ fortnight of March among the varieties. The time of fruit maturity was recorded during last week of October in Banarasi, Francis, NA-10 and last week of November in Krishna, Chakaiya, Kanchan, Anand-1 and Anand-2. Days of maturity of different varieties ranged between 208 -220 days.

Fruit was large in Banarasi, Krishna, Francis; medium to large in NA-7, NA-10 and small in Kanchan, Chakaiya, Anand-1 and Anand-2. The fruit shape was triangular in Banarasi and Krishna, flattened round in Francis, NA-7, Chakaiya, Kanchan and NA-10 whereas flattened oval in Anand -1 and Anand-2. Fruit colour of Banarasi and Kanchan was whitish green, light green in Krishna, Francis and Chakaiya; Yellowish green in NA-7, NA-10 and Anand-2 and Greenish yellow in Anand-2. Fruit stalk end was observed short and thick (Banarasi, Krishna, NA-7 and NA-10) and short and thin (Francis, Chakaiya, Kanchan, Aanand-1 and Anand-2.) Fruit stem end cavity was shallow (Banarasi, Francis, Chakaiya, Kanchan, Anand-1 and Anand-2) and deep (Krishna, NA-7 and NA-10). Styler end was levelled in Banarasi, Francis, Chakaiya, Kanchan, and NA-10; prominent in Krishna and less prominent in NA-7, Anand-1 and Anand-2. Number of segments in all the varieties had six but in few varieties like Krishna and Kanchan rarely 6-8 segments also found.

The juice content was found to be the maximum in NA-7(70.45%) and the minimum in Chakaiya (40.52%). The astringency level was maximum in Krishna, Chakaiya, and NA-10 and minimum in NA-7 whereas rest of the varieties had medium astringency. The acidity ranged between 2.03-2.21 %, and being the maximum in Banarasi (2.21%) and the minimum in Kanchan and Anand-1(2.03%). The pulp content was the maximum in

Banarasi (31.91 g) and same was the minimum in Kanchan (23.95 g). The value for vitamin C content among all the varieties ranged between 334.12-461.76 mg /100gm. It was maximum in NA-10

**Table 36. Vegetative and fruiting attributes of different jamun genotypes (14-15)**

| Characters | Gokak 1 | Gokak 2 | Gokak 3 | KJP86 | KJP95 | Goma Priyanka |
|---|---|---|---|---|---|---|
| Tree height | Semi- tall | Semi- tall | Semi-Tall | Semi- tall | Semi- tall | Semi-Tall |
| Tree form | Spreading | Spreading | Semi- spreading | Semi- spreading | Spreading | Semi- spreading |
| Branch | Angled | Angled | Angled | Angled | Angled | Angled |
| No of leaves /30cm | 17 | 17 | 15 | 17 | 18 | 10 |
| Foliage | Dense | Dense | Dense | Dense | Dense | Dense |
| Colour of shoot | Brownish green | Brownish green | Brownish green | Brownish green | Brownish green | Brownish green |
| Length of panicle (cm) | 11.20 | 12.20 | 10.20 | 10.00 | 11.10 | 11.20 |
| Initiation of bloom | 9/2 | 11/2 | 12/2 | 13/2 | 11/2 | 15/2 |
| Full bloom | 4/3 | 8/5 | 13/5 | 15/3 | 3/3 | 13/5 |
| End of bloom | 13/3 | 15/3 | 19/3 | 22/3 | 16/3 | 21/3 |
| Leaf length(cm) | 13.10 | 12 | 12 | 16.80 | 12.3 | 13.5 |
| Leaf width (cm) | 8.1 | 6.2 | 6.0 | 8.40 | 4.7 | 6 |
| Leaf Shape | Elliptical Lanceolate | Elliptical Lanceolate | Elliptical Lanceolate | Elliptical Lanceolate | Elliptical Lanceolate | Elliptical Lanceolate |
| Leaf colour | Green | Dark green | Dark green | Dark green | Dark green | Dark green |
| Leaf apex | Acuminate | Acuminate | Acuminate | Acuminate | Acuminate | Acuminate |
| Leaf base | Decurrent-obtuse | Decurrent obtuse | Decurrent obtuse | Decurrent obtuse | Decurrent obtuse | Decurrent obtuse |
| Leaf margin | Entire | Entire | Entire - crenulate | Entire | Entire | Entire |
| Annual extension growth | 85.10 | 88.10 | 82.00 | 93.20 | 90.10 | 86.00 |
| No.of leaves/30cm Shoot | 8.00 | 8.33 | 5.50 | 6.00 | 6.25 | 6.00 |
| Petiole length(cm) | 2.75 | 2.4 | 1.6 | 1.64 cm | 1.7 | 2.4 |
| Internodal – length (cm). | 3.7 | 4.3 | 6.4 | 4.7 | 3 | 4.3 |
| Time of harvest | June 3rd week | June 3rd week | June 3rd week | June 3rd week | June 3rd week | June 3rd week |
| Stone size | Small | Small | Small | Medium | Small | Small |
| Stone shape | Oblong | Oblong | Oblong | Oblong | Oblong | Oblong |
| Fruit shape | Elliptic | Elliptic | Elliptic | Flattened | Flattened | Oblong |
| Fruit skin | Smooth and thin | Smooth and thin | Smooth and thin | Smooth and thin | Smooth and thin | Smooth and thin |
| Fruit colour | Purple Black | Deep purple | Deep purple | Purple | Deep purple | Deep purple |
| Fruit length(cm) | 2.31 | 3.8 | 4.51 | 3.42 | 3.62 | 5.18 |
| Fruit width(cm) | 2.16 | 3.01 | 3.05 | 2.8 | 2.9 | 3.12 |
| Fruit size | Large | Large | Large | Medium | Medium | Large |
| Fruit weight | 14.24 | 13.23 | 13.82 | 10.25 | 9.27 | 16.82 |
| Stone weight (g) | 2.08 | 2.21 | 2.22 | 1.84 | 1.34 | 1.28 |
| Stone% | 14.56 | 16.70 | 16.06 | 17.95 | 14.45 | 7.60 |
| Pulp weight (g) | 12.16 | 11.02 | 11.60 | 8.41 | 7.92 | 15.54 |
| Pulp (%) | 85.39 | 83.31 | 83.92 | 82.04 | 85.44% | 92.38% |
| TSS (Degree Brix) | 12.20 | 10.75 | 11.4 | 10.2 | 12.25 | 18.4 |
| Acidity % | 1.92 | 1.05 | 0.84 | 0.76 | 1.96 | 0.84 |
| Total sugars % | 18.72 | 10.5 | 9.46 | 13.48 | 24.74 | 8.46 |
| Vitamin C mg/100gml | 40.66 | 22.83 | 33.20 | 20.83 | 41.66 | 35 |

(461.76 mg/100gm) followed by NA-7 (453.20 mg/100gm) and the same was minimum in Banarasi (334.12mg/100gm). The total soluble solids were recorded maximum in NA-7(11.50% Brix) and the minimum in Banarasi (8.00% Brix). The fruits of Banarasi had maximum specific gravity (1.43) and minimum in Francis (1.06) among all the varieties.

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

Co-Nodal Centre

Co-PI: Dr. Sanjay Singh

Six genotypes of jamun were studied for vegetative and fruiting attributes which are summerized in table 36.

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

Nodal Centre

PI: Dr. Sanjay Singh

Co-PI: Dr. A. K. Singh

Dr. R. Bhagava

#### Tamarind

Total 10 genotypes/ cultivars were studied. All cultivars were having semi- tall character. CHEST-7, CHEST-8, CHEST-9, CHEST-10, CHEST-12, CHEST-14 had semi spreading type growth habit, while CHEST-11, CHEST-13, was of drooping type growth pattern. The genotypes CHEST-15 and CHEST-16 showed spreading growth pattern. Number of leaves/shoot (Annual extension growth) was 42.00, 43.10, 40.12, 43.50, 40.12, 41.00, 43.20, 45.20, 38.12 and 34.10 in CHEST-7, CHEST-8, CHEST-9, CHEST-10, CHEST-11, CHEST-12 CHEST-13, CHEST-14, CHEST-15 and CHEST-16 respectively. Length of panicle was 12.00 cm, 10.00 cm,13.40 cm, 11.20 cm, 12.50 cm, 14.20 cm, 10.00 cm, 12.20 cm, 14.40 cm and 15.50cm in CHEST-7, CHEST-8, CHEST-9, CHEST-10, CHEST-11, CHEST-12 CHEST-13, CHEST-14, CHEST-15 and CHEST-16 respectively.

#### Chironji

Detailed characters like vegetative and fruiting attributes were recorded to develop the DUS descriptors. Total 10 genotypes were studied. It was observed that CHESC-11, CHESC-12 and CHESC-13 CHESC-16, CHESC-17 and CHESC-18 were found to be semi tall type, while CHESC-14, CHESC-15, CHESC-19 and CHESC-20 were found to be tall type. Foliage was dense and leaf was elliptical lanceolate. Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined in all genotypes.

**Table 37. Characteristics of tree and leaves of different chironji genotypes**

| Characters | CHESC-11 | CHESC12 | CHESC-13 | CHESC-14 | CHESC-15 |
|---|---|---|---|---|---|
| Tree height | Semi- tall | Semi- tall | Semi-tall | Tall | Tall |
| Tree form | Semi-spreading | spreading | Semi- spreading | Up right | upright |
| Branch | Angled | Angled | Angled | Angled | Angled |
| Foliage | Dense | Dense | Dense | Dense | Dense |
| Leaf | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined | Leaves thickly coriaceous, elliptical, obtuse, reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined |
| Tree height | Semi- tall | Semi- tall | Semi-tall | Tall | Tall |
| Tree form | Upright | Semi- spreading | Spreading | Up right | Up right |
| Branch | Angled | Angled | Angled | Angled | Angled |
| Foliage | Dense | Dense | Dense | Dense | Dense |
| Leaf | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined | Leaves thickly coriaceous, elliptical, obtuse, reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined | Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined |

# 8. PUBLICATION

## Research Papers


Arya, L, Narayanan, K., Verma, M., Singh, A. K. and Gupta, V. 2014. Genetic diversity and population structure analysis of *Morinda tomentosa* Heyne, with neutral and gene based markers. *Genetic Resources and Crop Evolution*, DOI10.1007/S10722-014-0168-4.

Attri, B. L., Krishna, H., Das, B., Ranjan, J. K., Pragya and Ahmed, N. 2014. Effect of salicylic acid and calcium on shelf life of different cultivars of peach. *Indian Journal of Horticulture*, 71(1):92-98.

Attri, B. L., Krishna, H., Ahmed, N., & Kumar, A. 2014. Effect of blending and storage on the physico-chemical, antioxidants and sensory quality of different squashes. *Indian Journal of Horticulture*, 71(4): 546-553.

Choudhary, B. R., Haldhar, S. M., Maheshwari, S. K., Bhargava, R. and Sharma, S. K. 2015. Phytochemicals and antioxidants in watermelon (*Citrullus lanatus*) genotypes under hot arid region. *Indian Journal of Agricultural Sciences*, 85(3): 414–417.

Choudhary, B. R., Kumar, S. and Sharma, S. K. 2014. Evaluation and correlation for growth, yield and quality traits of ridge gourd (*Luffa acutangula*) under arid conditions. *Indian Journal of Agricultural Sciences*, 84(4): 498-502.

Choudhary, B. R., Pandey, S., Singh, P. K. and Pandey, V. 2014. Genetic diversity analysis for quantitative traits in hermaphrodite ridge gourd [*Luffa acutangula* (Roxb.) L.]. *Indian Journal of Horticulture*, 71(2): 284-287.

Haldhar, S. M., Choudhary B. R., Bhargava R., and Sharma S. K. 2013. Screening of ridge gourd varieties/ genotypes (*Luffa acutangula*) for resistance to fruit fly (*Bactrocera cucurbitae*) in hot arid region of Rajasthan. *Indian Journal of Arid Horticulture*, 8 (1-2): 21-24

Karuppaiah, V., Krishna, H., Singh, R.S., Sharma, B.D. and Sharma, S.K. 2013. Status of stone weevil, *Aubeus himalayanus* Voss (Curculionidae: Coleoptera) in India: An emerging pest of *ber* (*Ziziphus mauritiana* Lamk). *Indian Journal of Arid Horticulture*, 8(1-2): 5-9**.** (Published in 2014).

Karuppaiah, V. 2014. Biology and management of ber fruitfly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae): A review. *African Journal of Agricultural Research*, 9 (16), 1310-1317.

Krishna, H., Attri B.L. and Kumar A. 2014. Improvised Rhododendron squash: processing effects on antioxidant composition and organoleptic attributes. *Journal of Food Science & Technology*, 11: 3404-3410.

Krishna, H., Alizadeh, M. and Chauhan, N. 2013. Exploitation of somaclonal variations in improvement of fruit crops - A review. *Indian Journal of Arid Horticulture*, 8(1-2): 1-4. (Published in 2014)

Maheshwari, S. K., Choudhary, B. R., Singh, D., Sharma, B. D. and Sharma, S. K. 2013. Screening of watermelon genotypes for resistance to mosaic disease under hot arid conditions of Rajasthan. *Indian Journal of Arid Horticulture*, 8: 16-17. (published in 2014).

Jatav, M. K., Manoj Kumar, Dua, V. K., Kumar, Sushil and Trehan, S. P. 2014. Distribution of different forms of potassium in potato growing soils of Jalandhar district of Punjab. *Int. J. Agricult. Stat. Sci***.,** 10(1):175-179

Patel, M. N., Parmar, L. D., Parihar, A. Singh, A. K. and Sheikh, W. A. 2014. A high throughput DNA Extraction Protocol and its utilization in molecular characterization of Noni (*Morinda citrifolia* L.) genotypes. *Current Trends in Biotechnology and Pharmacy*, 8(2):166-174.

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.

Sahoo, B., Nedunchezhiyan,M.and Acharyya,P.2014. Spectrophotometric estimation studies of mineral nutrients of elephant foot yam cv. Gajendra influenced by varied nutrient regimes under rainfed alfisols, *Indian Agric*. Vol. 58, No. 3 (In Press).

Sengupta, S., Das, B., Acharyya, P., Prasad, M. and Ghose, T. K. 2014. Genetic diversity analysis in a set of Caricaceae accessions using resistant gene analogues. BMC Genetics, 15: 137 doi: 10.1186/s12863-014-0137-0.

Singh, A. K., Singh, Sanjay, Appa Rao, V. V., Hiwale, S. S., Joshi, H. K. 2014. Dynamics of vegetative morphomatrix, productivity and economics of NA-7 aonla (*Emblica officinalis* Gaertn) in different planting systems under rainfed conditions. *Indian Journal of Agricultural Science*, 84 (9):21-26.

Singh, A. K., Singh, Sanjay, Singh, R. S., Joshi, H. K., and Sharma, S. K. 2014. Characterization of bael varieties under rainfed hot semi-arid environment of western India. *Indian Journal of Agricultural Sciences*, 84(10): 80-86.

Singh, A. K., Singh, S., Singh, R. S., Joshi, H. K. and Sharma, S. K. 2014. Characterization of bael *(Aegle marmelos*) varieties under rainfed hot arid environment of western India. *Indian Jour. of Agric. Scinces*,84 (10) :1236-42.

Singh, Sanjay and Singh, A K. 2015. Standardization of time of softwood grafting in mahua (*Bassia latifolia*) and khirni (*Manilkara hexandra* ) under semi-arid environment of western India. *Indian Journal of Agricultural Sciences*, 85(2): 166-70.

Singh, A. K. Singh, Sanjay and More, T. A. 2014. Preliminary evaluation of bael varieties under rainfed conditions of western India. *Indian Journal of Horticulture*, 71 (2): 264-68.

Singh, A. K., Singh Sanjay, Appa Rao, V. V., Hiwale, S. S. and Joshi, H. K. 2014. Long term effect of INM on aonla and soil quality under rainfed hot semi-arid environment**.** *Indian Journal of Agricultural Sciences*, 84 (5): 37-40.

Singh, A. K., Singh, Sanjay and Joshi, H. K. (2014). Characterization of *Morinda tomentosa* Heyne ex Roth genotypes under rainfed conditions of western India. *Indian Journal of Agricultural Sciences*, 84 (11):115-22.

Singh, R. S., Bhargava, R., and Singh, A. K.. 2013. Orgenoleptic rating of RTS prepared from pulp of bael cultivars. *Indian Jour Arid Hort.*, 8:62-64. (published in 2014).

Singh, R. S., Bhargava, R., Pal, Garima and Sharma, B. D. 2014. Effect of spacing on growth and biomass production in bael (*Aegle marmelos* Correa.) under hot arid conditions. *Prog.Hort., 258-260*.

Singh, R.S., Garima Pal, Bhargava, R. and Sharma, B. D. 2013 Utilization of Date fruits for Making Delicious Biscuits. *Annals of Arid Zone*, 52(2): 125-127.

## Abstract of paper published in proceedings of seminar/symposium

Acharyya, P. and Sharma, S. K. 2015. Plant genetic resource management under emerging climate change in "National seminar on Current trends in environmental research" organized by Dept. of Environmental Science, Maharaja Ganga Singh University, Bikaner during 28th February to 28th March, 2015. pp:45-46.

Haldhar, S. M., Bhargava, R., Singh, R. S., Krishna, H. and Sharma, S. K. 2014. Record of the small salmon Arab, *Colotis amata* F. on *pilu* (*Salvadora persica* L.) in arid region of Rajasthan: Incidence and morphometric analysis. Abstract. In: International Conference on Horticulture for Nutritional Livelihood and Environmental Security in Hills held at Kalimpong, Darjelling from March 22-24, 2014. Pp. D-47-48.

Maheshwari, S. K. Choudhary, B. R., Singh, D., Sharma, B. D. and Sharma, S. K. 2015. Management of mosaic disease of watermelon/ *mateera* in western Rajasthan. Paper presented an Oral in "National Symposium on Recent Advances in Diagnosis and Management of Diseases of Field and Horticultural Crops" held on 28th February-1st March, 2015 at Deptt. of Plant Pathology, N. D. Univ. of Agriculture & Technology, Kumarganj, Faizabad, (U.P.), Abs. pp. 20

Malakar, M., Biswas, S. and Acharyya, P. 2014. Diversity analysis of *Heliconia* species through the use of RAPD markers. in " National seminar on Integrated Approaches in Horticulture for sustainable development" organized by Palli Siksha Bhavana, Visva Bharati, Sriniketan and Uttar Banga Krishi Viswavidyalaya during 29-30th November, 2014.pp: 9

Meena, S. R., Sharma, B. D., Singh, R. S. and Haldhar, S. M. 2015. Bio-organic preparations complying to reduce the load of insect-pests on Horticultural crops In**.** Abstract of National Seminar on Hi-tech Horticulture for enhancing Productivity, Quality and Rural Prosperity at NRCSS, Ajmer from January, 19-20, 2015, pp. 119.

Meena, S. R., Singh, R. S., Singh, D. and Sharma, S. K. 2014. Traditional eco-friendly pesticides applied to protect the horticultural crops from the attack of insect-pests in hot arid regions of western Rajasthan published in book of abstract of International conference: Changing scenario of pest problems in Agri-horti ecosystem and their management to be organized by Entomological Research Association, Udaipur and Department of Entomology, RCA, Udaipur, MPUAT, Udaipur from 27 -29 November. pp. 7-8

Meena, S. R., Sharma, B. D., Singh, R. S. and Haldhar, S. M. (2015). Bio-organic preparations complying to reduce the load of insect-pests on horticultural crops without environmental risk: Conceptual evaluation published in book of abstract of book of abstract of National Seminar to be organized on "Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity" at ICAR-NRCSS, Ajmer, Rajasthan, during January 19- 20, 2015. pp.119

Meena, S. R., Sharma, B. D., Singh, R. S. and Singh, D. 2015. Rural talent in value addition and expend of underutilized fruits and vegetables in hot arid regions of western Rajasthan: Noble concepts and methods formation published in book of abstract of book of abstract of National Seminar to be organized on "Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity" at ICAR-NRCSS, Ajmer, Rajasthan, during January 19-20, 2015. pp.184

Meena, S. R., Sharma, B. D., Singh, R. S. and Singh, D. 2015. New dimensions of conservation of biodiversity in Indian desert through arid horticultural development published in book of abstract of National Seminar on current trends in environmental research (NACTER-2015) organized by Department of Environmental Science Maharaja Ganga Singh University Bikaner (Rajasthan) during February 28th-March 2nd, 2015. pp. 94

Muralidhara, B. M., Singh, R. S., Bhargava, R. and Krishna, H. 2014. Biochemical and Nutraceutical Compounds in Date Palm Cultivars. Abstract. In: 6th Indian Horticulture Congress held at Coimbatore (T.N.) from November 6-9, 2014,. Pp 31-32.

Murlidhara, B.M., Singh, R.S., Bhargava, R. and Veena, G.L. 2014. Morphological changes during different stages of fruit development in date palm cultivars. In. Souvenir & Abstract of International symposium on Innovation in Horticulture for Nutritional security, conservation biodiversity and poverty allevation,16-18 October,2014 at Babasaheb Bhimrao Ambedkar University, Lucknow, pp149.

Rajkumar, Tiwari, R. B., Sharma, B.D., Singh, R. S., and Sharma, S. K. 2014. Organoleptic evaluation of Spiced-aonla-segments. *In:* National Conference on Pre-/post-harvest losses and value addition in vegetables held at Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh from July 12$^{nd}$-13$^{th}$, 2014.

Haldhar, S. M., Choudhary, B. R., Bhargava, R. and Sharma, S. K. 2014. Screening of watermelon [*Citrullus lanatus* (Thunb.) Mansf.] varieties/ genotypes against fruit fly (*Bactrocera cucurbitae* (Coquillett)) in hot arid region of Rajasthan. International conference on "Changing scenario of pest problems in Agri-horti ecosystem and their management" during 27-29, November, 2014 at RCA, MPUAT, Udaipur.

Haldhar, S. M., Bhargava, R., Singh, R. S., Krishna, Hare and Sharma, S. K. 2014. Record of the

Small Salmon Arab, *Colotis amata* F. on Pilu (*Salvadora persica* L.) in Arid Region of Rajasthan: Incidence and Morphomatric analysis. International conference on 'horticulture for nutrition, livelihood & environmental security in hills: opportunity and challenges' organized by UBKV (Hill campus), Kalimpong, WB during 22-24, May, 2014.

Singh, Sanjay, Singh, A. K. and Sharma, S K. 2014. Potential of under utilized fruits for peri urban horticulture. Full lenth paper published in proceedings of International symposium on peri urban Agriculture for improving livelihood opportunities during 25-26 November, 2014, Lucknow, organized by Samagra Vikas Welfare Society, Lucknow, pp 37-43.

Sharma, B. D., Singh, R. S., Bhargava, R. and Sharma, S.K. 2014. Response of integration to nutrient sources on the growth, fruit yield and quality parameters of kinnow in hot arid conditions of western Rajasthan. In Book of Abstract, Global Conference on Technological Challenges and human resources for climate smart horticulture- Issues

Sharma, S. K., Hare Krishna, Singh, R.S. and Sharma, B. D. 2014. Plant Genetic resources of Underutilized arid fruits**.** In. Souvenir and Abstract of National Seminar on Strategies for conservation, improvement and utilization of underutilized fruits, at CHES, Chettali, Kodagu, 1-3 Dec., 2014, pp. 26-43.

Sharma, S. K., Hare Krishna, Singh, R. S. and Sharma, B. D. 2014. Plant Genetic resources of Underutilized arid fruits**.** In. Souvenir and Abstract of National Seminar on Strategies for conservation, improvement and utilization of underutilized fruits, at CHES, Chettali, Kodagu, 1-3 Dec., 2014, pp.26-43.

Sharma, S. K., Krishna, H. and Sharma, B. D. 2015. Status and prospects of hi-tech horticulture in arid regions. In: Souvenir of National Seminar on Hi-Tech horticulture for enhancing Productivity, Quality and Rural Prosperity held from January 19-20, 2015 at ICAR-NRCSS, Ajmer, Rajasthan, pp, 13-20.

Singh, R. S. and Sharma, S. K. 2014. Introduction and Evaluation of Exotic fruit species in hot arid region In National Seminar on "Global Conference on Technological Changes and Human Resources for Climate Smart Horticulture-Issues and Strategies scheduled to be held at NAU, Navsari during 28-31 May, 2014, pp50-51.

Singh, A. K., Singh, Sanjay and Makwana, P. 2014. Studies on phenological changes and variation in qualitative characters in bael varieties under zero irrigation conditions. International Conference on Technological Intervention in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value Addition, November 11-13, 2014.

Singh, A. K., Singh, Sanjay and Makwana, P. 2014. Evaluation of *Morinda tomentosa* genotypes for physico-chemical attributes in rainfed semi-arid environment of western India. Noni Search, 2014, Ninth National Symposium- Noni for everyone held at Goa on 27and 28 th September, 2014. Pp 24-27.

Singh, A. K., Singh, Sanjay and Makwana, P. 2014. Evaluation of *Morinda tomentosa Heyne ex Roth* genotypes under dryland conditions of hot semi-arid environment. International Conference on Technological Intervention in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value Addition, November 11-13, 2014.

Singh, A. K., Singh, Sanjay, Makwana, P. and Contractor, K. 2014. Characterization of aonla (*Emblica officinalis* Garten) varieties under rainfed semi arid condition of western India. Global Conference on Technological Challenge and Human Resources for Climate Smart Horticulture- Issue and Strategies during May, 2014, NAU, Gujarat pp. 50.

Singh, A. K., Singh, Sanjay, Singh, R. S., Contractor K. and Makwana, P. 2014. Evaluation of bael varieties for fruit characters under hot semi-arid environment of Western India. Global Conference on Technological Challenge and Human Resources for Climate Smart Horticulture- Issue and Strategies during May, 2014, NAU, Gujarat, pp. 49.

Singh, R. S., Bhargava, R., Sharma, B. D. and Sharma, S. K. 2014. Prospects and Constraints in Date palm cultivation under Hot Arid region. In**.** Global Conference on Technological Changes and Human Resources for Climate Smart Horticulture-Issues and Strategies

scheduled to be held at NAU, Navsari during 28-31 May, 2014,pp36-37.

Singh, R. S., Bhargava, R., Sharma, B. D. and Sharma, S. K. 2014. Influence of climate change on spathe emergence, flowering and fruiting in Date palm cultivars under arid conditions In: National Seminar cum Workshop on "Physiology of flowering in Perennial fruit crops" held at CISH, Lucknow during 24-26 May, 2014, pp 61.

Sivalingam, P. N., Singh, D., Gurjar, K. and Bhargava, R. 2014. Transcriptome profiling during low moisture stress in *Ziziphus nummularia* (Burm.f) Wight & Arn- A perennial fruit tree species for Rajasthan, India. In: International conference on Horticulture for nutritional livelihood and environmental security in hills. Kalimpong, Darjling, 22-24 May 2014. C-39

Sivalingam, P. N., Singh, D., Gurjar, K. and Bhargava, R. 2015. Differential expression of transcripts during low moisture stress in *Ziziphus nummularia*. In: Proc. of International Conference on Second International Conference on Bio-resource and stress management at Hyderabad during 07-10 January 2015.

## Popular articles

Choudhary, B. R., Haldhar, S. M., Maheshwari, S. K., Meena, S. R. and Sharma, S. K. 2014. Maximum profit from cucurbits in hot arid regions under changing conditions. *Phal Phool* (March-April). pp. 25-29.

Choudhary, B. R., Singh, P. K., Pandey, S. and Singh, M. 2014. Satputia Kashi Khushi to make farmers cheer. *Indian Horticulture*, 59(5): 11-12.

Haldhar, S. M., Singh, R. S., Bhargava, R. and Sharma, S. K. 2014. Small salmon arab on pilu in arid region of Rajasthan. *ICAR News*, January-March. Pp 17.

Karuppaiah, V. 2014. Eco-friendly Management of Leaf Webber and Capsule Borer (Antigastra catalaunalis Duponchel) Menace in Sesame. *Popular Kheti*, 2(2):127-130.

Maruthadurai, R. and Karuppaiah, V. 2014. Managing Menace of Insect Pests on Custard Apple. *Popular Kheti*, 2(3): 108-111.

Singh, H. and Haldhar, S. M. 2014. Termites control by avoiding chemicals. http://www.krishisewa.com/cms/disease-management/470-termites.html (on line publication).

Singh, A. K. 2014. *Gujarat ni jameen man Meethas Umertu Phad Bili. Ek Prayash*, Gandhnagar, July, pp. 42 – 44.

Singh, A. K., Singh, Sanjay and Appa Rao, V. V. 2014. Mulching enhances aonla yield in rainfed areas. *Indian Horticulture*, March-April, pp. 29-31.

Singh, A. K., Singh, Sanjay, Singh, R. S. and Makwana, P. 2014. Reaping diseases and pest free bael. *Indian Horticulture*, November-December, pp35-36.

Singh, A. K., Singh, Sanjay, Singh, R. S., Contractor, K. and Makwana, P. 2014. *In-situ* patch budding for better establishment of bael in rainfed areas, *Indian Horticulture*, September – October, pp. 24-25.

Singh, D., Sivalingam, P. N. and Meena, S. R. 2014. Hitech nursery management and mass propagation of fruit crops. In: New technique of arid horticulture production (edited by Meena et al.,) published by CIAH, Bikaner pp 79-85.

Sivalingam, P. N., Bhargava, R., Sharma, S. K. and Muralidharan, C. M. 2014. Meeting Report-Date palm. *Current Science* 107: 1373-1374.

सिंह, ए. के., सिंह, संजय और मकवाना, पी. 2015. शुष्क क्षेत्र के लिए उपयोगी गोमा यशी बेल, फल फूल, जनवरी–फरवरी 2015 पेज 6–8.

हलधर, एस. एम., करूप्पइया, वी., मीना, एस. आर. और सिंह, आर. एस. 2013. शुष्क क्षेत्र में बेर में लगने वाले मुख्य कीट, क्षति एवं पहचान, मरू बागवाणी 8: 25.27.

कस्वां, पी. के., कस्वां, एस. एल. और हलधर, एस. एम. 2013. जैविक कीट नियंत्रण, मरू बागवाणी, 8: 48. 50.

समादिया, दिलीप कुमार 2013. बागवानी आधारित फसल उत्पादन में प्रक्षेत्र प्रबंधन तकनीक की भूमिका। मरू बागवानी, केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर। 8: 13–17.

समादिया, दिलीप कुमार 2014. शुष्क क्षेत्रीय सब्जी उत्पादन की उन्नत तकनीक। वैज्ञानिक लेखः शुष्क बागवानी

फसलोत्पादन की नवीन तकनीकें (संपादक – एस. आर. मीना एवं आदि), केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर। पेज 23–35.

समादिया, दिलीप कुमार 2015. शुष्क क्षेत्रीय सब्जी फसल उत्पादन व्यवस्थायें। वैज्ञानिक लेखः नवीनतम तकनीकी द्वारा सब्जी का उत्पादन एवं कटाई उपरान्त प्रबंधन (संपादक – बी. के. दुबे एवं आदि), राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रति ठान, करनालः हरियाणा। पेज 35–44.

कृष्ण, हरे, कुमार, सुशील, माहेश्वरी, करूप्पैया, वी., मीना, शिवराम एवं चौहान, नितेश 2014. बेर, आंवला एवं फालसा की उन्नत खेती में शुष्क क्षेत्रीय फल एवं स्ब्जी फसलोंत्पादन की नवीन तकनीकें (संपादक शिवराम मीना, बी डी शर्मा, एम के जाटव, एस एम हलधर एवं डी सिंह पृष्ठ 13–13.

माहेश्वरी, एस. के. और चौधरी, बी. आर. 2013. तरबूज और लौकी की प्रमुख बीमारियां एवं एकीकृत नियंत्रण, मरू बागवाणी 8:34–37 2014 में प्रकाशित.

माहेश्वरी, एस. के. कृष्ण, हरे, मीना, एस. आर. और चौहान, एन. 2014. शुष्क क्षेत्रीय फलों वाली फसलों में समेकित बीमारी प्रबन्धन, शुष्क बागवाणी फसलोंत्पादन की नवीन तकनीकें में प्रकाशित (संपादनक मीना आदि पुष्ठ 86–88)

माहेश्वरी, एस. के., चौधरी, बी. आर. और मीना, एस. आर. 2014. शुष्क क्षेत्रीय फलों वाली फसलों में समेकित बीमारी प्रबन्धन, शुष्क बागवाणी फसलोंत्पादन की नवीन तकनीकें में प्रकाशित (संपादनक मीना आदि पृष्ठ 98–96).

राजकुमार, कुमार, रमेश एवं गोरा, जगन सिंह 2015. शुष्क क्षेत्र में फल एवं सब्जियों का आधुनिक तकनीकों द्वारा प्रसंस्करण शुष्क क्षेत्रों में बागवानी एवं मसाला फसलों की खेती, केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, क्षेत्रीय केन्द्र, बीकानेर द्वारा प्रकाशित पृष्ठ संख्या 87–94.

कुमार, रमेश, राजकुमार, एवं गोरा, जगन सिंह 2015. शुष्क क्षेत्र में पुष्प उत्पादन का महत्व एवं सम्भावनाएं शुष्क क्षेत्रों में बागवानी एवं मसाला फसलों की खेती केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, क्षेत्रीय केन्द्र, बीकानेर द्वारा प्रकाशित पृष्ठ संख्या 57–63.

गोरा, जगन सिंह, राजकुमार एवं कुमार, रमेश 2015. मूलवृंत एवं प्रवध्रन की तकनीकों का बागवानी में महत्तव, केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, क्षेत्रीय केन्द्र, बीकानेर द्वारा प्रकाशित पृष्ठ संख्या 5–18.

राजकुमार, गोरा, जगन सिंह एवं मीना, एस. आर. 2014. वैज्ञानिक तरीकों से शुष्क क्षेत्रों में फल और सब्जियों का संरक्षण, शुष्क बागवानी फसलोत्पादन की नवीन तकनीकें, केन्द्रीय शुष्क बागवानी संस्थान द्वारा प्रकाशित पृष्ठ संख्या 89–95.

हलधर, एस. एम., राजकुमार, करूप्पैया, वी. एस. और गोरा, जगन सिंह 2014. शुष्क बागवानी फसलोत्पादन की नवीन तकनीकें, केन्द्रीय शुष्क बागवानी संस्थान द्वारा प्रकाशित पृष्ठ संख्या 63–71.

मीना, शिवराम, राजकुमार, हलधर, एस. एम., जाटव, एम. के., माहेश्वरी, एस. के. एवं कृष्णा, हरे 2014. शुष्क क्षेत्रीय फल व सब्जियों के मूल्य सवंर्धित पदार्थः ध ानोपार्जन तथा आजीविका संरक्षण के स्त्रोत शुष्क बागवानी फसलोत्पादन की नवीन तकनीकें, केन्द्रीय शुष्क बागवानी संस्थान द्वारा प्रकाशित पृष्ठ संख्या 104–110.

मीना, एस. आर. एवं शर्मा, एस. के. 2013. शुष्क क्षेत्रों की प्रमुख अवप्रयोगी सब्जियों के पारम्परिक मूल्य संवध ान एवं आर्थिक लाभ–एक मूल्यांकन, मरूबागवाणी 8:1.

हलधर, एस. एम., करूप्पईया, वी., मीना, एस. आर. और सिंह, आर. एस. 2013. शुष्क क्षेत्रों में लगने वाले मुख्य कीट, क्षति एवं पहचान, मरूबागवाणी 8:25

जाटव, मुकेश, कुमार, उत्तम एवं कुमार, बबलेश 2014. उन्नत तकनीक से मूली की खेती. मरूबागवाणी पृष्ठ 21–24.

## Books and Book chapters

### Book

Choudhary, B. R. 2014. Vegetables. Kalyani Publishers, New Delhi. pp. 1-306.

### Book Chapters

Acharyya, P. and Singh, R. S. 2015. Mangosteen In : Underutilized fruit crops of India(Ed. Ghosh, S. N.) Narendra Publishing House, New Delhi. (In Press).

Bairwa, S. K. and Choudhary, B. R. 2014. Scientific cultivation of bitter gourd (*Momordica charantia* L.). In: Advances in Vegetable Agronomy. Edited by Choudhary *et al*. Published by Director, ICAR-IARI, New Delhi. pp. 123-126.

Choudhary, B. R. and Bairwa, S. K. 2014. Scientific cultivation of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. In: Advances in Vegetable Agronomy. Edited by Choudhary *et al*. Published by Director, ICAR-IARI, New Delhi. pp. 116-122.

Choudhary, B. R. and Sharma, S. K. 2015. Production technology of vegetables in hot arid regions (Hindi). In: Diversification of agriculture through vegetables. Edited by P.M.

Singh *et al*. Published by Director, ICAR-IIVR, Varanasi. pp. 29-34.

Krishna, Hare and Maheshwari, S. K. (2014). Physiology of rooting and growth in fruit plants. *In:* Propagation of Horticultural Plants-Arid and Semi-Arid Regions (Eds. Singh, R. S. and Bhargava, R.). New India Publishing Agency, New Delhi. pp. 55-72.

Krishna, H. 2014. Micro Propagation of Horticultural Crops. In: Propagation of Horticultural Plants: Arid and Semi-arid Regions (Eds. Singh, RS and Bhargava, R). New India Publishing Agency, Delhi, India. pp. 41-53.

Krishna, H., Parashar, A., Awasthi, O. P., Singh, K. 2014. Ber. In: Tropical and Sub Tropical Fruit Crops: Crop Improvement and Varietal Wealth, Part-I (Ed. Ghosh, SN). Jaya Publishing House, Delhi-110095 (India), pp. 137-156.

Maheshwari, S. K. and Krishna, Hare 2014. Management of disease and insects in nursery plants. *In:* Propagation of Horticultural Plants-Arid and Semi-Arid Regions (Eds. Singh, R. S. and Bhargava, R.). New India Publishing Agency, New Delhi. pp. 535-552.

Pandey, S. and Choudhary, B. R. 2014. Cucumber. In: Handbook of Vegetables. Vol. III. Edited by K.V. Peter and P. Hazra. Studium Press LLC, U.S.A. pp. 121-149.

Hiwale, S. S. 2014. Phalsa In: Hand Book of Horticulture Eds. K.L.Chadha Revised version.

Hiwale, S. S. 2014. Biodiversity in Horticultural crops Custrad apple Biodiversity" Chapter 8 Edits. Peter, K. V. Daya Publishing House, New Delhi.

Hiwale, S. S. 2014. Indian jujube breeding boo chapter no. 19 in book "Fruit Breeding" edits M.R. Dinesh NIPA publisher New Delhi.

Hiwale, S. S. 2014. Wood apple In: Hand Book of Horticulture, Eds. K.L.Chadha Revised version.

Sharma, R. R. and Krishna, H. 2013. Fruit Production: Major Fruits. Daya Publishing House, New Delhi, India (ISBN: 9788170358565). 493p.

Sharma S. K., Krishna, H,, Singh, R. S. and Sharma, B. D. 2014. Plant genetic resources of underutilized arid fruits. In: Souvenir of National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits (Eds. Tripathi PC, Sankar V, Senthilkumar R and Karurakaran G). 1-3 December, 2014 at CHES, ICAR-IIHR, Chettali, Kodagu. pp. 26-43.

Sharma, S. K., Krishna, Hare, Maheshwari, S. K. and Chauhan, N. (2014). Water chestnut (*Trapa bispinosa* Roxb.). *In:* Future Crops. Vol. 2 (E. Peter, K. V.). Daya Publishing House, New Delhi. pp. 337-341.

Sharma, S. K. and Krishna, H. 2015. Status and propects of hi-tech horticulture in arid regions. In: Souvenir of National Seminar on Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity held from January 19- 20, 2015 at ICAR-NRCSS, Ajmer, Rajasthan, pp. 13-20.

Sharma, S. K., Krishna, H. and Parashar A. 2014. *Lasoda* (*Cordia myxa* Roxb.). In: Future Crops, Vol. II (Ed. Peter, KV). Daya Publishing House, New Delhi, India. pp. 293-296.

Singh, A. K. 2014. Noni, Propagation of Horticultural plants of Arid and Semi-Arid region (Edts R. S. Singh and R. Bhargava). New India Publishing Agency New Delhi, pp.379-88.

Singh, A. K. and Singh, R. S. 2014. Aonla: Propagation of Horticultural plants of Arid and Semi-arid Region (Edts R. S. Singh and R. Bhargava). New India Publishing Agency, New Delhi, pp.177-88.

Singh, R. S. and Maheshwari, S. K. 2014. Manila Tamarind (*Pithecellobium dulce* Roxb.) *In:* Propagation of Horticultural Plants-Arid and Semi-Arid Regions (Eds. Singh, R. S. and Bhargava, R.). New India Publishing Agency, New Delhi. pp. 229-236.

Singh, R. S. and Krishna H. 2014. Nursery Management for Production of Quality Planting Materials. In: Propagation of Horticultural Plants: Arid and Semi-arid Regions (Eds. Singh, R. S. and Bhargava, R). New India Publishing Agency, Delhi, India. pp. 91-112.

जाटव, एम. के., मीणा, एस. आर., आचार्य, पी., गोरा, जे. एस. और पारीक, ओ. पी. 2014. शुष्क क्षेत्र में सब्जियों में पोषक तत्व की कमी एवंम उनकी पूर्ति

के उपाय पेज 57–62. शुष्क बागवाणी फसलों की नवीन तकनीकी में प्रकाशित, संपादक एस आर मीना, बी डी शर्मा, एम के जाटव, एस एम हलधर और धुरेन्द्र सिंह.

मीना, शिव राम, शर्मा, बी. डी., जाटव, मुकेश कुमार और हलधर, एस. एम. 2014. शुष्क बागवाणी फसलों की नवीन तकनीकी, केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर–334006 (राजस्थान), पेज 1–110.

मीना, शिव राम, शर्मा, बी. डी., जाटव, मुकेश कुमार, हलधर, श्रवण एम. 2014 शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें केन्द्रीय शुष्क बागवानी संस्थान, बीछवाल, बीकानेर.–334 006 राजस्थान प्रकाशन– पेज सं. 1 से 110.

मीना, शिवराम, राजकुमार, हलधर, श्रवण एम., जाटव, मुकेश कुमार, माहेश्वरीख एस. के. एवं कृष्ण, हरे शुष्क क्षेत्रीय फल व सब्जियों के मूल्यसंवर्धित पदार्थ : धनोंपार्जन तथा आजीविका संरक्षण के स्त्रोतः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर प्रकाशक निदेशक भाक अनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 104 से 110.

जाटव, मुकेश कुमार, मीना, शिव राम, हलधर, श्रवण एम. और पारीक, प्रेम प्रकाश. शुष्क क्षेत्रों में सब्जी उत्पादन के लिए मृदा परीक्षण के आधार पर उर्वरकों का उपयोगः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर प्रकाशक निदेशक भाकृअनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 45 से 48.

हलधर, श्रवण एम., चौधरी, बी. आर., मीना, शिवराम एवं जाटव, मुकेश कुमार. शुष्क क्षेत्र के सब्जी उत्पादन में लगने वाले मुख्य कीट एवं उनका समेकित प्रबन्धन की तकनीकियांः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर प्रकाशक निदेशक भाकृअनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 49 से 56.

कृष्ण, हरे, माहेश्वरी, एस. के., करूप्पैया, वी., मीना, शिवराम एवं चौहान, नीतेश. बेर, आंवला व फालसा की उन्नत खेतीः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी. शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर प्रकाशक निदेशक भाकृअनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 13 से 18.

राजकुमार, गोरा, जगन एवं मीना, शिवराम. वैज्ञानिक तरीकों से शुष्क क्षेत्रों में फल व सब्जियों का संरक्षणः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर, प्रकाशक निदेशक भाकृअनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 89 से 95.

माहेश्वरी, एस. के., चौधरी, बी. आर. व मीना, शिवराम. शुष्क क्षेत्रीय सब्जियों वाली फसलों में समेकित बीकारी प्रबन्धनः शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें, शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर, प्रकाशक निदेशक भाकृअनुप–केशुबास, बीकानेर, राजस्थान 2014 पेज 96 से 98

मीना, शिव राम, शर्मा, बी. डी., जाटव, मुकेश कुमार एवं हलधर, श्रवण एम. आधार पर उर्वरकों का उपयोग शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें पेज 45.48

हलधर, श्रवण एम., चौधरी, बी. आर., मीना, शिवराम एवं जाटव, मुकेश कुमार. शुष्क क्षेत्र के सब्जी उत्पादन में लगने वाले मुख्य कीट एवं उनका समेकित प्रबन्धन की तकनीकियां शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर पेज 49 से 56.

जाटव, मुकेश कुमार, मीना, शिव राम, आचार्य, पिनाकी, गोरा, जगन सिंह एवं पारीक, प्रेम प्रकाश. शुष्क क्षेत्रों में सब्जियों में पोषक तत्वों की कमी एवं उनकी पूर्ति के उपाय शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर पेज 57 से 62.

मीना, शिवराम, राजकुमार, हलधर, श्रवण, एम., जाटव, मुकेश कुमार, माहेश्वरी, एस. के. एवं कृष्ण, हरे. शुष्क क्षेत्रीय फल व सब्जियों के मूल्यसंवर्धित पदार्थ : धनोंपार्जन तथा आजीविका संरक्षण के स्त्रोत शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें शिव राम मीना, बी.डी.शर्मा, मुकेश कुमार जाटव, श्रवण एम हलधर पेज 104 से 110.

## Bulletin/ Leaflets/Folder

Bhargava, R., Maheshwari, S. K., Haldhar, S. M. and Sharma, S. K. (2014). Management strategies for adverse climate impacts and biotic stress in arid horticultural crops. ICAR-CIAH/Tech. Bulletin/Pub. No. 52, Bikaner, pp. 1-42.

Karuppaiah, V., Singh, R. S., Sharma, B. D. and Sharma, S. K. 2014. Pests of ber and their management, Technical Bulletin No. 51, CIAH, Bikaner, 22 p.

Samadia, D. K. 2015. Khejri – Thar Shobha: Grow for horticultural exploitation. Technical Folder, CIAH: Bikaner, 6p.

Samadia, D. K. 2015. Mateera – Thar Manak: Grow with innovative technological advancement. Technical Folder, CIAH: Bikaner, 6p.

Meena, S. R., Sharma, B. D., Jatav, M. K. and Haldhar, S. M. Shusk Bagawani Phasal-ontpadan kin Naveen Taknike (Hindi Book).Published by Director, ICAR- Central Institute for Arid Horticulture,Bikaner-334 006 (Rajasthan). 2014, P.1-110.

Hiwale, S. S. and Singh, A. K. 2014. Technical Bulletin on Aonla based cropping system, published by ICAR-CIAH, Bikaner.

हलधर, एस. एम., भार्गव, आर. एवं चौधरी, बी. आर. 2015. शुष्क क्षेत्रों में कद्दूवर्गीय सब्जी के मुख्य कीट एवं उनका प्रबन्धन. केशुबास/तकनीकी फोल्डर/पेज 1–6.

समादिया, दिलीप कुमार 2014. मतीरा – शुष्क क्षेत्र में अनुसंधान एवं विकास, तकनीकी बुलेटिन–49, केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, 44 पेज।

समादिया, दिलीप कुमार 2014. खेजड़ी – बागवानी अनुसंधान एवं तकनीकी विकास, तकनीकी बुलेटिन–53, केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, 44 पेज।

## Compendium

Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition' (2014). Edited by S. K. Sharma et al. ICAR- Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan).

Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Edited by B.D. Sharma , R. Bhargav, RS Singh, M.K. Jatav and S. R. Meena. ICAR- Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan).

## Reports/ Chapters in compendium

Choudhary, B. R. and Sharma, S. K. 2014. Breeding strategies for abiotic stresses in vegetable crops. In compendium of short course 'Advances in water management and fertigation in fruit and vegetable crops of hot arid region of India'. Published by Director, ICAR-CIAH, Bikaner. pp. 195-207.

Choudhary, B. R., Haldhar, S. M. and Maheshwari, S. K. 2014. Improved cultivation practices of watermelon, ridge gourd and *tinda*. In: Training Manual published by ICAR-CIAH, Bikaner. pp. 36-41.

Choudhary, B. R. and Sharma, S. K. 2014. Diversification through horticulture. In compendium of winter school 'Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition'. Published by Director, ICAR-CIAH, Bikaner. pp. 28-34.

Choudhary, B. R. and Sharma, S. K. 2014. Underutilized vegetable crops suitable under low water availability in arid region. In compendium of short course 'Advances in water management and fertigation in fruit and vegetable crops of hot arid region of India'. Published by Director, ICAR-CIAH, Bikaner. pp. 146-151.

Jatav, M. K., Acharyya, P., Krishna, H., Maheshwari, S. K., Sharma, B. D. and Meena, S. R. 2014. Micro-irrigation in arid fruit and vegetable crops: Status and prospects. Chapter published in compendium (compiled & Edited by Sharma *et al*., 2014) of short course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India" held on September 22 to October 01, 2014 at CIAH, Bikaner, Rajasthan, p. 29-38.

Maheshwari, S. K. 2014. Management of major diseases of arid fruit crops. Chapter published in compendium (compiled & Edited by Sharma *et al*., 2014) of winter school on "Hi-tech interventions in fruit production for enhancing productivity, nutritional quality and value addition" held on 5th November to 25th November, 2014 at CIAH, Bikaner, Rajasthan, p. 172-181.

Maheshwari, S. K., Krishna, H., Choudhary, B. R. and Meena, S. R. (2014). Integrated disease management in arid fruit and vegetable crops under macro-irrigation system. Chapter published in compendium (compiled & Edited by Sharma *et al*., 2014) of short course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India" held on September 22 to October 01, 2014 at CIAH, Bikaner, Rajasthan, p. 231-241.

Samadia, D. K. 2014. Innovative concepts, techniques and practices for enhancing productivity of vegetable crops under hot arid agro-climate. Chapter in compendium of short course: Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India (eds. Sharma, B.D. *et al.*), CIAH: Bikaner. pp 47–53.

Samadia, D. K. 2014. Utilization of genetic resources of vegetable crops for varietal development under hot arid agro-climate. Chapter in compendium of short course: Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India (eds. Sharma, B.D. *et al.*), CIAH: Bikaner. pp 189–193.

Samadia, D. K. and Sivalingam, P. N. 2014. Breeding strategies and scope of improvement in fruit crops under abiotic stresses of hot arid agro-climate. Chapter in compendium of winter school: Hi-tech interventions in fruit production enhancing productivity, nutritional quality and value addition (eds. Sharma, S.K. *et al.*), CIAH: Bikaner. pp 219–223.

Sharma, B. D., Bhargava, R., Singh, R. S., Jatav, M. K. and Meena, S. R. 2014. Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India. pp.258

Sharma, B. D. 2014. Enhancing water productivity in fruit crops. In: Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition, CIAH, Bikaner pp: 234-244.

Sharma, B. D. 2014. Integrated nutrient management for sustainable production of fruit crops. In: Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition, CIAH, Bikaner pp: 225-233.

Sharma, B. D. 2014. Integrated nutrient management in fruit crops under low water conditions. In: Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner. pp:128-139.

Sharma, B. D. and Jatav, M. K. 2014. Advances in water and nutrient management in horticultural crops of India. In: Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner. pp:10-28.

Sharma, S. K. and Sharma, B. D. 2014. Scenario of horticulture in arid region: Status and prospects, In: Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner. pp:1-9.

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

Sharma, S. K. and Sharma, B. D. 2014. Proceedings of XVIII Research Workers Group Meeting of All India Coordinated Project on Arid Zone Fruits. CIAH, Bikaner. 80p.

Sharma, S. K., Sharma, B. D., Bhargava, R. and Singh, R. S. Vision 2050. [Revised].

Sharma, S. K. and Sharma, B. D. 2014. Annual Report 2013-14, All India Coordinated Research Project on Arid Zone Fruits in English and Hindi.

Singh, R. S. 2014. Production technologies of fruits and vegetable with minimum input use in short course on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner.

Singh, R. S. 2014. Prospects and scope of exotic fruit under arid conditions. In. Compendium of winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition from 5-25 November, 2014, CIAH, Bikaner, pp.102-109.

Singh, R. S. 2014. Prospects of Date palm cultivation In: Compendium of winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition from 5-25November, 2014. CIAH, Bikaner pp.87-101.

Acharyya, P., Bhargava, R. and Jatav, M. K. 2014. Hydroponics and Aeroponics- Relevance of these systems towards horticultural crop management.pp:159-176. In Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India.Published by ICAR-Central Institute for Arid Horticulture & edited by B. D. Sharma, R. Bhargava, R. S. Singh, M. K. Jatav and S. R. Meena.

Sharma, B. D. and Jatav, M. K. 2014. Advances in water and nutrient management in arid fruit and vegetable crops in Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Edited by B.D. Sharma , R. Bhargav, RS Singh, M.K. Jatav and S. R. Meena pp 10-28

Singh, Dhurendra, Shivalingam, P. N. and Meena, S. R. 2014. Water management and fertigation in hi-tech nursary. in hot arid regions in Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Edited by B.D. Sharma , R. Bhargav, RS Singh, M.K. Jatav and S. R. Meena. Published by Director, ICAR-CIAH, Bikaner- 334 006 (Rajasthan). 2014, pp 73-78.

Haldhar, S. M. and Kruppaiah, V. 2014. Population dynamics of insect-pests and their management in vegetable crops under low rainfall areas and micro-irrigation. '*Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India*' is compiled of lectures delivered in ICAR short coarse from September, 22 to 01 October, 2014 edited by Sharma BD, Bhargava R, Singh RS, Jatav MK and Meena SR and published by CIAH, Bikaner. pp 218-230.

Haldhar, S. M., Choudhary, B. R., Meena, S. R. and Jatav, M. K. 2014. Insect-pests of arid vegetable crops and their management. "*Sushk bagvani phaslotutpadan ki navin taknike*" is compiled of lectures delived in farmers training from 27.08.14 to 29.08.14 edited by Meena SR, Sharma BD, Jatav MK, Haldhar SM and Singh D and published by CIAH, Bikaner. Pp 49-56.

Haldhar, S. M., Rajkumar, Karuppaiah, V. and Gora, J. S. 2014. Insect-pests of arid fruit crops and their management. "*Sushk bagvani phaslotutpadan ki navin taknike*" is compiled of lectures delived in farmers training from 27.08.14 to 29.08.14 edited by Meena SR, Sharma BD, Jatav MK, Haldhar SM and Singh D and published by CIAH, Bikaner. Pp 63-71.

Krishna, Hare, Jatav, M. K. and Meena Sr. r. 2014. Regulated deficit irrigation in fruit crops of arid region. In: Advances in water management and fertigation infruit and vegetable crops of hot arid region in India: Edited by B. D. Sharma, R. bhargava, R. S. Sing, M. K. Jatav and S. R. meena. Published by Director ICAR-CIAH, Bikaenr-334006, Rajasthan 2014 pp 118-121.

Jatav, M. K., Acharyya, P., Krishna, H., Maheshwari, S. K., Sharma, B. D. and Meena, S. R. 2014. Micro-irrigation in arid fruit and vegetable crops: Status and prospects. Chapter published in compendium (compiled & Edited by Sharma *et al*., 2014) of short course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India" held on September 22 to October 01, 2014 at CIAH, Bikaner, Rajasthan, p. 29-38.

Krishna, H. 2014. Physiological disorders in fruit crops and their management. In: Compendium of winter school on "H-itech intervention in fruit production for enhancing productivity, nutritional quality and value addition" held on 5-25 November, 2014 at ICAR-CIAH, Bikaner, Rajasthan, pp. 165-171.

Krishna, H. and Singh, U.V. 2014. Nursery management and production of quality planting materials. In: Compendium of winter school on "Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition" held on 5-25 November, 2014 at CIAH, Bikaner, Rajasthan, pp. 182-187.

Kumar, Mahesh and Jatav, M. K. 2014. Degraded and wasteland Utilization for Sustainable Agricultural Production in Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Edited by B.D. Sharma , R. Bhargav, RS Singh, M.K. Jatav and S. R. Meena pp 92-98.

Maheshwari, S. K., Krishna, H., Choudhary, B. R. and Meena, S.R. 2014. Disease management in arid fruit and vegetable crops under macro-irrigation system. In: Compendium of short course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid regions" held on September 22-October 01, 2014 at ICAR-CIAH, Bikaner, Rajasthan, pp. 231-241.

Jatav, M. K. 2014. Use of micro-nutrients and biofertilizers in fruit production in Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value

addition. compiled & edited by SK Sharma, RS Singh, R Bhargava, SK Maheshwari and BR Chaudary pp 145-153.

Rajkumar and Acharyya, P. 2014. Irrigation systems and scheduling of irrigation in horticultural crops pp: 99-108.In Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Published by ICAR-Central Inst for Arid Horticulture & edited by B.D. Sharma,R. Bhargava, R.S. Singh, M.K. Jatav and S.R. Meena..

Meena, S. R., Jatav, M. K., Singh, D. and Sharma, B. D. 2014. Traditional approaches of water and nutrient management horticultural crop production in hot arid regions in Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. Edited by B.D. Sharma , R. Bhargav, RS Singh, M.K. Jatav and S. R. Meena pp 152-158.

Singh, D. and Sivalingam, P.N. 2014. Tissue culture of arid fruit crops. In: Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition (edited by Sharma etal., 2014). 5-25 November 2014 at CIAH, Bikaner pp72-80

Singh, D., Sivalingam, P.N. and Meena, S.R. 2014. Water management and fertigation in hi-tech nursery. In Andvances in water management and fertigation in fruit and vegetable crops of hot arid region in India. 22nd September to 1st October 2014 at CIAH, Bikaner pp. 73-78

Sivalingam, P.N., Singh, D. and Bhargava, R. 2014. Biotechnological aspects of abiotic stress in plants with reference to arid fruits and vegetables. In Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India. 22nd September to 1st October 2014 at CIAH, Bikaner pp 208-217.

Jatav, M. K., Acharyya, P., Krishna, H., Maheshwari, S. K., Sharma, B. D. and Meena, S. R. 2014. Micro-Irrigation in arid fruit and vegetable crops: Status and prospects. In: Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner. pp:29-38.

Meena, S. R., Jatav, M. K., Singh, D. and Sharma, B. D. 2014. Traditional approaches of water and nutrient management in horticultural crop production in hot arid regions. In: Advances in water management and Fertigation in fruit and vegetable crops of hot arid region in India, CIAH, Bikaner. pp:152-158.

Bhargava, R., Sharma, B. D., Singh, R. S., Meena S. R. and Sharma, S. K. 2014. Annual Report 2013-14 in English and Hindi.

## RADIO TALK

### Dr. Sanjay Singh

Radio talk delivered at Godhra Radio station, Godhra on Nursery Management.

### Dr. A. K. Singh

Delivered radio talk on the topic *Bilina Bagichnu prabandhan*, 11th July, 2014, AIR, Godhra.

Delivered radio talk on the topic '*Bili paknu aushdhiya mahatva* 22nd December, 2014, AIR, Godhra.

Delivered radio talk on the topic *Unada man Bagayati pakni mavjat*, 22nd March, 2015, AIR, Godhra.

# 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<br>Dr. V. Karruppiah |
| (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. P. P. 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 |
| **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<br>Dr. S. M. Haldhar |
| (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<br>Dr. P. P. Singh |
| (c) | Identification of Institute germplasm through biotechnological interventions : | |

| Code | Title | Investigators |
|---|---|---|
| (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<br>Dr. M. K. Jatav |
| (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. R. S. Singh<br>Dr. D. K. Samadia<br>Dr. Dhurendra 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 |
| (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) | Value addition in semi-arid fruit crops. | Dr. S. S. Hiwale<br>Dr. V.V. Appa Rao |
| (h) | 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 |

| Code | Title | Investigators |
|---|---|---|
| (c) | 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 |
| | **Concluded Projects** | |
| CIAH-2 (c) | Breeding for yield, quality, biotic and drought resistance in cucurbitaceous crops. | Dr. Raja Shankar<br>Shri H. K. Joshi |
| CIAH-3 (g) | Organic farming studies in vegetables under semi-arid conditions. | Dr. V. V. Appa Rao<br>Shri H. K. Joshi<br>Dr. Raja Shankar |
| CIAH-3 (h) | Augmentation of vegetable cultivation by tribal farmers of Panchmahals district of Gujarat: An extention action research. | Dr. Raja Shankar |
| CIAH-4 (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 |
| | **Externally funded projects** | |
| EF 1 | Validation of DUS testing guidelines for cucurbits i.e. watermelon and muskmelon. | Dr. B. R. Choudhary |
| EF 2 | Validation of DUS descriptor for *ber* (*Ziziphus* sp.). | Dr. Hare Krishna<br>Dr. R. Bhargava |
| EF 3 | Validation of DUS descriptor for date palm (*Phoenix dactylifera*). | Dr. R. S. Singh<br>Dr. R. Bhargava |
| EF 4 | Enhancement of livelihood of tribal farm households of Panchmahals district in Gujarat State through agricultural diversification. | Dr. S. S. Hiwale |
| EF 5 | Validation of DUS descriptor for *bael.* | Dr. A. K. Singh |
| EF 6 | Characterization of *aonla* varieties for developing DUS testing guidelines. | Dr. A. K. Singh<br>(Co-Nodal Centre: CHES, Godhra) |
| EF 7 | Development of morphological descriptor and DUS testing guidelines for jamun. | Dr. Sanjay Singh<br>(Co-Nodal Centre: CHES, Godhra) |
| EF 8 | Validation of DUS descriptors for chironji and tamarind | Dr. Sanjay Singh<br>(Nodal Centre: CHES, Godhra) |
| | **Concluded 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 |

| Code | Title | Investigators |
|---|---|---|
| | **New Research Project Proposal** | |
| 1. | Intensification of research on tissue cultured date palm in hot arid region. | Dr. B. D. Sharma<br>Dr. R. S. Singh<br>Dr. R. Bhargava<br>Dr. Rajkumar |
| 2. | Toxicological investigation on plant-origin pesticides against major insect pests of arid fruit crops with special reference to defoliators, borers and termites. | Dr. V. Karruppiah<br>Dr. B. D. Sharma<br>Dr. R. S. Singh<br>Dr. Rajkumar |
| 3. | Nutrient management in chironji, custard apple, jamun and tamarind. | Dr. V. V. Appa Rao<br>Dr. Sanjay Singh<br>Dr. A. K. Singh |
| 4. | Standardization of production technology of bael under rainfed semi-arid conditions of western India. | Dr. A. K. Singh<br>Dr. Sanjay Singh<br>Dr. R. S. Singh<br>Dr. V. V. Appa Rao |
| 5. | Exploitation of arid fruits and vegetables for value addition and commercialization. | Dr. Rajkumar<br>Dr. R. S. Singh<br>Dr. S. R. Meena<br>Dr. Pinaki Acharyya |
| 6. | Nutrient and water management in vegetables of hot arid region in Rajasthan. | Dr. M. K. Jatav<br>Dr. B. D. Sharma<br>Dr. S. R. Meena |
| 7. | Alleviation of climatic constraints on growth of vegetable crops under hot arid regions with an understanding on its seed physiology. | Dr. Pinaki Acharya<br>Dr. R. Bhargava<br>Dr. P. N. Sivalingam |
| 8. | Breeding for abiotic stresses in solanaceous crops. | Dr. P. P. Singh<br>Dr. D. K. Samadia |
| 9. | Development of aonla varieties against frost resistance. | Dr. P. P. Singh<br>Dr. R. Bhargava<br>Dr. R. S. Singh |
| 10. | Introduction, collection, characterization, conservation and evaluation of germplasm of semi-arid vegetables. | Dr. Raja Shankar<br>Dr. V. V. Appa Rao |
| 11. | Improvement in drumstick. | Dr. Raja Shankar<br>Dr. V. V. Appa Rao |
| | **Flagship Project** | |
| 1. | Development of *khejri* based cropping models under rainfed conditions. | Dr. D. K. Samadia<br>Dr. B. D. Sharma<br>Dr. S. R. Meena |

# 10. RAC, IRC, IMC

## RAC

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

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

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

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

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

Director
ICAR-CIAH, Bikaner

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

### Member Secretary
Dr. B. D. Sharma
Head, Division of Crop Production
ICAR-CIAH, Bikaner

The meeting of RAC was held on 19-20th August, 2014.

## Institute Research Committee (IRC)

### Chairman
Dr. S. K. Sharma
Director
ICAR-CIAH, Bikaner

### Members
All Scientists of the Institute

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

IRC meeting was held on 9-10 April, 2014.

## Institute Manageemnt Committee

Chairman: Dr. S. K. Sharma, Director, ICAR-CIAH, Bikaner

| S. No. | Name of Members | Term | |
|---|---|---|---|
| 1 | ADG (H-1), ICAR, New Delhi | 28.7.2011 | 27.2.2017 |
| 2. | Director (Horticulture), Government of Rajasthan, Jaipur (Rajasthan) | 15.3.2012 | 14.3.2015 |
| 3. | Director of Horticulture, Gujarat State, Krsihi Bhavan, Sector No.10-A, Gandhinagar (Gujarat) | 15.3.2012 | 14.3.2015 |
| 4. | Director of Research, S.K. 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, P.S. & Head, CHES, Vejalpur, Godhra | 28.7.2011 | 27.7.2017 |
| 9. | Dr. B.D. Sharma, Head, Division of Crop Production, ICAR-CIAH, Bikaner | 28.7.2011 | 27.7.2014 |
| 10. | Dr. R. Bhargava, Principal Scientist, ICAR-CIAH, Bikaner | 28.8.2014 | 27.8.2017 |
| 11. | Dr. C.K. Narayana, Principal Scientist, IIHR, Bangalore | 28.7.2011 | 27.7.2014 |
| 12. | Dr. V.K. Singh, Principal Scientist, CISH, Lucknow | 28.7.2011 | 27.7.2014 |
| 13. | Dr. Kishan Kant, Principal Scientist, NRC on Seed Spices, Ajmer | 28.8.2014 | 27.8.2017 |
| 14. | Dr. N. D. Yadav, PS & Head, CAZRI, Regional Station, Bikaner | 28.8.2014 | 27.8.2017 |
| 15. | Administrative Officer & Member Secretary | Ex-officio whole time | |

IMC meeting held on 02.03.2015.

# 11. MEETING, CONFERENCE, LECTURE ETC.

## Meeting

### Dr. S. K. Sharma

Attended Research Council Meeting at SKNAU, Jobner and visit to AICRP Centre on 06.05.2014.

Attended meeting of Task Force, PPV&FRA at New Delhi on 08.05.2014

Attended DAC-ICAR Interface Meeting at NAAS Complex under the Chairmanship of Joint Secretary and Mission Director on 16.05.2014.

Attended Review Meeting of National Advisory Board on Management of Genetic Resource on 30th May, 2014 at IIHR, Bengaluru.

Attended NAIP Workshop on Impact of Capacity Building Programmes on 6-7 June, 2014 at NASC Complex, Pusa, New Delhi.

Attended Annual Review Meeting cum Consultation Meet on Date Palm at Mundra (Gujarat) on 21st June, 2014.

Attended Brain Storming Session on "Take it to Farmers- The Farmers' Rights through Awareness" at NAAS, NASC, New Delhi on 24th June, 2014.

Attended XXXII grouop meeting of AICRP (VC) and act as Co-Chairman in the Technical Session "Seed Production" at Raipur from 25-27 June, 2014.

Attended Meeting of ICAR Foundation Day and Vice Chancellors and Directors conference at NASC Comples, New Delhi during 29-30 July, 2014.

Attended the Regional Committee-VI Meeting at AAU, Anand on 13.09.2014.

To attend a meeting at ASRB, New Delhi as Directed by the Hon'ble Secretary, DARE and Director General, ICAR, New Delhi on 02.02.2015

Attended a meeting at Krishi Bhawan, New Delhi to be Chaired by Hon'ble Secretary, DARE and Director General, ICAR, New Delhi on 13.02.2015.

Attended a meeting at ARS, Durgapura, Jaipur to be Chaired by Hon'ble Secretary, DARE and Director General, ICAR, New Delhi on 15.02.2015.

Attended Group Meeting of AICRP on Fruits and to chaired the session on "Planting density, Propagation and Rootstocks" at MPUAT, Udaipur on 27 February, 2015.

### Dr. B. D. Sharma

Annual Group Meeting of AICRP on AZF at SKNAU, Jobner on 12-14th December 2014.

Attended Institute Management Committee meeting of DRMR, Bharatpur on 08-08-2014.

Attended Institute Management Committee meeting of CIAH, Bikaner on 02.03.2015.

Attended Institute Management Committee meeting of NRC on Camel, Bikaner, on 21-02-2015.

Attended Institute Technology Management Committee meeting as member at CIAH, Bikaner on 12-01-2015.

Attended Institute Variety Identification Committee of CIAH, Bikaner on 09-02-2015.

Attended as member of IJSC meetings held at CIAH Bikaner on 23-09-2014, 16-12-2014 and 03-03-2015.

Attended PG Committee meeting of the Institute on 16-07-2014.

Attended IRC meeting of the Institute from 9-10 April 2014.

Attended RAC meeting of CIAH, Bikaner held on 19-20th August 2014.

Attended ICAR Industry Meet at CIAH, Bikaner as Chairman on 18-12-2014.

Attended meeting of Committee for implementation Official languages and Hindi Karyashala on 17-06-2014, 03-03-2015 and organization of Hindi Diwas programme on 14 September, 2014.

Attended Project Monitoring Committee meetings of the Institute on 04-04-2014 and 25-03-2015.

Attended meeting of Germplasm Identification committee of Institute on 2.5.2014 and 9.2.2015.

Annual Rate Contract for Chemical, Glasswares and Plasticwares held at CIAH, Bikaner on 15-07-2014.

Attended workshop on Crop- Water Productivity in IGNP areas held at DHRD, SKRAU, and organized by CAZRI, RRS, Bikaner on21.8.14.

Attended ICAR- Foundation Day programme organized by ICAR Institutes at Jalwali village, Bikaner on 16.7.2014.

Attended meeting as Member of Advisory Committee of P.G. student (Hort.) in Deptt. of Horticulture, COA, SKRAU, Bikaner.

Attended Farmers Innovative Day at CIAH, Bikaner on 09-10-2014.

Acted as Chief Guest On valedictory function of Hindi Week at CAZRI, RRS, Bikaner on 20-09-2014.

Attended ZREAC Rabi 2014-15 meeting of the DOR, SKRAU, Bikaner on 2-3 September 2014.

### Dr. R. S. Singh

Attended RAC meeting of the Institute on 19.8.2014, CIAH, Bikaner.

Attended ICAR- Foundation Day programme organized by ICAR Institutes at Jalwali village, Bikaner on 16.7.2014.

Attended meeting of ITMC as member of committee on 12.1.2015 at CIAH, Bikaner.

Attended IMC meeting of CIAH as special invitee member on 2.3.2015 at CIAH, Bikaner.

Attended 9th Review meeting of DUS centre organized by PPV&FRA held at JAU, Junagadh during 9-10 March, 2015 and presented the report on DUS centre on date palm crop in the meeting.

Attended meeting as Member of committee in the Office of Addl. Director (Horticulture),Govt of Rajasthan, Pant Krishi Bhavan, Jaipur on 25.9.2014 regarding maintenance of tissue culture date plantations at Khara farm.

Attended Project Monitoring Committee meeting as member secretary held on 4.4.2014 and 24.3.2015 at CIAH, Bikaner.

Attended IRC meeting of the Institute held on 09-10 April, 2014 at CIAH, Bikaner.

Attended meeting of Germplasm/Variety Identification committee of Institute on 2.5.2014 and 09.2.2015.

### Dr. S. K. Maheshwari

Attended PMC Meeting of CIAH, Bikaner as invitee member on 03-12-2013 and 06-03-2014.

Institute Research Committee (IRC): Member Secretary – IRC meeting was held on 09-10th April, 2014.

Attended ITMC meeting of ICAR-CIAH as member on 12th January, 2015.

Attended PMC Meeting of ICAR-CIAH, Bikaner as invitee member on 25-03-2015.

## Conference/Semimar-Symposium/ Workshop/etc

### Dr. S. K. Sharma

Attended NAAS Silver Jubilee Symposium on Strategic Approaches for Horticulture Research, Education and Development - Way Forward durning 26-27th December, 2014 at New Delhi.

Participated in Agricultural Science Congress at Karnal on 3-4th Feb., 2015.

Conduct Research Workers Group Meeting AICRP on Arid Zone Fruits at SKN Agriculture University, Jobner during 11-15th December, 2014.

To attend the National Seminar on Underutilized fruits at CHES Chettalli and to deliver a lecture to the participants. during 30th November to 03rd December, 2014.

Participated and act as Co-Chair in the Technical Session on NRM during National Seminar on “Emerging Problems in Potatoes” w.ef. 1-2 Nov., 2014.

Attended Foundation Day Lecture of the National Academy of Agricultural Sciences on 5th June, 2014 at NASC Complex, Pusa, New Delhi.

Attended the NAIP Workshop on Impact of Capacity Building Programmes on 6-7 June, 2014 at NASC Complex, Pusa, New Delhi.

Attended Work Shop on Review of Progress for Preparation of Sixth National Report to UNCCD Secretariat at India International Centre, New Delhi on 15.05.2014.

### Dr. Dhurendra Singh

Participated annual review meeting of Network project on “Production & Demonstration of tissue culture raised plants under three locations

& collection & maintenance of elite germplasm of date palm" and National Meet at MDPRS, Mundra on 21-06-2014

Annual review meeting of Network project on "Production & Demonstration of tissue culture raised plants under three locations & collection & maintenance of elite germplasm of date palm" at AAU, Anand on 19-01-2015.

Attended workshop on Disposal of appeal under Right to Information on 14-08-2014 at ISTM, Dept of personnel, public grievances & pensions, Govt. of India, New Delhi.

Visited NIFTEM, Kundli, Sonipat (HR) for performance indicator on 10 Nov. 2014.

Delivered a presentation on Cactus pear research and development under hot arid agro-eco system in Zonal Research Advisory Committee meeting for Kharif 2015 of Zone 1c organised by ARS, SKRAU, Bikaner on 12.03.2015.

**Dr. R. S. Singh**

Attended workshop on Priority setting, monitoring and evaluation held at NASC, New Delhi on 27th May, 2014.

Attended Annual Review meeting on date palm held at SDAU, DRS, Mundra on 21June, 2014.

Attended Workshop on Crop- water productivity in IGNP areas held at ASC, SKRAU, and organized by CAZRI, RRS, Bikaner on21.8.14.

**Dr. P. N. Sivalingam**

Participate and delivered oral presentation on "Transcriptome profiling during low moisture stress in Ziziphus nummularia (Burm.f) Wight & Arn- A perennial fruit tree species for Rajasthan, India. In: International conference on Horticulture for nutritional livelihood and environmental security in hills. Kalimpong, Darjling, 22-24 May 2014.

Participated and delivered oral presentation on "Differential expression of transcripts during low moisture stress in *Ziziphus nummularia*" in International Conference on Second International Conference on Bio-resource and stress management at Hyderabad during 07-10 January 2015

Participated annual review meeting of Network project on "Production & Demonstration of tissue culture raised plants under three locations & collection & maintenance of elite germplasm of date palm" and National Meet at MDPRS, Mundra on 21-06-2014

Participated annual review meeting of Network project on "Production & Demonstration of tissue culture raised plants under three locations & collection & maintenance of elite germplasm of date palm" at AAU, Anand on 19-01-2015

**Dr. A. K. Singh**

Participated in SPJS and Global Conference on Technological Challenge and Human Resources for Climate Smart Horticulture- Issue and Strategies during May 28-31, 2014, NAU, Gujarat.

Participated Research Workers Group Annual Meet, AICRP on AZF, December 12 - 14, 2014 at KNAU, Jobner, Rajasthan.

**Dr. S. K. Maheshwari**

Participated and delivered an oral presentation of research paper in "National Symposium on Recent Advances in Diagnosis and Management of Diseases of Field and Horticultural Crops" held on 28th February-1st March, 2015 at Department of Plant Pathology, N. D. University of Agriculture & Technology, Kumarganj, Faizabad, (U.P.).

**Dr. M. K. Jatav**

Participated in National seminar on current trends in environmental research, at Maharaja Ganga Singh University, Bikaner from 28th Feb to 2nd March, 2015

**Dr. Pinaki Acharyya**

Participated in the the National seminar on "Current trends in environmental research" organized by Dept. of Environmental Science, Maharaja Ganga Singh University, Bikaner during 28th February till 28th March,2015.

**Dr. B. R. Choudhary**

Attended meeting of the Task Force for validation of DUS test guidelines for watermelon and muskmelon held at New Delhi on 08-05-2014.

Participated in 32nd workshop of AICRP on Vegetable Crops held at IGKV, Raipur from 24-27 June, 2014.

Attended a Workshop on 'Crop water productivity in IGNP area' held at ICAR-CAZRI RSS, Bikaner from 21-22 August, 2014

### Dr. S. R. Meena

Attended the International conference: Changing scenario of pest problems in Agri-horti ecosystem and their management, organized by Entomological Research Association, Udaipur and Department of Entomology, RCA, Udaipur, MPUAT, Udaipur from 27 -29 November, 2014.

Attended the National Seminar organized on *"Hi-tech Horticulture for Enhancing Productivity, Quality and Rural Prosperity"* at ICAR-NRCSS, Ajmer, Rajasthan, during January 19- 20, 2015.

Attended the 12th Agricultural Science Congress 2015 at ICAR-NDRI Karnal, Haryana organized by National Academy of Agricultural Science during 03 - 06 Feb, 2015.

Attended National Seminar on Current Trends in Environmental Research (NACTER-2015) organized by Department of Environmental Science Maharaja Ganga Singh University Bikaner (Rajasthan) during February 28th- March 2nd, 2015.

### Dr. S. M. Haldhar

Attended International Conference on "Horticulture for nutrition, livelihood & environmental security in hills: opportunity and challenges" organized by UBKV (Hill campus), Kalimpong during 22-24, May, 2014.

Attended international conference on "Changing scenario of pest problems in Agri-horti ecosystem and their management" during 27-29, November, 2014 at RCA, MPUAT, Udaipur.

### Dr. Rajkumar

Attended National Conference on Pre-/post-harvest losses and value addition in vegetables held at Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh from July 12$^{nd}$-13$^{th}$, 2014.

## Lecture

### Dr. Sanjay Singh

Lecture delivered on production technology underutilized fruits in the Winter School financed by ICAR and organized at CIAH, Bikaner on 15-11-2014.

Lecture delivered on production technology of mango, sweet orange and guava in the Winter School financed by ICAR and organized at CIAH, Bikaner on15-11-2014.

Lecture delivered on maturity standards and post harvest handling of fruits in the Winter School financed by ICAR and organized at CIAH, Bikaner on 15-11-2014.

### Dr. S. S. Hiwale

S.S.Hiwale (2014). Lead paper presented on Pomegranate cultivation in semiarid areas of Gujarat in National seminar on " Pomegranate for nutrition, livelihood security and entrepreneurship development at NRC, Pomegranate, Solapur, 5-7 Dec.2014.

### Dr. B. D. Sharma

Integrated Nutrient management in Arid Fruit crops in Farmers training programme on 27.8. 2014 held at CIAH, Bikaner.

Water and Nutrient Management in fruit and vegetable crops in Farmers training programme of ATMA, Kachchh, region, Gujarat on 28.8.2014 held at CIAH, Bikaner.

Enhancement of water productivity in arid horticultural crops in Model training programme for Scientist/Officers held at CAZRI, Jodhpur on 01.9.2014

Production technologies of fruits and vegetable with minimum input use in Short course on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India on 30.9.2014 at CIAH, Bikaner.

Prospects and scope of exotic fruit under arid conditions. In winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition 6$^{th}$ November, 2014 at CIAH, Bikaner.

Prospects of Date palm cultivation in winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition at CIAH, Bikaner on 17.11.2014.

Underutilized Fruits &Vegetable Cultivation in Arid region in Farmers training programme on 07.1.2015 at CAZRI, RRS, Bikaner.

Fruit crops as fodder for Livestock in farmers training programme at Arid region campus, CSWRI, Bikaner on 05.2.2014.

### Dr. Dhurendra Singh

Delivered a lecture of khejri propagation and nursery establishment in farmer training organised

by CIAH, Bikaner in Sarehrupayat village on 06.09.2014

Delivered a lecture of khejri propagation and nursery establishment in farmer training organised by CIAH, Bikaner in Sinthal village on 08.09.2014

Delivered a lecture on water management and fertigation in nursery on 24.09.2014 in Short course on Advances in water management in fruits and vegetable crops of hot arid region in India organized by CIAH, Bikaner during Sept.22 to Oct.1st 2014

Delivered a lecture on tissue culture of fruit crops on 10.11.2014 in ICAR- Winter School on Hi-tech intervention

**Dr. R. S. Singh**

Importance of Fruits production in Agriculture Education Day programme on 23.7.2014 at CIAH, Bikaner.

Cultivation of Underutilized Fruit crops in arid region in Farmers training programme on 27.8. 2014 held at CIAH, Bikaner.

Production technology of fruit crops in Farmers training programme of ATMA, Kachchh, region, Gujarat on 28.8.2014 held at CIAH, Bikaner.

Supply Chain management and marketing of horticultural produce in Model training programme for Scientist/Officers held at CAZRI, Jodhpur on 01.9.2014

Production technologies of fruits and vegetable with minimum input use in Short course on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India on 30.9.2014 at CIAH, Bikaner.

Prospects and scope of exotic fruit under arid conditions. In winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition 6th November, 2014 at CIAH, Bikaner.

Prospects of Date palm cultivation in winter school on Hi –tech interventions in fruit production enhancing productivity nutrition and value addition at CIAH, Bikaner on 17.11.2014.

Underutilized Fruits &Vegetable Cultivation in Arid region in Farmers training programme on 7.1.2015 at CZRI, RRS, Bikaner.

Utilization of fruit crops as fodder for Livestock in farmers training programme at Arid region campus, CSWRI, Bikaner on 05.2.2014

**Dr. D. K. Samadia**

Innovative concepts, techniques and practices for enhancing productivity of vegetable crops under hot arid agro-climate. In short course: Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India, CIAH: Bikaner on 24/09/2014.

Utilization of genetic resources of vegetable crops for varietal development under hot arid agro-climate. In short course: Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India, CIAH: Bikaner on 27/09/2014.

Breeding strategies and scope of improvement in fruit crops under abiotic stresses of hot arid agro-climate. In winter school: Hi-tech interventions in fruit production enhancing productivity, nutritional quality and value addition, CIAH: Bikaner on 11/11/2014.

Delivered scientific training lecture – PGR management, arid vegetable research and seed production. Professional training programme of Mr. B. M. Murlidhara, CIAH: Bikaner on 03/06/2014.

Delivered scientific training lecture – Underutilized and perennial vegetables of arid region. Professional training programme of Mr. B. M. Murlidhara, CIAH: Bikaner on 28/06/2014.

Delivered scientific training lecture – Orientation on arid vegetable research and perennial vegetables and seed production. Professional attachment training programme of Mr. Julius Uchoi, CIAH: Bikaner on 05/01/2015.

Delivered lecture – Innovative arid zone vegetable culture. In: Farm Innovations Day. Organized by CIAH at village - Sinthal on 09/10/2014.

डॉ. दिलीप कुमार समादिया (2014) द्वारा व्याख्यान – शुष्क क्षेत्रीय सब्जी उत्पादन की उन्नत तकनीक। कृषक प्रक्षिशण – शुष्क बागवानी फसलोत्पादन की नवीन तकनीकें, केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर दिनाँक 27/08/2014.

**Dr. M. K. Jatav**

A Lecture was delivered on Use of micro-nutrients and biofertilizers in fruit production in ICAR sponsored 21 days training programme on Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition during 5th November to 25th November, 2015.

A Lecture was delivered on Micro-irrigation in arid fruit and vegetable crops: status and prospects in ICAR sponsored 10 days training programme on Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India during 22 September to 1 October, 2014.

A Lecture was delivered on शुष्क क्षेत्रों में सब्जी उत्पादन के लिए मृदा परीक्षण के आधार पर उर्वरकों का उपयोग ATMA, Kutch, Gujrat sponsored three days training programme on शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें during 27/8/2014 to 29/8/2014.

A Lecture was delivered on शुष्क क्षेत्रों में सब्जियों में पोषक तत्वों की कमी एवं उनकी पूर्ति के उपाय ATMA, Kutch, Gujrat sponsored three days training programme on शुष्क बागवानी फसलोंत्पादन की नवीन तकनीकें during 27/8/2014 to 29/8/2014.

### Dr. Pinaki Acharrya

Hydroponics and Aeroponics - Relevance of these systems towards horticultural crop management. In Short course on " Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India." held at ICAR-CIAH during 22nd September, 2014 to 1st October, 2014.

### Dr. B. R. Choudhary

Delivered a lecture on 'Breeding strategies for abiotic stresses in vegetable crops' in short course 'Advances in water management and fertigation in fruit and vegetable crops of hot arid region of India' held at ICAR-CIAH, Bikaner from 22 Sept., 2014 to 1 Oct., 2014.

Delivered a lecture on 'Diversification through vegetables in fruit production' in winter school 'Hi-tech intervention in fruit production for enhancing productivity, nutritional quality and value addition' held at ICAR-CIAH, Bikaner from 5-25 Nov., 2014.

Delivered a lecture on 'Improved cultivation practices of watermelon, ridge gourd and *tinda'* in a training programme organized by ICAR-CIAH, Bikaner from 27-29 August, 2014.

Delivered a lecture on 'Vegetable cultivation in arid region during rabi season' in a training programme organized by ICAR-CAZRI RSS, Bikaner from 5-9 January, 2015.

### Dr. A. K. Singh

Lectures delivered during 7 days training programme on the topic Advances in Horticultural Technologies and Fruit Based Cropping Models in Semi-Arid Regions held at Central Horticultural Experiment Station (CIAH), Vejalpur-389340, Panchmahals (Godhra), Gujarat on differen aspects.

### Dr. V.V.Appa Rao

Delivered lectures to BRS students in a course entitled "Horticulture production under semi arid ecosystem of western india" directed by Dr.Sanjay Singh from 1.01.2015 to 21.01.2015 at CHES, Vejalpur.

### Dr. Hare Krishna

शुष्क क्षेत्रों में फल आधारित कृषि प्रणालियां पर व्याख्यान, किसान प्रशिक्षण कार्यक्रम शुष्क क्षेत्रों में बागवानी एवं मसाला फसों की खेती के दौरान आयोजन दिनांक 8.1.2015 को दिया, आयोजनकर्ता भाकृअनुप–काजरी, क्षेत्रीय अनुसंधान केन्द्र, बीकानेर

बेर, आंवला एवं फालसा की उन्नत खेती पर व्याख्यान, किसान प्रशिक्षण कार्यक्रम दिनांक 29.8. 2015 के दौरान दिया। जो कि भाकृअनुप–केशुबास बीकानरे पर आयोजितक किया गया।

Delivered lecture on 'Regulated deficit irrigation in fruit crops in arid regions' during ICAR sponsored short course on "Advances in water management and fertigation in fruit and vegetable crops of hot arid regions" held on September 22-October 01, 2014 at ICAR-CIAH, Bikaner.

Delivered lectures on topics 'Nursery management and production of quality planting materials' and 'Physiological disorders in fruit crops and their management' during the ICAR sponsored winter school on "Hi-itech intervention in fruit production for enhancing productivity, nutritional quality and value addition" held on 5-25 November, 2014 at ICAR-CIAH, Bikaner, Rajasthan.

Delivered a lecture on plant propagation techniques and production technology of *ber* during the Farm Innovators Day at Sinthal Village, Bikaner on 09.10.14.

### Dr. S. M. Haldhar

Delivered lecture to trainings on 'Population dynamics of insect-pests and their management in vegetable crops under low rainfall areas and micro-

irrigation' in 10 days short course programme entitled '*Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India*' during September, 22 to 01 October, 2014 at CIAH, Bikaner.

Delivered lecture to farmers on 'Insect-pests of arid fruits and their management' in "Sushk bagvani phaslotutpadan ki navin taknike" organized by CIAH, Bikaner during 27.08.14 to 29.08.14.

Delivered lecture to farmers on 'Insect-pests of arid vegetable crops and their management' in "Sushk bagvani phaslotutpadan ki navin taknike" organized by CIAH, Bikaner during 27.08.14 to 29.08.14.

Delivered lecture to farmers on 'Insect-pests and management of arid fruits and vegetable crops' in "ICAR Foundation Day" organized by CIAH and other sister institute of ICAR at Bikaner during 16 July, 2014.

Delivered lecture to farmers on 'Insect-pests and disease management of arid fruits, vegetable crops and spices' in "Farmers-Scientist interaction workshop" organized by CAZRI, RS, Bikaner during 28-29 October, 2014.

Shravan M Haldhar: Lecture delivered to farmers on 'Insect-pests and disease management of arid fruits and vegetable crops' in "Farm Innovation Day at Sinthal Village, Bikaner" organized by CIAH during 09 October, 2014.

Oral presentation on 'Record of the Small Salmon Arab, *Colotis amata* F. on Pilu (*Salvadora persica* L.) in Arid Region of Rajasthan: Incidence and Morphomatric analysis' in international conference on 'horticulture for nutrition, livelihood & environmental security in hills: opportunity and challenges' organized by UBKV (Hill campus), Kalimpong, WB during 22-24, May, 2014.

### Dr. S. K. Maheshwari

Delivered a lecture on "Integrated disease management in arid zone fruit crops" in three days farmers training programme on "New techniques of arid horticultural crop production" during 27-29 August, 2014 at ICAR-CIAH, Bikaner.

Delivered a lecture on "Integrated disease management in arid zone vegetable crops" in three days farmers training programme on "New techniques of arid horticultural crop production" during 27-29 August, 2014 at ICAR-CIAH, Bikaner.

Delivered a lecture on "Integrated disease management in arid fruit and vegetable crops under macro-irrigation system" in 10 days ICAR-Short Course entitled "Advances in water management and fertigation in fruit and vegetable crops of hot arid region in India" held on September 22 to October 1, 2014 at ICAR-CIAH, Bikaner, Rajasthan.

Delivered a lecture on "Management of major diseases in arid fruit crops" in 21 days ICAR-Winter School entitled 'Hi-tech interventions in fruit production for enhancing productivity, nutritional quality and value addition" held on 5-25 November, 2014 at ICAR-CIAH, Bikaner, Rajasthan.

### Sh. Jagan Singh Gora

Delivered lecture on Importance of rootstocks and propagation techniques in horticultural crops dated on 03.01.2015 during farmers training at CAZRI -RRS, Bikaner.

## Impoartant Events

### Celebration of Week/day

The Institute's Foundation day was celebrated on 1.4.2014 in the campus of the Institute.

Anti-terrorism day was celebrated in the Institute on 21.05.2014 and 09-09-2014

Celebrated Agriculture Education Day on 20.07.2014: More than 70 students and teachers from different secondary and senior secondary schools of Bikaner participated in this programme.

Celebrated National Science Day on 28th February, 2015.: More than 50 students and teachers from different secondary and Sr. Secondeary Schools of Bikaner participated in this programme.

Celebrated Farms Innovators Day on 9.10.2014.: More than 100 innovative farmers and students have parcipated.

Celebrated of ICAR Industry Meet on 18.12.2014: Several local industrialists related to agricultural and allied sectors participated and discussed at length about crops and future prospects of agro-horti-based industries in western Rajasthan.

Celebrated of Communial Harmony Campaign: Communal Harmony Compaign and the Fund Raising Week was celebrated in the Institute from 19.11.2014 to 25.22.2014.

# 12. DISTINGUISHED VISITORS

- S.D. Shikhamany, Former Vice Chancellor, Dr. Y.S.R. Horticultural University, Hyderabad, A.P. (India) on 02.04.2014.
- Dr. J.S. Chauhan, ADG (Seed), ICAR, Krishi Bhawan, New Delhi on 04.04.2014
- Justice Mohammad Rafiq, Rajasthan High Court, Jaipur on 19.04.2014
- Dr. M.S. Kala, IAS, Director, Watershed Development & Social Conservation, Jaipur on 25.06.2014
- Dr. S.L. Mehta, Ex. V.C., MPUAT, Udaipur on 19-20.08.2014
- Dr. B.B. Vashishtha, Ex. Director, NRCSS, Ajmer on 19-20.08.2014
- Dr. Y.N. Reddy, Member, Ex- Principal Scientist & Head, IIHR, Bangalore on 19-20.08.2014
- Prof. D.P.Ray, Former Vice-Chancellor, DUPT, Bhubneshwar visited this Central Horticlture Experiment Station on 25.08.2014.
- Er. M.D. Singh, Ex. Principal Scientist, CISH, Lucknow, U.P on November, 2014
- Dr. M.M. Roy, Director, CAZRI, Jodhpur on 15 November, 2014
- Dr. S.K. Malhotra, Horticulture Commissioner, Government of India, New Delhi on 05.11.2014
- Dr. Govind Singh, Director of Research, SKRAU, Bikaner on 25.11.2014
- Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture Science), ICAR, New Delhi visited on 20.03.2015.


**Inaguration of Diggi**

**Inaguration of Biotech Lab.**

**Plantation near Diggi**

**Laying of Foundation stone of Bourndary Wall**

**Visit of Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture Science) ICAR, New Delhi**

# 13. RAJBHASHA

## fgUnh dk;Z'kkykvksa dk vk;kstu

वित्तीय वर्ष की प्रथम तिमाही की हिन्दीन कार्यशाला का आयोजन दिनांक 28 जून, 2014 को किया गया। द्वितीय तिमाही की कार्यशाला का आयोजन दिनांक 11 सितम्बार, 2014 को किया गया था जिसमें बीकानेर के हिन्दी् साहित्यिकार श्री रमेश कुमार शर्मा ने ''भाषायी सह–अस्तिसत्वी की प्रतीक हिन्दी में दैनिक उपयोग की अपार संभावनाएं विषय पर अपना व्याख्यान दिया। इसी क्रम में तीसरी कार्यशाला का आयोजन दिनांक 24 दिसम्बार 2014 को किया गया जिसमें डूंगर महाविद्यालय, बीकानेर के हिंदी प्राध्यापक डॉ. ब्रज रतन जोशी ने ''हिन्दी भाषा की वैज्ञानिकता एवं वर्तनी शुद्धता विषय पर व्याख्यान देकर संस्थान के वैज्ञानिकों एवं कर्मचारियों के हिंदी के प्रति लगाव को और अधिक प्रबल किया। चौथी कार्यशाला का आयोजन दिनांक 25 मार्च 2015 को किया गया था जिसमें स्टेट बैंक ऑफ बीकानेर एण्ड जयपुर, बीकानेर के श्री दिवाकर मणी, प्रबंधक (राजभाषा) ने यूनीकॉड के द्वारा कम्यूटर पर हिन्दी का प्रयोग विषय पर अपना व्यांख्यान दिया था।

## lLFkku jkt Hkk"kk dk;kZUo;u lfefr dh cBd

वर्ष 2014–15 के दौरान संस्थान राजभाषा कार्यान्वयन समिति की तिमाही के आधार पर बैठकें आयोजित की गयी। प्रथम तिमाही की बैठक दिनांक 17 जून 2014 को द्वितीय तिमाही की बैठक का आयोजन दिनांक 23 सितम्बनर, 2014 तथा तीसरी बैठक दिनांक 16 दिसम्बर 2014 को आयोजित की गयी। चौथी तिमाही की बैठक का आयोजन दिनांक 03 मार्च 2015 को किया गया था।

## fgUnh psruk lIrkg vk;kstu

संस्थान में दिनांक 08 सितम्बकर से 15 सितम्बर, 2014 तक हिन्दीय चेतना सप्ताह का आयोजन किया गया । इस आयोजन का उद्घाटन समारोह दिनांक 8 सितम्बर 2014 को किया गया। उद्घघाटन समारोह के विशिष्ट अतिथि काजरी के बीकानेर स्थित प्रादेशिक अनुसंधान केंद्र के अध्यक्ष डॉ एन.डी. यादव थे । उन्होंने अपने उद्बोधन में कहा कि हिन्दी हमारी राजभाषा तो है लेकिन उसके प्रयोग के लिए हमें लोगों में चेतना जागृत करने की आवश्यकता है। इस संस्थान ने हिंदी चेतना सप्ताोह का आयेजन कर एक महत्व पूर्ण कार्य किया है। इस अवसर पर संस्थान के प्रभारी निदेशक और इस कार्यक्रम के अध्यक्ष डॉ. ब्रजेश दत्त शर्मा ने उपस्थित वैज्ञानिकों, अधिकारियों एवं कर्मचारियों से हिन्दी में अधिकाधिक कार्य करने का आग्रह किया । हिन्दी चेतना सप्ताह समिति के अध्यंक्ष एवं प्रधान वैज्ञानिक डॉ. राकेश भार्गव ने इस दौरान आयोजित किए जाने वाले कार्यक्रमों की विस्तृत जानकारी उपलब्ध करवायी।

चेतना मास के दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया। इनमें दिनांक 09 सितम्बर 2014 को हिंदी टिप्पण लेखन, 10 सितम्बर को हिंदी भाषा ज्ञान और 12 सितम्बर को वैज्ञानिक शोध लेख प्रतियोगिताओं का आयेाजन किया गया। इस दौरान आयोजित विभिन्न प्रतियोगिताओं में विजेताओं को समापन समारोह में मुख्य अतिथि बीकानेर के वयोवृद्ध हिंदी साहित्यकार और कवि श्री भवानी शंकर व्यास विनोद ने पुरस्काारों से सम्मानित किया।

इसमें हिंदी टिप्पयण लेखन प्रतियोगिता में श्री कुलदीप पान्डे, सहायक प्रथम, श्री स्वश्रूप चंद राठौड़, अ.श्रेणी लिपिक द्वितीय और श्री रावत सिंह अ.श्रेणी लिपिक ने तृतीय स्थान प्राप्त किया। हिन्दी भाषा ज्ञान प्रतियोगिता में वैज्ञानिक वर्ग में डॉ. हरे कृष्ण, वरिष्ठ वैज्ञानिक प्रथम, डॉ. बालूराम चौधरी, वरिष्ठ वैज्ञानिक द्वितीय और तृतीय स्थान डॉ. एस. के. माहेश्वरी वरिष्ठ वैज्ञानिक ने प्राप्त किया। तकनीकी वर्ग में डॉ. उदयवीर सिंह वरिष्ठ तकनीकी अधिकारी ने प्रथम और श्री भोजराज

pruk lIrkg dk mn?kkVu volj ij mifLFkr vfrfFkx.k ,oa lLFkku dk çHkkjh fun'kd M,- ch- Mh- 'kekZ

pruk lIrkg dk lekiu volj ij lEekfur djrs gq, ofj"B lkfgR;dkj Jh Hkokuh 'kadj 'kekZ foukn ,oa lLFkku dk çHkkjh fun'kd M,- ch- Mh- 'kekZ

pruk lIrkg esa fVli.k y[ku çfr;kfxrk esa Hkkx yrs gq, çfrHkkxh

pruk lIrkg esa fotrk çfrHkkxh ikfjrks"kd yrs gq,

खत्री तकनीकी अधिकारी ने द्वितीय स्थान प्राप्त किया। प्रशासकीय वर्ग में प्रथम स्थान पर श्री कुलदीप पान्डे , सहायक, द्वितीय श्री रावत सिंह अ.श्रेणी लिपिक और तृतीय श्री स्वरूप चंद राठौड़ अ.श्रेणी लिपिक रहे। इसी प्रकार वैज्ञानिक शोध लेख प्रतियोगिता में प्रथम स्था्न डॉ. श्रवण एम. हलधर, वैज्ञानिक ने और द्वितीय स्थान डॉ. हरे कृष्णी वरिष्ठ वैज्ञानिक ने प्राप्त किया। डॉ. बालू राम चौधरी, वरिष्ठ वैज्ञानिक और डॉ. पिनाकी आचार्य, वरिष्ठ वैज्ञानिक को प्रोत्साहन पुरस्कार दिया गया।

## fgUnh çdk'ku

इस अवधि के दौरान संस्थान द्वारा निम्न लिखित हिन्दी प्रकाशन प्रकाशित किए गये।

1. वार्षिक प्रतिवेदन 2013–14 (संस्थान)
2. वार्षिक प्रतिवेदन 2013–14 (एक्रिप)
3. छः माही समाचार पत्र (वर्ष में दो अंक द्विभाषी)
4. राजभाषा पत्रिका 'मरू बागवाणी 2013'
5. पौधा, किस्म एवं कृषक अधिकार संरक्षण अधिनियम एवं जागरुकता कार्यक्रम पर पुस्तिका
6. मतीरा (बुलेटिन)

# 14. PERSONNEL

## Staff Position as on 31.03.2015

### CIAH (including CHES)

| Sr.No. | Designation | Sanctioned Posts | Posts filled | Posts vacant |
|---|---|---|---|---|
| 1. | Director (RMP) | 01 | 01 | 00 |
| 2. | Scientific | 35 | 21 | 14 |
| 3. | Technical | 43 | 39 | 04 |
| 4. | Administrative | 23 | 20* | 04 |
| 5. | Skilled Support Staff | 33 | 28 | 05 |
| Total | 135 | 109* | 27 | |

*Sh. Raj Kumar, FAO has been posted against vacant post of other Institute and it will be reverted back as and when Sh. Raj Kumar vacated the post.

### Krishi Vigyan Kendra

| Category | Sanctioned Strength | In position |
|---|---|---|
| Programme Coordinator | 01 | 01 |
| Administrative | 02 | 02 |
| Technical | 11 | 10 |
| Supporting | 02 | 02 |
| TOTAL | 16 | 15 |

### 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 | Head, Division of Crop Production |
| 2. | Dr. Dhurendra Singh | Head, Division of Crop Improvement |
| 3. | Dr. R. Bhargava | Principal Scientist (Plant Physiology) |
| 4. | Dr. R.S. Singh | Principal Scientist (Horticulture) |
| 5. | Dr. D.K. Samadia | Principal Scientist (Horticulture) |
| 6. | Dr. S. K. Maheshwari | Senior Scientist (Plant Pathology) |
| 7. | Dr. Hare Krishna | Senior Scientist (Horticulture) |
| 8. | Dr. S.R. Meena | Senior Scientist (Agril. Extension) |
| 9. | Dr.M.K.Jatav | Senior Scientist (Soil Science) |

| S. No. | Name | Designation/Discipline |
|---|---|---|
| 10. | Dr.P.P.Singh | Senior Scientist (Vegetable Science) |
| 11. | Dr.Pinaki Acharya | Senior Scientist (Vegetable Science) |
| 12. | Dr. B. R. Chaudhary | Senior Scientist (Vegetable Science) |
| 13. | Dr. P. N. Sivalingam | Scientist (Plant Biotechnology) |
| 14. | Dr. S. M. Haldhar | Scientist (Agri. Entomology) |
| 15. | Sh. Ramesh Kumar | Scientist (Floriculture) |
| 16. | Dr.Rajkumar | Scientist (Fruit Science) |
| 17. | Dr. Jagan Singh Gora | Scientist (Fruit Science) |
| **III. ADMINISTRATIVE** | | |
| 1. | Shri Ramdeen | Administrative Officer |
| 2. | Shri Raj Kumar | Finance & Accounts Officer |
| 3. | Shri N. A. Patel | Assistant Administrative 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 K. V. Parmar | Technical Officer |
| 7. | Shri B. R. Khatri | Technical Officer |

## B. CHES, Godhra – Regional Station

| S. No. | Name | Designation/Discipline |
|---|---|---|
| **I. SCIENTIFIC** | | |
| 1. | Dr. Sanjay Singh | Principal Scientist & Head |
| 2. | Dr. S.S. Hiwale | Principal Scientist |
| 3. | Dr. V.V. Appa Rao | Senior Scientist |
| 4. | Dr. A.K. Singh | Senior Scientist |
| **II. ADMINISTRATIVE** | | |
| 1. | Smt. R. K. Shah | Assistant Administrative Officer |
| **III. TECHNICAL** | | |
| 1. | Sh. Nihal Singh | Chief Technical Officer - Field |
| 2. | Sh. G.U. Trivedi | Sr.Technical Officer - Library |
| 3. | Sh. M.N. Makwana | Sr.Technical Officer - O.L. |
| 4. | Sh. A.V. Dhobi | Sr.Technical Officer - Civil |

| S. No. | Name | Designation/Discipline |
|---|---|---|
| 6 | Shri G. R. Baria | Technical Officer - Field |
| 7 | Shri B.J. Patel | Technical Officer - Photography |
| 8 | Shri B. H. Patel | Technical Officer - Field |
| 9 | Sh.R.B.Baria | Technical Officer - Field |
| 10 | Sh.K.K. Vankar | Technical Officer |
| 11 | Sh. R. D. Rathva | Technical Officer |

## 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. Sh. Jagan Singh Gora, Scientist (Hort.) joined on 11.4.2014.
2. Sh. Ramesh Kumar, Scientist (Hort.-Floriculture) joined on 4.11.2014.

## PROMOTION

### SCIENTISTS

| Sr. No. | Name/Designation | Grade/post to which promoted | Date of Promotion |
|---|---|---|---|
| 1. | Dr. B.D. Sharma, Principal Scientist | Head, Division of Crop Production, CIAH, Bikaner | 07.11.2014 |
| 2. | Dr. Dhurendra Singh, Principal Scientist | Head, Division of Crop Improvement, CIAH, Bikaner | 26.02.2015 |
| 3. | Dr. Sushil Kumar Maheshwari, Senior Scientist (Plant Pathology) | PB-4 / Rs 37400-67000 + RGP 9000/- | 29.07.2012 |
| 4. | Dr. Hare Krishna, Sr. Scientist (Hort.) | PB-4 / Rs 37400-6700 + RGP 9000/- | 24.12.2013 |
| 5. | Dr. Balu Ram Choudhary, Scientist (Vegetable Science) | PB-3 / Rs.15600-39100+RGP Rs.8000/- with designation of Sr.Scientist | 27.06.2014 |
| 6. | Dr. S.M. Haldhar, Scientist (Agril. Entomology) | PB-3 / Rs.15600-39100+RGP Rs.7000/- | 15.12.2013 |

## TECHNICAL ASSESSMENT

| Sl. No. | Name and Present Grade/ Designation | Promoted to Grade/Scale | Date of merit Promotion | Present Place of Posting |
|---|---|---|---|---|
| 1. | Sh. Bhoj Raj Khatri, Senior Technical Assistant (Computer) | Technical Officer (Computer) Pay Band-2/ Rs.9300-34800 with Grade Pay of Rs.4600 | 29.03.2014 | CIAH, Bikaner |
| 2. | Sh. Sua Lal Choudhary, Technician (Driver) | Senior Technician (Driver) Pay Band-1/Rs.5200-20200 with Grade Pay of Rs.2400 | 28.7.2014 | CIAH, Bikaner |
| 3. | Sh. Birdhi Chand Meena, Technician (Driver) | Senior Technician (Driver) Pay Band-1/Rs.5200-20200 with Grade Pay of Rs.2400 | 28.7.2014 | CIAH, Bikaner |

## MODIFIED Assured Career Progression scheme (MacpS)

| S. No. | Name of Official with designation | Recommendation of the Screening Committee | Effective Date |
|---|---|---|---|
| 1. | Sh. S.N.Patel, UDC | II Financial Up-gradation PB-1/ Rs 5200-20200 + GP Rs 2800.00 | 09.11.2012 |
| 2. | Sh.V.G.Patel, SSS | III Financial Up-gradation . PB-1/ Rs 5200-20200 + GP Rs 2400.00 | 01.06.2013 |
| 3. | Sh.B.K.Jadav, SS | III Financial Up-gradation PB-1/ Rs 5200-20200 + GP Rs 2400.00 | 24.06.2013 |
| 4. | Sh.F.T.Patel, SSS | III Financial Up-gradation PB-1/ Rs 5200-20200 + GP Rs 2400.00 | 27.06.2013 |
| 5. | Sh.Chandubhai D. Rathva, SSS | II Financial Up-gradation PB-1/ Rs 5200-20200 + GP Rs 2000.00 | 05.12.2012 |

## PROBATION CLEARANCE

| Sr. | Name and Designation | Grade | Date of appointment | Recommended date of clearance of Probation |
|---|---|---|---|---|
| 1. | Sh. P.V. Solanki, Assistant | Pay Band-2/Rs.9300-34800 with Grade Pay of Rs.4200/- | 3.3.2011 | 2.3.2013 |

## JOINING ON TRANSFER

| Sl. No. | Name/Designation | Date of joining |
|---|---|---|
| 1. | Sh. K.V.Parmar, Technical Officer | 10.06.2014 |
| 2. | Sh. C.S.Chamar, Sr.Tech. Assistant | 10.06.2014 |
| 3. | Sh.D.B.Yadav, SSS | 05.01.2015 |

## RELIEVING ON PROMOTION/TRANSFER

1. Sh. K. K.Vankar, T.O. relived from the Institute on 18.06.14 on transfer to CHES, Godhra.
2. Sh.R.D.Rathva, T.O. relived from the Institute on 18.06.14 on transfer to CHES, Godhra.
3. Dr.V.Karuppaiah, Scientist relived from CHES, Godhra on 27.11.2014 on transfer to ICAR DOGR, Pune.
4. Dr.Raja Shankar, Scientist (Vegetable Science)), relieved on 24.5.2014 from CHES, Godhra for joining the post of Sr. Scientist (Vegetable Science) at CPRI, Shimla

## SUPERANNUATION/RETIREMENT

1. Sh. H. K. Joshi, Scientist retired on superannuation from the Council's service in the afternoon of 31.05.2014.
2. Sh. D. K. Saraswat, Chief Tech. Officer retired on superannuation from the Council's service in the afternoon of on 31.7.2014.
3. Dr. S. S. Hiwale, Principal Scientist retired on superannuation from the Council's service in the afternoon of on 31.3.2015.

# 15. BUDGET

| Head | Plan Expenditure 2014-15 | | | Non-Plan Expenditure 2014-15 | | |
|---|---|---|---|---|---|---|
| | Bikaner | Godhra | Total | Bikaner | Godhra | Total |
| **A. Grant in aid- Salary** | | | | | | |
| a. Salary | 0 | 0 | 0 | 39957977 | 33049632 | 73007609 |
| b. Wages | 0 | 0 | 0 | 0 | 18161983 | 18161983 |
| Total (A) | 0 | 0 | 0 | 39957977 | 51211615 | 91169592 |
| **B. Grant in aid - Capital** | | | | | | |
| a. Equipment | 1837676 | 2107167 | 3944843 | 213165 | 148700 | 361865 |
| b. Works | 32254879 | 5400000 | 37654879 | | | 0 |
| c. Library | 400081 | 200017 | 600098 | | | 0 |
| d. Furniture & Fixture | 0 | 0 | 0 | | | 0 |
| Total (B) | 34492636 | 7707184 | 42199820 | 213165 | 148700 | 361865 |
| **C. Grant in aid - General** | | | | | | |
| a. O.T.A. | | | 0 | 24653 | 0 | 24653 |
| b. T.A. | 999986 | 500018 | 1500004 | 197916 | 124988 | 322904 |
| c. H.R.D. | 260458 | 39498 | 299956 | | | 0 |
| D. Contingency | | | 0 | | | |
| Res. & Operation | 2699529 | 1899905 | 4599434 | 3107879 | 899502 | 4007381 |
| Administrative Exp. | 5737973 | 659107 | 6397080 | 2704579 | 1469623 | 4174202 |
| Misc. Exp.(PDTC+TSP) | 4000971 | 977912 | 4978883 | 296944 | 88252 | 385196 |
| Total (d) | 12438473 | 3536924 | 15975397 | 6109402 | 2457377 | 8566779 |
| Total (C) | 1260444 | 539516 | 1799960 | 222569 | 124988 | 347557 |
| **E. Others** | | | 0 | | | |
| a. Pension | | | 0 | 204347 | 7795653 | 8000000 |
| b. P-Loan | | | 0 | 422000 | 516000 | 938000 |
| Grand Total (A+B+C+D+E) | 48191553 | 11783624 | 59975177 | 47129460 | 62254333 | 109383793 |

## Revenue Receipt 2014-15

| S.No. | Head of Account | CIAH | CHES | KVK | SEED PROJ. | Amount |
|---|---|---|---|---|---|---|
| 1 | Sale of farm produce | 300949 | 704971 | 4350 | 543640 | 1553910 |
| 2 | Sale of Condemned Items | 17500 | 0 | | | 17500 |
| 3 | Licence fee | 46967 | 20454 | | | 67421 |
| 4 | Water Charges | 2296 | 23 | | | 2319 |
| 5 | Tender Fee | 267500 | 9950 | | | 277450 |
| 6 | Interest earned on loans & advances | 200023 | 23770 | 0 | | 223793 |
| 7 | Leave salary and pension contribution | 0 | | | | 0 |
| 8 | Guest House | 44395 | | | | 44395 |
| 9 | Interest earned on short term deposits | 1298541 | | | 98991 | 1397532 |
| 10 | Recoveries of Loans & Advances | 286680 | 492685 | | | 779365 |
| 11 | Miscellaneous Receipts | 0 | 0 | 0 | 0 | 0 |
| | TOTAL : OTHER RECEIPTS | 2464851 | 1251853 | 4350 | 642631 | 4363685 |

# 16. METEOROLOGICAL DATA

## Meteorological data for the year 2014-15 (Bikaner)

| Sl. No. | Month | Temperature ($^0$C) Max. | Min. | RH % | Rainfall (mm) | Rainy days | Wind Speed (km) |
|---|---|---|---|---|---|---|---|
| 1. | April, 2014 | 37.17 | 21.80 | 56.40 | 6.0 | 2 | 4.60 |
| 2. | May, 2014 | 41.11 | 27.56 | 58.10 | 72.6 | 4 | 7.38 |
| 3. | June, 2014 | 43.30 | 32.30 | 54.30 | 2.1 | 1 | 11.30 |
| 4. | July, 2014 | 40.00 | 29.00 | 67.30 | 47.0 | 5 | 10.10 |
| 5. | August, 2014 | 35.41 | 33.51 | 72.70 | 244.5 | 4 | 9.46 |
| 6. | September, 2014 | 35.72 | 26.28 | 78.90 | 111.4 | 4 | 8.91 |
| 7. | October, 2014 | 35.87 | 21.38 | 61.00 | — | — | 4.99 |
| 8. | November, 2014 | 31.40 | 15.50 | 56.90 | — | — | 4.87 |
| 9. | December, 2014 | 24.40 | 08.32 | 73.30 | — | — | 3.98 |
| 10. | January, 2015 | 21.90 | 08.36 | 80.90 | — | — | 5.00 |
| 11. | February, 2015 | 27.80 | 13.30 | 63.70 | 22.0 | 1 | 4.00 |
| 12. | March, 2015 | 29.84 | 17.58 | 71.50 | 35.0 | 3 | 4.20 |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