Annual Report

2015-16

ICAR

CENTRAL INSTITUTE FOR ARID HORTICULTURE
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ICAR- Central Institute for Arid Horticulture

Bikaner-334006 (Rajasthan)

(An ISO:9001:2008 Certified Institute)

ANNUAL REPORT

2015-16

ICAR-Central Institute for Arid Horticulture
Beechwal, Bikaner-334006, Rajasthan
(An ISO : 9001 : 2008 Certified Institute)

Published by
Dr. B. D. Sharma
Director (Acting)
ICAR-Central Institute for Arid Horticulture
Sri Ganganagar Highway, Beechwal, Bikaner 334 006
Rajasthan, India

Telephone : 91-151-2250147, 91-151-2250960, Fax : 91-151-2250145
E-mail : ciah@nic.in
Website : http://www.ciah.ernet.in

Compiled and edited by
Dr. R. Bhargava
Dr. R. S. Singh
Dr. Hare Krishna
Dr. S. R. Meena

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Sh. B. R. Khatri
Sh. M. K. Jain
Sh. Sanjay Patil
Sh. P. P. Pareek

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Preface

Dr. B. D. Sharma
Director (Acting)

It gives me immense pleasure in bringing out the Annual Report 2015-2016 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 are 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 & other input, handling and value addition technologies of the horticultural produce, introduction of genotypes 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 sense of gratitude to Dr. T. K. Mahapatra, 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) and to Dr. T. Janakiram, ADG (Hort.-1) for his ciritcal remarks and valuable suggestions.

This Annual Report is the culmination of dedicated and sustained efforts by our Scientists and other staff of the institute. I wish to express my sincere appreciation to Dr. R. Bhargava, Dr. R. S. Singh, Dr. Hare Krishna and Dr. S. R. Meena for their sincere and whole-hearted support in bringing out the Annual Report (2015-16). The technical support in terms of computerization by Sh. Bhoj Raj Khatri is appreciated.

Dated: May 2016, Bikaner

(B. D. Sharma)

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, 3 new accessions of date palm, 25 of Manila tamarind, 4 of mulberry, 25 in phalsa were collected and added to the germplasm gene bank.

A total of 26 genotypes of jamun, 24 of tamarind, 30 of mahua, 40 of karonda and 32 of khirni 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. During 2015-16 a total of 06 varieties of Karonda (Thar Kamal), Ridge gourd (Thar Karni), Bael (Thar Divya), Khirni (Thar Rituraj), Mahua (Thar Madhu) and Mulberry (Thar Lohit) were identified at Institute level.

Vegetable

For conservation of arid vegetable genetic resources at CIAH, monitoring of 500 germplasm as generated material including dessertic melons (125), non-dessertic melons (161) and gourds (60) was done under –20 ^{0}C deep freeze facilities. Snap melon (25) and kachri (65) genotypes consisted of generated breeding material from germplasm, advanced lines and varieties were studied for entomological parameters and melon fruit fly during 2015-16. During the period, seeds of potential lines / value added genotypes / varieties (>25) of arid vegetables were supplied under national network for use in breeding or performance studies.

The kachari AHC–2 (non-dessertic form of *Cucumis melo* and used for salad at tender stages and developed from indigenous material by the institute during 1998) was studied for maintenance breeding and seed enhancement was done using 10 years of stored seed and 45 crop parameters were studied with varying production techniques during spring-summer season of 2015.

The ridge gourd germplasm maintained as generated material (20) at the institute was studied for storage behaviour, maintenance cycle and evaluated for trait specific characterization and sufficient quantity of seed was produced for conservation during rainy-winter season of 2015. Based on multiple stress to lerance and quality yield potential, the fourth generation progeny from germplasm AHRG–15 was most potential for utilization in crop improvement.

During summer and rainy season of 2015, advanced round melon material (AHRM/2015/ F_5/1a) was tested for performance studies. Likewise, three developed lines of long fruited bottle gourd were tested for performance, stability and uniformity of material and AHLS/2014/F_6/01 exhibited superiority for marketable fruit yield under hot arid agro-climate.

During spring–summer and rainy–winter season of 2015–16, developed sponge gourd breeding lines namely AHSG–4 (P_4), AHSG–5 (P_5), AHSG–16 (P_{16}), F_4 [(P_4xP_5)xP_4], F_4 [(P_5xP_4)xP_4] BS, F_4 [(P_5xP_4)xP_4] WS and F_4 (P_4xP_{16}) were tested for uniformity and marketable yield potential under high temperature conditions of hot arid agro-climate, and the line F_4 (P_4xP_{16}) followed by AHSG–4 (P_4) exhibited superiority for most of desirable traits under investigation.

In khejri, 14 elite genotypes were maintained with good management practices in field repository for *ex situ* conservation. Khejri Selection–2 was studied for comparative traits and characterized for growth and pod quality attribute. The variety Thar Shobha exhibited superiority for tender pod, loong and total bio-mass yield in reference to three elite types under investigation.

For genetic quality and seed crop yield

potentials, studies on snap melon (AHS-82), kachri (AHK-119), kakri (AHC-2), palak (AHLP-1) and moringa (AHMO-1-4s) was done with varietal maintenance breeding and breeder seed production crops adopting HBCPSMA during 2015–16 under revolving funds of ICAR seed project. About 330.00 kg seed of institute varieties / genotypes was produced for distribution to farmers, NGO's, KVK's and national, state and private agencies for spread of the varieties and further seed chain in arid zone vegetables.

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 (44.3 kg per plant) system followed by aonla- ber (41.6 kg/plant), aonla-kinnow (38.8 kg/plant) and aonla- mulbery (36.7 kg/plant), while the lowest was recorded in aonla-moringa (33.4 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 2015-16 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.

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.

Studies on effect of different source of nitrogen on kachri production was studied and it was found that total yield increased by 97.4% by application of split appliction of nitrogen.

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 10 accessions of Mahua available at CHES, Godhra and 42 date palm at CIAH, Bikaner were developed to identify germplasm and assess the phylogenetic relationships. The impact of water stress on accumulation of secondary metabolities was also evaluated.

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. Attempts to harden the tissue culture plants was also attempted succesfully.

Post Harvest Technology

Various value added products such as biscuits with date palm fruit pulp, RTS from bael, rough lime, squash, kinnow squash, ber pickle, dehydrated products from karonda, aonla candy, aonla juice, aonla murabba, etc were prepared and assessed their acceptability.

Crop Protection

17 genotype of snapmelon were evaluated for incidence of *B. cucurbitae* and if was recorded that

3 genotypes were resistant to this pest. Among the biochemical traits, flavonoids, tannins, total alkaloid and phenols showed role in imparting resistance to the above pest.

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 be 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 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*. Screening of sponge gourd for resistance against mosaic disease was performed and it was recorded that minimum disease incidence appeared in Pusa Sneha.

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 eight externally funded projects were in operation.

Under DUS project on date palm, detailed morphological data of different varieties were collected and analyzed and draft guidelines for DUS have been prepared. 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 plenty 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

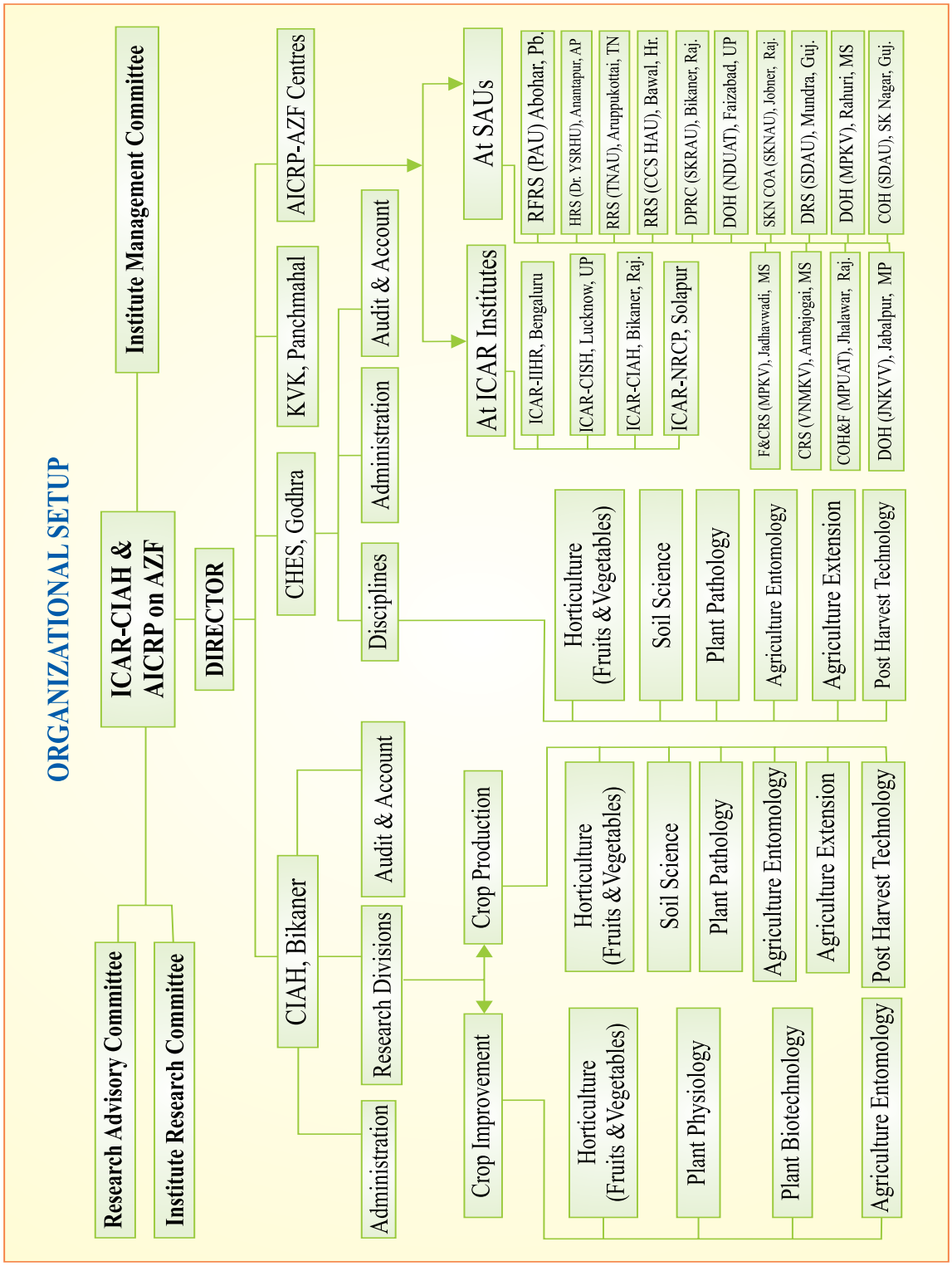
1. To undertake basic, applied and strategic studies for developing technologies to enhance productivity and utilization of arid horticultural crops.
2. To act as a national gene bank of arid horticultural crops.
3. To develop multistorey horticulture based sustainable cropping system under arid environment.
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 2015-16 and the significant results obtained in different projects are presented hereunder.



2. RESEARCH ACHIEVEMENTS

GENETIC RESOURCES

Introduction, collection, characterization, conservation and evaluation of germplasm of arid and semi-arid fruit and vegetable crops

FRUIT

At Bikaner

Ber (*Ziziphus mauritiana*)

A uniform decimal code, known as the BBCH-scale (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie), is presently being used for describing phenological stages of crops. Description of the principal phenological stages of Indian jujube (*ber* cv. Gola) tree according to the extended BBCH scale considering principal growth stages, starting at bud development (stage 0) and ending at the senescence and beginning of the rest period (stage 9), has been attempted during the period under report (Fig. 1 & 2)

00: Dormancy

01: Beginning of leaf bud swelling

09: Green leaf tips about 5 mm above bud scales

11: First leaves unfolded (others still unfolding)

15: More leaves unfolded, not yet at full size

19: First leaves fully expanded

31: Beginning of shoot growth

32: Shoots about 20% of final length

39: Shoots about 90% of final length

51: Inflorescence buds swelling

56: Flowers still closed; sepals slightly begin to separate

60: First flowers open

65: Full flowering: 50% of flowers open

71: Fruit set

79: Fruit at standard cultivar size, skin green in colour.

88: Fruit colour fully developed.

89: Beginning of fruit senescence.

93: Beginning of senescence of old leaves; leaves fall.

Fig.1 Phenological growth stages of Indian jujube (ber cv. Gola) tree according to BBCH scale.

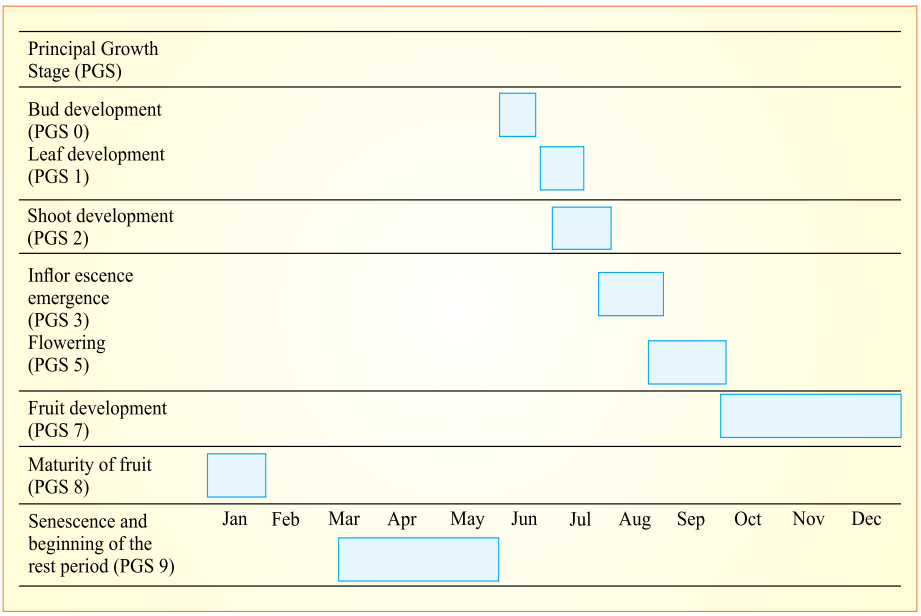


Fig 2. Schematic representation of the chronological progression of Indian jujube (ber cv. Gola) principal growth stages.

Performance of CIAH Ber S-15

A promising chance seedling of *ber* 'CIAH *Ber* S-15', which was noted at the institute last year, was assessed for its yield performance. The *ber* selection has profound bearing (≈110 kg/tree) as compared to last year bearing (≈65 kg/tree). The increase in yield could be attributed to attainment of full bearing age in chance seedling. Further, Indigenous Collection number (IC-0614771) was also acquired for CIAH *Ber* S-15 from ICAR-NBPGR, New Delhi.

Date palm (*Phoenix dactylifera*)

Collection and conservation

Sixty one date palm varieties/genotypes including exotics were conserved in the field repository. Three germplasm (M1NI, MRKS, MHN/B) were introduced from ICARDA, Amman, Jordan during April, 2015 and planted in the field during July, 2015 for evaluation. Plants are growing well under hot arid environment.

Evaluation

The maximum palm height and spread was observed in cv. Muscat followed by Halawy and Bikaner Local. The spathe emergence started from third week of February and completed in the month of March. However, 10-15 days delay in emergence of spathe was noted in germplasm during the year due to rains and low temperature conditions. The spathe emergence/opening and fruiting were recorded in 26 genotypes out of 61germplasms. However, the drop of berries was observed in many cultivars due to high wind speed/ dust storm in the month of May. Early emergence of spathe/flowering and fruit maturity was observed in cv. Muscat.

The highest bunch length was in cv. Sewi (108cm) followed by Zahidi (102) and Bikaner Local (100cm). The variation in number of bunches from 5-13 per plant and fruits yield varied from 1.50 to 68.0 kg/plant was observed among the germplasm. Similarly, number of strands/bunch ranged from 5-35; number of berries/strand varied from 9 to 27. The maximum number of bunches/ plant were observed in cv. Sevi (13) followed by Khadrawy (10) and Sabiah (9). The maximum number of berries (27 per strand) was recorded in cv. Zahidi followed by Khalas (21) and Khuneizi (19), while minimum was in Seddami (8). The bigger size and fruit weight (17.2g) was observed in cv. Medjool followed by Sewi, Chip chap, Bikaner Local (11.5g to 12.2g) and Dayari, Shamran (10g) and minimum fruit weight (3.70g) was in Abdul Rehman. The weight of stone also varied from 0.50- 1.50 g. The early *doka* stage was observed in cv. Siwi and Halawy and harvested at end of June, 2015. 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 first week of August. In a tissue culture plants of cv. Dhamas early maturity of fruit was observed. Maximum fruit yield at *doka* stage was observed in cv. Sewi (68.0 kg/tree) and Halawy (55.0kg), Khalas (50) followed by Khadrawy and Khuneizi (42.0kg), and Zahidi (40kg/tree). However, minimum fruit yield (1.50kg/ plant) was observed in cv. Siwi because of first time fruiting after 5years of planting.

During the year-2015, maximum berries (30-50%) were damaged due to rains in July month at the time of harvesting.

During the March, 2016, hails storm damaged the leaflets in date palm plants and fruit drop was also observed in date palm cultivars.

Varietal evaluation

A varietal trial consisting cvs. Halawy, Khalas, Zahidi, Medjool and Khadrawy were carried out for growth, flowering /fruiting, yield and quality of fruits under drip irrigation. Maximum plant height and spread was noted in cv. Halawy followed by cv. Khalas, Medjool, Khadrawy and Zahidi. The plant growth was vigorous in Halawy and Khalas in comparision to cvs. Zahidi and Medjool. The growth in Khadrawy was low & drooping nature of leaves. Flowering and fruiting was observed in all cultivars and 5-8 bunches/palm (4-6kg bunch weight) were recorded. Maximum fruit yield/tree was observed in cv. Khalas (48.0kg/tree) and Halawy (43.0 kg) followed by Zahidi (40kg). The lowest per plant fruit yield was observed in cvs. Khadrawy (30kg) and Medjool(25kg).

Evaluation of tissue culture plants

Tissue culture plants of cv. Barhee and KCS-143 were evaluated for growth, flowering/fruiting and vegetative growth in cv. Barhee was better than KCS-143 plant. The spathe emergence /fruiting

was observed in cv. Barhee plant. During the year, fruiting was in cv. Barhee. However, fruits were damaged due to low plant height.

Performance of seedlings

Seedlings were evaluated for male & female ratio and fruiting. Flowering and fruiting was observed in few seedlings after 7-8 years and the sex ratio in plant was 50% male and female. The berry characters of seedling type were noted and the fruit was yellow and reddish colour, medium size berry, astringent at *doka* stage.

Pomegranate (*Punica granatum*)

Ninety five pomegranate germplasm lines are being maintained and conserved in field gene bank. This germplasm block is old (more than 25 years), and hence there's a need to replant and in the past season about 70 germplasm lines have been replanted between line of old germplasm for conservation, maintenance, evaluation and utilization purposes. Data were recorded on growth, flowering and fruit cracking of pomegranate in old block. Cracking was reported in most of the varieties and it varied from 35 % to 60 % in different varieties. Cracking was reported 35 % in Phule Arakta, 40 % Bhagwa and 52 % in Jalore seedless. In the new plantation, survival rate was about 98% during the reporting period. Drip irrigation system was installed in entire pomegranate block. Data were being recorded on vegetative parameters of newly plated germplasm lines. Flowering and fruiting is also observed in NRCP 2014-1 pomegranate line. During November, 2015 nine germplasm lines (plants/cutting) *viz.* NRCP-2014-2, NRCP-2014-4, NRCP-2014-6, H-6, H-12, H-14, Bhagwa, Ruby and Amlidana, were introduced from ICAR-NRC on Pomegranate and kept under nursery condition. Planting will be done during July-August 2016. Fruit cracking tolerant germplasm line (IC-318712) was growing well in hot arid condition. Twenty two germplasm lines of pomegranate (cuttings) were supplied to ICAR-CSSRI, Karnal for assessment of salt tolerance and their subsequent introduction in farmer fields under Haryana condition.

Bael (*Aegle marmelas*)

At Bikaner

Bael germplasm (18) were maintained in the field gene bank at CIAH, Bikaner and evaluated for growth, flowering, fruiting and effect of frost/low temperature and fruit cracking. The vegetative growth of plants varied among germplasm under hot arid conditions. The maximum germplasm are of seedling type. The maximum height of plant 6.1m and spread (3.7m N-S and 3.2m E-W) was recorded in a seedling type at an age of 13 years. Fruiting was noted in 12 germplasm during the year 2015. On 19th May, 2015 severe dust /thunder storm (wind speed more than 100km/ hr) damaged branches of trees and flowering/ fruiting in bael plants. During the year-2016, effect of frost/low temperature was not observed in any genotypes. Variation in number of fruits/ plant was 05 to 58 was noted at maturity stage in February. The fruit weight varied from 200g to 1600g among germplasm. Out of 12, fruit cracking was observed in two germplasm. Fruiting in two genotype was found better with respect to size, weight (800-1000g. fruiting 25-58 per plant and cracking of fruits. Fruit cracking was also less in promising genotype than released cultivar. The bigger size fruit was recorded in NB-9 (1.60kg) and another germplam. These two genotypes were marked as promising line(CIAH Bael-1 and CIAH Bael -2) for further multiplication and evaluation. Foliage and fruit damage was observed in bael germplasm due to hails storm on 11 March, 2016 and about 5- 6 % fruits were dropped due to severity of hail storm and also spots on mature fruits were observed.

Development of varietal block of bael NB-5, NB-9, CISH Bael-1, CISH B-2, Pant Sujata, CIAH Bael Sel-2, Bael Sel.-1 and Goma Yashi was undertaken. *In situ* budding was done but success percentage was low. However, initial growth in young plant was observed slow.

Bael cv. Goma Yashi was planted at 6x8m distance for performance evaluation under hot arid

conditions. The survival of plants was cent per cent after a month.

On 19th May, 2015 Severe dust /thunder storm (wind speed more than 100km/hr) damage branches of trees and flowering/fruiting also.

Ethrel @1000ppm was sprayed during the month of January and February, 2016 on foliage/ branches and fruits to see the effect on fruit cracking and early maturity, ripening. Initial results showed that no fruit cracking was observed on sprayed plants fruit and also enhanced early maturity / ripening in second week of March in comparision to unsprayed plants.

At Godhra

Among the different genotypes, 101 genotypes were studied for their morphological characters out of which, 38 germplasm were studied for their flowering and fruiting characters under rainfed conditions.

Growth habit

The range of growth habit included tree with erect, spreading, drooping and semi spreading type growth habit and foliage with compact, dense and sparse type among all the characterized genotypes. Tree shape of different genotypes are dome, irregular, semi circular, broad vase and elliptical types in rainfed semi-arid ecosystem of western India among 101 germplasm of bael studied for growth habit.

Leaf

Established genotypes showed wide variation in leaf morphology *i.e.*, leaf shape (ovate to broadly ovate, elliptical, lanceolate, broadly ellipsoidal, slightly deltoid and obtuse), leaf base (broadly cuneate, narrowly cuneate, oblique cuneate, oblique round and round), however, in few genotypes central and lateral leaflet having different leaf base (cuneate and round, respectively), leaf apex (acute, acuminate, aristate, caudate and acuminate with bifid end), leaf margin (crenate,bicrenate and crenulate; deeply toothed or superficially toothed.), leaf colour (dark green, light green and yellowish green with differences in dorsoventral surface colour: abexial and adexial), leaf texture (glabrous, shiny papery coaraceous, coaraceous dull, leathery smooth shiny or dull). Heterophylly could be seen in few genotypes having bifoliate, trifoliate, quadrafoliate and pentafoliate types of leaves in few branches of the plant. The range of leaf length (11.4 -25.2cm), central leaflet length (7.4 -18.1 cm), width (4.2-11.1 cm), central petiolule length (1.0 -3.5cm), width (0.09-0.29 cm), right lateral leaflet length (4.5- 13.3), width(2.9-7.7 cm), left lateral leaflet length (4.9-13.2 cm), width(2.8-8.7 cm), lateral petiolule length (0.2-0.9 cm) and width (0.10 - 0.19 cm) varied widely among the genotypes characterized under rainfed condition of western India. Central petiolule could be categorised into short, long, medium and tubular to flate squarish in shape, whereas in few genotypes it was straight to slighty tilted. Lateral petiolules are sessile or with very short and slighty long in length. The internodal distance varied between 2.04-5.52 cm in all the 101 genotypes.

Stem and Bark

Stem bark is creamy, brownish, grey, and dark grey in colour, whereas stem may be long, straight and branched. Bark is thin, thick and medium thick, while bark splitting pattern was irregular, cylindric, intersecting, wedges and small rectangular type in different genotypes.

Spine

There is wide range of variation, which could be seen in the morphology of spine. The spine length, width and base girth varied between 0.8-5.32 cm, 0.2-0.49 cm and 0.9-1.9cm, respectively among the genotypes studied. In most of the genotypes spines emerged from the axil of the leaf base which was either single or in pair. Spines can be categorized into very short, short, medium, long and very long. In few genotypes, spine base has cushion like shape raised from the stem surface whereas some of them are directly originated from the surface and hardly few genotypes are completely spineless. In very few genotypes having spine, which itself regenerate another spine which either rejuvenate the leaf on it or lack of them. In very few genotypes thorn itself regenerate another thorns on it with leaf. On the basis of presence of spines, genotypes may be characterized as spineless or with very less, less, high and very high in numbers of spine. Basically,

spines are found on the basal portion of the lower branches that emerged initially from the tree in most of the genotypes.

Flowers

Mean values of floral traits showed wide range of variations with respect to pedicel length (4.00-10.50 mm), pedicel thickness (2.00-2.60), bud length (9.50-14.00mm), length width (6.50-9.50mm), flower length (10.75-19.50mm), flower width (23.75-36.00mm), petal length (10.50-18.50), petal width (7.00-10.00 mm), stamen length (6.75-9.00 mm), filament length (2.75-5.00 mm), filament width (0.40-0.80 mm), anther length (3.50-4.00), anther width (0.50-0.80 mm), pollen diameter (30.15-45.00 micron), ovary length (4.00 to 6.50 mm), ovary width (3.00-5.00 mm), style length (1.00-1.50 mm), style width (1.50-2.50 mm), stigma length (2.00-3.50 mm) and stigma width (2.00-3.00 mm) in 38 genotypes under rainfed semi arid ecosystem.

Fruit

Fruit characters of different genotypes varied greatly in terms its various physical characters viz., fruit shape (spherical, semi spherical, flattened round, oval, elliptical, oblong, sub globose median bilobed and pyriform), styler end cavity(sunken, raised, depressed, highly depressed, leveled, shallow and very deep), stem end cavity (raised, depressed, curved, slightly narrower, leveled) weight (0.46-6.90 kg), fruit length (6.09-21.25cm), fruit circumference (28.68 - 70.18cm), shell thickness (1.5 - 3.2 mm), seed number/ fruit (49-230), number of seed sacs (10.33-22.50), seed weight (0.10-0.24g), shell weight (109.82-401.57g) and pulp weight (0.23-4.69 kg), as also of its chemical composition including TSS in pulp (30.33- 44.73^{0}Brix), TSS in mucilage (37.17-54.50^0 Brix), acidity (0.25-0.51%), vitamin C (12.02-24.39 mg/100g), total phenol contents (1692-3075 mg/100g) and total sugar (16.14-23.14%).Their exists remarkable variability with regards to physical composition of fruit *viz.,* pulp (37.34-72.83%), shell (14.00-23.18%), fibre (1.50-6.12%), mucilage (12.00 -19.82%) and seed content (1.02-4.84%).Various other characters also ranged variedly as the bearing behaviour (shy to prolific bearer), maturity period (February to July) and flesh colour (creamy-yellow, whitish yellow, deep yellow and lemon colour), styler end cavity (sunken, depressed, highly depressed, slightly raised, levelled and shallow) and stem end (narrowly raised, curved depressed), fruit surface (smooth, rough, shiny, dull)among the38 genotypes in which fruiting was noticed during 2015-16

Salient features of identified elite genotypes of bael

Among the genotypes, CHESB-8, CHESB-11, CHESB-16, CHESB-21, CHESB-29 and CHESB-31were found promising. The striking characters of CHESB-8 and CHESB-11 are as under:

"CHESB-8"

An identified promising genotype CHESB-8 was collected from *Mera* village of Jaunpur district of Uttar Pradesh State and *in situ* budding was performed during 2008. It is superior genotype with desirable characters like earliness, compact growth, medium height, spiny, better yield with quality fruits having pleasant flavour with attractive colour of pulp. It started flowering and fruiting from 3rd year of budding. Plant height, stem girth and plant spread were recorded 4.87 m, 38.23 cm and 4.67m, respectively during 7th year of orchard life. Average yield per plant 61.25 kg (7th year), average fruit weight 1.45 kg, fruit size 15.10 cm x 15.00 cm, fruit girth 47.30 cm, shell thickness 0.18cm, total number of seed 73, seed weight 0.21g, total seed weight 15.46g, fibre weight 110.17 g, shell weight 265.00g, locules in cross section 13-16, pulp 71.30%, TSS pulp 40.10^{0}B, TSS mucilage 51.50^{0}B, acidity (0.30%) and vitamin C 19.90 mg / 100 g pulp were recorded. It is an early maturing variety (2nd week of March). The fruits of this genotype is having good flavour and aroma. It is highly suitable for sherbet, powder and squash making.

"CHESB-11"

Vegetative growth in terms of plant height, stem girth, plant spread was recorded 4.35 m, 36.20cm and 4.15 m, respectively during 2015-16. Average yield per plant 49.10 kg in 6th year, fruit weight 1.47 kg, fruit size 14.05 cm x 15.00 cm, fruit girth 43.20 cm, shell thickness 0.20cm, total number of seed 86, seed weight 0.20g, total seed weight 17.50g, fibre weight 25.50 g, shell weight 185.20g, locules in cross section 14-17, TSS pulp 39.20^{0}B, TSS mucilage 50.70^{0}B, acidity (0.28%) and vitamin C 21.80 mg /

100 g pulp were recorded. It is medium maturing variety (1st week of April). The fruits of this genotype are having good flavour and aroma. It is highly suitable for sherbet, candy and powder making.

Indeginous and exotic underutilized fruits

Karonda (*Carissa carandus*)

At Bikaner

Five genotypes were maintained and evaluated for growth, flowering and fruiting under arid conditions. Flowering was observed but fruit set was less due to poor moisture conditions. The growth features of germplasm were of bushy type.

At Godhra

Total 40 genotypes were evaluated in karonda. Konkan Bold recorded maximum fruit weight (14.30g) and TSS (11.30^0 Brix) but fruit yield was 6.10 kg per plant only. Minimum acidity (0.41 %) was recorded in Konkan Bold during ripening. Maximum fruit yield (10.00 kg/ plant), fruit weight (5.20 g) and TSS (9.50^0 Brix) was recorded in Thar Kamal, closely followed by CHESK-3. Pant Manohar recorded 3.50 g fruit weight, 10.10 kg yield/ plant.

Wood apple (*Feronia limonia*)

At Bikaner

Five wood apple genotypes were evaluated for survival and growth under arid conditions.The initial growth of plant was slow in all genotype. No flowering /fruitng was noted in any genotypes.

At Godhra

An extensive survey of diversity rich area of Gujarat was made during 2015-16, a total of 25 germplasm were collected and evaluated for their physico-chemical attributes. Among the genotypes, the fruit shape and fruit colour was observed oblong, round flattened round and triangular among the different genotypes. The fruit length and width ranged between 6.34-9.46 and 7.59-9.36 cm. The maximum length observed in the genotype GW-15 (9.46 cm) followed by GW-18 (9.30cm), GW-17 (9.22 cm) and GW-16 (9.00 cm), whereas similar was minimum in GW-9 (6.34 cm) followed by GW-13(6.82cm). The fruit width measured between 7.59-9.36 cm. It was maximum in the genotype GW-15(9.36cm) followed by GW-16 (9.25 cm), GW-18(9.24cm) and GW-17 (9.00cm) whereas it was minimum in GW-2 (7.59 cm) followed by GW-11 (7.6 7cm) and GW-9 (7.72 cm), respectively. The fruit girth was maximum (30.0 cm) in both genotype *i.e.*, GW-15 and GW-16 subsequently followed by GW-10 (29.2cm) and GW-17 (28.7 cm). The highest fruit weight was measured in the genotype GW-18 (432.9g) followed by GW-15 (418.3 g),GW-16 (400 g) and GW-17 (384.5 g) whereas the lowest fruit weight in the genotype GW-11 (156.4 g) followed by GW-21 (162.0 g), GW-1 (188.4) and GW-7 (210.5). The number of seed per fruit was counted between 132-625. The higher number of seeds observed in the genotype GW-25 followed by GW-9 (489) and GW-22 (48.5) and same was the lesser in the genotype GW-12 (132) succeeded by the genotype GW-12(132), GW-11 (145) and GW-15 (159). The fruits of different genotypes contained pulp (80.4-319.32g) among all the studied genotypes. The genotype GW-15 (319.32 g) contained highest pulp quantity than the rest of the genotype which followed by the genotype GW-18 (317.78g), GW-16 (295.8g) and GW-17 (270.5g), and the least quantity of pulp measured in the genotype GW-11 (80.4g) followed by GW-9 (85.7g) and GW-21 (64.4 g). The number of seed per fruit was calculated between 132-625. The higher number of seeds observed in the genotype GW-25 followed by GW-9 (489) and GW-22 (485) and it was the least in the genotype GW-12 (132) succeeded by the genotype GW-12 (132), GW-11 (145) and GW-15 (159).The total seed weight per fruit was recorded the highest in the genotype GW- 25 (7.932g) followed by GW-19 (7.921g), GW-17 (6.879 g) and GW-1 (6.466 g) and the value of the same was minimum in the genotype GW-12 (2.362 g) followed by GW-23 (2.431g) and GW-11 (2.798 g). The individual seed weight ranged between 0.119-0.298 g among all the genotypes. The shell weight measured maximum in the genotype GW-25 (109.7g) followed by GW-19 (107.0g), GW-18 (105.0g) and GW-17 (100.0g), whereas same was the minimum in genotype GW-13 (67.9g) followed by GW-12 (70.5g) GW- 11 (72.8) and GW-14 (76.9 g). The shell thickness was measured between 0.32-0.47cm. The thick shell was observed in the genotype GW-10 (0.47cm) followed by GW-24 and GW-6 (0.46cm) and GW-7 and GW-19 (0.44

cm) whereas the thin shell was observed the lowest in the genotype GW-12 (0.32 cm), GW-21 (0.35cm) and GW-15(0.36).

The total soluble solids were recorded maximum in the GW-12 (19.3 ^{0}Brix) followed by GW-25 as well as GW-5 (18.9) genotype and GW-19 (18.6), whereas similar was highest in the genotype GW-17(11.00 ^{0}Brix) followed by GW-16 & GW-23 having similar (13.8^{0}Brix) ,GW-8(14.3^{0}Brix) and GW-14 (14.4^{0}Brix). The highest acidity was determined in the genotype GW-4 (5.98%) followed by GW-19 (5.34%) and GW-23 (5.32%), and it was the lowest in the genotype GW-14 (3.23%) followed by GW-15 (3.42%) and GW-22 (3.46%). TSS/acid ratio was observed maximum in the genotype GW-12 (5.97) followed by GW-22 (5.17) and GW-15 (5.00) where as similar was the highest in the genotype GW-23 (2.59) followed by GW-5 (2.71), GW-14 (2.80) and GW-8 (2.87). The vitamin C content was estimated maximum in genotype GW-10 (19.6 mg/100 g of pulp) followed by GW-19 (18.79 mg /100g of pulp), GW-15 (17.69mg/100g of pulp) and GW-20 (17.67 mg /100g of pulp) and minimum in the genotype GW-6 (7.0 mg /100g of pulp) followed by GW-9 (7.4 mg /100g of pulp)and GW-13 (7.9 mg /100g of pulp). TSS/acidity ratio was observed in the genotype. The reducing sugar ranged between 0.54-1.45% being maximum in the genotype GW-22.GW-10 (1.45%) followed by GW-19 (1.43%) GW-20 (1.37%) whereas it was minimum in the genotype GW-4 (0.54%) followed by GW-3 (0.76%). Total reducing sugar observed maximum in the genotype GW-13 (3.18%) followed by GW-24 (3.06%)and GW-20 (3.05%) it was least GW-4 (1.56%) followed by GW-22 (1.76%). The P content ranged between 0037-0.078% having the maximum in GW-7, GW-4, GW-22 and GW-1 followed by GW-18 (0.074%) and GW-3 (0.073%) and the same was minimum in GW-12 (0.037%) followed by GW-8 (0.038%) and GW-23 (0.039%).The value of K content ranged between 1.29 -1.86%, being the highest in genotype GW-25 (1.86%) followed by GW-20 (1.85%), GW-4 and GW-13(1.78), whereas the lowest value of it observed in GW-12 (1.29%) followed by GW-14 (1.34%) and GW-6 (1.36%). The Ca content was measured the maximum in the genotype GW-1(0.39 %) followed by GW-8 (0.37%), GW-24 (0.34%) and GW-18 (0.29%) while minimum in the genotype GW-9 (0.11%) succeeded by GW-13 (0.14%)a nd GW-21 (0.16%). The magnesium content was observed highest in the genotype GW-1 (6.58%) followed by GW-13 (5.64%) and GW-3 (4.56) whereas similar was the lowest in the genotype GW- 6;GW-16(3.18%) followed by GW-15 (3.42%), GW-22 (3.53%)and GW-23 (3.65%). The sodium content was observed maximum in the genotype GW-19 (7.54%) followed by GW-18 (6.83%)and GW-3 (6.0%) and same was minimum in the genotype GW- 9 (3.07%) followed by GW-8 (3.16%), GW-23 (3.27%) and GW-20 (3.42%).

Evaluation of wood apple germplasm

All the germplasm (14) were evaluated for their flowering and fruiting characters. The genotype CHESW-2 and CHESW-6 were found to be promising. The flowering starts in CHESW-2 from first week of March and CHESW-6 in the first week of April under rainfed conditions.

CHESW-2

The average physical attributes of genotype CISHW-2 in terms of fruit weight (297 g), length (9.37cm), width (8.48 cm), total number of seed (212.10), weight of individual seed (0.25g), pulp weight (130.25 g), shell thickness (0.30 cm), shell weight (75.24 g) whereas chemical attributes were *i.e.* TSS (18.00 ^{0}Brix), acidity (3.71%), Vitamin C (14 mg/ 100 g of juice), reducing sugar (1.35%), non reducing sugar (1.54%), calcium (0.035), phosphorus (0.04%), potassium (1.35%), sodium (4.50%) and pectin (1.55%) among the oblong genotype. Ripening starts in the first week of October and belongs to early maturity group (Fig 3).

Fig 3. Fruit of CHESH-2

CHESW-6

The genotype CISHW-6 which had round shape having average fruit weight (369.00 g), length (7.64 cm), width (8.62 cm), total number of seed (197.25), weight of individual seed (0.030 g), pulp weight (105.20 g), shell thickness (0.46 cm)

and shell weight (85g). The observed value of chemical characteristics in round fruit genotype were TSS (21 ^{0}Brix), acidity (3.15%), Vitamin C (12.78 mg/100 g of juice), reducing sugar (0.94%), non reducing sugar (1.12%), calcium (0.25 %), phosphorus (0.070%), potassium (1.60%), sodium (6.08%) and pectin (1.50%). Fruits start ripening in the last week of November and belong to late mid maturity group (Fig 4).

Fig 4. Fruit of CHESW-6

Manila tamarind (*Pithecelobium dulce*)

At Bikaner

Three germplasm of *Pithecelobium* was evaluated for growth, flowering /fruiting under field conditions and the plants were growing well. Flowering was not observed in seedlings even after five years of planting.

At Godhra

Survey was made and 25 genotypes were collected from Panchmahal district of Gujarat. Promising genotypes have been established in the field. One of the genotypes recorded the maximum fruit weight 29.20 g with 76.10 per cent pulp was recorded.

Cactus pear (*Opuntia ficus indica* Mill.)

At Bikaner

Cactus pear genotypes were maintained in the nursery block. Three clones 1308, 1269 and Mount Abu collection including tissue culture 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 found better in respect of cladode's production per plant than other clones. The cladodes of four cactus clones were supplied to BAIF, Pune for multiplication and evaluation.

Evaluation of tissue cultured cactus pear

Morphological observation on growth and development of tissue culture plants of cactus pear recorded under green house and open environment conditions. Under open condition the plants were severely damaged by wild animals and squirrels and also affected by hails whereas the plants under greenhouse remains safe and yield and quality of leaf pads was better than open condition. Under greenhouse leaf pads can be harvested regularly at 15-20 days intervals (Fig. 5).

Fig. 5. Greenhouse grown crop of cactus pear for cladode production

Evaluation of Exotic species

At Bikaner

Exotic fruit species (Chinese jujube, Argan, Marula nut) were conserved under field repository. Flowering /fruiting was not observed in marula nut tree during the year.

During 2015, flowering/fruiting was observed in Argan seedling plants after 10years of planting. The fruit weight varied from 8-12g and 30-40 green colour fruits/plant was noted during February month. The shape of fruit was like to *ber* and latex was available after harvesting. Fruits were harvested in first week of May. Further, bumper flowering was also observed in March in clusters near thorns but there was no fruit set in any plants.

Mulberry (Morus alba)

At Bikaner

Four accession received from CSGRC, Hosur were planted under field conditions on 27.07.13. All accessions came into fruiting during March, 2016. 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.

A variety has been identified by ICAR-CIAH, Bikaner the detail description of the variety of Mulberry "Thar Lohit" is as under:-

The promising line of mulberry has been compared with Gurgaon local-1 collected from NBPGR, New Delhi as check. The variety has been found superior to Gurgaon local with respect to fruit quality and tolerance to low and high temperature stresses with enhanced value of antioxidants quality of fruits (Fig. 6).

Description of variety

Plant height (3.07 m), spreading growth habit, heterophyllous leaves cordate in shape and with fine serrated margin, leaf pubescence absent, leaf arrangement alternate and red colour, pendulous shape fruits, planting distance: 6x6 m, tree population : 275/ha, planting time: July-August, propagation method: budding/cutting). Skin colour of fruit is deep red.

Fig. 6. Fruits of mulberry variety Thar Lohit

Trait specific

Low (frost) and high temperature tolerant (-2^{0}C to 49^0 C), Yield: 12.4 kg to 26.5 kg per plant. It start bearing in 3rd year. Fruit weight: 9.13-9.91 g. fruit width: 9.13-9.91 mm and length: 0.98-1.27 mm., Maturity: Fruit ripens in 32-36 days from fruit set., TSS: 20.8 ^{0}Brix, Acidity: 1.6%, Vitamin C: 11.2 mg/100g. total flavonoids: 0.96 mg/g FW, total polyphenols 1.19 mg/g FW. total antioxidant activity (CUPRAC): 6.81µM TE/g.

Uses: Nutraceutical-rich and suitable for table and processing purpose.

Custard apple

At Godhra

Vegetative characters

The growth habit in different genotypes is visually observed as erect, spreading, semi-spreading and drooping, foliage with dense and sparse type among all the characterized genotypes. Tree shapes of different genotypes are irregular, semi circular and elliptical types among the studied germplasm. The leaf shape are oblong and narrow lanceolate having size ranging 10-20 cm x 2-5 cm with conspicuous veins.

Fruit physical and morphological characters

The fruits of the different genotypes varied in their physical-morphological character *i.e.,* shape (nearly round, round, round spherical, obovate, obdeltoid and irregular), (Fig. 7) fruit colour (light green, pale green, yellowish green, dark green). Variability with respect to fruit stem end cavity *i.e.,* sunken, depressed, highly depressed and shallow depressed was observed. The stone shape was observed triangular, semi elliptical and elliptical and color was black, dark brown in all the studied genotypes. The colour of pulp was found white and creamy. The fruits of different genotypes considerably varied with respect to measurable qualitative traits. The fruit weight, fruit length, fruit breadth, pulp weight, rind weight, rind thickness, seed weight, specific gravity, number of seeds per fruit, seed length, seed width, seed thickness, flakes with seed, flakes without seed, total flakes, flakes length and flakes width ranged between 110.45–335.37g, 45.32-84.12 mm, 55.28-90.35 mm, 50.75-205.87g, 33.47-143.28g, 2.29-8.61mm, 7.27-26.12g/fruit and 0.85-1.37,12-63, 9.40-15.60mm, 5.12-8.32mm, 2.90-5.10mm, 12-63, 2-25, 22-68, 17.72-28.85mm and 10.15-18.36mm, respectively among the genotypes studied.

Fruit chemical attributes

The genetic variability of fruit chemical attributes in terms of total soluble sugar (26.61-32.63°Brix),

Fig. 7. Variability in fruit shape size colour and structure of different germplasm

fruit acidity (0.20-0.30%), vitamin C content (18.25 -38.24 mg/100 ml of pulp), TSS: acidity ratio (88.70-156.75), reducing sugar (11.26-15.16%), total sugar (12.48-18.48%), Mg (21.24-38.65mg/100g fruit), K (257.26-295.74mg/100g fruit), Na (4.26-15.27mg/100g fruit) and Ca (15.35-21.43mg/100g fruit) were observed among the various genotypes estimated for chemical characters.

Jamun (*Syzigium cuminii*)

At Godhra

Twenty six promising genotypes of jamun were evaluated for growth, flowering, fruiting and fruit quality attributes. Peak period of panicle emergence was recorded in the month of February while peak period of blooming and fruit set was recorded in the month of March in all genotypes. Maximum panicle length and fruit set per panicle was recorded in Goma Priyanka closely followed by GJ-8. Time taken for complete development of flower bud ranged from 22.00-26.10 days in different genotypes. Peak period of ripening was recorded in the month of June. Maximum fruit yield per plant was recorded (58.10 kg) in Goma Priyanka followed by GJ-8. Fruit weight (20.00 g), pulp weight (16.90 g), pulp per cent (84.50%) and TSS (17.10 ^{0} Brix) was 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 and have been planted in the field.

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 19.30 g fruit weight, pulp weight 16.70g, 86.53% pulp, 15.80 ^{0} Brix TSS, 0.37 % acidity, 10.60 % total sugar and 4.20 mg/100g vitamin C.

Tamarind (*Tamarindus indica*)

At Godhra

Twenty four promising genotypes of tamarind were evaluated for growth, flowering, fruiting and fruit quality attributes. The maximum number of fruits per panicle was recorded in Pratisthan (4.10), closely followed by Goma Prateek (3.80) and T-263 (3.30). Peak period of ripening time in majority of genotypes was March. Goma Prateek recorded maximum pod weight (26.00 g), pulp per cent (52.20 %) and TSS (71.00°Brix). Developmental pattern and maturity standards in tamarind were studied. Separation of peel from the pulp at the time of ripening was one of easiest methods for assessment of ripening in tamarind. Further, 3 genotypes of tamarind collected from Arappukotai, Tamil Nadu have been established in the field, they are growing well.

Brief characteristics of tamarind CHEST-10 and CHEST-11

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 52.00 per cent pulp and 72.00°Brix TSS.

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 53.40 % pulp and 72.50°Brix TSS.

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 6.20m –3.90 m, plant spread ie N-S 2.10m – 5.90 m and E-W 2.20 m – 6.10 and stem girth 30.60 cm- 70.10 cm recorded 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 (26.10cm) and fruit set per panicle was 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 1.10 g fruit weight, 23.10°Brix TSS, 12.10 % total sugar and 48.20 mg/100g vitamin C. Kernel protein was recorded 31.20 %.

Mahua (*Bassis latifolia*)

At Godhra

Thirty promising genotypes 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 (28.00 g) and seed weight (12.00 g) was found in MH-10., while MH-14 recorded 27.10g fruit weight and 11.10 g seed weight.

MH-10 (Mahua) was identified as a variety "Thar Madhu" at Institute level detailed characters are as under.

Vegetative growth

The selected genotype was propagated through soft wood grafting and tested under field conditions for 10 years (2005-2015). It is having spreading type growth pattern. Mean data was recorded for 3 years (2013-2015). The tree height and rootstock girth was recorded 4.42 m and 72.21 cm, respectively. North- South and East-West spread was found to be 3.45m and 3.67, m respectively. Leaves clustered near the ends of the branches, coriaceous, hard and firm, elliptic or elliptic-oblong, shortly acuminate, pubescent or tomentose when young, at length glabrous, base rounded or acute.

Flowering and fruit set

Grafted plants start flowering during 5th year. Flowering takes place in the month of March. The inflorescences are terminal and lateral drooping and often panicled. The flowers are bisexual and 6.11mm in diameter. Cross pollination results in fruit set. Peak period of anthesis was recorded from mid night till morning. Anthers dehisced 2-4 days before the time of anthesis. Number of flowers per fascicle was recorded 38.14. Peak period of fruit set was noted in first week of April.

Fruit yield and quality attributes

It ripens in the month of May. Fresh flower of this variety recorded 2.30g weight, 65.43 % juice, 26.63° Brix TSS, 1.03 % acidity and 58.61mg/100g vitamin C. Fruit yield (20.14 kg) per plant was recorded during 10th year of orchard life under rainfed conditions of hot semi-arid ecosystem. The fruits of this variety recorded 29.00 g average weight, 41.74 % pulp, 14.26° Brix TSS, 0.10 % acidity, 10.80 % total sugar and 48.38 mg/100g vitamin C.

Khirni (*Manilkara hexandra)*

At Godhra

Thirty genotypes were evaluated for flowering, fruiting and fruit quality attributes. Number of flowers per cluster ranged from 3.20-5.30 in different genotypes being highest in Thar Rituraj. Fruit set per cluster ranged from 2.60 to 4.30 being highest in Thar Rituraj. Peak period of ripening was recorded from last week of April and May in all the genotypes. Maximum fruit weight (5.00 g) and TSS (24.40°Brix) was recorded in Thar Rituraj, closely followed by CHESK-1, CHESK-6, CHESK-11, CHESK-12 and CHESK-16.

Brief characters of Thar Rituraj

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 4.30. It ripens in third week of May and recorded 5.00g fruit weight, 24.40°Brix TSS, 31.00mg/100 vitamin C.

Phalsa (*Grewia subnequalis*)

At Godhra

Total 25 genotypes have been collected and established in the field. During 2015-16, 3 genotypes from Chiraigaon, Rustampur and Chunadihsio villages of Varanasi were collected. From Gujarat, 2 genotypes from Lawarpur, Gandhinagar were collected. Plants have been established in the field. Maximum fruit weight was recorded in CHESP-13 (2.10 g), closely followed by CHESP-14 and CHESP-15. Maximum TSS was also recorded in CHESP-13 (20.30 ^{0}Brix). Vitamin C was also noted highest in CHESP-13.

Aonla (*Emblica officinalis*)

At Godhra

Varieties of aonla (Chakaiya, Banarsi, Francis, Krishna, Kanchan NA-10, Anand-1, Anand-2, NA-7, BSR-1 and BSR-2) were studies for their growth and qualitative and quantitative characters of fruits during the year 2015-16.

Aonla varieties had considerable difference in tree growth 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 and BSR-1 under rainfed conditions of western India. The foliage in Banarasi, Chakaiya, Krishna, Kanchan, Anand-1, BSR-2 and Anand-2 had sparse whereas in Francis, NA-7, BSR-1 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 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, Aanand-1 and Anand-2. Fruit stem end cavity was noticed shallow and deep, it was observed to be 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 colour 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 (51.10%) followed by Krishna (47.50%), NA-10 (42.70%) and Kanchan (36.13%) and it was the lowest in Banarasi (21.24%) followed by Chakaiya (26.13%). The time of fruit set was noticed during the 1st fortnight of March in Krishna, Francis, Chakaiya, Kanchan and 2nd fortnight of February in Banarasi, NA-7 and NA-10 whereas it was recorded 2nd 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 206 -218 days.

Physical attributes of fruit in terms of weight ranged between 15.15-35.80g, being maximum in Banarasi (35.80 g) followed by NA-7 (34.17 g) and it was measured the minimum in BSR-1(15.15g) and Kanchan (25.15 g).The fruit length ranged between 3.10-3.50cm whereas it was observed the maximum in Banarasi (3.50 cm) followed by Krishna(3.47 cm) and NA-7 (3.42 cm) and the same was observed the minimum in Francis (3.10 cm) followed by Anand-1(3.15 cm) and Anand -2 (3.12 cm). Among the varieties, fruit breadth varied between 3.42-4.40cm and the maximum breadth was observed in Banarasi (4.40 cm) followed by NA-7 and Chakaiya (4.00 cm) whereas it was minimum in Francis (3.42 cm) followed by Anand-2 (3.45 cm) and Anand -1 (3.46 cm). The percentage of fruit set (53.80 %) and fruit retention (28.40%) were recorded the maximum in NA-7 followed by Krishna for 47.00 % fruit set and 22.53% fruit retention, and the minimum fruit set and fruit retention were recorded 33.15% and 17.50%, respectively in Banarasi followed by Francis (34.59%) for fruit set and Anand-2 (18.80%) for fruit retention under hot semi arid ecosystem.

Among all the varieties, the juice content was recorded the maximum in NA-7 (60.30 %) followed by Anand-1(65.20%), however Chakaiya had the minimum juice content (42.21%) followed by

Banarasi (40.50%). 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 2.03-2.21 % being the maximum in Banarasi (2.21%) followed by Krishna (2.16 %) whereas it was observed 2.03 % in Kanchan and Anand-1. The pulp content ranged between 23.40-32.90g and it was recorded the maximum in Banarasi (32.90 g) followed by NA-7 (31.67g) and Krishna (31.21g) whereas the minimum pulp content was in Kanchan (23.40 g). The estimated vitamin C content among all the varieties ranged between 338.50- 495.00 mg /100g. It was observed the maximum in NA-7 (495.00 mg/100g) followed by Kanchan (427.27 mg/100g) and the same was found to be the minimum in Banarasi (338.50mg/100g) followed by Francis (342.14 mg/100g) and Krishna (342.40 mg/100g). The total soluble solids were recorded the maximum in NA-7 (10.50% Brix) followed by Anand-1 (10.30^0 Brix) and Anand-2 (10.20^0 Brix) while Banarasi had the minimum value (8.50^0 Brix) followed by NA-10 (8.55^0 Brix). The value of specific gravity ranged between 1.05-1.47 being the highest in Banarasi (1.47) followed by Anand-1 (1.35) while it was least in Francis (1.05) followed by NA-7 (1.18). 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, BSR-1,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 (2.10g) followed by Krishna and Anand-1(2.05 g) and it was minimum in NA-7(1.98 g) followed by Kanchan and NA-10 (2.00 g) under rainfed hot semi-arid environment.

At Bikaner

Identification of aonla varieties against frost resistance

An extensive survey was made to explore the aonla germplasm and also to determine variability for physical and biochemical traits for different regions of the North-Eastern areas of India *i.e.* Manipur (Hundung and Lunghar area), Meghalaya (Khasi and Garo Hills), Aasam (Jorhat) and Nagaland (Mon, Longleng, Mokok Chung, Wokha, Kohima) during the year 2014-15. Genotypes were collected from the varied altitude ranging from 800-1850 m Mean Sea Level. Aonla genotypes were found almost all part of north eastern region, but the intensity varied from place to place according to agro-climatic conditions. Indian gooseberry accessions showed considerable variability with respect to morphological and physico-chemical characters. The elite genotype is characterized as self fruitful, yield potential 25-28kg /tree and fruit weight 6-8 g. Wide variability with respect to fruit weight (1.39 - 10.59 g), fruit length (1.26- 2.53 cm), fruit breadth (1.27-2.57 cm), fruit girth (4.16 to 8.10 cm), stone weight (0.28 to 1.50 g), specific gravity(1.00-1.62),TSS of juice (10.00-21.30 ^{o}Brix), P^H (2.48-3.41), Acidity(1.80-5.84), Total sugar (7.50-13.68 %), Vitamin c (375.00 -1428.50 mg/100 ml of fruit juice), Phenol content (944.85-4969.50 mg/100g of juice) and TSS/acid ratio (2.64-9.72) were observed among the genotypes. The genotype T_{12} and. T_{14}, were found superior in terms their physico-chemical attributes than the rest of the genotypes.

Studies on compatibility and adaptability of citrus rootstocks under hot arid environment of Rajasthan"

Rajasthan has a great potentiality in citrus fruit crops like Kinnow, sweet orange, lime and lemon. Introduction of suitable rootstock and variety can help in harnessing full potential in hot arid environment.

A new orchard of citrus was established with diverse commercial cultivars and rootstock species in five hectares at CIAH research farm during April, 2015 to March 2016. Twenty three varieties/species of Sweet orange, Mandarin, lime, lemon and rootstocks were collected from Centre of Excellence for Fruits, Horticulture Department, Govt. of Haryana, Mangiana, Distt. Sirsa; ICAR-CIAH Regional Station CHES, Godhra; Regional Fruit research Station, PAU, Ludhiana, Abohar and ICAR-Central Citrus Research Institute, Nagpur. After hardening

all the collected germplasm have been planted in the field at 6x6 m^2 spacing at new farm block No. 3 in six hectare. Total 1190 plants of different Citrus species namely sweet orange varieties *viz.* Blood Red (200 plants), Washington (100), Hamlin (100), New Hall Navel (100 plants) Sathgudi (100) and Jaffa (100 plants); lime varieties Baramasi seedlings (200 plants) Vikram (50 plants) and Baramasi lime grafted (200 plants); lemon viz. and Badri lemon (20 plants); and Kinnow (20 plants) along with seven rootstocks species i.e. Troyer Citrange, Pectinifera, Rubidox, Kharna Khatta, Rangpur Lime, Carrizo and Rough lemon with 15 plants each were planted in the field. Still 100 per cent plants are well in survival condition and no damage from frost or other environmental factors. Initial observations related to survive per cent, new flashes behavior, other growth parameters are in progress

Nine rootstocks namely Troyer Citrange, Pectinifera, Rangpur Lime, Carrizo, Rough Lemon, Swingle, Volkamericana, Cleoptera, Pommy Roy seeds are sown in farm nursery for compatibility and adaptability studies by using different scions of Kinnow, sweet Orange, lemon and lime in upcoming seasons. All the project activities are executed as per the project technical programme.

VEGETABLE

Germplasm Conservation

Monitoring for maintenance and conservation of vegetable germplasm

Regular monitoring of germplasm lines of dessertic melons, non-dessertic melons and gourds cucurbitaceous crops was done for their safe conservation in gene bank (–20 ^{0}C deep freeze storage) facilities at the institute. The potential crop germplasm being maintained as generated material is comprised of kachri (68), snap melon (65), mateera (65), muskmelon (60), round melon (10), kakri (18), bottle gourd (20), ridge gourd (20), sponge gourd (15), bitter gourd (4), chillies (45), brinjal (30), tomato (14), khejri (14), India bean (30), sword bean (01), cluster bean (02) and other (15) vegetables. As per seed enhancement work plan, the conserved germplasm of ridge gourd (20) was taken during 2015–16 and based on germination and field crop studies, it can be stored successfully for about eight years under ambient and 10–12 years under deep freeze conditions (–20 ^{0}C) for utilization and breeder seed production. Sufficient quantity of seed was enhanced during rainy season and deposited for conservation and this material will be regenerated after 2026 for storage studies under hot arid environment. Similarly, seed enhancement for kakri genotype AHC-2 and palak genotype AHLP-1 was also performed.

Watermelon

Performance of exotic lines

Evaluated 9 EC lines of watermelon during summer season of 2015 procured from ARS, Griffin, Georgia. Among the evaluated lines, EC-829542 (Fig. 8) was found promising which produced oblong fruits weighing 3.2-4.kg with 18.9-22.4 cm diameter in 86 days after sowing. The fruits of this line have red flesh with 11.2-14% TSS. Number of fruits/ plant varied from 2-3 with clear stripped rind of 0.8-1cm thickness. Single plant selection was exercised to develop superior inbred lines suitable for arid conditions.

Germplasm evaluation, selection and maintenance

EC-829542 EC-829541 EC-829545

Fig. 8. Promising exotic lines of watermelon

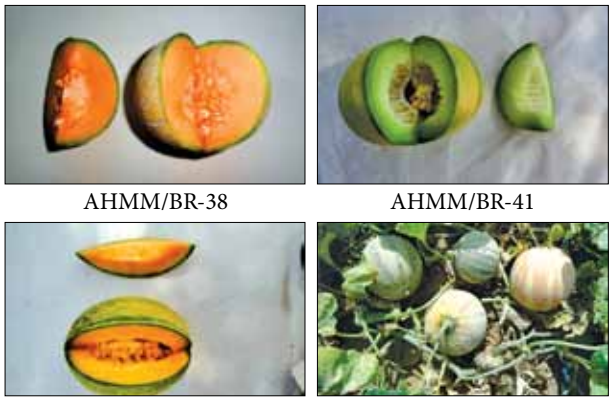
Evaluated a total of 30 genotypes of watermelon during summer season of 2015. The flesh colour was observed as red, pink and yellow. The sex expression (at full flowering) was monoecious in all genotypes except AHW/BR-5 which expressed andro monoecious sex from. Fruit shape was found to be round, oval, cylindrical and elongated globe. Among the genotypes AHW/BR-25 (Fig. 9) have non-lobed leaves with high TSS (11.5-12.4%). On the basis of fruit size, rind thickness, flesh colour, TSS, size of seed and number of seed/ fruit, AHW/ BR-5 and AHW/BR-25 were found promising and selected for further validation. Maintained the seed of all promising lines and reference varieties through selfing.

Fig. 9. AHW/BR-5: an andromonoecious line

Muskmelon

Germplasm evaluation, selection and maintenance

Evaluated 16 advance lines of muskmelon for yield and quality attributes. Among the evaluated lines AHMM/BR-49 was found superior with respect to TSS (14%), fruit weight (900 g), flesh thickness (2.5 cm) and have salmon orange coloured flesh. AHMM/BR-38 produced 4-5 fruits/ plant, fruits round with 12% TSS weighing 800 g, rind thickness (0.3 cm), flesh thickness (2.6 cm) salmon orange in colour. AHMM/BR-41, AHMM/BR-53, AHMM/BR-55 (Fig. 10) were also found superior for TSS and other fruit traits. Single plant selection was exercised for TSS, fruit shape, netted rind, salmon orange flesh and yield/ plant. Maintained the seed of all lines and reference varieties through inbreeding.



AHMM/BR-38 AHMM/BR-41

AHMM/BR-49 AHMM/BR-55

Fig. 10. Promising lines of muskmelon

Suppression of male flowers in muskmelon

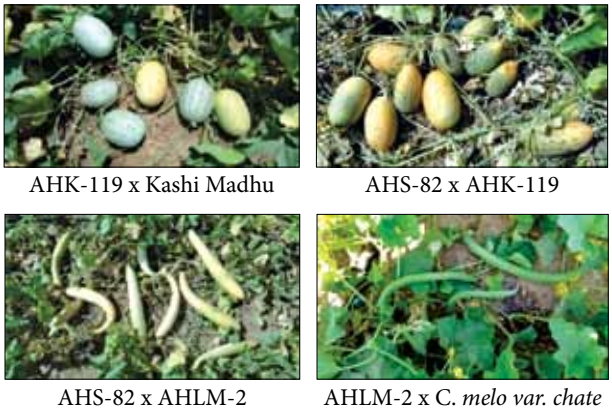
The effect of ethrel on suppression of male flowers was studied on a monoecious line of muskmelon (AHMM/BR-8; IC-0599709). Ethrel 40% (2-Chloroethylphosphonic acid, 40% in water) was mixed in distill water and sprayed during evening hours. The results revealed that two consecutive spray of 125 ppm ethrel (40%) at 2 true leaf stage and 20 days after first spray significantly reduced the number of male flowers over all other treatments and control. The plants of this treatment produced 50% female flowers in 52-55 days after sowing on lower nodes (11.40-11.80), initiation of male flowers occurred in 66-68 days after sowing on 16th node onward and produced 25-42 male flowers per plant (Fig. 11). The plants sprayed with 250 ppm ethrel at 2 true leaf stage were not survived and all plants died.

Untreated (52 DAS) Sprayed twice with 125 ppm ethrel (52 DAS)

Fig. 11. Effect of ethrel on suppression of male flowers

Evaluation of cross combinations

Evaluated 8 inter-specific crosses made by utilizing Punjab Sunehri, Pusa Madhuras, Kashi Madhu and IC-059970 (a monoecious line) of muskmelon (*Cucumis melo* L.), AHS-82 of snapmelon (*C. melo* var. *momordica*), AHLM-2 of longmelon (*C. melo* var. *utilissimus*), *Arya* (*C. melo* var. *chate*) and AHK-119 of *Kachri* (*C. callosus*). The maximum TSS (11.26%) was recorded in IC-0599709 x Pusa Madhuras. The cross, AHK-11 x Kashi Madhu produced 16.4 fruit/ plant followed by AHLM-2 x AHS-82 (10 fruit/ plant). Fruit weight varied from 76.4 g in AHLM-2 x AHS-82 to 1.14 kg in AHLM-2 x IC-0599709. Fruit length ranged from 11.5 cm in AHS-82 x AHK-119 to 53.8 cm in AHS-82 x AHLM-2 (Fig. 12). All evaluated F_1s showed monoecious sex form and the fruits of the crosses longmelon x muskmelon, snapmelon x longmelon, snapmelon x *kachri*, *kachri* x muskmelon were found bitter at immature stage and become edible at full ripening stage. Selfing was done in all cross combinations and seed was harvested to develop new segregates.



AHK-119 x Kashi Madhu AHS-82 x AHK-119

AHS-82 x AHLM-2 AHLM-2 x C. *melo var. chate*


AHLM-2 x IC-0599709


IC-0599709 x Pusa Madhuras

Fig. 12. F1's derived from different Cucumis sp.

Sponge gourd

Germplasm evaluation and maintenance

During summer season of 2015, evaluated 04 EC lines of sponge gourd introduced from ARS, Griffin, Georgia. Among the lines, EC-829550 was found promising with respect to earliness, fruit weight (75.2 g) and fruit length (18.78 cm). Single plant selection from EC-829550 was done and collected the seed separately. Maintained the seed of all lines for further evaluation.

Longmelon

Performance of AHLM-2

Evaluated the performance of AHLM-2 of longmelon (Fig. 13) during rainy season of 2015 which produced 50% female flowers in 43-46 days after sowing on lower nodes. The fruits at marketable stage were tender, non-bitter, light green, attractive and 20-25 cm long, weighing 70-80 g. Multiplied the seed of AHLM-2 and submitted to ICAR-NBPGR, New Delhi along with passport data to allot IC number.

Fig. 13. Longmelon (AHLM-2)

Ridge gourd

Studies on generated material and maintenance of ridge gourd: Based on results of varietal trials and evaluation of germplasm and lines up-to 2010 under hot arid agro-climate, the generated material was stored in ambient and –20 ^{0}C deep freeze conditions for utilization at CIAH. During rainy season of 2015, twenty lines were studied for germination, plant growth and fruit yield components under maintenance breeding (4th generation) and also assessed in reference to high temperature and abiotic stresses, fruit fly infestation and viral diseases to screen out the potential lines based on field tolerant and trait specific quality yield (Fig. 14-16). The line AHRG–15–4–1 (segregating material from *Luffa acutangula* x *Luffa hermaphrodita*) exhibited potentialities for multiple stresses tolerance and marketable fruit quality yield (Fig. 17).

Fig. 14. Field view of ridge gourd germplasm lines under evaluation during 2015

Fig. 15. Ridge gourd germplasm lines in flowering, fruiting and seed enhancement studies

Fig. 16. Fruit set, development and seed production studies in ridge gourd germplasm lines

Fig. 17. Marketable stage fruits of multiple stresses tolerant ridge gourd line AHRG –15–4–1 identified with good quality fruit and yield potential

Kakri

Maintenance and evaluation of kakri genotype: During spring–summer season of 2015, kakri variety AHC–2 was studied under varietal maintenance breeding using 10 years stored seed material (–20 ^{0}C deep freeze) for germination, plant growth and fruit yielding component characters. The stored seeds easily germinated and took 5.62–7.35 days with 52.57–65.43 % germination under varying production conditions in field. It is early in flowering and fruiting behaviour and observations were recorded on 45 characters including days to opening of first male flower (31.52–33.64 DAS), days to opening of first female flower (36.63–38.56 DAS) and days to first harvesting of tender fruits (47.73–49.23 DAS). Tender fruits at marketable stages for salad purpose are 168.65–222.43 g in weight, 26.56–35.32 cm in length and 2.55–2.84 cm in diameter. Similarly, immature and bigger sized fruits weighing 300–400 g can be used as cooked vegetables. The plants exhibited good growth, flowering and fruiting under high temperature conditions and tolerant to abiotic stresses of hot arid environment (Fig. 18)

Field view of kakri variety AHC – 2 under varietal maintenance and evaluation during 2015

Flowering, pollination and fruit set studies in kakri variety AHC – 2 for seed production

Fruiting behaviour and fruit growth development studies in kakri variety AHC – 2 for harvesting at marketable stages

Fruit growth development and seed production studies in kakri variety AHC – 2

Fig. 18. Different growth stages of kakri AHC-2.

CROP IMPROVEMENT

Vegetable

Ridge gourd

Performance of exotic lines

During summer season of 2015, evaluated 4 EC lines of ridge gourd procured from ARS, Griffin, Georgia (United States). Among the lines, EC-829555 was found promising which produced 23.8 cm long fruits weighing 77 g and 2.8 cm in diameter (Fig. 19). Superior plants were identified, selected; self pollinated and obtained the seed to purify the line and further evaluation. EC-829552 produced female flowers on lower nodes (6-9 nodes).

Fig. 19. Ridge gourd (EC-829555)

Evaluation, selection and maintenance of genotypes

Sixteen genotypes of ridge gourd were evaluated for growth, flowering and different yield attributes. AHRG-28, AHRG-30, AHRG-41, AHRG-50 and AHRG-61 were found promising under high temperature conditions and selected for further evaluation. The fruits of AHRG-28, AHRG-41 and AHRG-50 were found devoid of neck which is a desirable trait in ridge gourd. Selected phenotypically superior plants among the superior lines tolerant to high temperature conditions. The selected plants were self pollinated and harvested the seed separately for further evaluation. Maintained the seed of all genotypes including released varieties and conserved for further utilization.

Fig. 20. Thar Karni of ridge gourd

Identification of variety

During the year, AHRG-29 of ridge gourd is identified as variety 'Thar Karni' by the Institute's Variety Identification Committee. It is early in harvesting and takes 51-55 days to first picking from sowing. Fruits 20-25 cm long weighing 90-110 g and cylindrical with 10 longitudinal shallow ridges. Plants bear short internodes, profusely branched and high yielding. Suitable for cultivation during spring-summer and *kharif* season (Fig. 20).

Evaluation F_1's and generation advancement

Evaluated eight F_1's of ridge gourd during summer season of 2015 for different horticultural traits. The cross combination, AHRG-41 x Arka Sujath, AHRG-29 x AHRG-41 were found best for earliness, fruit length, fruit weight and yield/ plant under high temperature conditions. The earlier selected 15 F_3 families were raised during summer season of 2015 and selected desirable segregates based on earliness, fruit traits and tolerant to high temperature. Self pollination of selected plants was done to obtain desirable recombinants.

Varietal Trial AVT II

Five entries of ridge gourd along with two checks were evaluated during summer season of 2015. Maximum fruit length (23.23 cm), fruit diameter (2.98 cm), fruit weight (102.20 g), number of marketable fruits/ plant (17.07) and yield (105.53 q/ ha) was recorded in RGVAR-2 (Table 1)

Table 1. Traits of different germplasm lines of Ridge gourd.

Name of entry	Vine length (cm)	Node number at which first female flower appears	Fruit length (cm)	Fruit diam-eter (cm)	Fruit weight (g)	Number of market-able fruits/ plant	Yield (q/ha)	Number of ridges per fruit	Fruit bit-terness at marketable stage
2012/ RGVAR-1 1.98		8.93	20.51	2.84	92.93	14.73	81.66	10	Absent
2012/ RGVAR-2	2.42	9.80	23.23	2.98	102.20	17.07	105.53	10	Absent
2012/ RGVAR-3	2.08	8.67	21.16	2.81	96.00	13.87	79.55	10	Absent
2012/ RGVAR-4	2.04	10.40	20.46	2.88	91.93	15.20	83.88	10	Absent
2012/ RGVAR-5	1.97	8.93	21.25	2.91	89.73	13.73	73.82	10	Absent
PT-1 (C)	1.86	8.73	17.45	2.42	69.80	15.60	65.43	10	Absent
Arka Sujath (C)	2.09	10.93	20.20	3.02	95.87	15.47	89.44	10	Absent
CD at 5%	0.30	1.44	2.76	0.31	14.30	2.04	18.41	-	-
CV (%)	8.12	8.53	7.53	6.11	8.81	7.58	12.51	-	-

Round melon

Breeding for high temperature tolerance and fruit quality: During summer and rainy season of 2015, advanced breeding material of round melon progenies (AHRM/2015/F_5/1a) were tested for field performance. Plants of the progenies exhibited poor initial growth and susceptibility to high temperature (>42 ^{0}C) and drier conditions both during summer and rainy seasons of 2015. The progenies of dark green colour type fruits exhibited high level of incidence of fruit fly infestation and resulted to very low yield potential. The plants exhibited very slow initial growth and susceptible to viral diseases resulting to whitish yellow leaves and drying of plants in rainy season crop, and thus the progeny is rejected from selection cycle. Hence, other identified for purification, advancement of generation and selection breeding based on better fruit quality and marketable yield under high temperature and abiotic and biotic stresses of arid agro-climate shall be tested as per field facilities.

Bottle gourd

Breeding for high temperature tolerance and marketable yield in long fruited bottle gourd: During spring–summer and rainy–winter season of 2015, three selected progenies of long fruited bottle gourd developed at the institute were tested for growth, flowering, fruit set, fruit quality and yield characters under varietal trial. Detailed observations were recorded to screen the material under high temperature and abiotic stresses of hot arid agro-climate, and selection breeding based on uniformity, stability and field performance over the seasons was done. The advanced progeny AHLS/2014/F_6/01 exhibited superiority for marketable yield with temperature range 43–45 ^{0}C during May–June, and good quality fruit yield and harvesting for prolonged period of time with temperature range 42–43 ^{0}C was recorded (Fig. 21).

Field view of bottle gourd breeding lines under evaluation during 2015

Field view of bottle gourd breeding lines under evaluation during 2015

Fruits of advanced bottle gourd progeny under evaluation during summer season of 2015

Fruits of advanced bottle gourd progeny under evaluation during rainy season of 2015

Fig. 21. Views of bottle gourd cultivation

Sponge gourd

Breeding for better quality fruit yield under high temperature conditions: During spring–summer and rainy–winter season of 2015, eight sponge gourd genotypes including check was tested as varietal trials for comparative performance studies and identification of superior progenies from the developed breeding lines - AHSG – 4 (P_4), AHSG – 5 (P_5), AHSG –16 (P_{16}), F_4 [(P_4 x P_5) x P_4], F_4 [(P_5 x P_4)xP_4] BS, F_4 [(P_5 x P_4)xP_4] WS and F_4 (P_4 x P_{16}) under abiotic and high temperature conditions. Plants of line F_4 [(P_4 x P_5) x P_4], F_4 [(P_5 x P_4) x P_4] BS and F_4 [(P_5 x P_4) x P_4] WS exhibited good growth and vines are longer (>3.5 m) but low level of flowering was observed even temperature conditions (40–42^{0}C) was normal and very few flowers with the increasing temperatures (>44^0 C) and no female flower was recorded during May-June period. Six lines exhibited low level of female flower and fruit setting resulted to very low fruit yield potential under temperature range of 40–42^{0}C and therefore, rejected from selection cycle. The purified, uniform and stable breeding line F_4 (P_4 x P_{16}) followed by AHSG – 4 (P_4) exhibited superiority for most of desirable traits under investigation.

Characterization of sponge gourd line AHSG/2015/F_4/01: During spring–summer and rainy–winter season of 2015, detailed studies on sponge gourd line AHSG/2015/F_4/01 (F_4 pedigree of cross P_4 x P_{16}) was done for characterization over the seasons. The genotype exhibited earliness for days to appearance of first male flower (31.41–33.73 DAS), days to appearance of first female flower (35.64–37.48 DAS), node number to opening of first female flower (9.14–10.62) and days to first harvesting of tender fruits (44.82–47.36 DAS). The

tender fruits are medium sized in comparison to P_4 and as well bigger to $P_{16.}$ Moderate spreading vines depicted very good growth and flowering at start of fruit setting with temperature (35–38°C) and drier climate and it is normal with very dry weather (40–42°C) conditions. The genotype recorded least fruit fly infestation and viral incidence during October–November and thus spraying is must in August and September to control vectors.

Field view of sponge gourd breeding lines under evaluation during 2015

Field view of sponge gourd line AHSG/2015/F4/1 under performance studies and characterization

Fruits of sponge gourd line AHSG/2015/F4/1 (pedigree of cross P4 x P16) under characterization during 2015

Fig. 22. Field view of sponge gourd cultivation

Ivy gourd

Performance studies on ivy gourd genotype: The gynoecious line AHIG–1 producing excellent quality parthinocarpic fruits under high temperature and abiotic stressed conditions of arid region was selected during 2005 for maintenance and performance studies over the years. During the spring–summer and rainy–winter season of 2015, the genotype was tested for yield potential and fruit growth development studies (Fig. 23). The tender fruits for marketable quality and vegetable use are ready in 6.25–8.12 days from opening of female flower. At this time, the fruits are of 'A' grade in quality and are 5.72–6.11 cm length, 1.52–1.94 cm diameter and 11.61–13.58 g weight. The elongated–long shape tender fruits are light green-green-dark green in colour with non-clear strips and soft.

Fig. 23. Fruit growth development studies in gynoecious ivy gourd genotype AHIG–1 under hot arid agro-climate

Palak

Testing of palak genotype: The purification of native germplasm of hot arid region at CIAH from 2001 and evaluation over the years resulted to stabilization as value added palak genotype with excellent leaf quality and yield potential. During 2015, the genotype AHLP–1 was tested at CIAH farm and farmer's field with plot size of 250 sq. m to assess the yield potential, acceptability of produce and promotion for cultivation (Fig. 24). The genotype exhibited very good growth for leaf harvest and first harvesting was taken at 30–35 days after sowing in October. The tender leaves harvesting at 30, 50, 60 and 70 DAS is found better for plant growth and seed yield potential under resource constraint production sites (Fig. 25).

Fig. 24. Field performance studies on value added palak genotype AHLP – 1 during 2015 at CIAH, Bikaner

Fig. 25. Growth and flowering studies in value added palak genotype AHLP – 1

Moringa

Bikaner

Performance studies on value added Moringa genotype: The results of progeny testing with controlled pollination of identified elite types and utilization for four generation selection breeding at CIAH, an annual type Moringa genotype AHMO–1–4s was stabilized for uniform and better quality pod yield under hot arid agro-climate, and evaluated over the years (Fig. 26). During 2015, the value added genotype AHMO–1–4s was taken for seed production and large scale demonstration trials both at CIAH farm and farmer's field is initiated (Fig. 27).

Fig. 26. Plant multiplication, nursery raising and field establishment studies in developed moringa genotype AHMO – 1 during 2015 at CIAH, Bikaner

Fig. 27. Studies on moringa leaves dehydration for use as concentrated vegetable at CIAH

Drumstick

The thirty promising genotypes of drumstick were evaluated for growth, yield and quality attributes. These genotypes exhibited wide range of variability with respect to fruit weight (42.2-256.6 g/fruit), fruit length (46.6-89.3 cm), number of seed (13-28), fruit diameter (17-24 mm), fresh weight and dry weight ratio of fruit (2.9-4.3), pulp (1.9-3.4), skin (4.1-5.7), & leaves (6.07-8.02), number of seed (11.5-23), TSS (5.8-9.5%) and fruiting time (first week of January to last week of April) were observed among the existing genotypes. Based on the observation, it may be inferred that the exploration of wide range of variability to select better genotype and utilize these germplasm further improvement.

Khejri

Bikaner

Maintenance and evaluation of khejri genotypes: Fourteen elite genotypes identified by 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 variety Thar Shobha and Khejri Selection–2 was studied for comparison with reference to growth, flowering, pod quality, yield and related horticultural characters over the years under rainfed conditions. In addition, the identified genotype Khejri Selection–2 was characterized for

number of parameters for documentation (Fig. 28 & 29).

Fig. 28. Comparative studies on pod quality characters of Khejri Selection – 2 and Thar Shobha

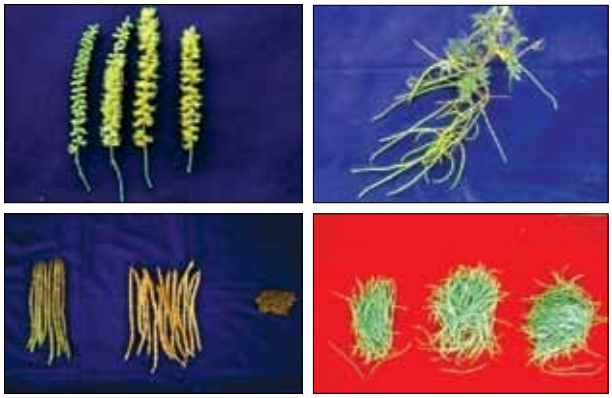


Fig. 29. Flowering, pod setting and pod development studies in Khejri Selection – 2

Comparative evaluation of antioxidants and mineral content of Indian summer leafy vegetables and their microgreens

Godhra

Twelve summer leafy vegetable were evaluated for their antioxidants and minerals content both at microgreen and mature stages. Among antioxidants total phenolics, total flavonoids, ascorbic acid were evaluated. Antioxidant activity was measured using four in vitro assays viz. ferric reducing antioxidant power (FRAP), cupric reducing antioxidant power (CUPRAC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) and Trolox equivalent antioxidant capacity assays (TEAC). In addition to this, various elements like potassium, iron, manganese, zinc and copper were evaluated. Total phenolic content varied from 95.73 mg GAE/100g to 679.58 mg GAE/100 g in mature stage where as phenolics value varied from 25.00 GAE/100g to 218 mg GAE/100g. Mature stage was found to be higher sources of total phenolics than microgreen stages. A similar trend was observed in case of flavonoids and antioxidant activity measured through four different methods. Regarding minerals no specific trend was observed in case of iron, copper and manganese content. However it was observed that microgreen were higher sources of potassium and zinc.

Fruit

Introduction, evaluation and improvement of indigenous and exotic under utilized fruit crops under hot arid region.

Morphological characterization of *lasoda*

In order to allow effective use of plant genetic resources for the purpose of improved crop productivity and to develop new varieties more adapted to abiotic and biotic challenges under changing environmental conditions, breeders must have essential information about them. Therefore, some large fruited *lasoda* (*Cordia myxa* Roxb.) genotypes *viz.*, V-3, V-15, V-19, V-21, V-25, V-48, V-51, V-60, S-1, S-2, B-1, B-2, J-1 and J-2, available at ICAR-CIAH were characterized morphologically for qualitative and quantitative characters. Distinct variations have been noted in leaf and fruit characteristics. Shape of leaf was predominantly cordate (broadly or narrow), while in genotype V-19, it was ovate. Similarly, leaf arrangement and petiole attachment was noted to be alternate and marginal, respectively. Nature of leaf base varied from round to cordate. Likewise, leaf margin found to be coarse serrated. Highest average fruit weight was recorded in V-25 (16.8 g) followed by V-3 (14.7 g) and V-19 (13.1 g) (Fig. 30).

Ovate leaf shape with round base

Cordate leaf shape with cordate base

Diversity in fruit size

Fig.30. Variations in morphology of lasoda genotypes.

Improvement in yield in Solanaceous crops under Abiotic stresses.

Substantial variability as evidenced from Range, PCV, GCV was noted for morphological and yield traits. PCV was higher than the GCV respectively. GCV for all the nine traits under study reveals that contribution towards final phenotypic characters was slightly diluted by environmental factor acting on the genetic makeup of the accessions under study (Table 2). PCVand GCV of higher order for average fruit yield of plant, fruit weight, number of fruits per plant, fruit length, and fruit width. The lowest PCV and GCV was observed in leaf length, which depicts that the character concern may hardly be improved and should be in combination approach. High heritability and high genetic advance was observed in traits like average fruit yield per plant and fruit weight which indicates participation of additive genetic variance. However, genetic traits like number of primary branches, fruit length, fruit width, number of fruits per plant as well as plant height showed high GCA as per cent of means. This reflects the selection for this traits in advance generation may be fruit full.

Correlation studies among morphological and yield related traits revealed that average fruit yield was having positive and significant correlation with fruit width, number of fruits per plant and average fruit yield per plant as phenotypic as well as genotypic level. However, number of fruits per plants showed negative and significant correlation with leaf length at phenotypic and genotypic level. Fruit width was also seen to have a positive and significant correlation with fruit length. Enhanced selection of this trait is more reliable in maximizing the yield potential of the brinjal genotype under studied.

The path coefficient revealed that the total fruit yield per plant was positively dependent in character like fruit weight, number of fruits per plant, leaf width and plant height. Negative effect were exhibited by leaf length, number of primary branches, fruit width and fruit length. Selection of characters having higher positive and direct effect on total fruit yield per plant might have impact on the total improvement of the crop.

The genotype of the brinjal under studies were grouped under five cluster within the highest number of genotypes which 8 in cluster followed by 6 genotype in cluster 2, rest of the cluster were having 2 genotype in each of them. 20 accessions group under five cluster itself speaks of the high level of variability existing among the accessions (Table 5).

Inter cluster distances showed that cluster V recorded maximum highest divergence from cluster III (106.21) followed by cluster II (95.452) (Table 6). Besides cluster II too showed a good level of of divergencefrom cluster I (91.464). More diversified cluster may be taken in the hybridization programme for evolving a good hybrid of segregates (Table 4).

The cluster wise mean value Table-7 revealed substaintially high differences in cluster means for traits like average fruit yield per plant, fruit weight, fruit length and number of fruits per plant.Cluster V was having the highest mean value for average fruit yield per plant (2305.00) and number of fruits per plant and fruit width Cluster IV was having the highest mean value fruit length and number of Primary branches.

Cluster III was having the highest mean value for leaf width only.

Table 2. Genetic parameters of variability for different traits of brinjal under study.

Characters	Grand Mean	Range	PCV	GCV	h2(%)	GA (%)	GA as % of mean
Plant height(cm)	33.63	25.15-46.60	15.33	14.99	95.67	10.16	30.21
No. of primary br	6.21	3.62-8.78	21.81	21.48	96.96	2.71	43.56
Leaf length	6.91	5.67-8.50	11.90	11.60	95.05	1.61	23.31
Leaf width	4.15	3.51-5.30	14.52	13.71	89.23	1.11	26.68
Fruit length	16.66	11.75-25.43	24.99	24.72	97.82	8.39	50.37
Fruit width	5.80	3.87-9.27	24.58	24.20	96.94	2.95	49.08
No. of fruits/pl	8.99	5.47-14.00	36.03	35.84	98.95	5.60	73.44
Fruit wt.	120.75	61.13-200.92	43.78	43.76	99.87	108.77	90.08
Avg. fruit yield/pl	1104.96	377.67-2455.00	59.92	59.77	99.50	1357.11	122.82

Table 3. Phenotypic correlation coefficients among the characters under study in brinjal.

Characters	Plant height(cm)	No. of primary br	Leaf length	Leaf width	Fruit length	Fruit width	No. of fruits/pl	Fruit wt.	Avg. fruit yield/pl
Plant height(cm)		0.309	0.276	-0.045	0.124	-0.067	-0.195	0.079	-0.060
No. of primary br			0.030	0.167	-0.125	-0.387	-0.298	-0.110	-0.271
Leaf length				0.352	0.133	-0.207	-0.452*	0.083	-0.306
Leaf width					0.386	0.115	0.081	-0.015	-0.051
Fruit length						0.406	0.249	0.387	0.407
Fruit width							0.126	0.495*	0.481*
No. of fruits/pl								0.177	0.689**
Fruit wt.									0.792**
Avg. fruit yield/pl									

NOTE : * and ** are significant at 5% and 1% levels of significance respectively.

Table 4. Average inter and intra clusters distances among five clusters in 20 genotypes of brinjal. (Dependent variable: Total fresh yield per plant).

Characters	Plant height(cm)	No. of primary br.	Leaf length	Leaf width	Fruit length	Fruit width	No. of fruits/pl	Fruit wt.
Plant height(cm)	0.07422	-0.03285	-0.06429	-0.00532	-0.00235	0.00164	-0.09121	0.05910
No. of primary br	0.02395	-0.10182	-0.00695	0.01766	0.00271	0.00904	-0.13678	-0.08412
Leaf length	0.02182	-0.00324	-0.21865	0.03578	-0.00262	0.00506	-0.21316	0.06085
Leaf width	-0.00391	-0.01780	-0.07747	0.10099	-0.00791	-0.00258	-0.03560	-0.01281
Fruit length	0.0893	0.01414	-0.02940	0.04093	-0.01952	-0.00950	0.11946	0.28662
Fruit width	-0.00535	0.04056	0.04869	0.01149	-0.00816	-0.02271	0.05838	0.36869
No. of fruits/pl	-0.01477	0.03038	0.10168	-0.00784	-0.00509	-0.00289	0.45836	0.13141
Fruit wt.	0.00597	0.01166	-0.01812	-0.00176	-0.00762	-0.01140	0.08202	0.73439

Residual effect : 0.1785336 Direct effects on main diagonal (Bold).

Table 5. Grouping of brinjal genotypes under study in clusters.

Cluster	No. of genotypesT	Name of genotype(s)
I	2	Brinjal-6-12,Brinjal-6-17
II	6	Brinjal-1-2, Brinjal-6-9, Brinjal-6-10, Brinjal-6-18, Brinjal-6-9-3, Brinjal-6-9-5
III	2	Brinjal-6-9-2, Brinjal-6-9-4
IV	8	Brinjal-6-22, Brinjal-6-19, Brinjal-6-19-A, Brinjal-6-9-1, Brinjal-6-9-6, Brinjal-6-9-7, Brinjal-6-11-1-3, Brinjal-6-13-1-3
V	2	Brinjal-6-13-1, Brinjal-6-15-1

Table 6. Average inter and intra clusters distances among five clusters in 20 genotypes of brinjal.

Clusters	I	II	III	IV	V
I	10.429	81.571	91.464	56.247	40.084
II		44.841	34.536	57.414	95.452
III			14.673	62.356	106.219
IV				47.764	64.660
V					33.561

Table 7. Cluster mean of the characters under study towards divergence in brinjal genotypes.

Characters	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V
Plant height(cm)	34.933	34.358	34.425	32.599	33.488
No. of primary br	5.618	6.312	6.518	6.768	3.978
Leaf length	8.175	7.066	7.260	6.693	5.727
Leaf width	3.753	4.040	4.598	4.359	3.570
Fruit length	14.908	15.750	12.000	18.962	16.562
Fruit width	5.800	5.344	4.575	5.844	8.237
No. of fruits/pl	6.117	7.458	8.608	9.994	12.850
Fruit wt.	193.508	83.079	61.667	130.527	181.00
Avg. fruit yield/pl	1188.540	624.322	522.733	1290.078	2305.00

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), desertic sand-dune land area of two hectare was developed for *in situ* establishment by planting seedlings (2007) and budding (2009) under absolute rainfed situation of hot arid agro-climate. During 2015–16, growth and development observations were recorded periodically in response to training–pruning of 6th year's trees and no significant differences were observed in growth parameters in variety Thar Shobha plantations with varying planting models. It is recorded that close spacing planting and paired rows (4m x 4m) exhibited maximum canopy at 5–6 years age of establishment in khejri and thus the stage of plant growth from which normal training and pruning has been recommended for annual harvesting of tender pod, loong and fuel-wood as total bio-mass/year.

During 2015-16, the production site was maintained adopting good management practices as technological recommendations developed for main and inter-crop cultivation studies. The summer season was normal but a heavy wind storm (>100 km/h velocity, 19/05/2015) was recorded in the region and resulted drastic damages to khejri plantations in the production site of CIAH farm.

A large number of young and budded khejri plants were damaged and it was because of breaking of branches. Summer / pre-monsoon rains were recorded during the month of May and June in the production site (85 mm with 6 rainy days and three spells). As per recommendations, the field land between the khejri plantations was prepared with deep and cross ploughing and harrowing with the end of June. The summer ploughing practices in field area was done after assessing the weather forecasting for monsoon rains in the region. After short rain spell (±15 mm) in second week of July, good rain was started from 20 July and found suitable for crop sowing as well first inter-culture operations were done in the plantations.

The start of monsoon rain in the region was in time and pre-monsoon rains were scattered, localized and started from third week of June 2015, and rainfed crop sowing was done after good rains from 20–07–2015 in the production site. The kharif season was normal and long dry–spell of 28 days from third week of August to first week of September was observed, and later on 2–3 scattered rainy days (± 05–12 mm) were recorded in first week of September and third week of October. For kharif season, total 14 rainy days and about 325 mm rain was recorded in the production site from crop sowing to harvesting period. The inter–crops studies on cluster bean, kachri and grasses were successful under the rainfed situations of hot arid agro-climate, and the performance was very good for the consecutive fourth year and this was because of adoption of management practices as per time schedule during the crop period and normal rains. During 2015–16, 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 as well as with one life-saving irrigation at 25 days in kachri and cluster bean due to long dry-spell from the last rainy day of August month (Fig. 31). Similarly, jharber and ker plantations exhibited normal growth behaviour and periodical observations were recorded for the compilation as inter-crops with khejri planting models.

After harvesting of monsoon supported crops in November, the area between the planting models were ploughed by harrowing in December as post-monsoon recommended practice to buried-out of monsoon supported weeds and crop residues for improving fertility of sandy soils and conserving soil moisture from winter rains in the field. The winter season was normal and longer in the region. Uneven low temperature range, frost (20-22 December), foggy and cloudy conditions were observed from December to February months, and it was for longer period during 2015-16. Light rains and windy hail-storms was recorded from end of February to Middle of March, 2016 in the arid region, and the wide–spread western disturbances resulting to severe hail-storm and rains (±2mm) in the production site of CIAH. This causes damages to crop-plants and khejri, *phog, khimp*, etc were drastically defoliated on 11/03/2016 hail-storm and initial floriferous growth was damaged greatly. However, the khejri plants recovered quickly due to active growth phase and further new growth started with last week of March and initiation of inflorescences was observed.

During June as well November–December months, intensive training / pruning operations were performed in khejri, *phog, jharber, ker, lasora, kumat* and *rohida* to understand the essential practices required for developing frame-work and also growth studies in plantations of native crop-plant species for maximum bio-mass harvesting under rainfed situations and resource constrains production sites. The crop-genotype-environment interaction observations were recorded on main and inter–crops for the compilation of experimental results over the years.

Fig. 31. Kachri and cluster bean inter-crop production with khejri planting models during rainy season of 2015

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 (5th year) with khejri planting models. The jh*a*rber 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 5th year of its establishment and with uniform growth and fruiting pattern for characterization. Based on passport information and observational studies on population from the year 2010 at CIAH, 39 variable genotypes were identified from the diversity under evaluation and wide range of observations were recorded with developed descriptor to generate information on jharber during 2015-16. Based on field performance over the years, two elite genotypes (R17P1 and R37P1) were identified as most potential for fruit, fodder and bio-mass production under absolute rainfed situations (Fig. 32 & 33).

c) Studies on boundary plantation and native species

During the crop period, studies on growth parameters in khejri, *rohida*, *kumat* and lasora seedling was taken as boundary plantations under production site management approach. Similarly, observations in response to training / pruning were recorded on native species such as phog and khimp to understand growth, development and bio-mass production with the naturally perpetuated shrubs of desert eco-system in the khejri based production site (Fig. 34 & 35).

d) Studies on plant establishment and growth behaviour

During the period, studies on ker and moringa for germination and growth parameters were undertaken under nursery conditions and also for field establishment. The seed generated progenies of *ker* and moringa were studied for plant growth parameters during the period.

Fig. 32. Plant growth, fruiting, fruit quality and biomass production studies in jharber genotype R37P1 under absolute rainfed conditions of 2015 with khejri planting models

Fig. 33. Plant growth, fruiting, fruit quality and biomass production studies in jharber genotype R17P1 under absolute rainfed conditions of 2015 with khejri planting models

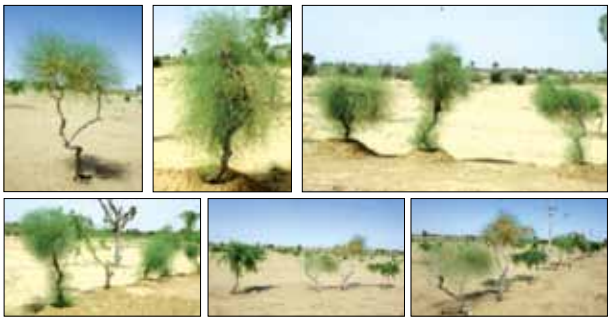


Fig. 34. Plant growth, training / pruning and biomass production studies in phog under khejri based crop production site management approach at CIAH, Bikaner.

Fig. 35. Plant growth and bio-mass production studies in sewan grass under absolute rainfed conditions over the years with khejri based crop production sites at CIAH, Bikaner

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 11 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.

Intercropping and yield assessment of over storey and ground storey crops

The average yield of *aonla* varied considerably in different cropping model systems with highest being recorded in *aonla-khejri* (44.3 kg per plant), *aonla-ber* (41.6) followed by *aonla*-kinnow (38.8 kg/plant) and *aonla*-mulberry (36.7), while the lowest was recorded in *aonla*-moringa (33.4 kg/plant). The higher yield in *aonla* involving *ber* and *khejri* could be due to synergistic crop interaction. The average yield of *bael* was recorded to be 25-30 kg per tree, while a single fruit weighed around 1.47 kg with maximum and minimum fruit weights recorded to be 2.3 and 0.4 kg, respectively. The average yield of *karonda* was recorded up to 12.8 kg/plant planted in between *aonla* plants. Likewise, the yield of *ber* cv. Seb was recorded to be 50.4 kg/plant in model M-1. The yield of *sewan* grass was recorded to be an average of 2.41 kg/m^2 on dry weight basis.

Eco-physiological interaction studies

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

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

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

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

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

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

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

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

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

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

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

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

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

Photosynthetically active radiation 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* (88.48) > *Khejri* (87.20) > *Bael* (85.31) > Moringa (81.64) > *Ber* (76.37)

May: *Khejri* (92.14) > *Aonla* (86.73) > *Karonda* (82.41) > Moringa (71.28)

June: *Karonda* (91.40) >*Aonla* (88.86) > *Khejri* (83.53) > Moringa (81.29) > *Bael* (80.01) > *Ber* (64.02)

July: *Karonda* (89.78) > *Khejri* (88.54) >*Aonla* (85.93) > *Bael* (84.51) > Moringa (71.12) > *Ber* (62.27).

August: *Bael* (89.67) > *Aonla* (87.83) >*Khejri* (81.95)> Moringa (81.70)> *Karonda* (81.49) > *Ber* (80.98).

September: *Aonla* (84.77) > Moringa (79.81) > *Khejri* (79.28) > *Karonda* (78.85) > *Bael* (78.20) > *Ber* (76.64).

October: *Aonla* (95.00) > *Karonda* (89.80) > *Bael* (89.65) >*Ber* (87.17) >*Khejri* (77.36) > Moringa (75.15).

November: *Ber* (92.44) >*Khejri* (92.19) > *Karonda* (89.67) > *Aonla* (81.78)> Moringa (76.50) > *Bael* (68.34).

December: *Aonla* (93.18) > *Bael (92.80)* > *Karonda*(91.99) > *Khejri* (88.63) > *Ber* (86.11) > Moringa (73.03).

January: *Aonla* (87.46) > *Khejri (84.88)* >*Karonda* (83.05) > *Ber* (76.75) > Moringa (62.78) > *Bael (62.01).*

February: Moringa (87.62) > *Bael (84.57)* > *Aonla (81.83)* > *Khejri* (77.73) > *Ber (70.96)* > *Karonda* (62.82).

March: *Bael* (82.60) > *Aonla* (78.60) > *Ber* (76.61) > Moringa (67.18) > *Khejri* (60.59) > *Karonda* (58.81).

Aonla and *karonda* leaves were observed to maintain the comparatively higher relative water content throughout the period under study followed by *khejri* and *bael,* while the lowest was noticed with *ber*. Likewise, with regards to the leaf water content, *khejri* and drumstick leaves were observed to be having higher moisture contents, while *aonla and karonda* had lower moisture contents in their leaves.

Leaf Water Contents (%) Pattern of Fruit Trees

April: Moringa (72.64) > *Karonda* (69.59) > *Ber* (61.26) > *Bael* (60.73) > *Khejri* (57.41)

May: *Khejri* (91.34) > *Aonla* (83.41) > *Karonda* (82.70) > Moringa (71.67)

June: *Khejri* (73.58) > *Bael* (69.39) > Moringa (69.01) > *Ber* (63.13) > *Aonla* (63.03) > *Karonda* (56.29).

July: Moringa (73.96) > *Bael* (69.91) > *Khejri* (68.30) > *Ber* (64.28) > *Aonla* (57.82) > *Karonda* (51.25).

August: Moringa (72.63) > *Bael* (65.16) > *Ber* (62.06) > *Karonda* (61.61) > *Aonla* (60.64) > *Khejri* (57.50).

September: Moringa (76.15) > *Khejri* (65.62) > *Ber* (63.30)> *Karonda* (61.52) > *Bael* (61.49) > *Aonla* (61.04).

October: Moringa (66.91) > *Khejri* (65.95) > *Bael* (64.50) > *Ber* (63.75) > *Karonda* (59.06) > *Aonla* (48.97).

November: *Bael* (73.46) > *Khejri* (73.05) >Moringa (71.43)> *Ber* (58.79) > *Karonda* (57.23)> *Aonla* (53.66).

December: *Aonla* (61.29)> *Khejri* (60.84)> *Ber* (60.78) > *Bael* (60.47) > Moringa (59.80) > *Karonda* (57.43).

January: *Khejri* (70.67) > *Aonla* (70.01) > *Ber* (61.51) > Moringa (55.89) > *Karonda* (55.06) > *Bael* (49.84).

February: *Khejri* (65.29) > Moringa (60.45) > *Bael* (58.48) > *Ber* (56.67) > *Karonda* (51.85) > *Aonla* (49.44).

March: *Bael* (62.78) > *Khejri* (56.26) > Moringa (53.22) > *Ber* (52.60) > *Karonda* (52.14) > *Aonla* (48.65).+

Studies on flowering regulation, cracking management, rootstock adaptability and value addition in pomegranate under hot arid environment of Rajasthan.

The field experiment was initiated to study the regulation of flowering, cracking management, rootstock adaptability and value addition in pomegranate under hot arid environment of Rajasthan. This trial was laid out under randomized block design with three replications and initiated during September, 2015. Pomegranate variety-Bhagwa was planted at a distance of 4x3m at farm block number-3 CIAH, Bikaner. The total area covered under this experiment was 1.25 hectare. The whole area was under drip irrigation system. Project activities were executed as per the technical programme. Data were recorded on survival percentage of pomegranate saplings in different experiments; where the survival rate was around 85 % in the new plantation. Maximum loss (12 %) in pomegranate was recorded due to termite. The termites feed on roots, shoots and trunks of the pomegranate plant moving upward making the tunnels.Termite management was done with application of chlorpyriphos through drip irrigation.

Fruit cracking management in bael

Fruit cracking is one of the major constraint in production of *bael* cultivation under arid environment. The wrapping of fruits with cling film resulted in reduced fruit cracking, previous year. To confirm the findings, this study was conducted during the reported period as well. No cracking was noticed in wrapped fruits till first week of March, 2016, while about 15% cracking was noticed in unwrapped control fruits. However, occurrence of

hail storm on 11.03.16, resulted in unprecedented fruit cracking in *bael*. Cling film wrapping resulted in less cracking of *bael* fruits, despite hail storm. Around 60% fruit were saved due to wrapping with cling film, while cracking was noted to the extent of 95% in control fruits. Besides, severity of cracking on individual fruits was more intense (multiple cracking with wider and deeper cracks) in unwrapped control fruits.

At Godhra

Organic and biodynamic farming

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 19.80-14.80, 20.60-16.70% in paddy straw and it was recorded 14.80-12.10, 16.40-13.50 % 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 (40.10 kg/plant), followed by grasses (35.10 kg/plant) and black polythene mulch (32.40 kg/plant) and it was recorded minimum in control (29.10 kg/plant). Maximum TSS (20.30° Brix) was noted in paddy straw mulch followed by grasses (20.10° Brix) and polythene mulch (20.00° Brix), it was recorded least in control (19.60° Brix).

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

Experiment was set up 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 (3.20 m), plant spread East- West (2.60 m), north-south (2.40m) and scion girth (42.10 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 fruit yield (10.50 kg/ plant), TSS (20.80° Brix) was also recorded in T -6, closely followed by T-8.

Pruning trial in mango

For conducting the pruning trial in mango, planting of 200 plants of Kesar mango under high density (5×5 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

The maximum fruit yield per plant (40.20kg) was recorded in paddy straw mulch followed by grasses (36.10 kg/plant), black polythene mulch (32.10 kg). Minimum fruit yield (24.00 kg/plant) was recorded under control. Maximum fruit weight

(236.10) and TSS (13.30°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 up in randomized block design which was replicated four times. Inter crops (bottle gourd, pumpkin, bitter gourd, sponge gourd, cucumber excluding control) were sown during rainy season between spaces of two rows of sweet orange, planted at 5 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

The maximum plant height (2.70 m), plant spread east- west (2.30 m), north-south (2.60m) and scion girth (27.00 cm) was recorded in T_6-FYM + std. dose of NPK + *Azotobactor* + PSB closely followed by T_8-Castor cake + standard dose of NPK+ *Azotobactor* + PSB.

Bael

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

To acquire vigorous and healthy scion shoots, the branches are detopped on 10 day of the month April and May when the plants were in leafless condition. The multiple axillary shoots arise 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.

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 onwards.

Plants grafted in May took the least time (7 days) to sprout closely followed by that done in June (12 days) and July (19days); however maximum time (20 days) was taken to sprout when grafting was performed in August. The highest percentage of graft success (96.12) was recorded when grafting was done in May closely followed by June (91.00), July (67.15) and August (65.00) with one month old shoots. The maximum mean length of sprout *i.e.* 65.00 cm was recorded when patch budding was done in May closely followed by June (55.50 cm) and July (52.12 cm) whereas least length of sprout was recorded in August (43.50cm). The maximum number of trifoliate leaves (38.17) per plant was recorded from the plants when the budding was done in May followed by June (30.60) and in July (25.00) and the minimum was recorded in August i.*e.* 20.32 leaves.

Leaf sampling of chironji, custard apple, jamun and tamarind

Chironji

In chironji, month wise leaf samples were collected, cleaned, dried and powdered and preserved. In January month floral bud initiation was started, peak flowering was noticed in February month and fruit setting and maturation started in March month and reached pea size fruits by March second fort night. In some plants by January month leaves became yellow and started dropping. But in plants where flower bud was initiated, leaves are dark green and these leaves started to become yellow in April month and started to drop, while fruits are green and attained a size of more than pea size indicating that the old leaves contribution was only for three and half months. From April to first week June new leaves and the chlorophyll present in fruits contribute to the development of fruits. Finally, it was concluded that three components are contributing the overall development of fruits from flower bud to final harvesting stage. They are 1.Old leaves from January to middle of the April month.2.The new leaves appeared in April month 3. The chlorophyll present on the surface of green fruits.

Custard Apple

In custard apple new leaves come in April month with flower buds and remain dormant in May and up to 1st fort night of June and growth starts from the onset of monsoon rains in June.

However some flowers are set in to fruits in April and May months but they are dried at marble stage and remain as black bodies on the stem due to lack of proper soil moisture during the summer period. Peak flowering was noticed in the month of July along with shoot growth and fruit set was taken place in July and August. The maximum leaf number per shoot reached in August month. Fruits reached maturity in October and November months. The average number of leaves observed per a shoot was 21.9 (100 samples average) after reaching complete maturation of leaves. To indicate leaf nutrient concentration variation according to leaf position from terminal leaves to basal leaves some observations from our experiments are given in the following photo. Here important observation to notice is the concentration of elements like nitrogen, phosphorous, potassium, and magnesium is more in young leaves and gradually decreased as we reach basal part of the twig where older leaves are present. The nutrients like calcium and sulphur were accumulated in older leaves, which prove the nutrient mobility concept in the plant. Moreover the optimum nutrient concentration was observed in the leaves of the middle part of the twig (Fig 36).

N-3.12%
P-1070 PPM
K-0.69%
Ca-1.44%
Mg-0.83%
S-2271 ppm

N-3.08%
P-746 PPM
K-0.51%
Ca-2.33%
Mg-0.68%
S-2203 ppm

N-2.73%
P-662 PPM
K-0.46%
Ca-2.81%
Mg-0.63%
S-3119 ppm

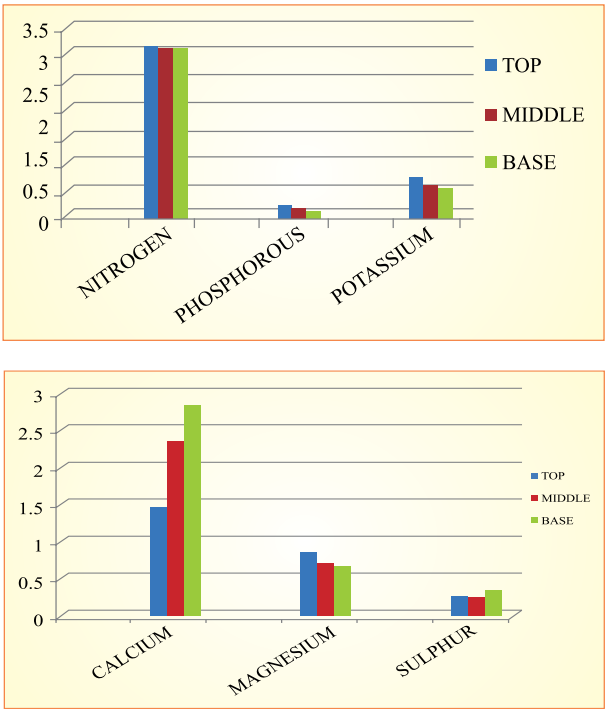


Fig. 36. Nutrient composition in different parts of twig of custard apple.

Jamun

In jamun, in January inflorescence bud appeared at very few places. In February many leaves dropped, new flush appeared and simultaneously more number of panicles appeared. By March complete blooming appeared. In April month the leaves matured properly but not turned in to dark green but complete stamens dropped from opened flowers and fruit set was taken place. But in May slowly the leaves turned dark green along with growth of young fruits. In September month, the leaves looked like completely free from pests and some of old leaves dropped and at some places on the tree new flush appeared. In all months, samples were taken and analysis was in progress. By observing leaf growth and appearance of new leaves, fruit setting stage the leaf sampling in April second fort night seems to be appropriate since leaf maturity of newly formed young leaves happened at this stage, which feed the developing fruits.

Standardization of integrated nutrient management practices in arid horticultural crops

Effect of different INM treatments on microbial population

In the present study three types i.e. *Azotobactor*, PSB and AMF biofertilizers are intend to use in the different treatments. For making standard doses of biofertilizers same were tested for their microbial load. Accordingly, all three biofertilizers were procured from ICAR-IARI, New Delhi. The *Azotobactor* biofertilizer was tested for bacterial population and 8.5 x 10^6 cfu were recorded and the other quality parameters like colour, moisture and granulation were also recorded and same were found in order. The PSB biofertilizer was tested for *Pseudomonas* population and observed 10.3x 10^9 bacteria population and other physiochemical properties were also found in order. Likewise, VAM was evaluated for the fungal colonies of *Glomus* species and large numbers of hyphae were recorded and also multiplying in the live host material.

Monitoring of microbial population at two depths (0.00 - 0.15 and 0.15 - 0.30 m) during 2015-16 was carried out in bael and kinnow field experiments of integrated nutrient management (Table 8). The bacterial population in different treatments ranged from 6 to 32 x10^5 cfu g^{-1} soil, fungal from 1 to 3 x10^5 cfu g^{-1} soil and actinomycetes from 12-25 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 8). Total population as well as individual population of different microorganism increased with involvement FYM and consortium of biofertilizers. This is because most of the soil micro-organisms are chemoheterotrophs which require

Table 8. Effect of different INM treatments on microbial population in kinnow orchard (15 year old plants)

Treatments	0-15 cm depth				15-30 cm depth			
	Bacteria (Cfug-1x 105)	Fungal (Cfug-1x 105)	Actinomycetes (Cfug-1x 105)	Total	Bacterial (Cfug-1x 105)	Fungal (Cfug-1x 105)	Actinomycetes (Cfu g-1x 105)	Total (Cfu g-1x 105)
Control	6	2	12	20.0	5	1.0	12	18.0
RDF	14	1.4	16	31.4	12	1.3	14	27.3
RDF + FYM	28	2.0	22	52	24	2.0	21	47.0
RDF +Azotobactor	30	1.4	12	43.4	27	1.5	14	42.5
RDF + PSB	31	1.5	15	47.5	24	1.8	15	40.8
RDF + VAM	10	2.5	13	25.5	11	2.6	10	23.6
RDF+FYM + AZB	32	2.0	20	54	28	1.5	18	47.5
RDF + FYM + PSB	31	1.5	16	48.5	27	1.5	14	42.5
RDF + FYM + VAM	32	3.0	22	57	30	2.5	18	47.5
RDF +FYM + PSB + AZB	32	2.0	23	57	30	2.0	20.0	52.0
RDF + FYM + PSB + AZB + VAM	32	3.0	25	60	30	2.5	22	54.5
SE±	3.20	0.11	3.25	-	2.63	0.13	3.10	-
CD 5%	8.65	0.33	9.25	-	7.32	0.31	8.90	-

organic source of carbon as food and oxidation for organic substances provides energy. Under different INM treatments, the total and individual population of different micro-organisms was higher where nutrients were provided by RDF of N, P, K + FYM + PSB + Azotobactor + VAM combinations followed by RDF of N, P, K +FYM + Azotobactor treatment and minimum population of micro-organism were observed in control treatment. In FYM treated plants, C: N ratio was wide which proved more carbon and low rate of mineralization, this might have resulted in increased total population as well as individual microbial population. Total as well as individual microbial population was higher in the surface than subsurface soil.

The data presented in table 9 revealed that 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 32x 10^5 cfu g^{-1} soil, fungal 1 to 2.5 x 10^5 cfu g^{-1} soil and actinomycetes 10 to 22x 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 parameter of kinnow

The data presented in table 10 revealed that significantly maximum plant height (4.50 m) was recorded in RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatment and minimum was in control (2.80 m). The pattern in plant height revealed that addition of RDF along with FYM and consortium of biofertilizers has the highest increment in plant growth. Likewise, plant spread in both the directions was also more in the same INM treatment. The data on stem diameter was also significantly differed among INM treatments and maximum stem diameter was recorded in RDF + FYM + PSB + AZB + VAM and RDF +FYM + PSB + AZB treatments.

Table 9. Effect of different INM treatments on microbial population (cfu x10^4 g^{-1} soil) in bael orchard

Treatments	0-15 cm depth				15-30 cm depth			
	Bacteria (Cfug-1x 105)	Fungal (Cfug-1x 105)	Actinomycetes (Cfug-1x 105)	Total	Bacterial (Cfug-1x 105)	Fungal (Cfug-1x 105)	Actinomycetes (Cfu g-1x 105)	Total (Cfu g-1x 105)
Control	8	1.5	15	24.5	5	1	10	16
RDF	13	1.5	17	31.5	10	1.0	10	21
RDF + FYM	25	2.0	21	47.0	20	1.0	20	41
RDF + Azotobactor	29	1.0	15	45.0	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 10. 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 (cm)
		N-S (m)	E-W (m)	
Control	2.80	2.65	2.65	80
RDF	3.00	2.70	2.65	80
RDF + FYM	3.65	3.00	3.00	80
RDF +Azotobactor	3.00	2.70	3.00	80
RDF + PSB	3.00	2.90	2.95	80
RDF + VAM	3.00	2.90	2.80	80
RDF+FYM + AZB	4.00	3.00	2.95	80
RDF + FYM + PSB	4.00	3.00	3.00	80
RDF + FYM + VAM	4.00	3.00	3.00	85
RDF +FYM + PSB + AZB	3.90	3.25	3.00	85
RDF + FYM + PSB + AZB + VAM	4.50	3.45	3.00	85
SE±	0.22	0.15	0.18	6.20
CD 5%	0.54	0.42	0.40	16.00

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 11 revealed that maximum fruit weight (235 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 (125 g) was recorded in control treatment. The fruit yield was estimated and maximum fruit yield (22.50 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 was ranged from 40 to 55 percent and maximum juice (55 %)was recorded in those treatments where FYM was the component of the treatment.

Table 11. Effect of different INM treatments on yield and fruit quality parameters of kinnow orchard (Average age of plant: 15 years)

Treatment	Fruit weight (g)	Fruit yield (t/ha)	TSS (° Brix)	Acidity (%)	Juice (%)
CONTROL	125	10.00	12.50	0.85	40.00
RDF	165	12.00	12.00	0.70	50.00
RDF + FYM	225	16.50	12.50	0.60	55.00
RDF +AZOTOBACTOR	175	12.00	12.50	0.60	50.00
RDF + PSB	165	12.00	12.50	0.70	55.00
RDF + VAM	165	12.00	12.50	0.70	50.00
RDF+FYM + AZB	190	19.00	15.00	0.70	55.00
RDF + FYM + PSB	200	19.50	15.00	0.70	55.00
RDF + FYM + VAM	200	18.50	15.00	0.70	55.00
RDF +FYM + PSB + AZB	225	20.25	15.00	0.65	55.00
RDF + FYM + PSB + AZB + VAM	235	22.50	15.00	0.65	55.00
SE±	15.25	1.95	0.65	0.26	1.20
CD 5%	42.90	5.25	1.80	NS	3.55

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

The benefit cost ratio of different INM treatments was evaluated for 15 year old crop kinnow fruit crop. The fixed cost was worked out having the 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 (2.91) was recorded in treatment T_{10} and minimum (1.74) was in treatment T_2 (Table 12). The data revealed that adding of FYM with recommended dose of NPK increased the benefit cost ratio while adding of AMF did not the benefit in the income.

Effect of different INM treatments on morphological parameter of bael

The parameters on plant height, tree spread and stem diameter were measured and data presented in table 13. The data revealed that maximum plant height (1.10 m) was recorded in RDF of N, P, K +FYM +PSB + Azotobactor and RDF of N, P, K + FYM + PSB + Azotobactor + VAM treatments and minimum plant height was recorded in control treatment likewise same pattern was recorded in tree spread and stem diameter.

Table 12. Evaluation of benefit cost ratio of different INM treatments in Kinnow fruit crop (15 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	10.00	80	55	2.20
RDF of N, P and K	25	10	35	12.00	96	61	1.74
RDF + FYM	25	15	40	16.50	132	92	2.30
RDF +AZB	25	12	37	12.00	96	59	1.60
RDF + PSB	25	12	37	12.00	96	59	1.60
RDF + AMF	25	12	37	12.00	96	59	1.60
RDF+FYM +AZB	25	17	42	19.00	152	110	2.62
RDF + FYM + PSB	25	17	42	19.50	156	114	2.71
RDF + FYM + AMF	25	17	42	18.50	148	106	2.52
RDF +FYM +PSB + AZB	25	19	44	20.25	162	118	2.68
RDF+FYM+ PSB + AZB + AMF	25	21	46	22.50	180	134	2.91

able 13. Effect of different INM treatments on morphological parameter of bael orchard (Average age of plant: 7 years)

Treatment	Tree height (m)	Tree Spread		Stem diameter (cm)
		N-S (m)	E-W (m)	
Control	0.85	0.28	0.33	20
RDF	1.10	0.33	0.33	20
RDF + FYM	1.20	0.35	0.35	28
RDF +Azotobactor	1.10	0.35	0.35	28
RDF + PSB	1.120	0.34	0.35	25
RDF + VAM	1.10	0.35	0.25	25
RDF+FYM + AZB	1.25	0.40	0.35	25
RDF + FYM + PSB	1.25	0.45	0.35	30
RDF + FYM + VAM	1.25	0.45	0.35	30
RDF +FYM + PSB + AZB	1.25	0.42	0.40	30
RDF + FYM + PSB + AZB + VAM	1.25	0.50	0.40	30
SE±	0.16	0.15	0.14	4.25
CD 5%	0.42	NS	NS	NS

The soil physico-chemical properties of the soil under different INM treatments were measured periodically and data presented in table 14 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 but on the application of FYM, pH of the soil lower down. On the application of biofertilizers pH of the soil did not change much. Data regarding the organic carbon status revealed that application of FYM increased the level of OC while inorganic fertilizers and biofertilizers have not changed the OC status of the soil. Available P and K_2O also have been affected by the application of INM treatments and recommended dose of N, P and K increased the availability of P and K_2O in the soil and their maximum status were recorded on the application of application of inorganic fertilizers along with FYM. Likewise Availability of zinc and iron content in the soil has also been increased over the application of FYM.

The soil moisture status of the soil under different INM treatment was monitored and results revealed that application of FYM alone or in combination with inorganic and biofertilizers increased the soil moisture status at both the strata. Monitoring of soil status at two depths revealed the more moisture has been accumulated at lower depths (Table 15). Application of biofertilizers alone did not improve the soil moisture status of the soil.

Table 14. 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	0.12	08.50	175.00	0.50	3.50
RDF	8.20	0.15	14.50	210.00	0.50	3.50
RDF + FYM	7.50	0.25	14.50	215.00	0.60	4.25
RDF +Azotobactor	8.00	0.15	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	0.15	16.50	200.00	0.60	3.80
RDF+FYM + AZB	7.60	0.28	14.50	210.00	0.65	4.80
RDF + FYM + PSB	7.60	0.28	17.50	210.00	0.65	4.80
RDF + FYM + VAM	7.60	0.28	18.50	220.00	0.65	4.80
RDF +FYM + PSB + AZB	7.60	0.28	18.50	220.00	0.65	5.00
RDF + FYM + PSB + AZB + VAM	7.50	0.28	18.50	220.00	0.65	5.00
Initial level	8.20	0.08	08.00	180.50	0.50	3.50

Table 15. 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

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 by Medjool (90%) and minimum(75%) survival was recorded in Khuneizi cultivar
- Maximum plant height (180 cm) was recorded in Barhee followed in Khalas (170 cm) and minimum in Khuneizi cultivar (60cm).
- Maximum plant spread (N-S) and (E-W) was recorded in Barhee (1.10 m and 1.15 m) and minimum in Khuneizi cultivar (0.20 m and 0.15m).
- In cultivar Khalas and Barhee cultivars, 10-12 new leaves emerged while in Medjool it was 6-7 and minimum leave emergence i.e.2-3 was in Khuneizi cultivar

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 (1×1 x 1m and 0.5 × 0.5 × 0.5m)
Cultivar:	Barhee, Khalas, Khuneizi and Medjool
Replications:	5
Design:	RBD
Observations:	Survival (%), Plant height (m), Plant spread (m × m), emergence of new leaves

The results of the said experiment are given here:

- Irrespective of cultivar, maximum survival (95%) was recorded in 1 × 1 × 1 m pit size and minimun survival 85% was recorded in 0.5 × 0.5 × 0.5m size of pit.
- Maximum plant height (185cm) in Khalas and Barhee cultivar with 1 × 1 × 1 m pit size while minimum plant height (50 cm) in Khuneizi cultivar with 0.5 × 0.5 × 0.5m pit size. The maximum leaf emergence was also recorded in cultivar Barhee and Khalas cultivar in the bigger size pit while minimum leaves were emerged in cultivar Khuneizi with small pit size. same treand was also recorded in plant spread also.

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 × 6m and 8 × 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 of date palm, impact of spacing (row to row and plant to plant) i.e. 6 × 6m and 8 × 8m was not seen and survival, plant height and spread were not differed significantly in both the spacing.

Nutrients management in vegetables (Mateera, kachri, snap melon and cluster bean) of hot arid region of Rajasthan

Effect of different sources of nitrogen on Kachri performance

Growth and yield of *kachari*: Vine length (cm), fruit production/plant (g), number of fruits/Plant and No. of branches/plant showed significant effect

of different sources of N application (Table 16). Maximum vine length (cm), fruit production/plant (g), number of fruits/plant and number of branches/plant (1.5, 5.2, 13 and 560, respectively) was observed with spilt application of N @ 80 kg N /ha through neem coated urea followed by 80 kg N /ha through Neem coated urea as entire dose at time of sowing. Different sources of N containing fertilizers increased yield of *kachari* as compared to control (Table 16 & 17). Spilt application of N @ 80 kg N / ha through neem coated urea gave higher growth parameters like vine length, number. of branches, fruits/plant and fruit production/plant followed by spilt application of N through calcium nitrate and spilt application of N @ 80 kg N /ha through urea. Spilt application of N @ 80 kg N /ha through neem coated urea gave maximum yield (109.25 q/ha) followed by spilt application of N through calcium nitrate (102.65 q/ha) and spilt application of N @ 80 kg N /ha through urea (98.25 q/ha).

The increase in total yield was 97.74% higher over control by spilt application of N @ 80 kg N /ha through neem coated urea. Application of N through urea also increased yield significantly by 77.83% compared to control. Whereas, this treatment gave only 11.19% less *kachari* yield as compared to spilt application of N @ 80 kg N /ha through neem coated urea.

Table. 16 Role of different sources of Nitrogen on growth attributes of *Kachari*

Treatments	Vine length (cm)	No. of branches/plant	No of fruits/ Plant	Fruit production/Plant (g)
Control	1.5	5.2	13	560
80 kg N /ha through CAN	1.9	7.9	18	648
80 kg N /ha through Urea	1.7	6.1	15	510
80 kg N /ha through Neem coated urea	2.3	8.4	22	946
80 kg N /ha through CAN (spilt application of N)	2.1	7.3	25	950
80 kg N /ha through Urea (spilt application of N)	2.4	8.8	23	828
80 kg N /ha through Neem coated urea (spilt application of N)	2.6	9.6	28	1036
CD at 5%	0.35	1.15	3.45	124.25

Table 17. Role of different sources of Nitrogen on performance of *Kachari*

Treatments	Yield (q/ha)	Yield response (%)	N uptake (kg/ha)	AE (kg/ kg N)	AR%	PE (kg/kg N)
Control	55.25	-	7.74	-	-	-
80 kg N /ha through Calcium nitrate	89.2	61.45	14.44	42.44	8.38	506
80 kg N /ha through Urea	82.45	49.23	13.29	34.00	6.94	490
80 kg N /ha through Neem coated urea	95.78	73.36	15.54	50.66	9.75	520
80 kg N /ha through Calcium nitrate (spilt application of N)	102.65	85.79	17.32	59.25	11.97	495
80 kg N /ha through Urea (spilt application of N)	98.25	77.83	16.65	53.75	11.14	483
80 kg N /ha through Neem coated urea (spilt application of N)	109.25	97.74	18.17	67.50	13.03	518
CD at 5%	14.21	74.23	0.82	-	-	-

Nutrient uptake and apparent recovery: The uptake of N was significantly affected by different treatments (Table 17). Maximum uptake of N (18.17 kg/ha) by *kachari* was obtained with 80 kg N /ha through Neem coated urea (spilt application of N) followed 80 kg N /ha through Calcium nitrate as spilt application of N (17.32 kg/ha). Since the 80 kg N /ha through Neem coated urea (spilt application of N) resulted in increased yield and yield attributes of *kachari* so the uptake values of above nutrients also registered a simultaneous increase. The apparent recovery is the increase in the quantity of nutrient absorbed over control per unit nutrient applied. The increase in nutrient uptake was reflected in the enhanced recoveries of applied fertilizer N with the application of N through sources and methods. Maximum apparent recovery was observed by the application of 80 kg N /ha through Neem coated urea as spilt application (13.03%) followed by 80 kg N /ha through Calcium nitrate as spilt application (11.97%) and urea (11.14%). Spilt application was superior than basal application.

Physiological and agronomic efficiency: Physiological efficiency is the increase in *kachari* production obtained per unit increase in nutrient absorbed over control, whereas, agronomic efficiency is the increase economic yield obtained per unit increase in nutrient applied. Physiological and agronomic efficiency of *kachari* crop were significantly influenced by the various source of N fertilizers. Maximum physiological efficiency of N (518 kg/kg) was obtained when N applied through 80 kg N /ha through Neem coated urea as spilt application, which was followed by application of N @ 80 kg N /ha through Neem coated urea (Entire dose at time of planting). Whereas, 80 kg N /ha through Calcium nitrate as basal and 80 kg N /ha through Calcium nitrate as spilt application gave 506 and 495 kg/kg of N, respectively.

Lowest physiological efficiency of N was observed in treatment where N through Urea was applied indicating that due to absorbed N could not be converted in the yield. Therefore, their physiological efficiency was the lowest when urea fertilizer was applied. The apparent agronomic efficiency of fertilizer N increased with the different sources of N. The maximum efficiency was observed when 80 kg N /ha through Neem coated urea as spilt application (67.50 kg/kg N) followed by 80 kg N /ha through Calcium nitrate as spilt application (59.25 kg/kg N).

To determine the requirement of N, P and K fertilizers of kachri using omission plot technique

Field experiments were conducted at CIAH research farm with popular kachari cultivar AHK119 during 2015 in the kharif season to investigate the site specific nutrient management on kachari performance. 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.* 1/3rd at planting, 1/3rd at 25 DAP and rest 1/3rd 50 DAP from fertilizers . PK fertilizers was applied in furrows at the planting time as per treatment.

Application of different combinations of NPK doses significantly increased yield (%), DM and dry matter of *kachri* as compared to control. Application of 120, 60 and 60 kg/ha of N, P_2O_5 and K_2O gave the highest *kachri* yield (108.87 q/ha) which was significantly higher than all other treatments, but at par with 80, 40 and 40 kg/ha of NPK and 80 and 40 kg/ha of NP. The increase in total yield was 7.85% higher over recommended NPK through fertilizers. Application of 100% NPK increased yield significantly by 81.63% compared to control. Whereas, this treatment gave only 2.10% more kachri yield as compared to recommended dose of fertilizers.

Maximum yield was obtained when 120, 60 and 60 kg/ha of N, P_2O_5 and K_2O (108.87 q/ha) followed by 80, 40 and 40 kg/ha of N, P_2O_5 and K_2O (100.95 q/ha) and 80 and 40 kg/ha of N and P_2O_5 (98.87 q/ha) and 40, 20 and 20 kg/ha of N, P_2O_5 and K_2O

(82.65 q/ha). Same trend was observed for per cent yield response of different treatments (Table 18).

Higher dry matter (%) was observed where 80 and 40 kg/ha of NK were applied followed by 120, 60 and 60 kg/ha of N, P_2O_5 and K_2O. However, dry matter yield (11.29 q/ha) was obtained where, 120, 60 and 60 kg/ha of N, P_2O_5 and K_2O followed by 80, 40 and 40 kg/ha of N, P_2O_5 and K_2O.

Maximum per cent yield response was observed where 120, 60 and 60 kg/ha of N, P_2O_5 and K_2O was applied (95.88%) followed by 80, 40 and 40 kg/ha of N, P_2O_5 and K_2O (81.63%) and 80 and 40 kg/ha of N and P_2O_5 (77.89%) as compared to control. This might be due to more partitioning of dry matter to *kachri* as a result of balance nutrition in these treatment (Fig. 37 and 38).

Table 18. Requirements of N, P and K fertilizers of *kachri* using omission plot technique

Treatments	Yield (q/ha)	Average of fruit (g)
40, 20 and 20 kg/ha of NPK	82.65	37
80, 40 and 40 kg/ha of NPK	100.95	40
120, 60 and 60 kg/ha of NPK	108.87	42
40 and 40 kg/ha of PK	71.25	38
80 and 40 kg/ha of NK	80.45	40
80 and 40 kg/ha of NP	98.87	33
Without NPK (Absolute control)	55.58	29
CD at 5%	13.95	9

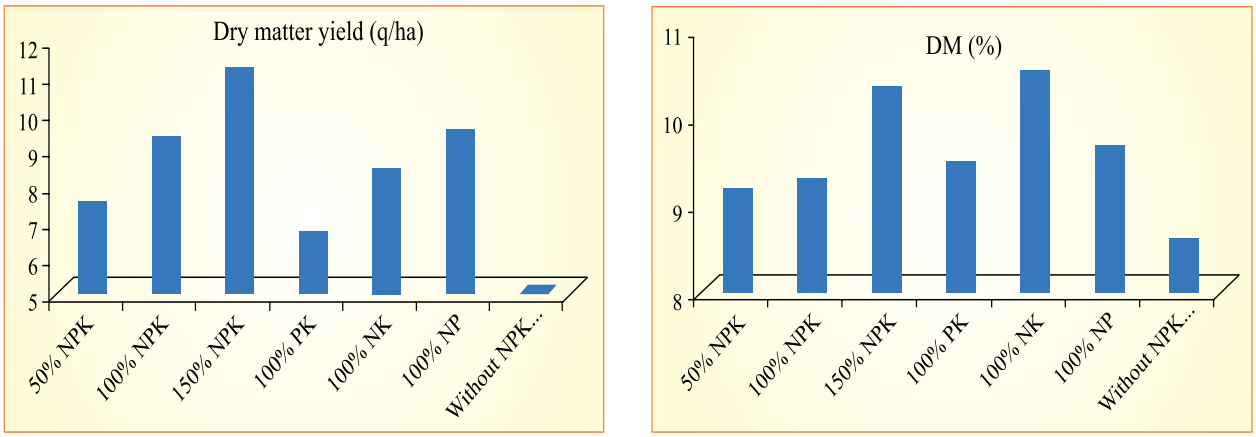


Fig 37. Dry matter per cent and yield of *kachri* using omission plot technique

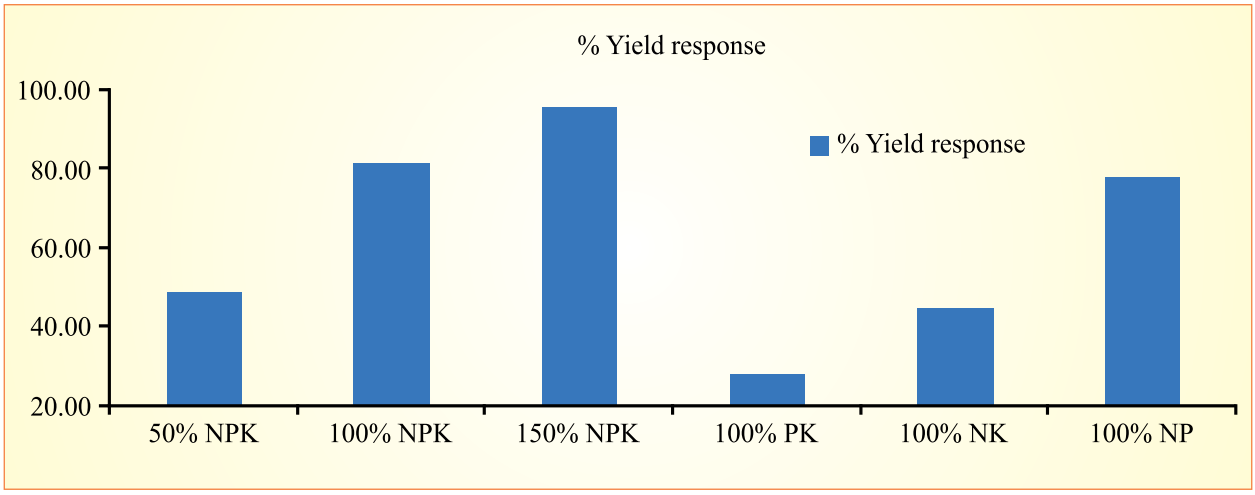


Fig 38. Per cent yield response of *kachri* using omission plot technique

Net return and benefit cost ratio of the *kachri*

Net return from *kachri* followed similar trend (Table 19) as that of fruit yield with highest values of Rs 178650/ha was observed in 120, 60 and 60 kg/ha of NPK treatment. This was closely followed by 80, 40 and 40 kg/ha of NPK (Rs 164827/ha) and 80 and 40 kg/ha of NP (Rs 161947/ha). 40, 20 and 20 kg/ha of NPK application gave net return of Rs 130263/ha as compared control (Rs 83708/ha). The benefit : cost ratio was highest in the treatment receiving 120, 60 and 60 kg/ha of NPK (4.57) closely followed by 80 and 40 kg/ha of NP treatments (4.52). Whereas, control gave the lowest B:C ratio (2.54).

Table 19. Net return and B:C ratio under treatments

Treatments	Cost of cultivation	Yield q/ha	Price/kg	Gross return	Net return	B:C ratio
40, 20 and 20 kg/ha of NPK	35037	83	20	165300	130263	3.72
80, 40 and 40 kg/ha of NPK	37073	101	20	201900	164827	4.45
120, 60 and 60 kg/ha of NPK	39110	109	20	217740	178630	4.57
40 and 40 kg/ha of PK	36030	71	20	142500	106470	2.96
80 and 40 kg/ha of NK	35323	80	20	160900	125577	3.56
80 and 40 kg/ha of NP	35793	99	20	197740	161947	4.52
Without NPK (Absolute control)	33000	56	21	116708	83708	2.54

Role of organic and inorganic source of nutrient on performance of Kachri in hot arid region.

Field experiments were conducted at CIAH research farm with popular kachari cultivar AHK119 during 2015 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.* 1/3rd at planting, 1/3rd at 25 DAP and rest 1/3rd 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 growth parameters and yield of kachri as compared to control (Table 20 & Fig. 39 & 40). Maximum vine length (cm), No. of branches, fruits/plant and fruit production/plant (g/plant) were 2.3, 8.8, 26.0 and 1115 when organic and inorganic sources at equal proportion (application of 50% NPK from inorganic fertilizers and 15 t/ha FYM) was applied followed by 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. Integration of organic and inorganic sources in equal proportion (application of 50% NPK from inorganic fertilizers and 15 t/ha FYM) gave the highest kachri yield (104.31 q/ha) which was significantly higher than all other treatments. The increase in total yield were 72.48, 96.29, 99.64, 85.22 and 78.47% higher over control by the application of 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.

Maximum per cent yield response was observed where 50%(I)+ 15 t/ha FYM was applied (99.64%) followed by 75% (I)+7.5 t/ha FYM (96.29%) as compared to control. This may be due to more partitioning of dry matter in kachri as a result of balanced nutrition in the treatment receiving FYM application.

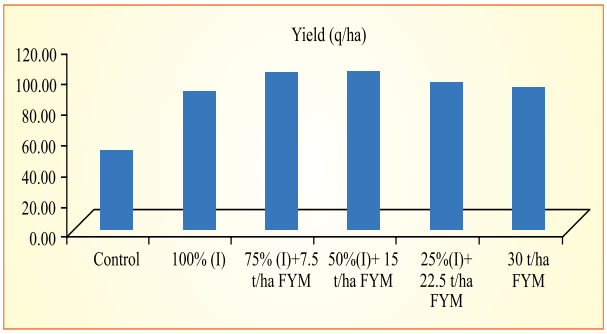


Fig. 39. Role of organic and inorganic source of nutrient on yield of Kachri

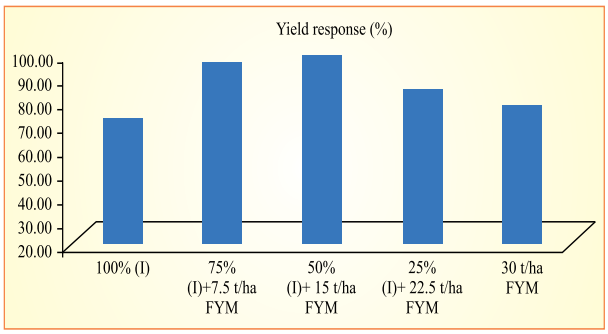


Fig. 40. Role of organic and inorganic source of nutrient on yield response (%) of Kachri

Table 20. Role of organic and inorganic source of nutrient on growth attributes of Kachri

Treatments	Vine length (cm)	No. of branches	Fruits/branches	Fruit production/plant (g/plant)
Control	1.2	4.1	13.0	601
100% (I)	1.5	7.3	18.0	757
75% (I)+7.5 t/ha FYM	1.7	7.8	22.0	908
50%(I)+ 15 t/ha FYM	2.5	8.8	26.0	1115
25%(I)+ 22.5 t/ha FYM	2.1	7.3	21.0	891
30 t/ha FYM	1.8	8.4	22.0	871
Mean	1.8	7.3	20.3	857

Quantification of contribution of rhizobium biofertilizer in reducing the requirement of nitrogen fertilizer in Cluster bean in hot arid region of North-Western Rajasthan.

Nitrogen is a first limiting nutrient in arid region, thus has a great influence on crop growth, yield and its quality. The Indian soils are generally deficient in organic matter thus unable to release N at a rate required to maintain adequate N supply to the growing plant. Therefore, application of nitrogen in form of fertilizers, manures and biofertilizer becomes indispensable to meet N needs of the crop.

A experiment was conducted on quantification of contribution of *Rhizobium* biofertilizer in reducing the requirement of nitrogen fertilizer in Clusterbean in hot arid region. The cluster bean crop received differential doses of N with and without *Rhizobium* viz. control, 15 kg N/ha, 30 kg N/ha, 45 kg N/ha, 60 kg N/ha, *Rhizobium* biofertilizer, *Rhizobium* biofertilizer +15 kg N/ha, *Rhizobium* biofertilizer +30 kg N/ha, *Rhizobium* biofertilizer +45 kg N/ha and *Rhizobium* biofertilizer +60 kg N/ha.

Seed inoculation of cluster bean with rhizobium biofertilizer +60 kg N/ha gave higher yield of grain seed cluster followed by *Rhizobium* biofertilizer +45 kg N/ha as compared to other treatment combinations. Saving of N requirement for different target yield by the seed inoculation of *Rhizobium* between 13- 21 kg/ha N was explored in the present set up.

Effect of graded dose of N application increased the yield of the cluster bean with or without inoculation of *Rhizobium*. Application of 60 kg N/ha along with *Rhizobium* seed inoculation gave highest grain yield (13.28 q/ha) which was 1.05 q/ha higher as compared to 60 kg N/ha application (Table 21, 22). This treatment gave 8.02 and 5.21 % higher yield as compared to absolute control and only *Rhizobium* application, respectively. The grain yield obtained with 60 kg N/ha (12.23 q/ha) was statistically at par with that of 45 kg N/ha + *Rhizobium* (12.26 q/ha). Similarly, yield under 45 kg N/ha was statistically at par with that of 30 kg N/ha + *Rhizobium* . 18% higher mean yield (10.88 q/ha) was observed with seed inoculation with *Rhizobium* as compared to without *Rhizobium* (9.20 q/ha). Maximum per cent increase in cluster bean grain yield was observed by inoculation of seed grain with

Rhizobium only compared to absolute control (no N was applied).

Per cent increase in yield by the application of 15, 30, 45 and 60 kg N/ha was 63.12, 87.64, 91.31 and 132.51%, respectively whereas, per cent increase in yield by the application of 15, 30, 45 and 60 kg/ha along with seed inoculation with *Rhizobium* was 88.02, 117.08, 133.08 and 152.47 %, respectively. At 15, 30, 45 and 60 kg N/ha, the per cent increase over with seed inoculation with *Rhizobium* was 24.90, 29.44, 41.77 and 19.96%, respectively and maximum increase in yield was at 15 kg N/ha application with *Rhizobium* .

Nitrogen use efficiency: Nitrogen use efficiency is the increase in economic yield obtained per unit increase in nutrient applied. Nitrogen use efficiency by cluster bean crop were significantly influenced by the graded doses of nitrogen application with or without *Rhizobium* (Table 22). Nitrogen use efficiency (kg grains/kg N) showed considerable variation. Higher mean nitrogen use efficiency (20.08 kg grains/kg N) was observed with seed inoculation with *Rhizobium* as compared to without *Rhizobium* (14.95 kg grains/kg N). Nitrogen use efficiency (NUE) was maximum (30 kg grains/kg N) under lower dose of N with *Rhizobium* (15 kg N/ha + *Rhizobium*) as compared to only 15 kg N/ha application without *Rhizobium* (22.13 kg grains/kg N) and maximum NUE was observed when minimum dose of N was applied. In general, increasing dose of N decreased the N use efficiency in all the treatments. Whereas, per cent decrease in NUE was more when only graded dose of N was applied as compared to seed inoculation with *Rhizobium* .

The grain yield obtained in presence of or absence of *Rhizobium* with respect to varying N levels fitted well in quadratic model. For different target yields, N required in presence and absence of *Rhizobium* was calculated (Table 23 & Fig. 41). For producing 8 to 12 q/ha target yield of cluster bean grains, 2.30 to 37.25 kg N/ha is needed without *Rhizobium* inoculation . Whereas, for same target yield 15.67 to 58.98 kg N/ha is required with *Rhizobium* inoculation. Maximum yield (13 q/ha) was not achievable with recommended dose of N, whereas, this yield target can be achieved by 52.92 kg N/ha with *Rhizobium* . The results of this study indicated the beneficial effects of *Rhizobium* inoculation on grain yield and 13.37 to 21.73 kg N/ha can be saved to get yield from 8 to 12 q/ha with the seed inoculation by *Rhizobium* .

Table 21. Effect of N and *Rhizobium* inoculation on growth parameters of clusterbean crop

Treatments	Plant height at 40 DAS	Plant height at 40 DAS	No. of pods/ plant	Pod length (cm)
control	40.3	58.4	54.7	5.8
15 kg N/ha	42.7	61.9	58.1	6.1
30 kg N/ha	45.9	66.5	62.4	6.6
45 kg N/ha	47.7	69.2	64.9	6.8
60 kg N/ha	55.4	80.3	75.3	7.9
Rhizobium biofertilizer	43.3	62.7	58.8	6.2
Rhizobium biofertilizer +15 kg N/ha	46.9	68.0	63.7	6.7
Rhizobium biofertilizer +30 kg N/ha	51.3	74.3	69.7	7.3
Rhizobium biofertilizer +45 kg N/ha	55.3	80.1	75.2	7.9
Rhizobium biofertilizer +60 kg N/ha	58.3	84.5	79.2	8.3
Mean	48.7	70.6	66.2	7.0

Table 22. Effect of N and *Rhizobium* inoculation on performance of clusterbean crop

Treatments	Yield (q/ha)		NUE (kg seed/kg N)		ANR (%)	
	Without Rhizobium	With Rhizobium	Without Rhizobium	With Rhizobium	Without Rhizobium	With Rhizobium
Control	5.26	7.57	22.13	30.87	63.12	88.02
15 kg N/ha	8.58	9.89	15.37	20.53	87.64	117.08
30 kg N/ha	9.87	11.42	10.67	15.56	91.31	133.08
45 kg N/ha	10.06	12.26	11.62	13.37	132.51	152.47
60 kg N/ha	12.23	13.28	--	--	--	--
Mean	9.20	10.88	14.95	20.08	93.65	122.66

Table 23. Contribution of *Rhizobium* to N nutrition of clusterbean crop as derived from quadratic ($y= ax^2+bx+c$) model

Treatments	Quadratic equation	N requirement for different target yield						
		8	9	10	11	12	13	
Without Rhizobium	y = -0.001x2 + 0.167x + 5.629	15.67	23.49	32.50	43.48	58.98	-	
With Rhizobium	y = -0.001x2 + 0.154x + 7.651	2.30	9.32	17.17	26.21	37.25	52.92	
Saving of N requirement for different target yield by the seed inoculation of Rhizobium (kg/ha)		13.37	14.17	15.33	17.28	21.73	-	

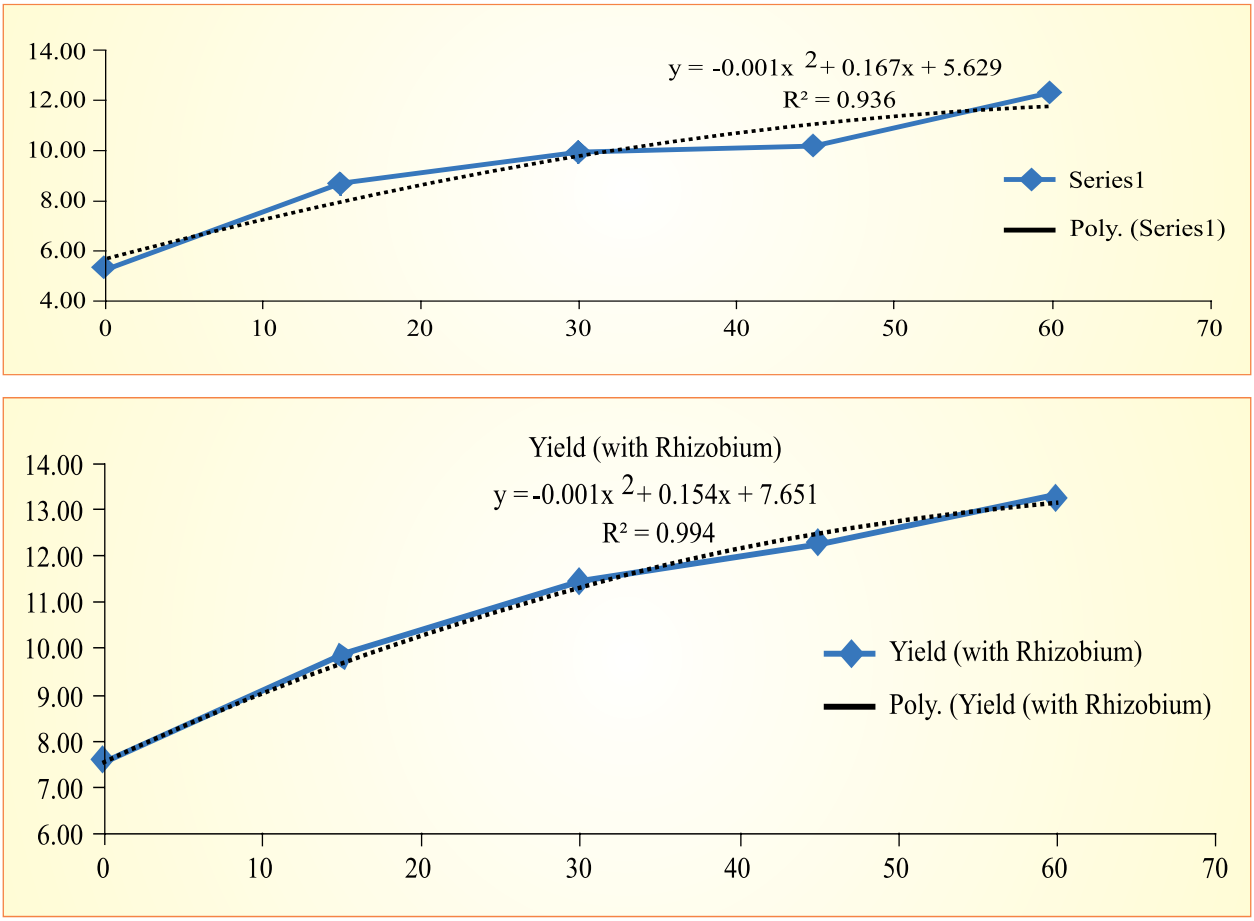


Fig. 41. Yield response of clusterbean with and without *Rhizobium* application

Nutrient requirement of cluster bean using omission plot technique to determine the requirements of P and K fertilizers

An experiment was conducted on nutrient requirement of cluster bean using omission plot technique to determine the requirements of P and K fertilizers. The Cluster bean crop received differential doses of PK viz 30 kg/ha each of P_2O_5 and K_2O , 60 kg/ha each of P_2O_5 and K_2O , 90 kg/ha each of P_2O_5 and K_2O , without P +60 kg/ha K_2O, without K+60 kg/ha of P_2O_5 and without PK (Absolute control) replicated 3 times in a randomized block design. Nitrogen dose was applied in three splits *i.e.* 1/3rd at planting, 1/3rd at 25 DAP and rest 1/3rd 50 DAP from fertilizers. PK fertilizers was applied in furrows at the planting time as per treatment. Application of 90 kg/ha each of P_2O_5 and K_2O gave higher grain yield of cluster bean followed by 60 kg/ha each of P_2O_5 and K_2O and without P +60 kg/ha K_2O as compared to other treatments. Same trend was observed for per cent yield response of different treatments (Table. 24 & Fig 42).

Physical and Microbial Properties of Soil under Different Fruit Based Diversified Cropping Models in Arid Region of Rajasthan

After completion of nine year cycles of 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) were assessed at CIAH, Bikaner which are presently in the ninth year of plantation. Composite surface soil samples (0-15 cm) were taken from each cropping system, air-dried and passed through 2 mm sieve. Soil samples were analyzed as par standard methods. Maximum value of OC, EC, pH, was under *Aonla-Khejri*-Cluster bean-*Ajowain* cropping model followed by *Aonla-Ber*-Cluster bean-Fennel. The higher values

Table 24. Site specific nutrient management in cluster bean crop

Treatments	Plant height at 40 DAS (cm)	Plant height at 60 DAS (cm)	No. Pods/ plant	Pod length	No of leaves/ plant	Seed yield
30 kg/ha each of P2O5 and K2O	45.9	66.5	78	6.6	66	7.99
60 kg/ha each of P2O5 and K2O	47.7	69.2	81	6.8	83	9.10
90 kg/ha each of P2O5 and K2O	55.4	80.3	94	7.9	104	10.31
Without P +60 kg/ha K2O	43.3	62.7	74	6.2	58	7.78
Without K+60 kg/ha of P2O5	46.9	68.0	80	6.7	72	8.10
Without PK (Absolute control)	40.3	58.4	68	5.5	62	5.71
Mean	46.5	67.5	79	6.6	74	8.16

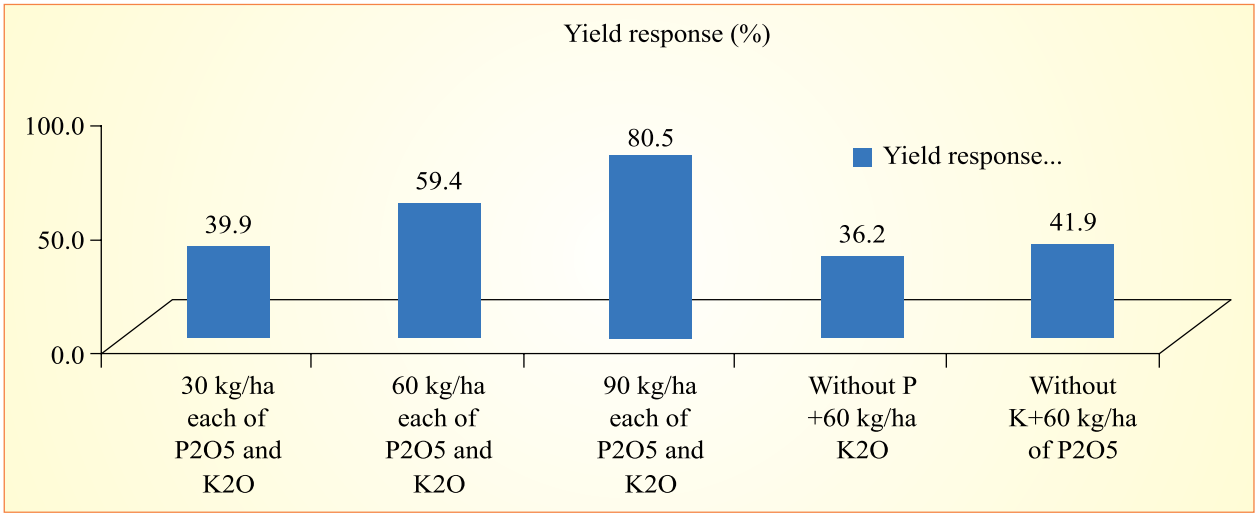


Fig 42. Per cent yield response of grain yield of cluster bean using omission plot technique

in *aonla* involving *ber* and *khejri* could be due to synergistic crop interaction. Maximum water holding capacity at 0.33 and 6% bar was observed under *Aonla+Ber* (2.28 and 1.10%) followed by *Aonla+Khejri* (2.07 and 1.03%), *Aonla+Bael* (2.44 and 0.99%), *Aonla+Karonda* (1.76 and 0.61%) and *Aonla+Morianga* (1.84 and 0.56%). Higher bacterial, fungal and actinimycetes population (271 cfux10^6, 221 cfux10^3 and 116 cfux10^3) were observed in *Aonla+Khejri* followed by *Aonla+Ber* (205 cfux10^6, 164 cfux10^3 and 105 cfux10^3), *Aonla+Bael* , *Aonla+Karonda* and *Aonla+Morianga*. Physical and microbial properties of soil improved more under cropping model aonla-*khejri* (Model-III) followed by Model-I.

Field experiments were conducted at CIAH research farm with popular mateera cultivars Thar manak during 2015 in the kharif season to investigate the role of application micronutrient nutrient on mateera performance. 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 of planting,NPK+ Cupper Sulphate @ 15 kg/ha at the of planting, NPK+ Zn, Fe, Mn and Cu Sulphate @ 15 kg/ha each at the

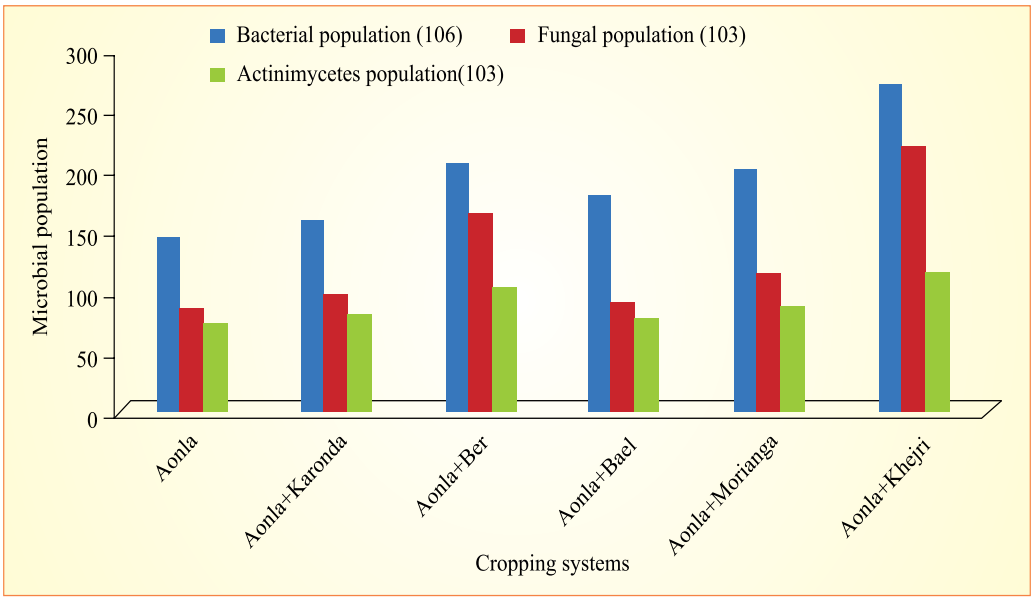


Fig. 43. Effect of aonla based cropping model systems on microbial population in soil

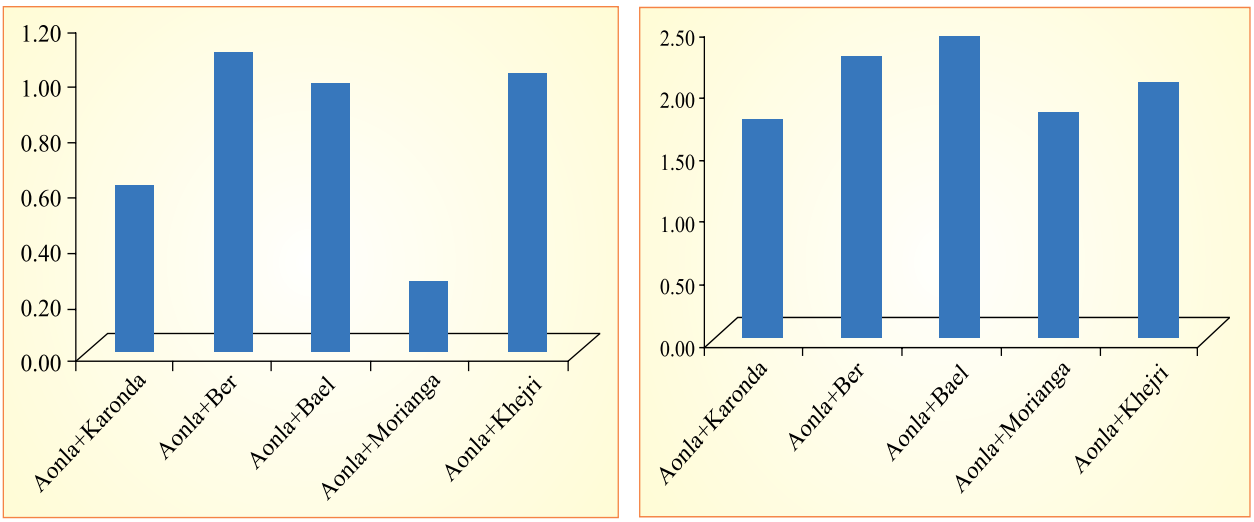


Fig. 44. Effect of aonla based cropping model systems on available moisture % at 6 and 1/3 bar in soil

Table 25. Photosynthetic rate and associated parameters in musk melon under water stress and recovery

Treatment (Days after imposing stress)	Water stress				Control				
	Pn (µ mol CO_2 m^{-2} s^{-1})	Transpiration (mmol H_2O m^{-2} s^{-1})	Leaf level WUE (µ mol CO_2 mmol H_2O^{-1})	Carboxylation efficiency (µ mol m^{-2} $s^{-1}ppm^{-1}$)	Treatment (Days corresponding to stress treatent)	Pn (µ mol CO_2 m^{-2} s^{-1})	Transpiration (mmol H_2O m^{-2} s^{-1})	Leaf level WUE (µ mol CO_2 mmol H_2O^{-1})	Carboxylation efficiency (µ mol m^{-2} $s^{-1}ppm^{-1}$)
0	20.45	8.6	2.37	0.086	0	20.45	8.6	2.377	0.086
5	16.4	7.35	2.23	0.076	5	20.64	8.56	2.52	0.072
10	11.09	4.98	2.22	0.059	10	18.91	7.60	2.48	0.099
5 days recovery	16.1	8.25	1.95	0.084	15	19.01	8.22	2.31	0.114
10 days recovery	17.03	7.35	2.31	0.119	20	18.34	7.72	2.37	0.091
15 days recovery	17.52	7.46	2.34	0.08	25	17.85	7.65	2.32	0.864

of planting and NPK +Zn+Fe Sulphate @ 15 kg/ha each at the of planting were replicated 3 times in a randomized block design. micronutrients were applied as per treatments. but due wild animals, experiment has been damaged. However three times, mateera was sown.

Field experiments were conducted at CIAH research farm with popular mateera cultivars Thar manak during 2014 in the kharif season to investigate the role of boron application on mateera performance. The mateera crop received differential doses of different micronutrient as per schedule of treatments. 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 time of planting, 4 kg/ha Borax soil application at time of planting and 6 kg/ha Borax soil application at time of planting. but due wild animals, experiment has been damaged. However three times, mateera was sown.

CROP PHYSIOLOGY

Physiological and biochemical investigations in horticultural crops under abiotic stresses.

Impact of water stress on photosynthesis and related parameters

An experiment was laid out in field to study the impact of water stress on photosynthetic activity and related parameters in musk melon and snap melon. The seeds were sown in the field on 16th February, 2015 and irrigated for normal growth and development. At 45 days after sowing, the plants were divided into two groups and one set was kept under normal irrigation (Control) and the irrigation was withheld in the second set for 10 days (Stressed). Thereafter, the plants were re-irrigated and recovery in the physiological parameters was recorded at 5 days interval. Table 25 presents the summary of the observations recorded.

Perusal of table 25 reveals that the photosynthesis rate at time of imposition of stress was 20.45 µ mol CO_2 m^{-2} s^{-1} which dropped to 16.4 µ mol CO_2 m^{-2} s^{-1} and 10.09 µ mol CO_2 m^{-2} s^{-1} after 5 and 10 days of imposition of water stress. Subsequently, on re-irrigation, the photosynthesis rate recovered and it reached to 16.1, 17.03 and 17.52 µ mol CO_2 m^{-2} s^{-1} at 5, 10 and 15 days after recovery, respectively. However, in controls, the photosynthetic rate was 20.45, 20.64, 18.91, 19.01, 18.34 and 17.85 µ mol CO_2 m^{-2} s^{-1} at 0, 5, 10, 15, 20 and 25 days after the start of experiment. Similarly, the transpiration rate in controls was 8.6, 8.56, 7.60, 8.22, 7.72 and 7.65 mmol H_2O m^{-2} s^{-1} at 0, 5, 10, 15, 20 and 25 days after start of experiment. In the treatments, the transpiration rate was 8.6 mmol H_2O m^{-2} s^{-1} at the start of experiment which dropped to 7.35 and 4.98 mmol H_2O m^{-2} s^{-1} at 5 and 10 days after imposition of stress. On recovery, the magnitude of transpiration rate goes to 8.25, 7.35 and 7.46 mmol H_2O m^{-2} s^{-1} at 5, 10 and 15 days after re-irrigation. Accordingly, the WUE of plants under treatment was 2.37, 2.23, 2.22 µ mol CO_2 mmol H_2O^{-1} at 0, 5 and 10 days after imposition of stress and was 1.95, 2.31 and 2.34 µ mol CO_2 mmol H_2O^{-1} at 5, 10 and 15 days after re-irrigation. In control plants the magnitude of WUE remained nearly same.

Table 26. Photosynthetic rate and associated parameters in snap melon under water stress and recovery

Treatment (Days after imposing stress)	Water stress				Control				
	Pn (µ mol CO2 m-2 s-1)	Transpiration (mmol H2O m-2 s-1)	Leaf level WUE (µ mol CO2 mmol H2O-2)	Carboxylation efficiency (µ mol m-2 s-1ppm-1)	Treatment (Days corresponding to stress treatent)	Pn (µ mol CO2 m-2 s-1)	Transpiration (mmol H2O m-2 s-1)	Leaf level WUE (µ mol CO2 mmol H2O-2)	Carboxylation efficiency (µ mol m-2 s-1ppm-1)
0	18.73	6.25	2.99	0.068	0	18.73	6.25	2.99	0.068
5	17.05	6.01	2.83	0.077	5	18.64	5.24	3.55	0.062
10	14.75	5.42	2.72	0.052	10	15.97	5.72	2.79	0.052
5 days recovery	19.88	7.87	2.52	0.080	5	15.92	6.83	2.33	0.059
10 days recovery	18.32	6.64	2.75	0.069	20	15.67	6.48	2.41	0.064
15 days recovery	18.64	7.09	2.62	0.070	25	14.97	6.01	2.49	0.064

Perusal of table 26 reveals that the photosynthesis rate at time of imposition of stress was 18.73 µ mol CO_2 m^{-2} s^{-1} which dropped to 17.05 µ mol CO_2 m^{-2} s^{-1} and 14.75 µ mol CO_2 m^{-2} s^{-1} after 5 and 10 days of imposition of water stress. Subsequently, on re-irrigation, the photosynthesis rate recovered and it reached to 19.88, 18.32 and 18.64 µ mol CO_2 m^{-2} s^{-1} at 5, 10 and 15 days after recovery, respectively. However, in controls, the photosynthetic rate was 18.73, 18.64, 15.97, 15.92, 15.67 and 14.97 µ mol CO_2 m^{-2} s^{-1} at 0, 5, 10, 15, 20 and 25 days after the start of experiment. Similarly, the transpiration rate in controls was 6.25, 5.24, 5.72, 6.83, 6.48 and 6.018 mmol H_2O m^{-2} s^{-1} at 0, 5, 10, 15, 20 and 25 days after start of experiment. In the treatments, the transpiration rate was 6.25 mmol H_2O m^{-2} s^{-1} at the start of experiment which dropped to 6.01 and 5.42 mmol H_2O m^{-2} s^{-1} at 5 and 10 days after imposition of stress. On recovery, the magnitude of transpiration rate goes to 7.87, 6.64 and 7.09 mmol H_2O m^{-2} s^{-1} at 5, 10 and 15 days after re-irrigation. Accordingly, the WUE of plants under treatment was 2.99, 2.83 and 2.72 µ mol CO_2 mmol H_2O^{-1} at 0, 5 and 10 days after imposition of stress and was 2.52, 2.75 and 2.62 µ mol CO_2 mmol H_2O^{-1} at 5, 10 and 15 days after re-irrigation. In control plants the magnitude of WUE remained nearly same.

Water and Carbon use efficiency in different lines of musk melon

An experiment was laid out in the field to evaluate the water and carboxylation efficiency in musk melon. A total of 34 germplasm lines were evaluated which included varieties, collections and hybrids. A wide genetic diversity with respect to water and carboxylation efficiency was recorded in this species. Perusal of table 27 reveals that water use efficiency among varieties ranged from 0.771 µ mol CO_2mmol^{-1} H_2O in Punjab Sunehri to 2.718 µ mol CO_2mmol^{-1} H_2O in GMM-3. Similarly, in collections the magnitude ranged from 1.325 in AHMM/BR/51 to 3.554 in AHMM/BR/41. The carboxylation efficiency in varieties ranged from 0.014 in Punjab Sunehri to 0.093 µ mol CO_2 m^{-2} s^{-1}ppm^{-1} in Hara Madhu. Similarly, in collections the values ranged from 0.034 in AHMM/BR/53 to 0.080 µ mol CO_2 m^{-2} s^{-1}ppm^{-1} in AHMM/BR/42. This illustrates that Musk melon can be improved for these parameter which is utmost required in arid region. However, it is yet to be ascertained whether this trait can be maintained in hybrids also.

Table 27. Water and carbon use efficiency in different accessions of musk melon

S. No.	Varieties	Pn (μ mol $CO_2 m^{-2} s^{-1}$)	E (mmol H_2O $m^{-2} s^{-1}$)	WUE (μ mol CO_2 mmol^{-1} H_2O)	Carboxylation Efficiency (μ mol CO_2 m^{-2} s^{-1}ppm^{-1})
1	RM-43	11.07	4.35	2.544	0.038
2	RM-50	9.715	4.41	2.200	0.040
3	MHY-3	5.9	6.45	0.914	0.023
4	MHY-5	19.79	8.86	2.233	0.084
5	Durgapura Madhu	12.16	5.27	2.305	0.059
6	Hara Madhu	19.65	8.32	2.361	0.093
7	Kashi Madhu	16.42	8.29	1.980	0.080
8	Pusa Madhuras	5.025	5.42	0.926	0.021
9	GMM-3	21.74	8.0	2.718	0.094
10	Punjab. Sunehri	3.445	4.46	0.771	0.014
11	Arka Rajhans	15.22	7.12	2.136	0.065
12	AHMM/BR/38	14.43	6.27	2.301	0.044
13	AHMM/BR/41	18.37	5.17	3.554	0.075
14	AHMM/BR/42	12.83	6.52	1.966	0.080
15	AHMM/BR/44	16.95	6.54	2.589	0.063
16	AHMM/BR/46	16.00	8.63	1.854	0.075
17	AHMM/BR/47	15.56	8.67	1.795	0.066
18	AHMM/BR/48	13.45	5.99	2.24	0.051
19	AHMM/BR/49	13.0	6.48	2.006	0.063
20	AHMM/BR/50	14.23	7.69	1.850	0.074
21	AHMM/BR/51	8.475	6.39	1.325	0.042
22	AHMM/BR/52	11.48	6.23	1.843	0.077
23	AHMM/BR/53	7.19	6.17	1.165	0.034
24	AHMM/BR/54	12.93	7.21	1.792	0.065
25	AHMM/BR/55	9.615	7.46	1.288	0.046
26	AHMM/BR/56	12.03	7.11	1.691	0.066
27	Arya	3.16	5.33	0.592	0.010
28	AHMM8 X Pusa Madhuras (F1)	9.83	5.69	1.727	0.033
29	AHLM-2 X AHS -82 (F1)	7.40	5.08	1.456	0.024
30	AHLM-2 X AHMM 8 (F1)	11.12	5.84	1.903	0.044
31	AHLM -2 X Arya (F1)	10.27	8.19	1.253	0.039
32	AHS-82 X AHK- 119 (F1)	8.26	7.39	1.116	0.031
33	AHK-119 x Kashi Madhu (F1)	8.6	6.89	1.248	0.034
34	AHK 119 X Kashi Madhu (F2)	4.04	5.15	0.784	0.009

Metabolite composition of under water stress

An experiment was conducted using snap melon and musk melon to assess the impact water stress on metabolite composition in leaves. The experiment was laid out in the field and when the plants have attained age of 45 days they were divided into two groups. One set was maintained as control and other set was given water stress by withholding irrigation. Stress treatment was given for 10 days and after that the plants were irrigated and observations on metabolite composition were recorded during recovery.

Perusal of data in table 28 reveals the changes in total flavonoid content in musk melon and snap melon with imposition of water stress. In musk melon, the flavonoid content decrease with imposition of water stress but after re-irrigation, the magnitude increases. Similar trend was also observed in snap melon.

Perusal of data in table 29 reveals that tannin content in musk melon increases with age in control. However, under water stress it decrease slightly but on re-irrigation the magnitude is maintained high. Similar trend was also observed in snap melon also.

Perusal of data with respect to alkaloid content shows that this metabolite increases with increase in age in control plants in musk melon. However, under water stress, it decreases nearly 50% but on re-irrigation its magnitude increases. Similar trend was also observed in snap melon (Table 30).

Perusal of data with respect to total sugar demonstrate that the magnitude of total sugar remains nearly same in control plants of musk melon whereas in water stress plants there is a marked increase after 10 days of re-irrigation (Table 31).

Table 28. Total flavonoid content in plants under different treatment

Treatment	Total Flavonoid (mgg^{-1} dry wt.)				
	Days after stress		Days after re-irrigation		
	5	10	05	10	15
Musk melon control	1.32±0.011	2.11±0.055	2.75±0.130	1.71±0.010	0.966±0.055
Muskmelon treatment	1.34±0.015	0.81±0.062	2.80±0.045	2.37±0.202	0.76±0.036
Snapmelon control	3.42±0.075	1.33±0.085	5.67±0.030	7.12±0.090	1.196±0.030
Treatment	1.44±0.087	6.55±0.133	5.186±0.106	4.36±0.096	1.46±0.140

Table 29. Tannin content in plants under different treatment

Treatment	Tannin (mgg^{-1} dry wt.)				
	Days after stress		Days after re-irrigation		
	5day	10	05	10	15
Musk melon control	3.19±0.036	2.92±0.11	5.19±0.03	4.41±0.04	4.55±0.04
Muskmelon treatment	2.34±0.061	3.30±0.04	5.11±0.21	5.033±0.045	4.05±0.015
Snapmelon control	3.79±0.065	3.5±0.062	5.44±0.04	5.38±0.036	5.41±0.025
Treatment	3.49±0.19	3.91±0.088	5.016±0.032	5.153±0.035	4.9±0.097

Table 30. Alkaloid content in plants under different treatment

Treatment	Alkaloid (%)				
	Days after stress		Days after re-irrigation		
	5day	10	5	10	15
Musk melon control	0.8±0.1	1.56±0.15	1.65±0.05	1±0.1	1.24±0.045
Muskmelon treatment	1.46±0.11	0.78±0.07	1.27±0.07	1.46±0.06	2.71±0.206
Snapmelon control	1.23±0.15	0.8±0.05	1.2±0.1	1.47±0.07	1.246±0.05
Treatment	2.28±0.10	0.8±0.1	1.43±0.057	1.2±0.05	1.48±0.076

Table 31. Total sugar content in plants under different treatment

Treatment	Total Sugar (mgg^{-1} dry wt.)				
	Days after stress		Days after re-irrigation		
	5day	10	5	10	15
Musk melon control	26.12±0.13	39±1.89	32.29±0.51	43.52±1.37	37.69±1.95
Muskmelon treatment	24.04±0.29	32.97±1.02	30.94±0.45	52.41±0.56	36.50±4.11
Snapmelon control	29.26±0.14	41.49±3.82	26.71±0.23	33.91±3.42	29.86±0.22
Treatment	28.88±1.17	41.63±1.32	37.27±0.08	40.39±0.44	36.89±0.25

Table 32. Phenol content in plants under different treatment

Treatment	Total Phenol (mgg^{-1} dry wt.)				
	Days after stress		Days after re-irrigation		
	5day	10	5	10	15
Musk melon control	2.9±0.09	2.25±0.011	5.94±0.015	2.73±0.105	3.06±0.238
Muskmelon treatment	2.45±0.03	1.303±0.028	7.36±0.06	4.66±0.34	1.413±0.049
Snapmelon control	4.37±0.04	1.52±0.055	3.97±0.061	7.126±0.091	1.42±0.175
Treatment	3.85±0.05	4.64±0.261	6.12±0.191	5.21±0.211	3.58±0.108

No specific trend was observed with respect to total phenols in both the species under study (Table 32).

Development of phytochemical markers for arid horticultural crops

Mahua

A total of 10 germplasm lines of mahua were collected from Central Horticultural Experiment Station, Vejalpur (Godhra). Young leaves from different genotypes of mahua were collected separately and immediately fixed in ethyl alcohol for 24 hrs. Total genomic DNA was extracted from 100mg of leaf from each sample discretely by using the DNeasy® Plant Mini kit (QIAGEN, India Pvt. Ltd.) following with some modification. The lysis was achieved by the addition of 400 µl warm (65° C) lysis solution modified by the addition of 10mg/ml PVP (polyvinyl polypyrrolidone), 10mg/ml SDS (Sodium Lauryl Sulphate) and 4 µl of Proteinase K stock solution (100mg/ml) prior to grinding. After grinding the samples were collected into the 1.5 ml eppendorf tube separately. The samples were centrifuged for 30s at low speed (4000g) and 4µl RNase A stock solution (100mg/ml) was added to each tube, followed by mixing until no tissue clumps were visible. Rest of the protocol followed as per standard procedure. To remove RNA, genomic DNA was treated with RNase and stored at -20°C. The quality of DNA was checked by electrophoresis in 0.8 % agarose gel.

RAPD data analysis

All the amplified bands were counted manually along with their size. Computer analysis of RAPD patterns were performed as described by Halmschlager *et al.* (1994) in which the band pattern obtained from agarose gel electrophoresis was digitalized by hand to a two-discrete-character-matrix (0 and 1 for absence and presence of RAPD-bands, respectively) The data of all primers were combined. The analysis data was based on the Nei and Lee coefficient (Nei & Lee, 1979). Dendrograms were constructed by the unweighted paired group method of arithmetic average (UPGMA) based on Jaccard's similarity coefficient by using NTSYSpc-2.02e version 2.0.1.5 software (Applied biostatistics, Inc).

Polymorphism and marker efficiency

The largest fragment amplified was in the range of 250 to 3000 bp while the smallest but easily

Table 33. List of primers and degree description of the polymorphism obtained among 10 mahua genotypes.

S. No.	Primer code	Sequence 5' to 3'	Sizes (bp) min-max	Total band No.	Polymorphic bands	Polymorphism ratio (%)	PIC
1	OPF-1	ACGGATCCTG	330-1800	15	11	73.33	0.391
2	OPF-2	GAGGATCCCT	290-2200	17	11	64.71	0.378
3	OPF-3	CCTGATCACC	600-1300	6	3	50.00	0.406
4	OPF-4	GGTGATCAGG	450-2500	15	6	40.00	0.343
5	OPF-5	CCGAATTCCC	400-1800	15	10	66.67	0.260
6	OPF-6	GGGAATTCGG	280-2800	17	14	82.35	0.467
7	OPF-7	CCGATATCCC	600-2000	10	6	60.00	0.241
8	OPF-8	GGGATATCGG	500-1500	6	2	33.33	0.153
9	OPF-9	CCAAGCTTCC	550-3000	11	5	45.45	0.388
10	OPF-10	GGAAGCTTGG	440-2500	17	11	64.71	0.389

recognizable fragment was approximately of 250 bp. Most bands were concentrated between 500 to 2000 bp. An example of RAPD pattern, obtained with different primers (OPF-01 to OPF-10), is shown in Fig. 45. The number of bands scored for each primer varied from 6 to 17. The highest number of bands (17) was generated with Operon primers OPF 2, OPF 6, and OPF 10, while the lowest number (6) was obtained with Operon primers OPF 8 and OPF 3. The 10 primers yielded a total of 129 fragments, of which 79 amplicons (61.24%) were polymorphic, the number of polymorphic bands per primer ranged from 2 to 14 (Table 33). It was observed that the scored 50 RAPD-PCR fragments were monomorphic (38.75%). However the five primers such as OPF-1, OPF-2, OPF-05, OPF-7, and OPF-10, were the informative primers as 60% or more of the amplicons were polymorphic (Fig. 45). The results of the RAPD-PCR analysis indicated that some polymorphic RAPD bands are present were found to be shared among more than one genotype (Table 33).

Genetic relationships among accessions and cluster analysis

Cluster analysis based on similarity values classified genotypes into two distinct clusters (I & II, figure 46). The first cluster (I) included only four genotypes MH-14, MH-2, MH-6 and MH-1, whereas the second cluster (II) included six genotypes (MH-10, MH-3, MH-15, MH-8, MH-5 and MH-4) and was further divided into three sub-clusters . Both of the cluster I and II were further divided into two sub-clusters labeled (I-A, I-B) and (II-A, II-B) respectively. The sub-cluster I-B and II A are monophyletic branches including MH-1 and MH-10 genotypes, respectively. The sub cluster II-B was further grouped into two sub-sub clusters II-B_1 (MH-3, MH-8 and MH-15) and II-B_2 (MH-5 and MH-4) Similarity coefficients between *Madhuca longifoli*a ranged from 0.028 to 0.236. Among the similarity coefficients of the genotypes, the similarity coefficient of MH-2 and MH-6 was highest (0.900), which indicates a closer affinity among them while the similarity coefficient of MH-10 and MH-14 was observed lowest (0.622) (Table 34).

Table 34. Dice Jaccard's similarity co-efficient matrix of 10 different genotypes of mahua.

Genotypes	MH-14	MH-10	MH-2	MH-1	MH-3	MH-5	MH-4	MH-6	MH-8	MH-15
MH-14	****									
MH-10	0.622	****								
MH-2	0.820	0.661	****							
MH-1	0.741	0.687	0.678	****						
MH-3	0.636	0.670	0.689	0.630	****					
MH-5	0.678	0.684	0.718	0.644	0.730	****				
MH-4	0.652	0.643	0.692	0.619	0.766	0.817	****			
MH-6	0.763	0.681	0.900	0.669	0.681	0.754	0.669	****		
MH-8	0.681	0.734	0.650	0.675	0.783	0.750	0.691	0.669	****	
MH-15	0.670	0.645	0.624	0.634	0.740	0.645	0.664	0.643	0.780	****

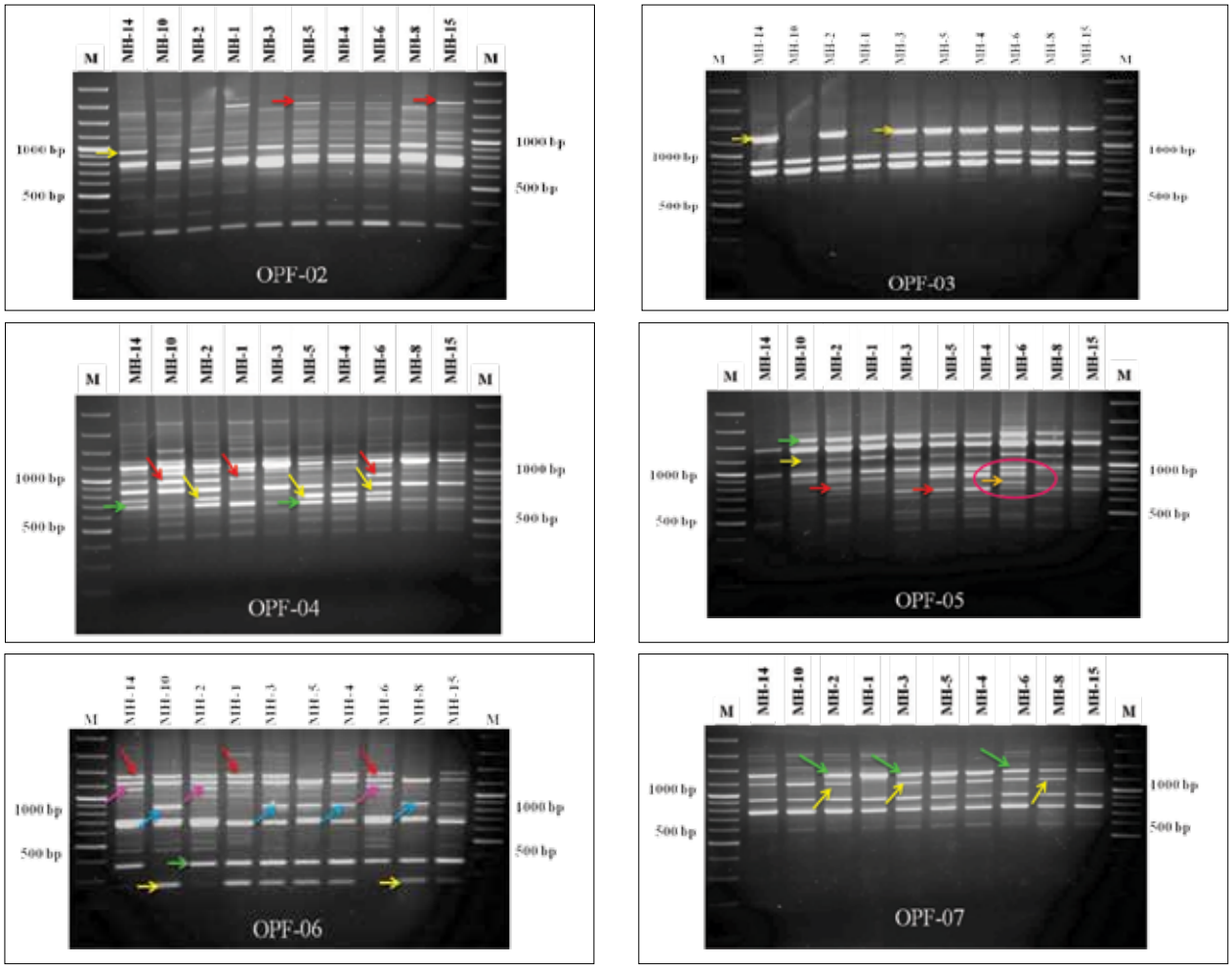


Fig 45. RAPD profiles of accessions of Mahua using different primers.

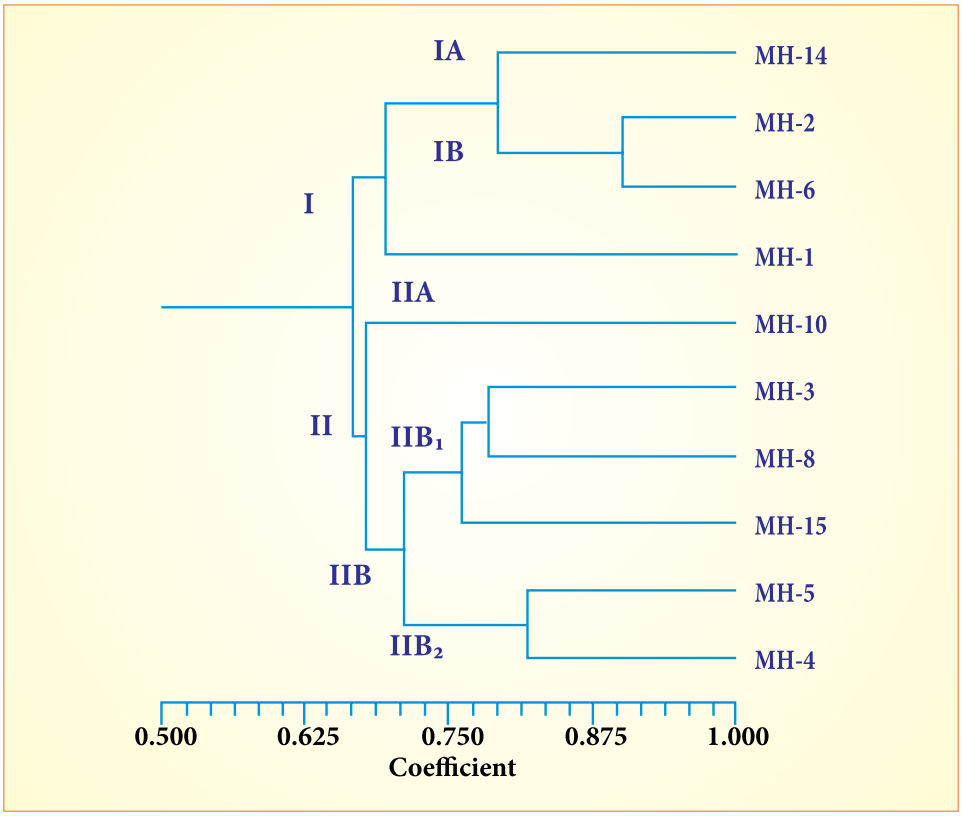


Fig 46. Dendogram of UPGMA cluster analysis based on Jacard's similarity co-efficient obtained from RAPD polymorphism data of 10 mahua genotypes.

Date palm *(Phoenix dactylefera)*

Forty two varieties of date palm were procured from core collection maintained at Central Institute for Arid Horticulture, Bikaner, Rajasrhan, India (Table 35). Young emerging leaves were collected from single plant of each variety for DNA isolation.

Table 35. List of cultivar of pomegranate genotypes included in the present study.

S.No.	Variety names	S.No.	variety names	S.No.	variety names
1	Halawy	15	Khairpur-Pakistan	29	Tayar
2	Khalas	16	Dayari	30	Suriya
3	Khadrawy	17	Medini	31	Ahmat
4	Shamran	18	Saidy	32	Sopari
5	Zahidi	19	Sabiah	33	AbdulRehman
6	Braim	20	Javantri	34	Migraf
7	Zagloul	21	Gulchati	35	Hateni
8	Chip Chap	22	PunjabRed	36	Bhukso
9	Sewi	23	Medzool	37	Kotho
10	Khunezi	24	Gizaj	38	Hilali
11	BintAisha	25	Mejnaz	39	Umshok
12	Nagal Hilali	26	Khasab	40	Amir
13	Hayani	27	Muscat	41	Hamara
14	Sakloti	28	Sayar	42	Seddami

Genomic DNA isolation

Genomic DNAwas isolated from young leaf samples using following a standered 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 4°C. Extracted DNA was quantified by visual comparison on ethidim bromide stained 0.8% (w/v) agarose gels.

PCR amplification and Polymorphism analysis

All tested RAPD primers generated 137 polymorhic, stable and reproducible bands in all samples. The seventeen RAPD primers (Table 36) used in this study produced 152 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 137 (90.13%) polymorhic, stable and reproducible bands out of 152 and 15 (9.86%) monomrphic banding sites. The highest number of bands was achieved with primer RPID-09 (12 bands), while the amplifications with three primers viz. RPID-02, RPID-04, RPID-06 and OPF-03 resulted in only five bands.

The highest percentages of polymorphism belonged to six primers RPID-02, RPID-09 RPID-10 , RPID-11, OPF-01 and OPF-04 (100%), and the lowest percentages of polymorphism belonged to two primers with OPF-03 and RPID-08 (60.00%, 66.67%) respectively. The largest fragment amplified

Table 36. 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).

S. No.	Oligo Name	Sequence (5' to 3')	Band sizes (bp)	Total no. of Loci	No. of polymorphic bands	% Polymorphism	PIC
1	RPI-D 1	AAAGCTGCGG	350-2000	11	9	81.82	0.385
2	RPI-D 2	AACGCGTCGG	400-1800	5	5	100.00	0.427
3	RPI-D 3	AAGCGACCTG	500-1550	10	9	90.00	0.410
4	RPI-D 4	AATCGCGCTG	400-1200	5	4	80.00	0.416
5	RPI-D 5	AATCGGGCTG	450-1700	10	9	90.00	0.463
6	RPI-D 6	ACACACGCTG	500-1400	5	4	80.00	0.500
7	RPI-D 8	ACCACCCACC	550-1800	9	6	66.67	0.324
8	RPI-D 9	ACCGCCTATG	350-1600	12	12	100.00	0.483
9	RPI-D 10	ACCGCCTATG	350-1900	10	10	100.00	0.436
10	RPI-D 11	ACGGAAGTGG	300-1800	9	9	100.00	0.427
11	RPI-D 12	ACGGCAACCT	300-2100	11	9	81.82	0.378
12	RPI-D 14	ACTTCGCCAC	650-2000	10	9	90.00	0.471
13	OPF-01	ACGGATCCTG	300-1700	10	10	100.00	0.471
14	OPF-02	GAGGATCCCT	400-1600	10	10	100.00	0.489
15	OPF-03	CCTGATCACC	300-2000	5	3	60.00	0.500
16	OPF-04	GGTGATCAGG	250-1500	10	10	100.00	0.408
17	OPF-05	CCGAATTCCC	400-1800	10	9	90.00	0.441
Total			-	152	137	-	-
Average		-	250-2100	8.941176	8.058823529	88.84	0.437

was of 2100 bp while the smallest but easily recognizable fragment was approximately of 250 bp. Most bands were concentrated between average ranges of 250 to 2100 bp. The primers RPID-01 and RPID-11 (11) generated the largest number of bands compared to the others. The number of bands scored for each primer varied from 5 to 11 (Fig 47).

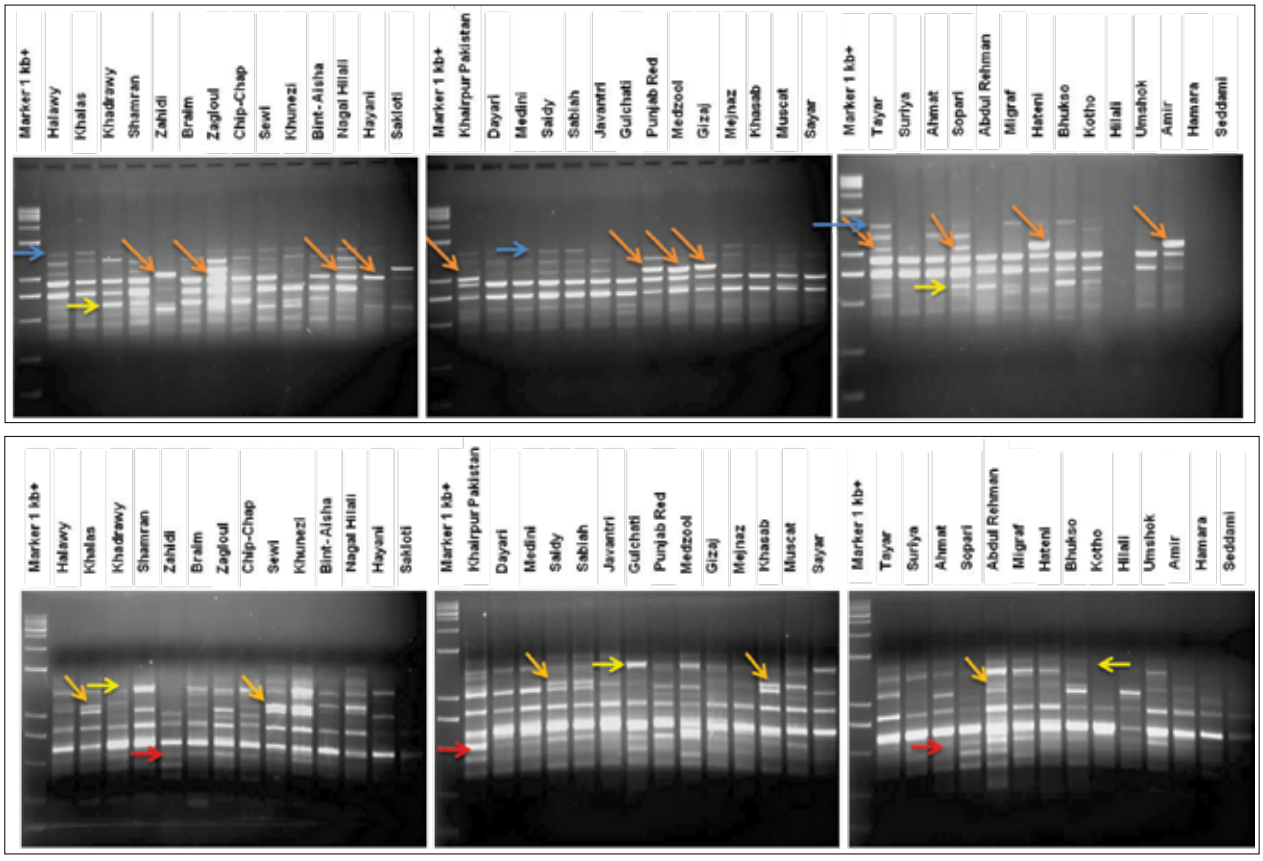


Fig. 47. RAPD profile generated using the primer OPF2 and RPID-01 on total genomic DNAs from 42 date palm accessions (1-42) as templates. M= 1kb ladder as size marker. Arrows show the polymorphic bands.

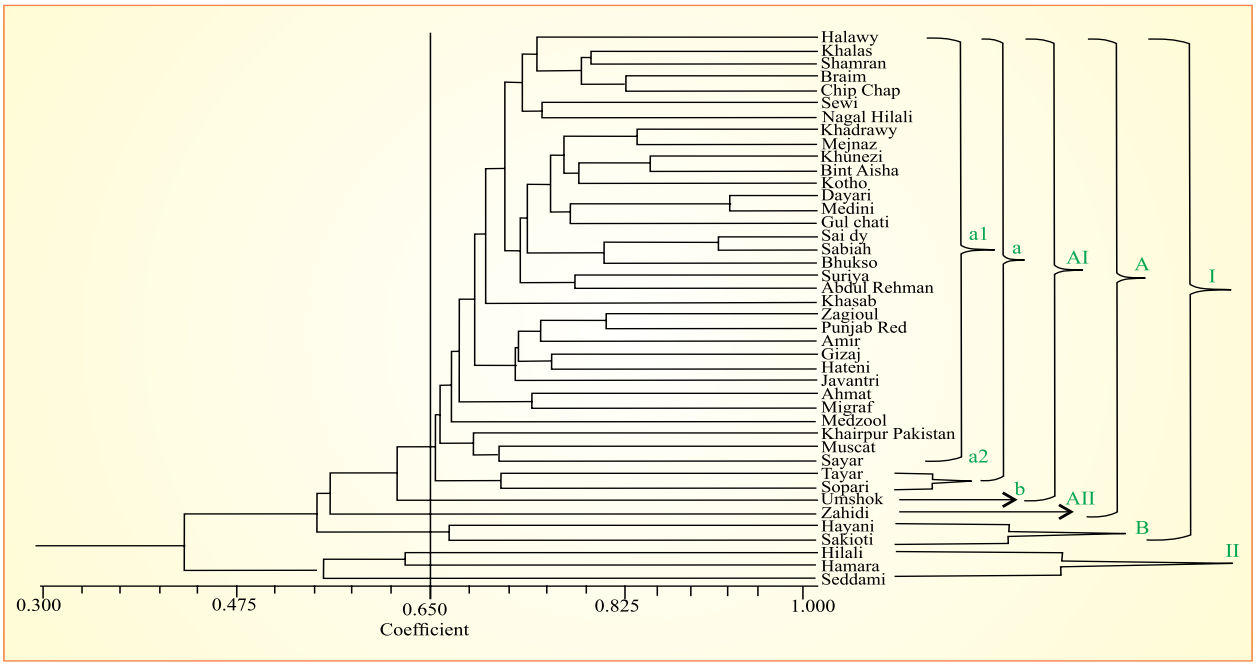


Fig. 48. Phylogenetic similarity distance generated among 42 Date Palm varieties by using RAPD markers using UPGMA procedure according to Nei and Li (1979) method.

The cluster analysis were estimated by unweighted paired group method of arithmetic mean (UPGMA) method with Jaccard's similarity coefficient. The dendrogram (Fig. 48) resulted from the RAPD markers grouped the 42 varieties into two major groups. Group I included varieties thirty nine and group II consists of three varieties including Hilali, Hamara and Seddami. The major group I exhibited further two clusters labeled A (37) and B (2) viz. Hayani and Sakloti. The sub-cluster labeled A is further divided into two sub-clusters AI and AII. Cluster AI included varieties thirty six and again divided into two sub-sub clusters (a) and (b). The sub-sub cluster (a) was further divided into a1 and a2 including 33 (Halawy, Khalas, Khadrawy, Shamran, Braim, Zagloul, Chip Chap, Sewi, Khunezi, Bint Aisha, Nagal Hilali, Khairpur Pakistan, Dayari, Medini, Saidy, Sabiah, Javantri, Gulchati, Punjab Red, Medzool, Gizaj, Mejnaz, Khasab, Muscat, Sayar, Suriya, Ahmat, Abdul Rehman, Migraf, Hateni, Bhukso, Kotho, Amir) and 2 (Tayar and Sopari) varieties respectively. Cluster AII monophyletic branch including Zhidi. The similarity matrix showed that the lowest genetic similarity (0.327) was between varieties Seddami and Tayar and the highest similarity (0.920) was among varieties between Medini and Dayari.

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

Germination and morpho-phenological parameters of osmoprimed cucurbit seeds under pot culture.

Pot culture experiments pertaining to osmopriming was carried out at ICAR-CIAH. Experimental units were arranged for each of the four cucurbits under study in a completely randomized design (CRD) with three replicates. The number of treatments for each was six. Observations pertaining to germination percentage, mean germination time, germination index, time to reach 50% germination and seed vigour of osmoprimed seeds were recorded. In watermelon cv. Sugar Baby, in snap melon cv. Phoot Kakri, in ridgegourd cv. 12 leaves and in bittergourd cv. Pusa Do Mausumi was selected for the experiment. The data pertaining to germination parameters revealed that KH_2PO_4 -10^{-1}M treated seeds of snapmelon cv. Phoot Kakri and watermelon cv. Sugar Baby was having the highest germination percentage (Table 37).

Both snapmelon and watermelon shared similar results with respect to mean germination time, least being observed in KH_2PO_4 -10^{-1}M and time to reach 50% germination was fastest in Thiourea-1%. However, they differed with germination index

Table37. Germination parameters of osmoprimed seeds of Watermelon cv. Sugar Baby and Snapmelon cv. Phoot Kakri under pot culture.

Treatments	Cucurbits	Germination percentage	Mean germination time	Germination index	Time to reach 50% germination	Seed vigour index
T1- Thiourea 1%	Watermelon	39.75	3.74	13.50	7.45	905.65
	Snapmelon	64.22	1.121	5.30	4.66	865.50
T2- KH2Po4 10 -1 M	Watermelon	60.22	2.82	10.07	8.15	774.00
	Snapmelon	90.10	0.651	8.76	4.85	1570.08
T3- Salicyclic acid 50ppm T5-	Watermelon	49.86	3.40	17.64	8.05	790.42
	Snapmelon	81.44	0.788	3.40	4.70	1304.72
T4- KNO3 1%	Watermelon	55.10	3.35	23.20	7.85	874.16
	Snapmelon	85.24	1.102	4.88	4.78	1321.10
T5 -PEG 6000(30% at OP -1.5 MPa)	Watermelon	50.22	3.24	11.12	7.90	865.12
	Snapmelon	84.65	1.352	9.96	5.12	1288.45
T6- CONTROL	Watermelon	47.01	3.65	14.86	7.70	890.45
	Snapmelon	60.80	1.347	5.16	5.01	812.22

and seed vigour index. Similarly, the seeds of ridge gourd cv. Twelve leaves excelled under salicyclic acid 50ppm 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 PEG6000-30%, however they showed solidarity with respect to germination index under salicyclic acid 50ppm. Morphological and phenological parameters of the plants were recorded and it was observed that the length of the vine and number of primary branches were high in KH_2PO_4 $-10^{-1}M$ treated seeds of watermelon and snapmelon .It was at par with seeds treated with 50 ppm salicyclic acid as well as $KNO_3$1% solution. However, with respect to node number, total number of male and female flowers as well as days to first male and female flowering, Thiourea1% followed by KH_2PO_4 $-10^{-1}M$ were the most effective. In both ridge gourd as well as bitter gourd, vine length as well as number of primary branches were high in seeds treated with 50 ppm salicyclic acid and PEG6000-30% respectively. The least vine length and primary branches were observed under control and Thiourea1% for both ridge and bittergourd (Fig:1). With respect to flowering , the least node number position of the first female flower as well as the total number of female flowers were observed in control and seeds treated with Thiourea 1%respectively.

Germination parameters of the thermo primed seeds

The cucurbitaceous seeds were subjected to thermopriming for a period of six months after getting them treated with the requisite osmo regulates and subsequently storing under ambient condition at room temperature(S_1), -5°C(S_2) and -20°C deep freezer (S_3).For watermelon, KH_2PO_4 $-10^{-1}M$ treated seeds proved to be the best for all environments with respect to germination percentage and mean germination time (Table 38). However, with respect to 50% germination and seed vigour index, Thiourea 1% proved superior under S_1 environment.

Isozyme profile of osmo primed seeds

Catalase activity of the thermo primed seeds under three distinct environments were studied separately. Results revealed that higher catalase activity was observed in all the treated seeds compared to control. Higher catalase activity in

Table 38. Germination percentage, mean germination time, germination index, time to get 50% germination and seed vigour index of thermoprimed Watermelon seeds cv. Sugar Baby under three storage environments.

Treatments	Germination percentage			Mean germination time			Germination index			Time to attain 50% germination			Seed vigour index		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1- Thiourea 1%	52.15	53.67	48.10	2.87	2.87	3.05	8.75	9.28	8.42	6.48	6.94	7.04	1428.17	1438.10	1397.20
T_2-KH_2Po_4 10^{-1M}	67.25	76.48	70.10	1.82	1.86	2.01	6.16	6.48	6.34	7.50	7.58	7.70	940.86	1085.70	990.64
T_3- Salicyclic acid 50ppm	56.00	62.35	58.12	2.54	2.64	2.69	12.10	12.85	12.52	7.22	7.30	7.75	685.04	720.10	702.15
T_4- KNO_3 1%	65.02	68.36	73.05	2.22	2.30	2.38	16.16	16.80	17.12	6.74	6.90	7.12	980.26	1012.18	1049.50
T_5- PEG 6000(30% at OP -1.5 MPa)	58.25	60.00	67.08	2.27	2.34	2.40	7.25	7.80	8.16	7.20	7.48	7.96	680.59	725.15	796.28
T_6- CONTROL	52.80	57.38	61.25	2.78	2.64	2.58	9.20	9.64	9.88	6.68	7.01	7.18	600.10	628.18	680.35
T_7- Non treated	62.10	69.01	70.55	1.96	2.31	2.40	10.28	10.80	11.18	6.70	7.10	7.25	648.26	708.20	714.26

S_1- Ambient room temperature in dessicator S_2 : At -5°C, Refrigerated S_3: -20°c, Deep freezer Storage Period: Six months

watermelon seeds stored under S_1 was observed in Thiourea 1% while under S_2 and S_3, it was KH_2PO4 10^{-1}M . In snapmelon, highest catalase activity was observed for KH_2PO_4 10^{-1}M treated seeds under S_3 and S_1 environment while non-treated seeds followed by KNO_3 1% under S_2. Most of the treatments elicited the activity of catalase over control by 150%, a bit less over fresh osmoprimed seeds. In ridge gourd, Salicyclic acid (50 ppm) exhibited the highest activity in S_3 and S_1 stored seeds while under S_2 environment it was KH_2PO_4 10^{-1}M. Bittergourd seeds showed higher activity in PEG6000 30% treated seeds stored under S_1 environment , closely followed by non treated seeds. However, for S_2 and S_3, stored KH_2PO_4 10^{-1}M treated seeds exhibited higher catalase activity over others. There was noted reduction in catalase activity of stored seeds due to the aging process wherein the antioxidant activity of the enzymes got reduced due to lesser scavenging activity of the H_2O_2 ,thus leading to lesser ROS stress during the aging process which varied among the species

In snapmelon and watermelon, higher activity of peroxidase was being observed in KH_2PO_4 10^{-1}M (105 %) for S_1 and S_3 environment and KNO_3 1% (112 %) for S_2 which also corelated with germination data. Thermoprimed ridge gourd and bitter gourd seeds baring Thiourea-1% showed an increase in enzyme activity in the range of 90-120% over control for all the environments which was lead by Salicyclic acid 50 ppm in ridge gourd and KH_2PO_4 10^{-1}M in bittergourd. Peroxidase like catalase acts as H_2O_2 scavenger which in turn is generated under ROS stress. Most of the treatments with inorganic chemicals showed an increased peroxidase activity which corroborates with earlier germination study. Thus elevated peroxidase levels ensures better protection of seeds against abiotic stresses.

Polyphenol oxidase activity showed significant ($p \leq 0.05$) differences among thermoprimed seedlings of snap melon and watermelon. The highest activity of the enzyme was recorded for PEG6000-30% (<170 %) in snap melon as well as in watermelon for S_1 stored seeds while for S_2 and S_3 environment it was KH_2PO_4 10^{-1}M treated seeds. With respect to ridge gourd highest activity in S_1 stored seeds was observed in Salicyclic acid (50 ppm) while for S_2 and S_3 it was KH_2PO_4 10^{-1}M , closely followed by KNO_3 1% Thiourea-1% showed the least activity. This enzyme plays a crucial role during seed germination and seed establishment process and acts as an anti-oxidant to reduce the adverse effects of ROS (Reactive Oxygen Species).

Esterase activity of KH_2PO_4 (10^{-1}M) treated snap melon and watermelon seeds showed the highest enzymatic activity of S_1 stored seeds while PEG6000-30% as well as KNO_3 1%. treated seeds under S_2 and S_3 environment showed higher activity, which were at par. Thiourea-1% showed a 38 % decline in activity in comparison to control under all the environments. In ridge gourd, S_1 and S_2 stored seeds were having higher esterase activity in KH_2PO_4 10^{-1}M treated seeds while for S_3, PEG6000-30% was more effective in enhancing the activity. In bittergourd, the highest percent increase in the esterase activity was observed in PEG6000-30% (225 %) for S_1 stored seeds while for S_2 it was KH_2PO_4 10^{-1}M and KNO_3 1% for seeds stored in S_3 environment.In our present experiment we have mixed results i.e. both increse/decrease activities of the enzyme pertaining to the treatments.

Amylase activity: All the treatments in water melon and snap melon showed a hike in the amylase activity of the seeds, the highest being noted in KH_2PO_4 10^{-1}M (>175%) under S_1 and S_2 environment while for S_3 stored seeds higher activity was noticed in PEG6000 30% (160%) closely followed by KNO_3 1% (Table 39). The lowest activity of the enzyme was recorded in Thiourea 1% as well as in non treated. During seed germination a higher respiratory level is noted which needs more substrates to break down for generating the required energy. Amylase provides the simple carbohydrate as substrate to respiration. In the present experiment the cucurbits responded differentially to the enzymatic activity under different set of treatments.

Table 39. Changes in Amylase activity of thermoprimed seeds of Watermelon cv. Sugar Baby and Snapmelon cv. Phoot Kakri stored under three storage environments.

Treatment	Watermelon Δ O.D. change min-1			Snapmelon Δ O.D. change min-1		
	S1	S2	S3	S1	S2	S3
T1- Thiourea 1%	0.0051±0.0014b	0.0065±0.0018e	0.082±0.0012f	0.0035±0.00052b	0.0054±0.00040g	0.0098±0.00034g
T_2- KH_2PO_4 10^{-1} M	0.014±0.0007f	0.0151±0.0008d	0.0157±0.0007d	0.018±0.00021f	0.020±0.00024f	0.0210±0.00014f
T3- Salicyclic acid 50ppm	0.0123±0.0037c	0.0134±0.0026c	0.0141±0.0018e	0.0135±0.0001c	0.0147±0.0006e	0.174±0.0007e
T4- KNO3 1%	0.0136±0.0082d	0.0142±0.0024b	0.0162±0.0022c	0.0142±0.0005d	0.0175±0.00011d	0.0218±0.00008d
T5- PEG 6000(30% at OP -1.5 MPa)	0.0137±0.0027e	0.0148±0.0022b	0.0169±0.0014b	0.0142±0.0021e	0.0188±0.00016c	0.0223±0.00010c
T6- CONTROL	0.0072±0.0004a	0.0095±0.0006a	0.0112±0.0010a	0.0085±0.0014a	0.0094±0.0009b	0.0121±0.0014b
T7- Non treated	0.0045±0.0006g	0.0060±0.0006f	0.0074±0.0010g	0.0034±0.0008g	0.0047±0.0010a	0.0083±0.0015a

Values followed by similar letters are not significantly different at $p \leq 0.05$.
S_1- Ambient room temperature in dessicator **S_2** : At -5°C, Refrigerated **S_3**: -20°C, Deep freezer
Storage Period: Six months

The highest invertase activity was recorded for KNO_3 1% (121 %) in snapmelon seeds stored under S_1 condition. The observations were synonymous in watermelon. Under S_2 and S_3 situation, PEG6000 30% treated seeds had higher invertase activity over others which was followed by KH_2PO_4 10^{-1}M . With respect to ridge gourd, higher activity was observed for PEG6000 (30%) treated seeds under S_1 situation while for S_2 and S_3 it was KH_2PO_4 10^{-1}M and KNO_3 1% respectively.However, certain treatments namely Salicyclic acid 50 ppm and Thiourea 1% showed a lower enzyme activity than control for all the seeds under varied environments as both had significantly higher amylase activity which may have resulted in the suppression of the invertase activity. In ridge gourd and bittergourd, PEG6000 30% showed a more heightened enzyme activity under S_1 situation. Invertase catalyzes the hydrolysis of sucrose, the activity depends on the nature of seeds and rate of germination. In some of the treatments under study the activity was augmented while in some there was suppression which may be related to higher amylase activity in such seeds.

In watermelon and snap melon stored seeds under S_1 environment, significant rise in protease activity was observed for seeds treated with KH_2PO_4 10^{-1}M while for S_2 and S_3 stored seeds it was KNO_3 1% and PEG6000 30% respectively. Thiourea 1% treated seeds in all the environments showed reduced activity. In ridgegourd, Salicyclic acid 50 ppm as well KH_2PO_4 10^{-1}M showed similar activities for S_1 and S_2 stored seeds , while for bittergourd it was PEG6000 30% for S_1 treated seeds and KNO_3 1% for S_2 and S_3 .During germination embryonic axis develops rapidly which requires raw material for synthesizing the building block of that developing organo cellular structure. Protease serves the raw material mainly in the form of amino acids,di, tri-peptides. In the present study protease significantly increased in those seeds which showed higher germination rate.

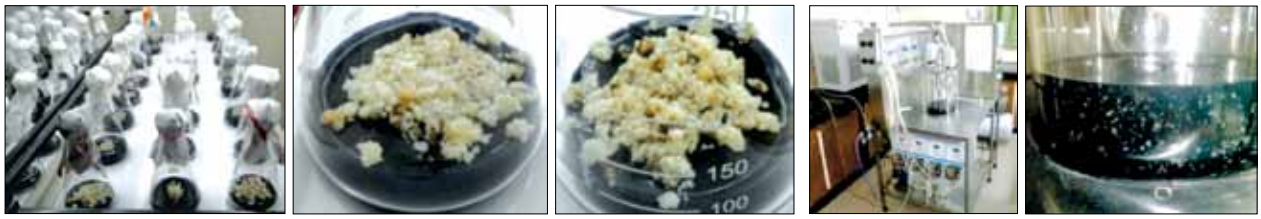
BIOTECHNOLOGY

At Bikaner

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

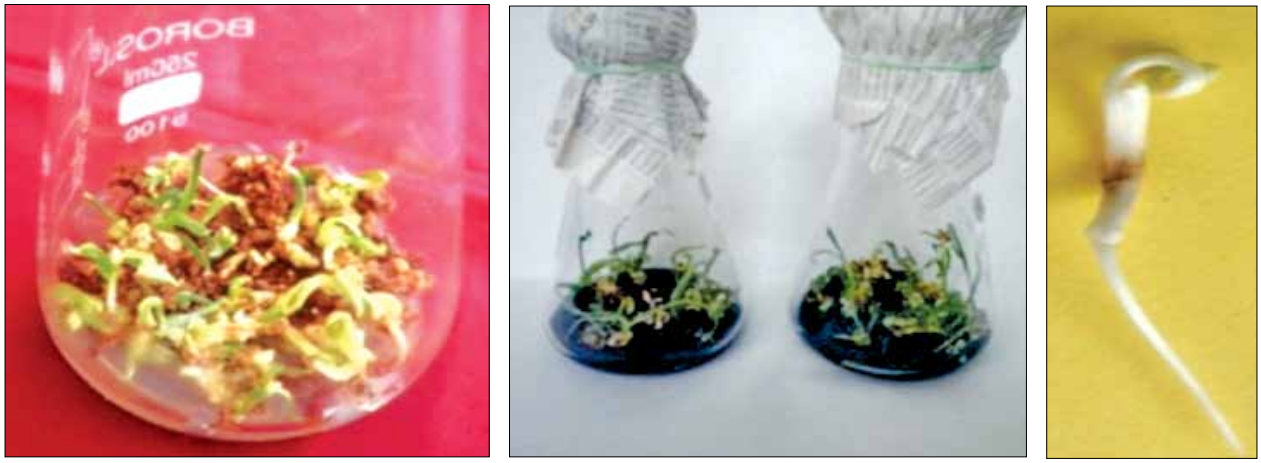
Somatic embryo germination

The growing cultures of date palm cv. Halawy of different stages such as callus, embryogenic callus and germinated somatioc embryos were periodically



Maintenance of callus cultures of date palm on different media composition fortified by NAA and BA and subcultured periodically

Mass multiplication of somatic embyos through bioreactor in liquid medium



Somatic embryo germination of date palm on MS media with or without activated

Somatic embryo germinatiom

Shoot elongation of date palm cv. Halawy and Khalas

Well rooted plants ready for primary hardening in environmental controlled green house

Fig. 49. Different stages of micro propagation of date palm cultivars.

sub-cultured on different media compositions. The microshoots were subjected for shoot elongation in MS media with different concentration of GA_3. Initially the plants were transferred in rooting media with low concentration of NAA. After 2-3 subculturing on the same media, the microshoots were subcultured on higher concentration of NAA for better root formation (Fig. 49).

Standardization of environmental parameters for primary and secondary hardening of plantlets of date palm

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. 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 plants survive better at environmental regimes of 28± 5 °C, 70-80 % RH and 8000- 10000 lux light intensity. For secondary hardening, the survived

plants were transferred in green house under 30± 2°C temperature, 60-70 % RH and 10000-15000 lux light intensity (Fig. 50).

Rooted plantlets of date palm

Primary hardening of date palm tissue culture plantlets covered by polythene bags

Secondry hardening of date palm tissue culture plantlets kept under environment control green house

Fig. 50. Different steps of hardening in tissue culture date palm

CROP PROTECTION

At Bikaner

Disease management

Management of different diseases of arid horticultural crops through botanicals and inorganic salts under hot arid conditions of Rajasthan.

Occurrence of major diseases in ridge gourd under field conditions

Ridge gourd variety 'Thar Karni' was sown on 23rd July, 2015 for occurrence of major diseases at Pathology Block of the Institute. The cultural practices were done during crop season. No control measures were applied in the crop. Mosaic disease occurred during rainy season of this year under field conditions. Most characteristic disease symptoms were found on leaves of the plants. Affected leaves are showing mosaic type symptoms accompanied by blistering green areas. Leaves were variously deformed and reduced in leaf size. Infected plants are stunted and fruit yield was affected. This disease is caused by virus strain. Disease incidence of mosaic symptoms was found up to 20.0%.

Screening of sponge gourd genotypes for resistance against mosaic disease

Fifteen genotypes (Pusa Sneha, AHSG-16, AHSG-17, AHSG-18, AHSG-19, 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 2015. *Alternaria* leaf blight and mosaic disease were observed in the field. Disease severity of *Alternaria* leaf blight was recorded from 3.20 to 32.10% while incidence of mosaic disease appeared up to 25.0% in different genotypes of this crop. Minimum disease severity of *Alternaria* leaf blight was appeared in 'Pusa Sneha', and AHSG-28 while maximum disease severity was found in genotype 'AHSG-18'. Lowest disease incidence of mosaic was found in 'Pusa Sneha' while highest incidence was also observed in genotype 'AHSG-18'.

Evaluation of field resistance of muskmelon genotypes against *Fusarium* wilt disease

Twelve muskmelon genotypes (AHMM/BR-1, AHMM/BR-38, AHMM/BR-41, AHMM/BR-42, AHMM/BR-44, AHMM/BR-46, AHMM/BR-47, AHMM/BR-51, AHMM/BR-54, MHY-3, RM-43 and RM-50) were evaluated for field resistance against *Fusarium* wilt disease caused by *Fusarium acuminatum* at New Vegetable Block of the Institute during summer season of 2015. Disease incidence of *Fusarium* wilt was recorded up to 50.0% in different genotypes. Lowest wilt incidence (6.50, 7.65 and 8.93%) was noted in the genotypes *viz*., AHMM/BR-42, AHMM/BR- 41 and AHMM/BR-51 while highest disease incidence (50.0%) was observed in AHMM/BR-54, followed by RM-50 and AHMM/BR-47 with disease incidence of 33.33%.

Screening of muskmelon genotypes for resistance against wilt disease under field conditions

Table 40. Presents the incidence of wilt disease among 12 genotypes of muskmelon. Perusal of data reveals that minimum incidence was received in AHMM/BR-42 and AHMM/BR-41.

S. No.	Name of genotypes	Average incidence of wilt disease
1.	AHMM/BR-1	25.0 * (29.76)
2.	AHMM/BR-38	30.0 (33.09)
3.	AHMM/BR-41	7.65 (15.96)
4.	AHMM/BR-42	6.50 (19.66)
5.	AHMM/BR-44	17.78 (24.90)
6.	AHMM/BR-46	24.74 (29.70)
7.	AHMM/BR-47	33.33 (35.20)
8.	AHMM/BR-51	8.93 (17.32)
9.	AHMM/BR-54	50.0 (45.0)
10.	MHY-3	16.02 (23.53)
11.	RM-43	26.67 31.06)
12.	RM-50	33.33 (35.15)
	CD at 5% = 5.45	CV = 11.29

*Figures in parenthesis are angular transformed value

Pest management

At Bikaner

Survey of insect-pests, their natural enemies and pest management strategies for cucurbits in arid region of Rajasthan.

The periodical observation on major insect pests of arid fruits and vegetables has been carried out at fortnight intervals. The screening of snapmelon genotypes was done against fruit fly resistant.

Host Plant resistance study on snapmelon genotypes

From amongst the 17 genotypes of snapmelon selected for final evaluation trials against *B. cucurbitae* resistance during summer, 2015, the genotypes; IC-430190, DKS-AHS 2011/4, and DKS-AHS 2011/3 were resistant; IC-430160, IC-430162, IC-430175, IC-430179, IC-430180, IC-430185, IC-369788, and DKS-AHS 2011/2 were found moderately resistant whereas IC-430155, IC-430164, IC-430169, IC-430171, IC-430172 and IC-430184 were susceptible genotypes in both seasons (Table 41). The percentage fruit infestation increased with an increase in larval density per fruit and there was a significant positive correlation (r = 0.988; p < 0.01) between per cent fruit infestation and larval density per fruit. The fruit infestation in rainy season of 2014 ranged from 11.64 to 69.26% whereas in the 2015 summer season, it ranged from 10.78 to 69.67%. Pooled data of fruit infestation in both seasons (11.21- 69.67%) was significantly low in resistant and high in susceptible genotypes (Fig. 51). In pooled data, the per cent fruit infestation was the highest in IC-430184 (69.67 %) and the lowest in IC-430190 (11.21 %) followed by DKS-AHS-2011/4 (14.97 %). The larval density ranged from 8.63 to 17.57 and 8.30 to 17.20 larvae per fruit in the rainy season, 2014 and summer season, 2015, respectively. Pooled data of larval density per fruit in both seasons (8.47- 17.37 larvae per fruit) were significantly lower in resistant and higher in susceptible genotypes. In pooled data, the larval density were maximum in IC-430169 (17.37 larvae per fruit) and minimum in IC-430190 (8.47 larvae per fruit) followed by DKS-AHS 2011/3 (8.8 larvae per fruit) (Table 41).

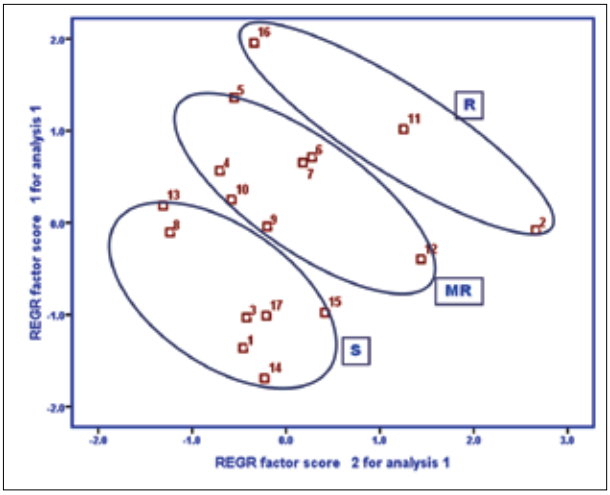


Fig. 51. Plot of PC1 and PC2 showing clusters of snapmelon, *C. melo var. momordica* genotypes are showing resistance to melon fruit fly, *B. cucurbitae*.

Table 41. Larval density and per-cent fruit infestation of melon fruit fly on different genotypes of snapmelon, *C. melo* var. *momordica* during summer, 2015

Genotypes	Larval density/ fruit	Fruit infestation (%)	Resistance category
IC-430169	17.17e	67.66 (55.35)j	S
DKS-AHS 2011/3	8.70ab	18.06 (25.13)bc	R
IC-430172	17.07e	65.35 (53.98)ij	S
IC-430175	11.73c	40.51 (39.49)f	MR
IC-369788	9.20ab	24.99 (29.97)de	MR
IC-430160	8.73ab	22.06 (27.99)cd	MR
IC-430162	9.40ab	25.85 (30.53)de	MR
IC-430171	14.63d	53.09 (46.76)gh	S
IC-430179	13.60d	46.95 (43.23)fg	MR
IC-430180	14.43d	47.70 (43.66)g	MR
IC-430190	8.30a	10.78 (19.16)a	R
DKS-AHS 2011/2	10.43bc	28.39 (32.11)e	MR
IC-430185	14.30d	47.51 (43.56)g	MR
IC-430184	17.20e	68.92 (56.17)j	S
IC-430155	14.33d	53.60 (47.06)gh	S
DKS-AHS 2011/4	8.77ab	14.49 (22.35)ab	R
IC-430164	14.93d	59.22 (50.32)hi	S
Mean+ SD	12.53+3.28	40.89+19.35	
SEm+	0.62	1.42	
LSD (P = 0.05)	1.80	4.09	
F calculated	27.92	71.36	
Error degree of freedom	32	32	

*Values in parenthesis are angular-transformed; Value following different letter down the column are significantly different using Tukey's HSD test, R- resistant, MR- moderately resistant and S- susceptible

Biochemical Fruit Traits of the Re-Evaluated Snapmelon Genotypes

Flavonoid, tannins, total alkaloid and phenols contents ranged from 0.59 to 2.3 mg/g, 6.1 to 11.79 mg/g, 0.53 to 2.17 % and 9 to 14.83 mg/g (on dry weight basis), respectively with values significantly higher in resistant and lower in susceptible genotypes. The flavonoid content (2.3 mg/g) and total alkaloid content (2.17 %) were found maximum in IC-430190 and minimum in IC-430169 (flavonoid content 0.66 mg/g & total alkaloid content 0.53 %). The tannin (12.87 mg/g) and phenols content (15.96 mg/g) were found the highest in DKS-AHS 2011/4 and the lowest in IC-430184 (6.1 & 9 mg/g). The free amino acid and total soluble solid (TSS) of different genotypes fruits ranged from 4.57 to 9.52 (mg/g on dry weight basis) and 4 to 8.07 %, respectively with values significantly lower in resistant and higher in susceptible genotypes (Table 42). The percentage of fruit infestation and the larval density per fruit with free amino acid (0.97 & 0.96) and TSS (0.3 & 0.3) of fruit had a significant positive correlation whereas; flavonoid (-0.98 & -0.96), tannins (-0.97 & -0.95), phenols (-0.96 & -0.95) and total alkaloid (-0.97 & -0.94) had significant negative correlation (Table 43).

Table 42. Biochemical (allelochemical) fruit traits of different genotypes of snapmelon, *C. melo* var. *momordica*

Genotypes	Flavonoid content (mg/g)	Tannins content (mg/g)	Total alkaloid content (%)	Phenols content (mg/g)	Free amino acid (mg/g)	TSS (%)
IC-430169	0.66^{ab}	6.91^{abc}	0.53^{a}	10.19^{ab}	9.52^{k}	7.63^{gh}
DKS-AHS 2011/3	2.00^{jk}	11.27^{gh}	1.78^{gh}	14.33^{fg}	4.97^{ab}	8.07^{hi}
IC-430172	0.86^{abc}	7.19^{abc}	0.64^{ab}	10.34^{ab}	8.94^{ijk}	6.60^{de}
IC-430175	1.55^{fgh}	9.86^{efg}	1.27^{e}	13.11^{def}	7.56^{ef}	6.20^{bcd}
IC-369788	1.89^{ij}	10.75^{fgh}	1.39^{f}	13.84^{efg}	5.67^{c}	4.70^{ab}
IC-430160	1.70^{hi}	11.33^{ghi}	1.66^{g}	14.20^{fg}	5.72^{c}	6.03^{bc}
IC-430162	1.72^{hij}	10.63^{efg}	1.48^{f}	14.04^{fg}	6.40^{d}	5.47^{ab}
IC-430171	1.14^{cde}	8.06^{cd}	0.87^{c}	11.08^{bc}	8.39^{hi}	6.77^{ef}
IC-430179	1.41^{efg}	9.44^{def}	1.19^{de}	12.55^{de}	7.71^{efg}	6.57^{cde}
IC-430180	1.34^{def}	8.30^{cd}	1.10^{d}	11.37^{bc}	8.00^{fgh}	4.00^{a}
IC-430190	2.30^{l}	11.79^{hi}	2.17^{i}	14.83^{gh}	5.44^{bc}	6.87^{ef}
DKS-AHS 2011/2	1.66^{ghi}	10.55^{efg}	1.35^{ef}	13.51d^{efg}	6.87^{d}	8.00^{hi}
IC-430185	1.12^{cd}	9.12^{de}	1.07^{d}	12.04^{cd}	8.35^{ghi}	7.20^{fg}
IC-430184	0.59^{a}	6.10^{a}	0.69^{ab}	9.00^{a}	9.22^{jk}	8.53^{i}
IC-430155	1.14^{cde}	7.98^{bc}	0.78^{bc}	11.20^{bc}	8.89^{ijk}	7.97^{hi}
DKS-AHS 2011/4	2.21^{kl}	12.87^{i}	1.94^{h}	15.96^{h}	4.57^{a}	5.47^{ab}
IC-430164	0.94^{bc}	6.47^{ab}	0.79^{bc}	9.49^{a}	8.76^{ij}	6.53^{cde}
Mean± SD	1.43±0.52	9.33±2.02	1.22±0.48	12.42±2.03	7.85±1.61	6.62±1.24
SEm±	0.10	0.53	0.05	0.51	0.23	0.19
LSD (P = 0.05)	0.28	1.54	0.16	1.47	0.66	0.56
F calculated	28.76	14.47	78.37	15.99	49.80	41.55
Error degree of freedom	32	32	32	32	32	32

Value following different letter down the column are significantly different using Turkey's HSD test

Table 43. Correlation coefficient (r) between per cent fruit infestation and larval density per fruit with different allelochemical fruit traits of snapmelon, *C. melo* var. *momordica* genotypes

	Per cent Damage	Larval Density	FC	TC	TA	PC	FAA
Larval Density	0.988**						
FC	-0.980**	-0.961**					
TC	-0.970**	-0.951**	0.960**				
TA	-0.971**	-0.940**	0.965**	0.945**			
PC	-0.964**	-0.948**	0.960**	0.997**	0.936**		
FAA	0.971**	0.961**	-0.958**	-0.950**	-0.952**	-0.943**	
TSS	0.300^{NS}	0.300^{NS}	-0.358^{NS}	-0.307^{NS}	-0.271^{NS}	-0.321^{NS}	0.328^{NS}

**Significant at P = 0.01 (two-tailed), * Significant at P = 0.05 (two-tailed)
FC- flavonoid content (mg/g), TC- tannins content (mg/g), PC- phenols content (mg/g), TA- total alkaloid (%), FAA- free amino acid (mg/g), TSS- total soluble solid (%)

Morphological mechanism fruit traits of the re-evaluated snapmelon genotypes

The length of ovary pubescence, rind hardness at immature stage, rind hardness at mature stage and pericarp thickness which ranged from 1.39 to 2.7 mm, 10.08 to 14.75 kg/ cm^2, 4.84 to 10.97 kg/ cm^2 and 0.43 to 1.16 mm, respectively, were significantly high in resistant and low in susceptible genotypes. However, the flesh thickness (11.19 to 22.34 mm), fruit length (10.43 to 18.99 cm) and fruit diameter (6.40 to 10.13 cm) were significantly shorter in resistant and longer in susceptible genotypes (Fig. 52, Table 44). The length of ovary pubescence (-0.99

Fig. 52. Different female ovary pubescence and various genotypes of snapmelon, *Cucumis melo* var. *momordica.*

Table 44. Morphological (antixenotic) fruit traits of different genotypes of snapmelon, *C. melo* var. *momordica*

Genotypes	Length of ovary pubescence (mm)	Rind hardness at immature stage (Kg/ cm^2)	Rind hardness at mature stage (Kg/cm^2)	Pericarp thickness (mm)	Flesh thickness (mm)	Fruit diameter (cm)	Fruit length (cm)
IC-430169 1.39^{a}		10.44^{ab}	5.86^{b}	0.46^{ab}	18.67^{f}	9.65^{ij}	17.23^{f}
DKS-AHS 2011/3	2.48^{j}	13.92^{ijk}	9.80^{ef}	1.16^{h}	11.19^{a}	6.40^{a}	10.47^{ab}
IC-430172	1.52^{bc}	11.46^{bcd}	5.37^{ab}	0.46^{ab}	17.53^{ef}	9.72^{ij}	15.12^{bcde}
IC-430175	2.05^{h}	12.77^{efgh}	7.59^{cd}	0.86^{f}	18.33^{ef}	9.10^{ghi}	16.83^{ef}
IC-369788	2.34^{i}	13.68^{hij}	7.19^{cd}	1.06^{gh}	17.66^{ef}	7.69^{bcd}	14.99^{bcd}
IC-430160	2.27^{i}	13.57^{ghij}	6.75^{c}	0.43^{ab}	13.57^{bc}	7.51^{bc}	14.84^{bcd}
IC-430162	2.24^{i}	12.65^{efg}	5.68^{ab}	0.85^{f}	15.14^{cd}	7.41^{bc}	13.82^{b}
IC-430171	1.73^{ef}	12.86^{efgh}	5.01^{a}	0.39^{a}	22.34^{g}	8.86^{fgh}	17.30^{fg}
IC-430179	1.91^{g}	12.23^{def}	6.19^{b}	0.76^{ef}	17.39^{ef}	8.46^{efg}	15.61^{cdef}
IC-430180	1.86^{g}	12.47^{def}	7.83^{d}	0.68^{de}	14.99^{cd}	7.37^{b}	16.14^{def}
IC-430190	2.64^{k}	14.30^{l}	10.97^{g}	1.14^{h}	12.66^{ab}	7.39^{bc}	14.05^{bc}
DKS-AHS 2011/2	2.12^{h}	12.97^{fghi}	6.16^{b}	0.76^{ef}	18.18^{ef}	7.10^{b}	10.43^{a}
IC-430185	1.83^{fg}	12.37^{def}	6.18^{b}	0.80^{f}	20.53^{g}	10.13^{j}	18.99^{g}
IC-430184	1.43^{ab}	10.08^{a}	4.84^{a}	0.43^{ab}	20.68^{g}	9.27^{hi}	16.96^{f}
IC-430155	1.65^{cde}	11.89^{cde}	10.56^{fg}	0.63^{cd}	15.25^{cd}	9.48^{hij}	16.95^{f}
DKS-AHS 2011/4	2.70^{k}	14.75^{k}	9.53^{e}	0.99^{g}	16.66^{de}	8.04^{cde}	15.65^{cdef}
IC-430164	1.56^{cd}	10.89^{abc}	5.86^{b}	0.52^{bc}	17.11^{ef}	8.29^{def}	16.57^{def}
Mean± SD	1.98±0.42	12.55±1.31	7.14±1.95	0.73±0.26	16.93±2.92	8.35±1.09	15.41±2.27
SEm±	0.03	0.35	0.29	0.04	0.61	0.23	0.60
LSD (P = 0.05)	0.10	1.02	0.84	0.11	1.77	0.65	1.73
F calculated	47.63	13.97	45.80	47.85	22.81	23.35	14.52
Error degree of freedom	32	32	32	32	32	32	32

Value following different letter down the column are significantly different using Turkey's HSD test

Table 45. Correlation coefficient (r) between per cent fruit infestation and larval density per fruit with different antixenotic fruit traits of snapmelon, *C. melo* var. *momordica* genotypes

	Per cent damage	Larva density	Length of ovary pubescence	Rind hardness at immature stage	Rind hardness at mature stage	Pericarp thickness	Flesh thickness	Fruit diameter
Larval density	0.988**							
Length of ovary pubescence	-0.986**	-0.963**						
Rind hardness at immature stage	-0.930**	-0.897**	0.944**					
Rind hardness at mature stage	-0.586*	-0.544*	0.608**	0.603*				
Pericarp thickness	-0.776**	-0.746**	0.815**	0.719**	0.664**			
Flesh thickness	0.617**	0.614**	-0.586*	-0.484*	-0.696**	-0.509*		
Fruit diameter	0.761**	0.767**	-0.719**	-0.627**	-0.358^{NS}	-0.538*	0.679**	
Fruit length	0.609**	0.618**	-0.558*	-0.463^{NS}	-0.260^{NS}	-0.473^{NS}	0.589*	0.809**

**Significant at P = 0.01 (two-tailed) * Significant at P = 0.05 (two-tailed)

& -0.96), rind hardness at immature stage (-0.93 & -0.90), rind hardness at mature stage (-0.59 & -0.54) and pericarp thickness (-0.78 & -0.75) had significant negative correlations whereas flesh thickness (0.62 & 0.61), fruit length (0.61 & 0.62) and fruit diameter (0.76 & 0.77) had significant positive correlations with the percentage fruit infestation and the larval density per fruit (Table 45).

Based on Kaiser Normalization method

Based upon the above morphological and biochemical characters individually it was impossible to group the entries as variables were not in agreement to each other. Hence, principal component analysis was performed to achieve parsimony and reduce the dimensionality by extracting the smallest number of components that accounted for most of the variation in the original multivariate data. Taking into consideration thirteen parameters viz., flavonoid content, TSS, free amino acid, total alkaloid, tannins content, phenols content length of ovary pubescence, rind hardness at immature stage, rind hardness at mature stage, fruit length, flesh thickness and fruit diameter principal component analysis (PCA) was performed. Four principal components (PCs) were extracted with eigen value ≥1.0, after varimax rotation with Kaiser

normalization procedure which converged in three iterations. The extraction communalities for all the variables tested were ≥ 0.5 indicating that the variables were well represented by the extracted PCs which together explained a cumulative variation of 82.8 %. PC1 explaining 53.41 % of the variation while PC2 explained 29.39 % of variation. PC1 had the loadings for flavonoid content (0.86), tannins content (0.88), total alkaloid (0.82), phenols content (0.88), free amino acid (-0.83), total soluble solid (-0.66), length of ovary pubescence (0.88), pericarp thickness (0.67) and rind hardness at immature stage (0.89). Rind hardness at mature stage (0.52), flesh thickness (-0.74), fruit length (-0.86) and fruit diameter (-0.68) were loaded in PC2 (Table 46).

Table 46. Component loadings of parameters for resistance against melon fruit fly in snapmelon, *C. melo* var. *momordica* fruits

N.	Parameters	Principal components	
		1	2
1	Fruit infestation (%)	-0.84	-0.53
2	Larval density per fruit	-0.82	-0.53
3	Flavonoid content	0.86	0.49
4	Tannins content	0.88	0.42
5	Total alkaloid	0.82	0.52
6	Phenols content	0.88	0.42
7	Free amino acid	-0.83	-0.51
8	Total soluble solid	-0.66	0.39
9	Length of ovary pubescence	0.88	0.47
10	Rind hardness at immature stage	0.89	0.35
11	Rind hardness at mature stage	0.43	0.52
12	Pericarp thickness	0.67	0.47
13	Flesh thickness	-0.32	-0.74
14	Fruit diameter	-0.48	-0.68
15	Fruit length	-0.18	-0.86

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 3 iterations

POST HARVEST MANAGEMENT AND VALUE ADDITION IN ARID HORTICULTURAL CROPS

At Bikaner

The *doka* stage of date palm fruit of cv. Sewi harvested and was used to prepare biscuits. The date pulp was dried and biscuit prepated by adding 10 & 20% pulp powder with other ingradients in local bakery. Organoleptic test was carried out and it was found acceptable among the tasters and sweet in taste than control. Preparation of soft date was also tried using acetic acid, salt, freezing and dip in boiling water treatments. Freezing of doka fruits for 48 hrs and then drying was found suitable than other treatments however, sweetness was low. Other treatments were not suitable for making softness of doka fruits. RTS from Sewi variety fruits prepared and was acceptable among testers. Preparation of dry date from Halawy cultivar fruits was tried. Dipping in boiling water for 60 seconds and drying. About 40-45 per cent recovery of dry date was observed

Exploitation of arid fruits and vegetables for value addition and commercialization

The various value added products were prepared such as Rough lemon squash, Kinnow squash, Ber pickle and squash. These products were kept for organoleptic evaluation with CIAH officials. Squashes have mean organoleptic score secured more than seven (liked very much) by the judges. In pickle of rough lemon critical suggestion emerged that its pericarp have dominant flavor, so next time balancing of pericarp pieces (2.5 cm) was required to reduce its dominant odour and reduce its salt mix waiting period during the pickle preparation would be followed.

Standardization of karonda dehydration technology for value addition

Karonda is a very hardy underutilized fruit crop of arid region. It is grown commonly as a protective hedge which thrives well as a rainfed crop. After establishment, it hardly needs any care and gives yield (8-10 kg/plant) with minimum management. It is richest source of iron mineral among the fruit

crops and also good in calcium and vitamin C. Its unripe fruits which are sour and astringent in taste are used as vegetable, and in preparation of chutney and pickles locally. The storage life of karonda is very short because of its soft flesh and high moisture content. Karonda remains unexploited commercially owing to lack of standardized post harvest and value addition technology. Therefore, an experiment was conducted for standardization of dehydration technology for value addition in karonda. Unripe fruits small size (2.0 to 2.5 g with soft seed) and big size (4.0 to 4.5 g with hard seed) as a whole, big size fruit sliced with seed and without seed used in this experiment. The treatments combination consist of control, with and without blanching (3 minute) and preservatives treatments of potassium meta bisulphate, citric acid and sodium benzoate each at 0.1 and 0.2 % concentrations for five minutes and dried in sun. Among all the treatments, small size unripe fruits (2.0 to 2.5 g) as whole blanched for 3 minutes and treated with sodium benzoate 0.1 % was found superior for dehydration of karonda. These dehydrated fruit can be used as mouth freshener, chutney, vegetable and powder making. Dehydrated karonda powder was found good in organoleptic taste for tartness and could be used in masala mixtures for typical sour taste.

Value addition in aonla (*Emblica officinalis* Gartn.)

Aonla is an important arid fruit crop, which is used in ayurvedic medicine, health foods and herbal products. It is also found to be a rich source of ascorbic acid and other bioactive substances as compared to any other fruits. Due to scanty use as a fresh fruit's consumption and short shelf life, it creates glut situation in market and farmers get throw away price for their produce. By processing and preparation of value added products namely aonla candy (sweet and salty), juice, powder and murabba etc. the fruit will have high demand and fetches good market price (100-150/kg). Among the products, aonla candy sweet as well as salty has good market demand. Therefore the flow charts for preparation of aonla candy have been standardized /revalidated for value addition in aonla.

Aonla fruit

(Fully mature free from blemish)

↓

Washing

↓

Blanching (5-10 minutes according to variety)

↓

Removal of segments

↓

Addition of sugar (750 g sugar/kg fruits)*

↓

Keep for 2-3 days in sugar syrup

↓

Removal of sugar syrup

↓

Sun drying of aonla segment (2-3 days)

↓

Aonla segment

↓

↙ ↘

Mixing/coating with sugar powder for black salt powder for salty candy

Mixing/coating with amchur, black pepper and sweet candy

↓

Packaging and storage at room temperature

*Note: Add only sugar to aonla segments as water comes out through exosmosis makes sugar syrup automatically and sugar will act as preservative

Fig. 53. Flow chart for preparation of aonla candy

Rough lemon (*Citrus jambhiri* Lush.) squash

Fully ripened rough lemon fruits in colour and free from any blemishes on surface were harvested, washed thoroughly in tap water, wiped by muslin cloth and cut into two halves with sharp stainless steel knife and removed the seed from the fruit in post harvest technology lab. The cut pieces of fruit were used for extraction of juice with lime squeezer and the juice was strained through a coarse muslin cloth to discard the remaining seeds inside the fruit. The extracted juice were kept in glass bottle for settlingthe suspended materials of juice in bottom and this juice was treated with KMS + sodium benzoate @ 500 ppm each preservative. To this was added sugat solution. This syrup was cooled to ambient temperature and mixed with the juice and its acidity and TSS, was checked and maintained at 0.5-0.7 and 50 ^{0}Brix, respectively. This squash was ready for serving after addition of water in the ratio of 1:3.

Ber syrup

Ber (*Ziziphus mauritiana*) is one of the common and ancient fruit of India which is an ideal fruit for growing in arid and semiarid region. Ber fruit can be processed in to different products such as ber squash and pickle. The ber fruits were procured from ICAR-CIAH Farm, ber block and harvested at colour turning stage. The harvested fruits were brought in post harvest technology lab and washed thoroughly with tap water. Fruit stalk were removed and the fruits were dried under the fan and after an hour, the fruits were weighed and an equal quantity of sugar was taken. The pasteurized glass bottle was filled with sugar and fruits in alternate layers by leaving 3 cm head space. The filled bottle was shacked everyday till sugar syrup included fruit juice through osmosis. After fortnight, this syrup was strained with sieve and filled into the bottles. This ber syrup was ready for serving after addition of water in the ratio of 1:4.

Ber pickle

The ber fruit at green stage was harvested from the tree and brought in the lab. The fruit were washed under the tap water and kept for removing the moisture. The washed fruit were cut in to small pieces with sharp stainless steel knife and the seed was removed from the fruit. The small pieces of fruit were dipped in calcium hydroxide water for onehour, all pieces become purple in neutralizing the pH and pericarp gets firmer. The calcium hydroxide treated fruits were washed thoroughly with normal water and kept for removing the moisture for few hrs in cool and dry place. After that, treated fruit pieces were treated with lime juice and salt and kept for one day to mix properly. The treated fruit pieces with lime juice and salt next day morning were fried with mustard oil and mixed with the ingredients. Switch off the flame and once it cools down slightly add berries. It can be eaten as it is, or can be stored after reducing the water content in it. Store the berries in airtight jar for 3-4 days until all the water is released. The berries got shrieked. After four days, they were transferred into a wide container, and kept under hot sun every day for few hours till the water dries up. Later, it was transferred back into the airtight container every day so that it does not catch the humidity from the air.

At Godhra

Effect of Zero Energy Cool Chamber and post harvest treatments on storage life of Jamun cv. Goma Priyanka

An experiment was conducted to evaluate the efficacy of different post harvest treatments ie 1 - Control, 2- Zero Energy Cool Chamber (ZECC), 3 - Calcium chloride 1. 0 %, 4 - Calcium chloride 1. 5 %, 5- Calcium chloride 1. 0 % + ZECC, 6- Calcium chloride 1. 5 %+ ZECC, 7 - Mustard oil 2.0 % emulsion, 8- Mustard oil 2.0 % emulsion+ZECC, 9 - Potassium sulphate 2 %, 10- Potassium sulphate 2 %+ZECC on storability and fruit quality attributes during storage. Fruits treated with calcium chloride 1.5 % and kept in Zero Energy Cool Chamber recorded 4 days shelf life while untreated control had 2 days shelf life. Zero Energy Cool Chamber alone recorded 3 days shelf life.

Evaluation of bael varieties for organoleptic scoring of RTS

The bael varieties *i.e.,* CHESB-2, CHESB-1, NB-5, NB-7, NB-9, NB-16, NB-17, Pant Aparna, Pant Urvashi, Pant Shivani, Pant Sujata, Goma Yashi and Thar Divya were evaluated for their organoleptic scoring.

Sensory parameters

Among the varieties, the acceptance level of RTS prepared from the pulp of Goma Yashi was having high quality for its different sensory evaluation by the panel of judges on score basis when compared to rest of the varieties for RTS. At the first stage of testing, the appearance of RTS of Goma Yashi was dark yellowish having score (7.94) followed by CISHB-2 (7.52), whereas the highest acceptability score (8.40) and colour rating score (8.43) were maximum in Goma Yashi followed by CISHB-1 (8.34, 8.35) by the panel of judges. Rating of RTS for taste and flavour was maximum in Goma Yashi (8.15, 8.48) followed by NB-5 (8.15, 8.30) and NB-9 (7.98) for taste and CISHB-1 (8.27) for flavour. The colour of product is an important attribute of any value added products. There was no artificial colour mixed in drink as the pulp retains the natural yellow colour. The scores for the colour was given the maximum to Goma Yashi (8.41) followed by CISHB-1, Pant Shivani (8.32) and the minimum rating was acquired in the variety NB-16 (7.32) followed by Pant Aparna (7.45). The sensory things, the taste are the other important factor which indicates its value towards its utility after colour and flavour. The 2nd highest score for taste given by testers was observed in NB-5 (8.10) followed by NB-9 (7.98) and least value for the taste was observed in Pant Aparna (6.79).The sweetness of the RTS was observed the highest in Goma Yashi (7.78) followed by NB-5 (7.32) and the lowest in the NB-16 (6.73) followed by NB-7(6.97) as compare to rest of the varieties.

AGRICULTURAL EXTENSION

A study on rural wisdom and resources of arid horticultural importance

Under the extension research project entitled as "A study on rural wisdom and resources of arid horticultural importance, different studies were under taken as per objectives and targets of the same. The major achievements of this project during 2015-2016 are as follows.

(1) Collection of information/data, documentation and evaluation of the potential rural resources/ rural wisdom based technologies of arid horticultural importance.

(a) Potential land races/germplasms/wild species of arid fruits and vegetables for the crop improvement and arid horticultural development:

During the reported time of period, the targeted data / information about the socio-economic and psychological characteristics of the respondents/ farmers (34) were collected and evaluated. Some of the land races/germplasm/wild species or genotypes like *ker* (*Capparis deciduas* Edgew), *phog (Calligonum polygonoides* L.), cactus (*Opuntia ficus indica*), *khejri* (*Prosopis cineraria* (L) Druce), *Khimp* (*Leptadenia pyrotechnica* (Fork.) Decne), moringa *(Moringa oleifera* Lamk), *lasoda (Cordia myxa Roxb.),* Indian aloe (*Aloe vera barbadensis Mill*) and mango (*Mangifera indica*), pilu, spiny local brinjal (*Solanum spp.), tumba* (*Citrullus colocynthis*), *Mat kachar* (*Cucumus ssp*.), loiya of mateera (*Catullus ssp*.), *local mushroom (Agaricus spp),* single stemed local clusterbean (*Cyamopsis spp.)*, drumstick (*Moringa ssp.), and* leafy vegetable *viz., Chaulai (Amaranthus ssp.), bathua (Chenopodium album),* fenugreek (*Trigonella foenum-graecum),*etc., were identified and documeted. These land races/ germplasm/wild species or genotypes 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 identified, collected, and documented using different sources. 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 in the field of 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.

(2) Collection, documentation, validation and refinement/standardization of the potential rural wisdom based traditional technologies:

(a) Validation, refinement and standardization of production of value added products, processes /techniques:

During the period of the study, collected information/ data (from respondents, secondary and online sources) on rural wisdom based

traditional technologies/ ideas and also self developed hypothesizes/ ideas to develop an innovative processes /techniques and value added products of arid horticultural crops. Further, the work of validation, refinement and standardization on so collected traditional technologies/ ideas and self developed hypothesizes/ ideas was carried out. During the reported period, the following efforts were made in this direction.

(i) Validation, refinement, standardization and development of the processes, products and techniques of preparing the pickle *of* ber (*Ziziphus mauritiana) and Tumba (Citrullus colocynthis).*

Process/ technique of preparing the pickle of *ber*	Process/ technique of preparing the pickle of *Tumba*
↓	↓
Selection and harvesting of healthy fruits of ber.	Selection and harvesting of healthy fruits of tumba .
↓	↓
Washing fruits with clean water	Washing fruits with clean water
↓	↓
Cut the ber fruits in desirable pieces & remove the fruit stone	Cut the tumba fruits in desirable pieces & remove the seeds of the fruits
↓	↓
Put the pieces in water solution of limestone for 4 -5 hours	Put the pieces in water solution of limestone for 48 - 72 hours
↓	↓
Remove the pieces from water solution of limestone & dry the same for 2-3 hours at room temperature to remove excess water	Remove the pieces from water solution of limestone & dry the same for 6 - 10 hours at room temperature to remove excess water
↓	↓
Mix 50 - 60 ml lemon juice per kg of so dried pieces of ber fruits & put them as it is for 2-3 hour	Mix 100 -125 ml lemon juice per kg of so dried pieces of tumba fruits & put them as it is for 5 - 6 hour
↓	↓
Dry the ber pieces again for 2-3 hours at room temperature to remove excess water	Dry the tumba pieces again for 3-4 hours at room temperature to remove excess water
↓	↓
Slightly fry the so processed pieces of ber fruits with mustard oil in a pan	Slightly fry the so processed pieces of tumba fruits with mustard oil in a pan
↓	↓
Gently, juxtapose mixing of the salt, spices/ condiments (powder of aesfoitida, red chilli, turmeric, cumin, and seeds of fenugreek, fennel, *kalongi*, etc.) while frying pieces of ber fruits with mustard oil	Gently, juxtapose mixing of the salt, spices/ condiments (powder of aesfoitida, red chilli, turmeric, cumin, and seeds of fenugreek, fennel, *kalongi*, etc.) while frying pieces of tumba fruits with mustard oil
↓	↓
After mixing & slight rousting of the above material for 5 -6 minutes, switch off the gas *chulha* and take down the pan of mix prepared material of pickle and cool down the same.	After mixing & slight rousting of the above material for 5 -6 minutes, switch off the gas *chulha* and take down the pan of mix prepared material of pickle and cool down the same.
↓	↓
After cooling, the prepared material of pickle is filled in any suitable glassware	After cooling, the prepared material of pickle is filled in any suitable glassware

Process/ technique of preparing the pickle of *ber*	Process/ technique of preparing the pickle of *Tumba*
↓	↓
Boiled the mustard oil and get cool it and pour the same in glassware of pickle untill sinking of the prepared material of pickle and put it at a neat and cool place. It is ready to serve after a week of preparation and has long self-life.	Boiled the mustard oil and get cool it and pour the same in glassware of pickle untill sinking of the prepared material of pickle and put it at a neat and cool place. It is ready to serve after a week of preparation and has long self-life.
↓	↓
 Fig. Pickle of ber fruit (Var. Gola)	 Fig. Pickle of tumba fruit

(ii) Information/data (from respondents, secondary and online sources) on rural wisdom based traditional technologies, processing techniques, ideas, self hypothesizes methods, etc., of value addition of arid horticultural crops were collected and the works on their refinement/ standardization were also under taken. The initiation in this direction were like like dehydration of kachri, dehydration of round melon, *murrabah* of *tumba* fruits, dry pickle of date palm fruits, pickle and vegetable of cactus, *namakin dry* clusterbean pods, dry date fruits from degraded fruits of date palm, etc. (Fig. 54)

Dehydrated kachri | Dehydrated round melon | Murrabah of *tumba* | Dry pickle of date fruits

Pickle of cactus | Vegetable of cactus | Namakin clusterbean pods | Dry date fruits (degraded)

Fig. 54. Dehydrated products from arid horticultural crop.

(b) Synthesis/generation of technological new concepts/methods: In extension, a "Concept" is a term that expresses an abstract idea formed by generalizing from particulars and summarizing the related observations. 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, toffee of kinnow, ber, bael, pickle of mature pods (*sangari*) of *khejri, sarbat* of phalsa & ber, pickle and ice-cream of date palm fruits, jam, sauce & *sarbat* of karonda, honey of mulberry, sweets of *tumba*, etc., were synthesized to strengthen the wing of value addition/ post harvest management of the Institute. With the help of traditional/ indigenous knowledge, various concepts of eco-friendly pesticides/bio-pesticides used by the farmers to protect their arid horticultural crops were evolved. Such major were 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.

Other activities

Extension programme and activities

As per objectives and targets of the project, "*Technological intervention for arid horticultural development and its impact assessment*" various technological interventions/extension programmes were carried out/organized during 2015–16. Out of these, the major interventional activities/extension programmes carried out under this project during the year 2014 – 16 are being mentioned in short below.

Front line demonstrations/ adaptive trials: During the reported period of time, 10 frontline demonstrations of improved varieties of arid vegetable crops *viz*- AHS-82 (snap melon), AHK- 119 (*Kachri*) and Thar *Shobha* variety of khejri were conducted on farmers' fields at Chak No., 22KYD-Khajuwala Kalyansar, Bachhasar, 22KYD-Khajuwala, Akkasar, and Lunkarnsar village of Bikaner district dated: 16.07.15, 30.07.15, 28.09.15,16.110.15, 04.03.16 and 28.02.16 respectively. 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: 07 farmer's training programme (on/off campus) were conducted / organised and coordinated at the Institute and at farmer's fields. They were conducted at Bachhasar, 22KYD-Khajuwala, Khinchiya, *Akkasar* village of Bikner district and at the Institute dated *28.09.15*, 16.10.15, 18.11.15, 04.03.16, 11.03.16, 29.03.16 and 30.03.16, respectively on "improved agro-techniques of arid vegetable production and "orchard development of improved variety of khejri (*Thar Shobha*) through *in-situ* budding technique". Due to these training programmes increased knowledge, awareness, and interest among trainee > 200 farmers and field workers about improved agro-techniques of arid fruits and vegetable production in hot arid regions.

Participation in farmer's fair and arranging technological exhibitions: During the reported period 03 exhibitions of arid horticultural technologies were organized/ displayed at Lakhusar village of Bikaner district, RAJUVAS, Bikaner and At IARI, Pusa, New Delhi, dated- 06.08.15, 27. 02 .2016, 19- 21 March, 2016.

Visit and interaction/ meetings with farmers at the Institute : More than 600 farmers (both men& women), >250 school students, >100 supervisors, professionals, and other personnel were visited to the Institute's farm/experimental blocks and held acquainted/ exposed them with latest arid horticultural technologies as developed by the Institute.

Visit and interaction with students/young farmers at the Institute: Besides the farmers, >250 young farmers/students came from different

agricultural colleges/ university and schools of the Rajasthan state and other states of the country were visited to 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. were 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.

Visit to farmer's fields and interaction/ meetings with them: More than 30 farmer's fields were visited and they were provided with technical guidance/assistance in overcome their problems related to arid horticultural crop production. During the reported period, there were held >18 Research-Extension- Farmers- Interface Meeting (REFIM) with farmers and their fellow farmers while visiting their fields. Such kind of meetings was also held at the site of the demonstrations

Research- extension-farmers-interface meetings: During the reported period, there were held > 20 Research-Extension-Farmers-interface meeting 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.

During the reported period, the work on organization of Farmer's Interest Groups / Commodity Interest Groups/ Self-Help Groups were also initiated at the different sites/ locations/ villages of Bikaner districts (Rajasthan) where front line demonstrations of improved varieties of arid fruits/vegetables crops and their agro-techniques were conducted. Moreover, more than 110 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. were also organized. Later on, these groups were fallow upped and they were visited to the Institute and had essential technological interaction/ discussion with them to meet their interest. They were also motivated to adopt other improved arid technologies on their fields.

Inter Intuitional linkages/programmes organised/assisted: Strengthen functional linkage with sister organization / Institutions of the ICAR, KVKs, ATIC and Directorate of Extension of SKRAU, Bikaner, CAZARI 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.

Extension teaching- learning aids and e-learning materials developed: Technological photographs, graphs, charts, written materials for training programmers, slides/ CD/ DVD for presentation of technical matter/ films, newsletters, etc. were prepared and communicated to needy clients.

Providing technical literature: About 250 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.

Initiatives for commercialization of technologies : The important activities like conduction of method demonstrations, front line demonstrations/ adaptive trials on farmer's fields, organizing farmer's trainings programmes, celebration of Farm Innovators Day, research-extension-farmers-interface meetings, organization of farmers interest groups to acquaint them with latest improved technologies arid fruits and vegetables crop production and commercialization of the same. Moreover, the seeds/planting materials of improved varieties and knowledge on their production technologies were provided to farmers to encourage the production of the same at large commercial scale. As a result of technological exposure, some of the farmers have started the production of arid fruits and vegetables for direct consumption, marketing, value addition and also for seeds and planting material for commercial/ business point of view.

Technological interventions and impact assessment: As a one of the target/ objective of this project is to held activities for technological intervention and carry out the impact assessment of the same. 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 and my own observations are being presented in short as below.

(I) 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.

(II) Intervened technologies/processes/ methods: (1) Seed production techniques of improved varieties of arid vegetables like Kachri (AHK-119), Snaplmelon (AHS- 82), Seed treatment and fruit fly controlling technologies (2) In-situ budding based orchards development of improved varietiy of *khejri, ber* and other fruit crops (3) Seeds production technique of improved varieties of arid vegetables like *kachri,* snapmelon, etc. **(4)** 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*) (5) Innovative techniques of value addition/post harvest management of

arid fruits and vegetables (6) Improved/refined/ New agro-techniques of arid fruits and vegetable production (7) Production of planting materials of improved varieties arid fruits like *ber,* pomegranate, *phalsa, lasora,* etc. and management of nurseries of the same.

(III) Impacts assessment and success indicators observed and responded by farmers/ clients: As the results of technological interventions/ extension programmes/activities, the following impacts/out comes with respect to dissemination, adoption and diffusion of improved technologies, processes, products and methods were observed.

(IV) Impact in terms of increasing area and population of 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 as a result of direct or indirect technological interventions efforts of the ICAR- Central Institute of Arid Horticultural Institute, Bikaner. Presently, > 700 farmers/ clients are growing above improved varieties of arid fruits crops at large to subsistence level. Likewise, > 5200 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 net income of Rs. 146000-188000 /ha / season by growing improved varieties of arid vegetable like Kachri (AHK-119), Snaplmelon (AHS- 82), Mateera(Thar Manak). In case of arid fruits farmers' are getting gross income of Rs. 74000 - 105000/ha/year depending on age of the orchard, climatic conditions and orchard management practices

Some the farmers (7 - 8) 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 the farmers/ persons (3 - 4%) 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.

Increased the quality and quantity (> 32%) 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,(released by the Institute) 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: There were observed several changes as a result of extension interventional programmes and adoption/ reaching the improved technologies to users fields/clients working places. There were sign of motivation for adoption of horticultural crops and commodities. Increasing flow of farmers from laggardism to innovatism. 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 sifting 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 being including the horticultural crops as one of the essential component of their existing farming / cropping system.

3. TRAINING AND CAPACITY BUILDING

TRAINING/ CAPACITY BUILDING

Dr. B. D. Sharma

Attenmded management development programme on Leadership Development (a pre-RMP programme) attended during November 30 - December 11, 2015 at National Academy of Agricultural Research Management, Hyderabad.

Dr. Pinaki Acharrya

Attended the winter school on "Advances in Improvement of Vegetable crops using biotechnological approaches" at Division of Vegetable Science, ICAR Indian Agricultural Research Institute, New Delhi from 18th September-8th October, 2015.

In the capacity of Course-coordinator, ICAR sponsored 10 days training programme on "**Good management practices for Arid horticultural crops to combat current Agrarian Crisis in arid region"** held at ICAR CIAH, Bikaner from 25th Feb to 5th March, 2016.

Dr. S. K. Maheshwari

Dr. S. K. Maheshwari organized one day off campus farmer's training programme entitled: "Disease management of arid fruit crops" on 23-11-2015 at Bachchhasar village of the Bikaner district with extension scientist (As per RFD target).

Dr. M. K. Jatav

Off campus farmers training programme on Nutrient management of clusterbean and mateera in the arid region" in Khinchiya village of Bikaner district on 30-11-2015.

Off campus farmers training programme on Nutrient management of *kachari* and snap melon" in Sherekunjiya/Khinchiya village of Bikaner district on 18-11-2015

Dr. R. S. Singh

Worked as Major guide for a P.G. (Hort.) student (Ms. Meena Kumari) and research work conducted at CIAH, Bikaner and thesis work completed for award of degree in July 2015.

Major guide for a PG student (Mr. Ganga Dutt Awasthi), of COA,SKRAU, Bikaner & completed his thesis research work on date palm at CIAH, Bikaner during 2015-16.

Organized Agricultural Education Day programme on 22.7.2015 for students/teachers at CIAH, Bikaner and 106 participants were attended the programme.

Conducted Orientation Training Programme of ARS Probationer Scientist (Dr.L.P.Yadav, Scientist, (Vege.) and Dr. VikasYadav, Scientist (Fruit Sci.) as mentor for four weeks at CIAH, Bikaner from 8April to 10 May, 2015.

Conducted Orientation training programme of ARS Probationer Scientist (Mr, Gangadhara, K., Scientist, (Vege.) and Dr. Vijay Rakesh Reddy,S., Scientist (Fruit Sci.) for four weeks at CIAH, Bikaner from 12 October to 13 November, 2015.

Dr. P. P. Singh

Attended 10 days ICAR sponsored short course on Crop Wild Relatives (CWR): Identification collection and utilization during 19-28 August 2015 at Germplasm, Conservation Division, NBPGR, New Delhi.

Attended refresher course on Agricultural Research Management organized at ICAR-NAARM, Hyderabad during February 23 to Mach 05, 2016.

Attended 10th Fefresher course on Agricultural Research Management at NAARM, Hyderabad from 23rd February to 5th March, 2016.

Attended in Competency Development Programme for HRD nodal Officers of ICARs at NAARM, Hydeerabad on 10-12 Feb., 2016.

At Godhra

Farmers visit

1. A total of 2554 visitors which include the farm men 1837, women 340, extension workers 111, students 266, who visited CHES from government and Non-government organizations during the 2015-2016
2. One day exposure visit to CHES by 266 RAWE Students from Navsari Forestry and Horticultural College and SPEE College of Agril. University, Gujarat.

Dr A. K. Singh

1. Actively particiapted in Krishi Mahotsawa, 2015 held at Lunawada, District Mahisagar on 22 April, 2015. Live samples of different varieties of bael, Khirni, Sapota, Drumsticks were exhibited during the programme.
2. Particiapted in Ravi Krishi Mahotsawa, 2015 held at Adiwasi Sansodhan Talim Kendra Lunawada, Devgadh Varia on 02/01/ 2016. Live samples of different varieties of bael, Khirni, Sapota, Drumstick were exhibited during the programme.

TRANSFER OF TECHNOLOGY

Dr Sanjay Singh

Lectures delivered in training programmes (ATMA).

1. On 10/8/2015 (Dahod Taluka, 30 farmers), 11/8/2015 (Garvada, 30 farmers), 12/8/2015(Jhalod Taluka, 30 farmers) and 13/8/2015 (Limkheda, 30 farmers), Lecture was delivered to the farmers of ATMA, from different Talukas of Dahod district on cultivation of jamun, tamarind, mahua, chironji, karonda, phalsa, mango and sweet orange.
2. On 13/10/2015(Jhalod Taluka, 30 farmers), 14/10/2015(Fatepura Taluka, 30 farmers) 16/10/2015(Limkheda taluka, 30 farmers), and 17/10/2015(Dhanpur taluka, 30 farmers),, Lecture was delivered to the farmers of different Talukas of ATMA, Dahod on cultivation of underutilized fruits mango and sweet orange.
3. On 19/10/2015(Deogarh Baria taluka, 34 farmers),, Lecture was delivered to the farmers of ATMA, district Dahod on cultivation of underutilized fruits, mango and sweet orange.
4. On 27/1/2016(Dhanpur taluka, 33 farmers), 28/1/206(Dahod taluka, 30 farmers), 30/1/2016, (Garvada taluka, 33 farmers), 1/2/2016(Jhalod taluka, 30 farmers) and 8/3/2016 (Dhanpur taluka 25 farmers) Lecture was delivered to the farmers of different Talukas of ATMA, Dahod on cultivation of underutilized fruits, mango and sweet orange.

Training programmes.

1. Short course programme sanctioned by ICAR for 10 days was conducted at the station for scientists of the country on the topic "xploitation of underutilized horticulture crops for sustainable production from 11th-20th Feb, 2016.
2. At the station, training from 01-01-16 to 31-01-2016 was organized on Semi arid horticulture for livelihood and nutritional security for BRS students at CHES, Vejalpur. Following lectures were delivered (Acted as course Coordinator).

Date	Name of the topics
01.01.2016	Activities of CHES
06.01.2016	Diseases of vegetables
7/1/16	Crop production of karonda
14/1/2016	Crop production of chironji and Mahua
16/1/2016	Crop production of manila tamarind.
18/1/2016	Crop production of pomegranate cv Goma Khatta.
19/1/2016	Sweet orange cultivation
20-1-2016	Canopy management
20-1-2016	Fruit quality analysis
20-1-2016	Value addition of fruits
20-1-2016	Practical
21/1/16	Crop production in jamun cv Goma Priyanka
21/1/16	Pest management in mango
22/1/16	Cultivation of mango
23/1/16	Crop production in tamarind cv Goma Prateek
25/1/16	Propagation techniques of under utilized crops
28/1/16	Extension methods for dissemination of horticultural technologies

Dr A. K. Singh

Training to BRS Students

Lecture delivered to BRS Student during training entitled Semi-arid horticulture for livelihood and nutritional Security to BRS student's from 01/01/2016 to 31/01/2016

1. Cultivation of aonla, 02/01/2016
2. Cultivation of Jamun and Phalsa, 02/01/2016
3. Planting system cum high density in aonla, 02/01/2016
4. Production technology of wood apple, 06/01/2016
5. Value added products, 06/01/2016
6. Crop improvement in bael, 07/01/2016
7. Consumption of fruit and vegetable for overcoming malnutrition, 11/01/2016
8. Medicinal value of noni , 13/01/2016
9. Agro-techniques of rainfed horticulture development, 14/01/2016
10. Precision farming, 22/01/2016
11. Production technology of bael, 23/01/2016
12. Production technology of noni, 25/01/2016
13. Production technology of aonla, 28/01/2016
14. Landscaping, 28/01/2016

Training to ATMA farmers

No.	Department/ Agency ATMA	No. of Farmers		Total	Lectures delivered	Date
		Male	Female			
1	Dahod,Garbada	-	30	30	Production technology of bael	11-8-2015
2	Zalod	-	30	30	Varieties of bael	12-8-2015
3	Limkheda	30	-	30	Production technology of aonla	13-8-2015
4	Sanjeli	-	30	30	Cultivation of wood apple	14-8-2015
5	Dhanpur	32	-	30	Medicinal value of bael	15-8-2015
6	Dev garh Baria	34	-	30	Cultivation custard apple	17-8-2015
7	Fatehpura	30	-	30	Propagation of bael and aonla	18-8-2015
8	Zalod	-	30	30	Scientific cultivation of bael	11-10-2015
9	Garbada	30	-	30	Ber cultivation	12-10-2015
10	Dahod	-	30	30	Wood apple propagation	13-10-2015
11	Fatehpura	30	-	30	Stress management in bael	14-10-2015
12	Limkheda	30	-	30	Varieties of aonla	16-10-2015
13	Dhanpur	30	-	30	Canopy management in bael	17-10-2015
14	D.Baria	34	-	30	Fruit drop and sunscald management in bael	19-10-2015
15	Sanjeli	-	30	30	Scientific cultivation of bael	20-10-2015
16	Dhanpur	-	33	30	Production technology of aonla	27-11-2015
17	Dahod	30	-	30	Production technology of bael	28-11-2015
18	Garbada	33	-	33	Inter cropping in bael orchard	30-11-2015
19	Zalod	-	30	30	Cultivation of noni	01-02-2016
20	Dhanpur	24	-	25	Post harvest products of bael and aonla	08-03-2016

Dr V. V. Appa Rao

Training to BRS Students

Lecture delivered to BRS Student during a training course entitled "Semi-arid horticulture for livelihood and nutritional Security" coordinated by Dr. Sanjay Singh from 01/01/2016 to 31/01/2016 at CHES, Vejalpur.

1. Micronutrient spray in horticultural crops-V.V.AppaRao (5.01.16)
2. Micronutrient spray in horticultural crops (Practical)-V.V.AppaRao (5.01.16)
3. Nutrient management in vegetable crops - V.V.AppaRao(12.01.16)
4. Nutrient management in vegetable crops (Practical) - V.V.AppaRao(12.01.16)
5. Nutrient deficiency symptoms and its correction-V.V.AppaRao(14.01.16)
6. Nutrient deficiency symptoms and its correction (Practical)-V.V.AppaRao(14.01.16)
7. Soil testing-V.V.AppaRao(15.01.16)
8. Role of water management-V.V.AppaRao(5.01.16)
9. Organic farming in vegetable crops-V.V.AppaRao(18.01.16)
10. Soil analysis -V.V.AppaRao(19.01.16)
11. Role of water management-V.V.AppaRao(19.01.16)
12. Soil analysis and Role of water management (practical)-V.V.AppaRao(19.01-16)
13. Irrigation water analysis-V.V.AppaRao(22.01.16)
14. Preparationofcompost-V.V.AppaRao(23.01.16)
15. Preparation of compost (Practical)-V.V.AppaRao (23.01.16)
16. Plant Analysis-V.V.AppaRao (25.01.16)
17. Nutrient management in fruit crops - V.V.AppaRao(28.01.16)
18. Nutrient management in fruit crops (Practical)-V.V.AppaRao(28.01.16)

Farmers' Training

Front Line Demonstrations

4. WOMEN EMPOWERMENT

PROGRAMMES/ACTIVITIES FOR EMPOWERMENT OF FARM WOMEN

>200 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 during 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- Govern organization.




5. AWARDS AND RECOGNITIONS

AWARD

Dr. B. D. Sharma

Best Oral Presentation Award for the paper on "Morphological characterization for DUS testing of Indian Jujube (Ziziphus mauritiana Lamk.)" by H. Krishna, R. Bhargava, B. D. Sharma and S. K. Sharma (2015). In: 3rd International symposium on minor fruits, medicinal & aromatic plants at Bangladesh Agricultural University, Mymensingh, Bangladesh,

Best Oral Presentation Award for the paper on "Reaching the masses. Farmers with recent innovations in arid horticulture: Problems and Prospects" by Meena, S. R., R. S. Singh B. D. Sharma and D. Singh. In: National Symposium on Modern Agro-technologies for nutrition security and Health. Dr. Y. S. Parma of Hort. & Forestry, Nauni, Solan. 21-23 April 2015.

Best Oral Presentation Award for the paper on "Reaching the masses. Farmers with recent innovations in arid horticulture: Problems and Prospects" by Meena, S. R., R. S. Singh B. D. Sharma and D. Singh. In: National Symposium on Modern Agro-technologies for nutrition security and Health. Dr. Y. S. Parma of Hort. & Forestry, Nauni, Solan. 21-23 April 2015.

Best Poster Presentation Award for the paper "Production and consumption systems of cucurbitaceous arid vegetables in the hot arid zone of the western Rajathan: Evaluation" by Meena, S. R., R. S. Singh B. D. Sharma and D. Singh (2015). In: 4th Jammu and Kashmir Agricultural Science Congress on Technological innovations, opportunities and challenges for sustainable rainfed agriculture for food and livelihood security from 28-30 October 2015.

Dr. Sanjay Singh

Received award for excellence in developing technologies for dry land horticulture by N M Sadguru water and development Foundation, Dahod, Gujarat during the National Seminar on Potential of Dry land Horticulture in Semi Arid Ecosystem on 7-12-2015.

Dr. S. R. Meena

Awarded with Best oral presentation award for the presentation a research paper entitled "Reaching the masses/farmers with recent innovations in arid horticulture : Problems and prospects" during the National Symposium on Modern agro- technologies for nutritional security and health, organized by society for advancement of human and nature at YSPUSH, Solan, HP, India, from 21 - 23 April, 2015.

Awarded with Third Best Poster presentation award for the research paper entitled " A study on farming systems and crop diversification through horticultural crops for livelihood security in hot arid region of the Western Rajasthan, India " during the 4th Jammu and Kashmir Agricultural Science Congress on technological innovations, opportunities and challenges for sustainable rainfed agriculture and livelihood security, held at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu, From 28 - 30 October, 2015.

Awardede with BHARAT SHIKSHA RATAN AWARD by the *Global Society for Health and Educational Growth* in recognition of sterling merit excellent performance and outstanding contribution for progress of nation and worldwide, during a national seminar on Individual Achievements & National Development, dated 21st September, 2015, at New Delhi.

Dr. S. K. Maheshwari

Dr. S. K. Maheshwari, Senior Scientist (Plant Pathology) awarded "SPPS Fellow 2015" from Society of Plant Protection Sciences, ICAR-NCIPM, Pusa Campus, New Delhi in "11th National Symposium on Dynamics of Crop Protection: Challenges in Agri-horticultural Ecosystems Facing Climate Change" scheduled to held during 23-25th April, 2015 at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan).

Dr. S. K. Maheshwari, acted as 'Rapporteur' (Technical session) in National Symposium on "Dynamics of Crop Protection: Challenges in Agri-horticultural Ecosystems Facing Climate Change" scheduled to held during 23-25th April, 2015 at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan).

Dr. S. K. Maheshwari, acted as 'Rapporteur' (Technical session) in National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District-Satna (M.P.).

Dr. S. K. Maheshwari selected as Journal Editor of *Current Horticulture* published by Society for Horticulture Research and Development, Ghaziabad (U.P.).

Dr. S. K. Maheshwari served as Invigilator for conducting examination for AIEEA-UG-2015 of ICAR (New Delhi) at SKRAU, Bikaner on 11-04-2015.

Dr. S. K. Maheshwari secured third position in "Hindi Samaanya Vyaakaran Gyaan Pratiyogita" in celebrating Hindi Chetna Saptaah at our Institute during September, 2015.

Dr. S. K. Maheshwari acted as 'Outside Subject Expert' in Rajiv Gandhi National Fellowship for assessment of progress of Mr. A. K. Meena, Ph. D. Scholar to held on 10th July, 2015 at Department of Plant Pathology, COA, SKRAU, Bikaner.

Dr. Dhurendra Singh

Awarded Fellowship of Confederation of Horticulture Association of India during May 2015

Dr. Hare Krishna

Awarded Best Oral Presentation for presentation entitled 'Characterization of *ber* (*Ziziphus mauritiana* Lamk.) varieties as per DUS guidelines' during National Symposium on Modern Agro-technologies for Nutritional Security and Health (MANUSH) held on 21-23 April, 2015 at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan.

Adjudged Best Oral Presenter for presentation entitled 'Morphological characterization for DUS testing of Indian jujube (*Ziziphus mauritiana* Lamk.)' during 3rd International Symposium on Minor Fruits, Medicinal & Aromatic Plants (ISMF&MAP)' held on 20-21 May, 2015 at Bangladesh Agricultural University, Bangladesh.

Awarded First Prize in oral presentation for presentation entitled '*Karonda* (*Carissa carandus* L.): a source of natural colourant and nutraceuticals-supplement' during *International Conference on Natural Resource Management: Ecological Perspectives* held on 18-20 February, 2016 at Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu Chatha-Jammu (J&K).

Acted as Co-Course Director for ICAR sponsored Short Course on 'Good management practices for arid horticultural crops to combat current agrarian crisis (25th February-5th March, 2016)'.

केन्द्रीय शुष्क बागवानी संस्थान में सितंबर माह, 2015 में हिन्दी चेतना सप्ताह के दौरान आयोजित 'हिन्दी में वैज्ञानिक शोध पत्र पोस्टर' प्रतियोगिता में प्रथम स्थान प्राप्त किया।

राष्ट्रीय उष्ट्र अनुसंधान केंद्र, बीकानेर में सितंबर माह, 2015 में आयोजित 'हिन्दी में वैज्ञानिक शोध पत्र पोस्टर' प्रतियोगिता में द्वितीय पुरस्कार प्राप्त किया।

Dr. M. K. Jatav

Young Scientist Award by SSDAT (Society for Scientific Development in Agriculture & Technology) on occasion of National Conference on Global Research Initiatives for Sustatable Agriculture & Allied Sciences (GRISAAS-2015 during 12-13 December, 2015 held at Rajmata Vijayaraje Sciendia Krishi Vishwa Vidyalaya, Gwalior (MP).

Best Oral presentation was given on Effect of micronutrient application in mateera under arid region of Rajasthan in International Conference on "Agriculture, Food Engineering and Environmental Sciences- Sustainable Approaches" (AFESA- *2015) Organized by* Jawaharlal Nehru University, New Delhi during 9th and 10th May, 2015.

Best Oral presentation was given on Nutrient Dynamics of Fruit Based Diversified cropping Models for Arid Region of Rajasthan in National Conference On Innovative Research in Agriculture, Food Science, Forestry, Horticulture, Aquaculture, Animal Sciences, Biodiversity, Environmental Engineering and Climate Change (AFHABEC-2015) Organized by "Krishi Sanskriti" On 17th and 18th October, 2015 Organized by Jawaharlal Nehru University, New Delhi.

Dr. A. K. Singh

A. K. Singh, Sanjay Singh, R. S. Singh, and Purnima Makwana (2014). Evaluation of bael germplasm under rainfed hot semi-arid environment of western India. In Second world Noni Congress, Noni and medicinal plants for inclusive growth and wellness held at Chennai from 19th to 21st March, 2016, p.55. (Awarded as best oral presentation)

Arya, L, Narayanan, K.,Verma, M., Singh, A. K. and Gupta, V. (2014). Genetic diversity and population structure analysis of *Morinda tomentosa* Heyne ex Roth with neutral and gene based markers. *Genetic Resources and Crop Evolution*, DOI10.1007/ s10722-014-0168-4. In Second world Noni Congress, Noni and medicinal plants for inclusive growth and wellness held at Chennai from 19th to 21st March, 2016 (Awarded as best paper).

A. K. Singh, Sanjay Singh, Kavi Contractor and Purnima Makwana (2015). *Sukha vistar na kheduto mate uttam ane labhkari bili ni kheti*. Uttam Lekh Award from AAU, Anand for the article entitled, published in Krishi Govidya March, 2015.

RECOGNITION

Dr. B. D. Sharma

Director, CIAH, Bikaner nominated me to act as Examination Nodal Officer of the AIEEA-UG-2015 Examination held at Bikaner on 09-04-2015

Acted as Rapporteurs in Action Taken Report and Plenary Sessions in XX Workshop of AICRP on AZF, held at SKRAU, Bikaner during 4-6th February 2016

Delivered the Invited lecture on "Evolving -Horticulture production systems in climate change of arid region". In: National Workshop on Climate Change: Mitigation and Adaptation in Hot Arid Regions (NICRA) on 26th February 2016.

Acted as Co-Chairman in the Technical Session II In: National Workshop on Climate Change: Mitigation and Adaptation in Hot Arid Regions (NICRA) on 26th February 2016.

Delivered the Invited lecture on "Nutritional and Economic Crop Water productivity in Arid and Semi-Arid Region". In: Workshop on Improving Water Productivity in IGNP Canal Command Areas. national Workshop on Indo-ICARDA project at CAZRI, RRS, Bikaner.

Dr. S. R. Meena

Life membership as a Founder member of "Society for Agriculture and Arid Ecology Research (SAAER)" during the reported period.

Dr. Dhurendra Singh

President of Society for Agriculture and Arid Ecology

Dr. Jagan Singh Gora

Editorial member in Hindi patrika namely KRISHI KIRAN.

Dr. P.P. Singh

Acted as 'Rapporteur' (Technical session) in National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District- Satna (M.P.).

Received Second position in Hindi sabda lekhan pratiyogta (Scientists group) during Hindi Chetna saptaha September 2015.

Dr. Pinaki Acharyya

Nominated as an "Editor" for the online journal " Open Agriculture" for Tropical agriculture and horticulture sections brought out by De Gruyter Open, Warsaw, Poland in September, 2015.

Appointed as Associate Editor (Agriculture, Veterinary Sciences, Forestry, Food Sciences) as Book Author of De Gruyter, Warsaw, Poland in September 2015.

Selected as a Member and reviewer of Notulae Botanicae Horti Agrobotanici -Napoca, Romania.

Appointed as "Editor -In -Chief" of the journal " Journal of Agriculture and Ecology"(On line) brought forth by Society for Agriculture and Arid Ecology Research, Bikaner.

Co-Organizing Secretary in the National Seminar on " Agriculture Resource Management for Sustainability and Eco-Restoration", held from 11th-13th March,2016 and organized by Society for Agriculture and Arid Ecology Research, Bikaner.

Dr. R. S. Singh

Nominated by Council as Memebr of IMC, CAZRI, Jodhpur for three years from 29.8.2015 to 28.8.2018.

Acted as Chairman in a Technical Session in National Symposium on Modern Agrotechnologies for Nutrition and Health at Dr.YSPUHF ,Solan on 21.4.2015.

Acted as Co-Chairman in Technical session on Horticulture, Medicinal plants National Conferecne on Natural Resource managementin semi arid and arid ecosystem for climate resssilent agriculture and rural delopemnt at SKRAU,Bikaner on 18.2.2016.

Acted as Rapporteur in Session o n Farmers-Interaction Meet in AICRP on AZF Annual Group Meet on 6.2.2016 at SKRAU,Bikaner.

Dr Sanjay Singh

Participated in Agriculture Research Council meeting at Navsari Agricultural University, Navsari, Gujarat on 4/4/2015.

Conducted Ph.D. preliminary viva-voce exam Student Sh. R.M Thakkaral AAU, Anand, Gujarat on 6/4/2015.

Acted as member in the SAC meeting of KVK, Panchmahals, Vejalpur on 13-5-2015.

Acted as member for selection of SRF in Borer Project on 15-5-15.

Conducted Ph.D. Thesis viva at AAU, Anand, name of Student was Rajnikant Thakkar on 28/8/2015.

Acted as member for selection for SRF at DMAPR,Boriavi Anand in DST Project on Mango burl on 14/9/2015.

Acted as member (DG nominee) in the Board of management meeting at NAU Navsari on 1/10/2015.

Acted as Co Chairman of the session" Fruit cracking in pomegranate" on 3-10-2015 at NRC Pomegranate, Solapur on the workshop on fruit cracking and soil health management in pomegranate.

Attended meeting to finalize the draft guideline on Jamun at CHES, Godhra on 15/10/2015..

Acted as member (DG nominee) in the Board of management meeting of NAU, Navsari at Ghandhinagar, krishibhavan on 21/10/2015.

Attended expert in viva voce exam of Ph.D. student thesis at NAU, Navsari student Khopade Rohan Y. on 16/11/2015.

Acted as member in 1st meeting of committee for internal evaluation to forward research papers to scientific journals at NM College, NAU, Navsari on 18/12/2015.

Presented keynote lecture on "Arid fruits for livelihood and rural development on 28-5-2015 in the National seminar on "Dynamics of smart horticulture for livelihood and rural development organised by ASM foundation at MGCGV, Chtrakoot.

Acted as Co-Chairman in the Technical Session-6 on Shelf life enhancement, Value addition and Waste utilization on 29-5-2015 in the National seminar on "Dynamics of smart horticulture for livelihood and rural development organised by ASM foundation at MGCGV, Chtrakoot.

Acted as member in the organizing committee in the National seminar on "Dynamics of smart horticulture for livelihood and rural development organised by ASM foundation at MGCGV, Chtrakoot.

Presented the lead paper on "Potential of underutilized fruits in India with special reference to indigenous technologies in the International seminar on indigenous technologies for sustainable agriculture and better tomorrow during 9-10th January, 2016 at NBRI, Lucknow organized by Samagra Vikas Welfare Society, Lucknow.

Acted as Chairman for the oral presentation of the session-2 in the International seminar on indigenous technologies for sustainable agriculture and better tomorrow during 9-10th January,2016 at NBRI, Lucknow organized by Samagra Vikas Welfare Society, Lucknow.

Acted as chairman of the organizing committee of the International seminar on indigenous technologies for sustainable agriculture and better tomorrow during 9-10th January,2016 at NBRI, Lucknow, organized by Samagra Vikas Welfare Society, Lucknow.

Acted as member of Judging committee to select best oral and poster presentation in the Second World Noni Congress from 19-3-2016-20-3-2016 at SRM University, Chennai.

Acted as organizing secretary in the national seminar on potential of dry land horticulture in semi arid ecosystem on 7-12-2015, organized by N M Sadguru Water and Development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

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 SKRAU, Rajasthan.

Delivered invited paper entitled 'Advances in production of mango and sweet orange" in the national seminar on potential of dry land horticulture in semi arid ecosystem on 7-12-2015, organized by N M Sadguru water and development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

Delivered invited paper entitled 'Advances in underutilized fruits and their conservation in semi arid ecosystem of western India" in the national seminar on potential of dry land horticulture in semi arid ecosystem on 7-12-2015, organized by N M Sadguru water and development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

Reviewed the research paper of Journal of food science and Technology entitled Antioxident components and physico chemical characteristics of Jamun Powder supplemented rear juice on 31/8/2015.

Reviewed the research paper entitled Effect of GA3 and BA on germination and morpho-physiological characteristics in jamun (Syzygium cumini L. Skeels) under different propagation substrates in the Journal Agricultural Research on 8/9/2015.

Reviewed the research paper of Journal of food science and technology on development of osmo air dried product from litchi fruits affected with fericarp browning using RSM on 23/10/2015.

Reviewed the research paper entitled study on Study on physico-morphological characteristics of 14 Bael (*Aegle marmelos* Corr.) genotypes grown at Chapainawabganj

Acted as Course Director during one month training course entitled Semi-arid horticulture for livelihood and nutritional Security to BRS students from01/01/2016to31/01/2016 at CHES (CIAH) Vejalpur, Panchmahals, Gujarat.

Acted as Course Director during the short course entitled exploitation of underutilized horticultural crops for sustainable production from 11/02/2016-20/02/2016 at CHES (CIAH) Vejalpur, Panchmahals, Gujarat.

Dr. A. K. Singh

Reviewed the research paper of IJAS entitled Influence of climate change on flowering and fruiting behavior of mango authored by D. R. Kanjaria, R. S. Chovatia, N. D. Polara and D. K. Varu June17, 2015.

Worked as external referee for to examine the thesis entitled ''Effect of PGRS and rooting media on air layring in guava (*Psidium guajava*)"submitted by Mr Baldaniya B. D. , P. G. Student, Department of Horticulture, JAU, Junagadh, 25/05/2015.

Worked as external referee for to examine the thesis entitled Effect of season and growing environment on success of soft wood grafting in chironji (*Buchnania lanzan* Spreng) submitted by Gohil Chiragkumar Hemraj Bhai, P. G. Student, NAU Navsari, dated 16/05/2015.

Worked as external referee for to examine the thesis entitled Effect of shoot thinning and 24—homobrassinolide spray on growth, flowering, yield and quality of mango cv. Kesar submitted by Ramani Manish Mukesh Bhai P. G. Student, NAU Navsari, dated 16/07/2015.(Registration no. 2020213040).

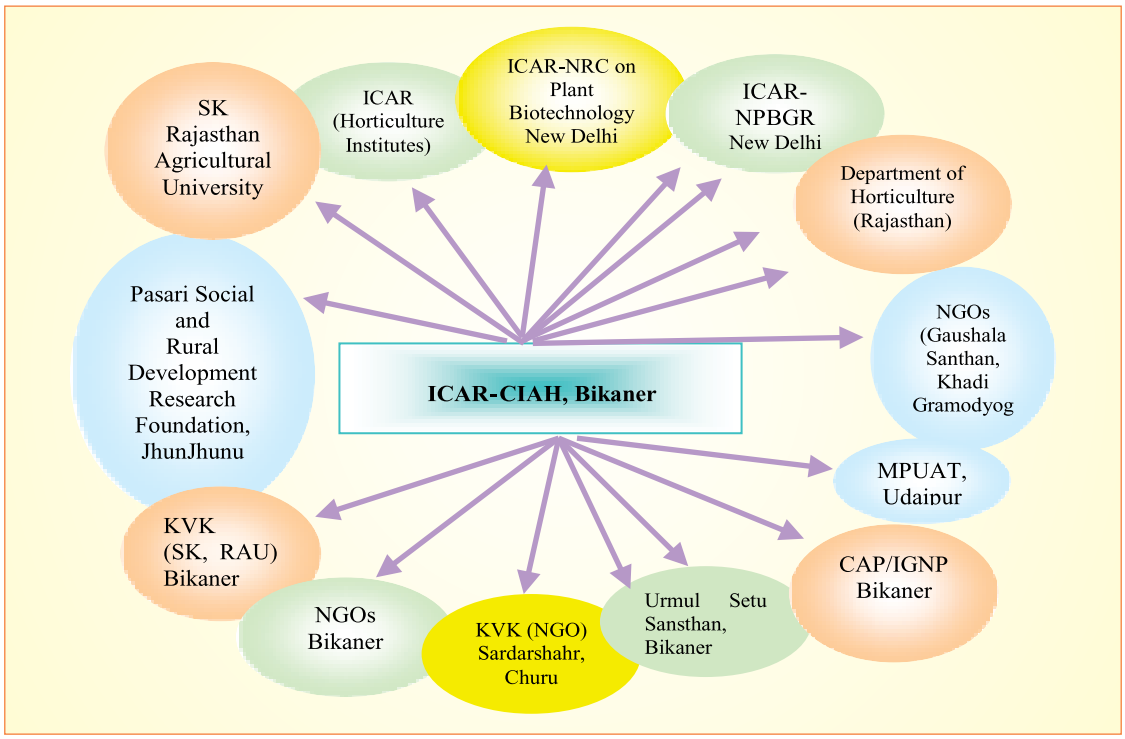
Aced as member of Joint Inspection Team (JIT) for monitoring of National Horticulture Mission (NHM) component of Mission of Integrated development of Horticulture (MIDH), National Mission on Micro Irrigation (NMMI) and other horticultural related programme (NHB, RKVY, OFWM, CBD) from 21 – 27 September, 2015 through field verification of Gujarat state.

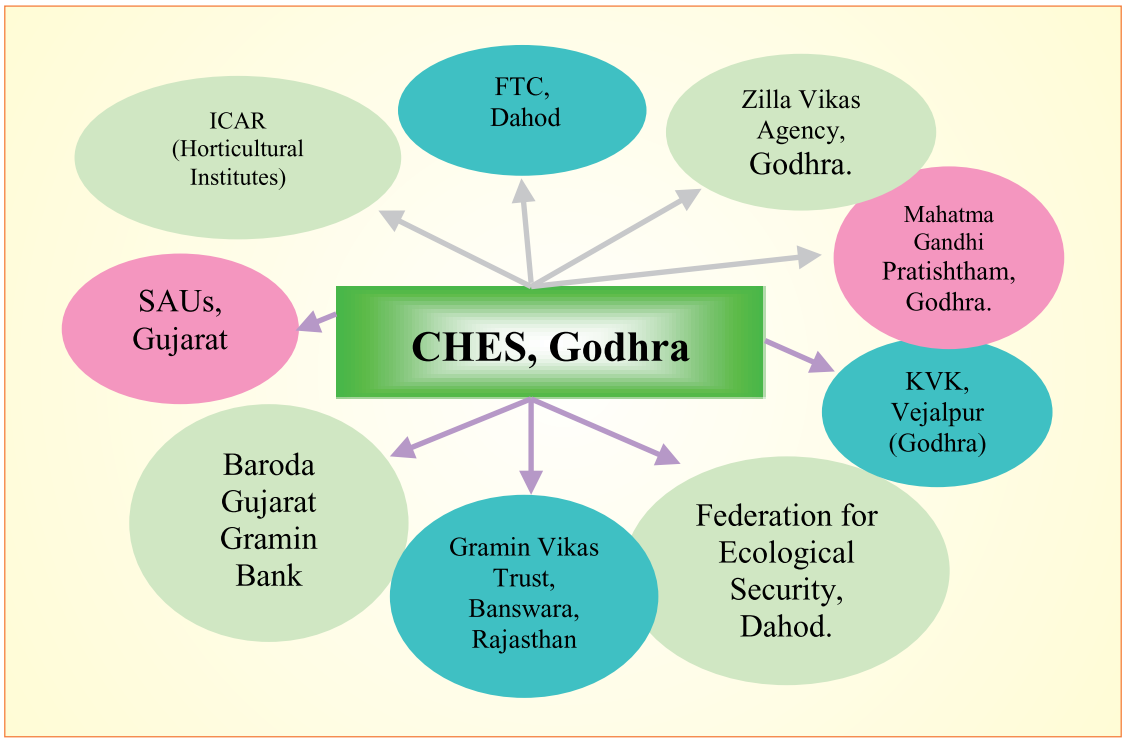
Acted as rapporteur during the technical session, training, pruning growth and development and fruit processing of AICRP on AZF held from 4-6 February, 2016 at Bikaner.

Acted as Course coordinator during the short course entitled exploitation of underutilized horticultural crops for sustainable production from 11/02/2016-20/02/2016 at CHES (CIAH) Vejalpur, Panchmahals, Gujarat.

Acted as Co Course coordinator during one month training course entitled Semi-arid horticulture for livelihood and nutritional Security to BRS students from01/01/2016to31/01/2016 at CHES (CIAH) Vejalpur, Panchmahals, Gujarat.

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
Funding Agency	:	Protection of Plant Varieties and Farmers' Rights Authority, New Delhi

During summer season of 2015 maintained the seed of watermelon (Sugar Baby, Arka Manik, Asahi Yamato, Durgapura Kesar, Durgapura Lal, AHW-19, AHW-65, Thar Manak) and muskmelon (Pusa Madhuras, Durgapura Madhu, MHY-3, MHY-5, RM-43, RM-50, GMM-3, Arka Jeet, Arka Rajhans, Kashi Madhu, Punjab Sunehri, Hara Madhu) varieties through inbreeding for further use in DUS testing.

2. DUS Centre on *Ber*

PI: Dr. Hare Krishna, Sr. Scientist

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

During the reported period, a new separate block of Indian jujube (*Ber*) is being developed at ICAR-CIAH, Bikaner for the 26 reference varieties as mentioned in National DUS Test Guidelines for *Ber*. These reference varieties are also being maintained at Germplasm block of *ber*. Morphological characteristics of these reference varieties were also recorded so as to confirm the distinctness, uniformity and stability in the described characters.

3. DUS Center on Date palm

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

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

Under the DUS centre on Date palm, the spathe emergence/opening characters, leaflet size, thorns were recorded in 26 date palm varieties and variation was observed among the varieties. Delay in emegence of spathe was noticed in male and female palms during the year .The data on fruiting character was recorded during third year of study. However, fruits were damaged in maximum varieties due to continuous rain at harvesting time. The draft guidelines for DUS on date palm was prepared and submitted to Chairman, Task force committee and Joint Registrar, PPV&FRA for suggestion/comments and to conduct of meeting for further course of action for finalization of DUS guidelines.

4. Consortium Research Platform (CRP) on Agro-biodiversity

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

Co-PI: Dr. Hare Krisha, Sr. Scientist

The project was initiated as Co-operating centre for characterization, documentation, regeration and conservation of arid fruit crops. The work on characterization of ber and Mulberry and documentation was started. During the period under report, 86 ber and 10 mulberry varieties/ accessions were chracterized on morphological and fruit characters basis . A survey was also conduted in Panchmahals district, Gujarat to identify and collect wood apple fruit sample. Genetic diversity was observed in fruit size and tree growth in natural population. 10 fruit sample were collected from natural diversity and morphological and quality parameters were studied.

A survey was made in Godhra for collection of elite wood apple genotypes. Later, fruits of these genotypes were were subjected to physico-chemical analyses. Distinct variations were noted for the recorded characteristics. Highest fruit weight was noticed in genotype GWC-3, while highest TSS was noted in GWC-5 (Table 47).

Table 47. Physico-chemical properties of wood apple collections.

S. No.	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Shell weight (g)	Pulp weight (g)	TSS (°Brix)
GWC-1	64.5	72.8	224.3	110.1	114.5	10.2
GWC-2	63.4	75.1	190.1	84.6	105.6	12.6
GWC-3	69.8	74.2	405.2	167.8	237.6	14.4
GWC-4	58.3	59.9	114.3	52.00	62.6	8.4
GWC-5	63.1	69.7	224.9	97.5	127.6	19.2
GWC-6	76.2	77.4	281.3	66.1	215.1	15.6
GWC-7	56.6	62.4	127.7	56.0	71.6	6.6
GWC-8	52.6	48.1	59.5	26.0	33.6	13.8
GWC-9	62.1	62.8	142.4	77.8	64.7	12.6
GWC-10	52.5	54.3	85.8	47.6	38.4	11.4

5. Production & Demonstration of tissue culture raised plants under three locations & collection & maintenance of elite germplasm of date palm

Evaluation of tissue culture raised plants supplied by coordinating centers under field conditions

Selection and preparation of field for tissue culture plants and plantation

Two hectare land his identified for field evaluation of tissue culture plants. Necessary field preparation and layout work has been completed. Several planting requirements of FYM, fertilizers, pesticides and chemicals have been arranged. 25 tissue culture plants of date palm of elite local genotype produced under project at AAU, Anand have been procured and planted on 27.07.2013. 160 tissue culture plants of date palm of elite local genotype produced under project at AAU, Anand were planted on 28.08.2014 and planted 133 plants on 09.09.2014. Remaining 27 plants kept in green house for further growth and development and will be planted in the month of March 2015. These plants were irrigated regularly. Two applications of chloropyrophos were given during September and October 2014 to protect the plants from termite attack. 25 plants planted during July 2013 were protected from wild boar by fixing thorny biomass of *Ziziphus* species surrounding these plants. The plants were protected from wild animals by fixing wire mesh fencing.

During third year of project period 180 plants of Barhee variety were procured from AAU, Anand at secondary hardening stage during the month of November 2015. The plants kept under greenhouse for further hardening and growth and development of plants.

The following observations were recorded on these plants.

The observation recoded with respect to:

- Percentage of field establishment of tissue culture plants
- Plant height
- Number of opened leaves per plant
- Canopy size of plants
- Incidence of pests and diseases

It appears from the table 48 that encouraging results were obtained with respect to morphological growth and development of one year date palm TC plants elite local genotype (Figure 55). The success rate of establishment was 100 per cent and height of plants reached to almost double to the initial plants. Number of leaves per plant were also increased from 6-7 to 12-18 per plant. Canopy size of the plants was increased to three times to that of initial canopy. Further no pests and diseases were noticed in any of the plant.

Table 48. Observation of 25 plants planted in field during July 2013

Parameters	During planting (July 2013)	December 2013	June 2014	December 2014	December 2015
Establishment success	-	100%	100%	100%	100%
Average Plant Height (cm)	45	64	74	90	186
No. of leaves per plant	6-7	8-10	9-14	12-18	22-28
Canopy size (cm x cm)	55x60	70x74	110x116	156x170	212-218
Incidence of pest	Nil	Nil	Nil	Nil	Nil
Incidence of disease	Nil	Nil	Nil	Nil	Nil

Fig. 55. Growth of date palm plants planted during 2013

Initiation of spathe

In another lot of 133 TC plants of local elite type of date palm were planted during September 2014 out of 160 plants. The remaining 27 plants have been kept in green house for gap filling. The performance of these palnts are presented in table 49. Two date palm plants were adversely affected by root rot and some of the plants were also affected by rabbit and ants. To manage the problem of rabbit and ants, chloropyrophos @ 2ml/L of water was drenched. The plants are growing well and regular management practices of watering, weeding and hoeing are being done.

Table 49. Observation of 133 plants planted in field during September 2014

	During planting (Sept, 2014)	Dec. 2014	Dec. 2015
Establishment success		98.45%	98.45%
Average Plant Height (cm)	30	45	76
No. of leaves per plant	4-5	6-7	11-16
Canopy size (cm xcm)	45x47	60x58	94-98
Incidence of pest	Nil	Ants and Rabbit attack	Ants and Rabbit attack
Incidence of disease	Nil	Root rot in 02 plants	Nil

Growth and development of tissue culture plants of barhee variety under greenhouse

During third year of project period 180 plants of Barhee variety were procured from AAU, Anand at secondary hardening stage during the month of November 2015. The plants kept under greenhouse for further hardening and growth and development of plants. During the month of January the plants were infected by Graphiola leaf spot *(Graphiola phoenicis)* with the Symptoms of Small spots on both sides of leaves and yellow spore masses on underneath of leaves. For its management, the leaves of infected plants were pruned out and plants were sprayed weekly with copper oxychloride and bavastin fungicides alternatively. In about 50 plants 1or 2 pinnate leaves have been emerged (Fig. 56).

Fig. 56. Tissue cultured plants of Barhee variety procured from AAU, Anand Graphiola leaf spot (*Graphiola phoenicis*) infected plant

Secondary Hardening Of Tissue Culture Plants Of Date Palm

Sixty tissue culture imported plants of date palm cv. Barhee deposited by private companies at primary hardening stage to CIAH, Bikaner for evaluation of date palm plants at field level as per directives of Deputy Commissioner (QC), Department of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India. The primary hardened plants transferred from torpedo container to big pots of 30 x 30 cm size. The pots were filled with potting mixtures of sand and sheep yard manure in the ratio of 3:1. The pots were kept in high-tech hardening unit. Initially under environmental regimes of 30-33°C and relative humidity ranging 60-80 per cent for three month. Thereafter these plants were transferred to hardening chamber having temperature 34-40°C and 40-60 % RH. The initial lot of 35 plants was successfully hardened and attained plantation stage after twelve month of hardening and planted in field for further evaluation. No insect pest and disease was recorded during secondary hardening process and under field condition. Another lot of 25 plants has been hardened successfully and ready for field plantation

6. Revolving fund scheme of ICAR funded seed project

For genetic quality and seed crop yield potentials, studies on snap melon (AHS-82), kachri (AHK-119), kakri (AHC-2), palak (AHLP-1) and moringa (AHMO-1-4s) was done with varietal maintenance breeding and breeder seed production crops adopting HBCPSMA during 2015–16 under revolving funds of ICAR seed project. About 330.00 kg seed of institute varieties / genotypes was produced for distribution to farmers, NGO's, KVK's and national, state and private agencies for spread of the varieties and further seed chain in arid zone vegetables.

7. Network Project on Micronutrient management in Horticultural Crops for Enhancing Yield and Quality

PI: Dr. B. D. Sharma, Head, Division of Crop Production, ICAR-CIAH, Bikaner

Co-PI: Dr. B. R. Choudhary, Sr. Scientist (Vegetable Science), ICAR-CIAH, Bikaner

Crop

Name of the crop	Variety	Duration (Long/ medium/short)	Date of sowing/ transplanting	Date of harvest
Muskmelon RM-50		Short	February 2015	May 2015
Watermelon	Thar manak	Short	February 2015	May 2015

Treatment details:

Experiment: Effect of different micronutrients on yield and quality of muskmelon.

Experimental details:

1.	Crop	:	Muskmelon (*Cucumis melo* L.)
2.	Sowing time	:	27 February, 2015
3.	Spacing	:	2.0x0.5m
4.	Experimental design	:	Randomized Block Design (RBD)
5.	Replications	:	3
6.	No. of treatments	:	10
7.	Plot size	:	2mx7m=14m^2
8.	Variety	:	RM-50

Details of treatments:

			Source
T_1	:	Zn @ 15kg/ha	Zinc sulphate (21% Zn)
T_2	:	B @ 5kg/ha	Borax (11.3% B)
T_3	:	Fe @ 15kg/ha	Ferrous sulphate (20% Fe)
T_4	:	Cu @ 5kg/ha	Copper sulphate (35% Cu)
T_5	:	Mixture of all	
T_6	:	Mixture of all without Zn	
T_7	:	Mixture of all without B	
T_8	:	Mixture of all without Fe	
T_9	:	Mixture of all without Cu	
T_{10}	:	Control	

In all treatments RFD will be applied @ N 100kg/ha, P_2O_5 60 kg/ha and K_2O 60 kg/ha. Half quantity of N and full quantity of P_2O_5 and K_2O will be applied before sowing in channels *i.e.* at the time of field preparation. The remaining half quantity of N will be divided in two equal portions and applied in standing crop at 20 DAS and 40 DAS.

Experimental Design: Randomized Block Design

Replications: Three

Variety used: RM-50

Micronutrient application in muskmelon under arid conditions

Field experiments were conducted at CIAH research farm with muskmelon cultivar, RM-50, during 2015 in the kharif season to investigate the role of application of micronutrient on performance of muskmelon. The muskmelon crop received differential doses of different micronutrient as per schedule of treatments. The ten treatments consisting Zn @ 15kg/ha, B @ 5kg/ha, Fe @ 15kg/ha, Cu @ 5kg/ha, Mixture of all, Mixture of all without Zn, Mixture of all without B, Mixture of all without Fe, Mixture of all without Cu and Control and planting were replicated 3 times in a randomized block design.

The maximum fruit yield was recorded T5 (Mixture of all) and T9 (Mixture of all without Cu) which was statistically at par with T7, T8, T6 and T3 and in other treatment yield was significantly less. The TSS was in the range of 9.50 to 11.35 and maximum TSS was recorded in T5 while minimum was in T10. The average fruit weight ranged from 600 to 690g and maximum fruit weight was recorded in T5 and minimum fruit weight (600g) was in T10. Application of different micronutrient increased the flesh thickness of the fruit and maximum flesh thickness was recorded in T5 and minimum in T10 (Table 50).

Table 50. Micronutrient application in muskmelon (*Citrulus lanatus*) under arid conditions

Treatments	Yield (q/ha)	TSS (%)	Av fruit wt (g)	Flesh thickness (cm)
Zn @ 15kg/ha (T1)	185.00	10.02	660.00	1.77
B @ 5kg/ha (T2)	160.00	09.57	600.00	1.73
Fe @ 15kg/ha (T3)	194.00	11.00	650.00	1.75
Cu @ 5kg/ha (T4)	165.00	09.75	610.00	1.65
Mixture of all (T5)	210.00	11.35	690.00	1.87
Mixture of all without Zn (T6)	195.00	10.50	670.00	1.81
Mixture of all without B (T7)	206.00	11.00	680.00	1.80
Mixture of all without Fe (T8)	200.00	10.50	660.00	1.82
Mixture of all without Cu (T9)	210.00	10.60	680.00	1.78
Control (T10)	155.00	09.50	600.00	1.60
CD	38.20	00.96	0.52	0.15

Effect priming with iron and boron on germination and yield of mateera (watermelon type)

The laboratory seed priming tests of mateera were performed in a completely randomized design using solutions containing 4 concentrations of iron and boron. There were three replications of priming solution plus three replications of an unprimed control. Seeds were soaked in the required aqueous solutions of chemicals as $FeSO_4.7H_2O$ (Fe 26%, S 11.5%) or H_3BO_4 (B 17%). The priming solution concentrations chosen for the tests were 0.5%, 1.0%, 1.5% and 2.0% each of Fe and B, and a seed treatment with combined 1.5% Fe + 1.0% B. Each treatment involved weighing approximately 10 g of seeds into a plastic cup, adding 20ml of the priming solution and allowing mixture for 12h. Seeds, after soaking were rinsed with distilled water. A portion of the primed seeds were dried and analyzed for Fe and B concentrations in primed and before primed seeds which are presented here (Table 51).

Table 51. Effect of concentration of Fe and B in the priming solution on their concentrations in primed mateera seeds

Micro-nutri-ents	Concentrations in		
	Priming solution (%)	Seeds before priming (mg kg^{-1})	Seeds after priming (mg kg^{-1})
Fe	0.5	4.75	32.50
	1.0		48.23
	1.5		55.20
	2.0		58.00
B	0.5	3.25	14.25
	1.0		22.00
	1.5		27.00
	2.0		29.00

For each replicate, 25 seeds were placed in a germinator at 25± 1°C for a germination test in a petri dish containing Whatman filter paper No. 1. Germination was checked once in a day for 10 days. The recorded data were final germination percentage, seedling biomass and seedling vigour index. The final germination percentage (GP) was calculated as the cumulative number of germinated seeds with normal redicles . The seedling vigour index (SVI) was calculated by using the following equation below:

GP = SDW and SSVI, where GP, SDW and SVI are the final germination percentage, seedling dry weight and seed vigour index, respectively.

The effect of studied treatment on the final germination percentage was significant. Seed priming with concentration of 1 and 1.5% Fe and 1% B solely or in combination and 1.5% Fe + 1% B for 12h increased the rate of germination of all mateera seeds compared to an unprimed control. The mean of germination from Fe-primed seeds was 85% but the B-primed seeds, the rate was same as that of unprimed seeds (Table 52). The final germination percentage after 10 days increased in all solutions as compared with the control, except for a 3% and 5% reduction in germination in those seeds primed with the 1.5% and 2% B solutions, respectively.

In the laboratory experiments, the effect of seed treatments with Fe and B solely or in combination on seedling dry weight (SDW) was significant. The highest SDW (25mg plant^{-1}) was noticed with 1.5% Fe + 1% B followed by the 1.5% Fe and 1% B treatments (22 and 20mg plant^{-1}, respectively). Lower values for SDW were recorded in the 2% B (10mg plant^{-1}) and control treatments (12mg plant^{-1}). In this experiment the SDW from seeds treated 0.5% Fe was found to be similar to that of the 2% Fe treatment. The difference between the control and seeds primed with 2% B was not significant for SDW.

The seedling vigor index (SVI) responded positively and significantly to seed priming with Fe, B, and Fe + B as compared to that of unprimed seeds. The data show that the SVI can be increased by seed priming with Fe and B up to 1.58 and 1.21, respectively against the control. In the present study, seeds primed with 1.5% Fe had a higher SVI (2.11), but a further increase in Fe concentration in the solution did not increase the SVI. Similarly, when the B concentration increased beyond 1%, the SVI in B-primed seeds was restricted (Table 2).Priming the seeds with micronutrients makes them able to rapidly imbibe water and revive metabolism and germination. This then results in a higher

Table 52. Some of the germination and growth parameters of mateera as affected by priming treatments.

Priming treatments	Final germination percentage (%)	Seedling dry weight (mg plant^{-1})	Seedling vigour index
Fe (0.5%)	80	16.0	1.40
Fe (1.0%)	89	18.2	1.65
Fe (1.5%)	93	22.0	2.11
Fe (2.0%)	78	14.5	1.20
B (0.5%)	86	15.9	1.43
B (1.0%)	90	20.0	1.50
B (1.5%)	79	14.5	1.20
B (2.0%)	78	10.0	0.75
Fe (1.5%) + B (1%)	98	25.0	2.30
Control	83	12.0	0.92
LSD	3.2	2.90	0.27

germination rate improved stand establishment, increased drought and pest tolerance, and ultimately higher yields.

Progress made till date

Following salient achievements have been made during the year

- In muskmelon, maximum fruit yield (210.00q/ha) was recorded in application of mixture of Zn, B, Cu and Fe micronutrients
- Application of 100 ppm boron foliar application at 25, 35 and 45 gave higher yield, number of fruits and average fruit size in mateera (watermelon type) cv. Thar manak in hot arid region.

Priming the seeds with micronutrients makes them able to rapidly imbibe water and revive metabolism and germination and results in a higher germination rate improved stand establishment, increased drought and pest tolerance, and ultimately higher yields.

8. NETWORK PROJECT ON ORGANIC HORTICULTURE

PI: Dr. B. D. Sharma, Head, Division of Crop Production, ICAR-CIAH, Bikaner

Co-PI: Dr. B. R. Choudhary, Sr. Scientist (Vegetable Science), ICAR-CIAH, Bikaner

Name of the crops dealt in the project with scientific name

1. Kinnow mandarin: Hybrid of citrus 'King' (*Citrus nobilis*) × 'Willow Leaf' (*Citrus* × *deliciosa*)
2. Muskmelon (Cucumis melo L.)

Detailed annual progress report

Name of the crop	Variety	Duration (Long/ medium/short)	Date of sowing/ transplanting	Date of harvest
Muskmelon	RM-50	Short	February 2015	May 2015
Kinnow mandarin	Hybrid of two citrus mandarin 'King' (*Citrus nobilis*) × 'Willow Leaf' (*Citrus* × *deliciosa*)	Long	February 2015	January 2016

Muskmelon crop grown under organic cultivation at ICAR-CIAH, Bikaner

Treatment details

For Muskmelon crop

Treatment	Details
T_1	FYM @ 200q/ha
T_2	Vermicompost @ 50q/ha
T_3	Neem cake@ 5q/ha
T_4	FYM @ 200q/ha+ Biofertilizer*
T_5	Vermicompost @ 50q/ha +Biofertilizer
T_6	Neem cake @ 5q/ha+ Biofertilizer
T_7	FYM @ 100q/ha+ Vermicompost@ 25q/ha
T_8	FYM @ 100q/ha+Neem cake@ 2.5q/ha
T_9	Vermicompost @ 25q/ha + Neem cake@ 2.5q/ha
T_{10}	FYM @ 100q/ ha+ Vermicompost @ 25q/ ha +Biofertilizer
T_{11}	FYM @ 100q/ha+ Neem cake@ 2.5q/ha+ Biofertilizer
T_{12}	Vermicompost @ 25q/ ha + Neem cake @ 2.5q/ha+Biofertilizer
T_{13}	Inorganic control
T_{14}	Absolute control

Experimental Design: Randomized Block Design

Replications: Three

Varity used: RM-50

A field experiment was conducted during summer season of 2015 at research farm of ICAR-CIAH, Bikaner to observe the effect of different organic treatments on growth, yield and quality of muskmelon variety RM-50. The experiment was laid down in randomized block design with three replications comprising 14 treatments. The spacing maintained between rows was 2.0m and between plants 0.50m. The statistical analysis of the data presented in table 53 revealed that application of FYM @ 100q/ha+ Vermicompost @ 25q/ha+ Biofertilizers (T_{10}) resulted in maximum number of vines/ plant (4.87), fruit weight (840.00g), fruit diameter (12.51cm), flesh thickness (2.29cm), TSS (11.41%), marketable fruit/ plant (4.13) and marketable yield/ ha (240.43q) which was found to be significant over all treatments but at par with FYM@ 100q/ha + Vermicompost @ 25q/ha (T_7).

Table 53. Effect of different organic treatments on growth, yield and quality of muskmelon.

Treatments		No. of vines/ plant	Fruit weight (g)	Fruit diameter (cm)	Flesh thickness (cm)	TSS (%)	Marketable fruit/ plant	Marketable fruit yield/ ha (q)
T_1	FYM @ 200q/ha	4.20	663.33	10.59	1.77	10.02	3.20	167.63
T_2	Vermicompost @ 50q/ha	4.00	654.00	10.53	1.73	9.57	3.40	182.51
T_3	Neem cake @ 5q/ha	3.73	574.00	9.63	1.52	9.16	2.80	126.24
T_4	FYM @ 200q/ha + Biofertilizers*	4.33	684.67	10.63	1.80	9.87	3.40	184.16
T_5	Vermicompost @ 50q/ha +Biofertilizers	4.27	691.33	10.89	1.87	10.35	3.33	182.61
T_6	Neem cake @ 5q/ha+ Biofertilizers	4.20	676.67	10.59	1.91	9.57	3.47	188.00
T_7	FYM @ 100q/ha+ Vermicompost@ 25q/ha	4.67	789.33	11.51	2.09	11.15	3.67	206.78
T_8	FYM @ 100q/ha + Neem cake @ 2.5q/ha	4.27	700.67	10.95	1.87	10.29	3.40	186.51
T_9	Vermicompost @ 25q/ha + Neem cake @ 2.5q/ha	4.33	698.33	10.72	1.98	10.63	3.47	192.24
T_{10}	FYM @ 100q/ ha + Vermicompost @ 25q/ha +Biofertilizer	4.87	840.00	12.51	2.29	11.41	4.13	240.43
T_{11}	FYM @ 100q/ha+ Neem cake@ 2.5q/ ha+ Biofertilizers	4.20	685.00	10.64	1.95	10.68	3.47	187.95
T_{12}	Vermicompost @ 25q/ ha + Neem cake @ 2.5q/ha+ Biofertilizers	4.13	687.67	10.79	1.72	10.04	3.53	197.87
T_{13}	Inorganic control	4.20	702.67	11.09	1.94	10.46	3.40	190.19
T_{14}	Absolute control	3.53	514.67	9.29	1.41	9.37	2.47	111.19
CD at 5%		0.42	130.52	1.17	0.28	0.27	0.55	43.09
CV (%)		5.97	11.39	6.48	9.04	1.59	9.78	14.13

*Azotobactor @ 5kg/ha and Phosphorus solubilizing bacteria (PSB) @ 5kg/ha applied as soil treatment.

Treatment details:

For Kinnow mandarin crop

Treatment	Details
T_1	FYM @ 100 kg/plant
T_2	Vermicompost @ 30kg/plant
T_3	Neem cake@ 10kg/plant
T_4	FYM @ 100 kg/plant + Biofertilizers*
T_5	Vermicompost @ 30kg/plant +Biofertilizers
T_6	Neem cake@ 10kg/plant + Biofertilizers
T_7	FYM @ 50 kg/plant + Vermicompost @ 15kg/plant
T_8	FYM @ 50 kg/plant + Neem cake@ 5kg/ plant
T_9	Vermicompost @ 15kg/plant + Neem cake@ 5kg/plant
T_{10}	FYM @ 50 kg/plant + Vermicompost @ 15kg/plant +Biofertilizers
T_{11}	FYM @ 50kg/plant + Neem cake@ 5kg/ plant + Biofertilizers
T_{12}	Vermicompost @ 15kg/plant + Neem cake@ 5kg/plant +Biofertilizers
T_{13}	Inorganic control
T_{14}	Absolute control

Experimental Design: Randomized Block Design

Replications: Three (Two plant / replication)

Varity used: Hybrid of citrus 'King' (*Citrus nobilis*) × 'Willow Leaf' (*Citrus* × *deliciosa*)

The experiment was conducted on 12 year old orchard of kinnow mandarin at research farm of ICAR-CIAH, Bikaner. The plants were receiving the recommended dose of FYM along with the N, P and K fertilizers till the year 2013. In the month of February 2015, the doses of different organic treatments were deployed from 1 to 12 treatments while in treatment 13, recommended doses of N, P and K were applied and in treatment No. 14 fertilizers and no organic treatments were applied and kept as absolute control. The flowering was noticed in in the month of March-April and in the last week of April 2015, fruit set was observed. The picking of fruits have been started in the month of December 2015 and complete harvest was done in the month of January 2016. The total fruit yield, fruit quality parameters were recorded in all treatments. data presented in table 54 revealed that maximum fruit

Kinnow mandarin crop grown under organic cultivation at ICAR-CIAH, Bikaner

Table 54. Effect of different organic treatments on growth, yield and quality of kinnow

Treatments		Fruit weight (g)	Juice content (%)	Acidity (%)	TSS (%)	Marketable fruit yield (t/ha)	Plant height (m)
T_1	FYM @ 100 kg/plant	180	50.00	0.75	13.50	18.00	2.85
T_2	Vermicompost @ 30kg/ plant	180	50.00	0.75	13.00	17.00	2.75
T_3	Neem cake@ 10kg/plant	165	45.00	0.80	12.50	17.50	2.70
T_4	FYM @ 100 kg/plant + Biofertilizers*	190	50.00	0.75	13.50	18.00	2.75
T_5	Vermicompost @ 30kg/ plant +Biofertilizers	185	50.00	0.75	13.50	16.00	2.75
T_6	Neem cake@ 10kg/plant + Biofertilizers	170	48.00	0.80	12.50	16.00	2.60
T_7	FYM @ 50 kg/plant + Vermicompost @ 15kg/ plant	225	55.00	0.70	14.00	19.00	2.80
T_8	FYM @ 50 kg/plant + Neem cake@ 5kg/plant	195	55.00	0.70	13.00	18.50	2.80
T_9	Vermicompost @ 15kg/ plant + Neem cake@ 5kg/plant	195	50.00	0.70	13.00	17.50	2.50
T_{10}	FYM @ 50 kg/plant + Vermicompost @ 15kg/ plant +Biofertilizers	235	55.00	0.70	14.00	19.25	2.65
T_{11}	FYM @ 50kg/plant + Neem cake@ 5kg/plant + Biofertilizers	225	55.00	0.75	13.50	17.25	2.75
T_{12}	Vermicompost @ 15kg/ plant + Neem cake@ 5kg/plant +Biofertilizers	220	50.00	0.80	13.00	17.00	2.65
T_{13}	Inorganic control	175	50.00	0.80	11.50	17.00	2.85
T_{14}	Absolute control	150	45.00	0.85	11.50	16.00	2.60
CD at 5%		**20.52**	**4.85**	**NS**	**1.52**	**2.56**	**0.15**

*Azotobactor @ 250g/plant and Phosphorus solubilizing bacteria (PSB) @ 250 g/plant applied as soil treatment.

yield (19.25t/ha) was recorded in T10 and which was statistically at par with fruit yield received in T1, T4, T7 and T8 treatments. The minimum fruit yield was recorded in absolute control treatment (16.00t/ha). The maximum juice recovery (55%) was recorded in treatment T7, T8, T10 and T11. The maximum fruit weight (235g) was recorded in TT10 and minimum in T14 (125g). The plant height ranged between 2.50 to 2.85m. Fruit juice acidity has been lowered down in organically treated plants.

Site characterization/observations

No.	Properties	Value (0-30cm)
1	Major textural class	Loamy sand
2	Particle size distribution(%) Sand Silt clay	 88.50 06.50 05.00
3	Bulk density	1.45 gcm^{-3}
4	Porosity (%)	48
5	Water holding capacity (%)	5.50
6	pH	8.20
7	EC (dSm^{-1})	0.18
8	CEC	
9	Organic carbon (%)	0.11
10	Available P (kg/ha)	12.50
11	Available K (kg/ha)	195
12	Iron (ppm)	3.80
13	Zinc (ppm)	0.50
14	Copper (ppm)	0.15
15	Manganese (ppm)	2.60

Progress made till date

Following salient achievements have been made during the year

- In muskmelon, maximum fruit yield (240.43q/ha) was recorded in application of FYM @100q/ha along with vermicompost @25q/has and biofertilizers consortia.
- The Kinnow fruit yield (19.25t/ha)was also maximum in treatment T10 comprising of FYM @50kg + vermicompost @15kg + biofertilizers/plant.
- The total microbial load was higher in bulky organic source in comparison to concentrate organic sources.

GODHRA

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

PI: Dr. A. K. Singh

Co-PI: Dr. Sanjay Singh

A total of twelve varieties *viz.*, Goma Yashi, Thar Divya, CISH-B-1, CISH-B-2, NB-16, NB-17, NB-5, NB-7, NB-9, Pant Aparna, Pant Shivani, Pant Sujata and Pant Urvashi were characterized for their morphological, flower and fruit characters during 2015-16. The details of the study are as follows:

Vegetative characters

Results revealed that vegetative characters of different bael varieties exhibited differences for the growth in terms of plant height, stem girth, plant spread, leaf and flower characters under rainfed hot- semi -arid environment..

Growth

Various growth characters showed significant differences in respect of their vegetative characters. The differences in plant height stem girth, plant spread ranged between 3.38-5.57 m, 28.95-88.39 cm and 3.74-7.68 m. The plant height (5.85m), stem girth (88.39cm), plant spread (E-W-7.68 m and N-S-7.52m) were recorded the maximum in Pant Shivani, CISHB-2 and NB-7, respectively, while the vegetative characters in terms of plant height (3.38 m), stem girth (30.38 cm) and plant spread (E-W-3.74 m and N-S-3.40m) were measured the minimum in Goma Yashi and Pant Aparna, respectively among the varieties.

Leaf

Varieties showed wide differences in their leaf characters under dryland conditions of western India. It was noticed that the terminal leaf size in terms of length (15.02) and breadth (9.38cm) was found maximum in NB-7 followed by CISHB-2, Pant Shivani and NB-17, while the minimum length (10.72 cm) and breadth (6.15cm) was recorded in NB-9 followed by NB-16, Goma Yashi, Pant Sujata and NB-5. The lateral leaflet length (11.38cm) and breadth (6.57 cm) was observed the maximum in CISH-B-2 and NB-7, respectively, whereas the minimum lateral leaflet length (7.45 cm) and breadth (4.13cm) was observed in NB-9 and NB-16, respectively followed by Goma Yashi and NB-16 in all varieties studied for the leaf morphological characters.

Flower

The flower of bael varieties showed considerable differences for all the characters studied. Flower characters with respect to bud size in terms of bud length (10.25-13 mm), bud width (7.00-9.70

mm), flower length (12-19 mm), flower width (22-35 mm), pedicel length (4.50-10.50 mm), pedicel width (2.00-2.50 mm), petal length (11-19 mm), petal width (7-10 mm), stamen length (6.75-9.00 mm), filament length (2.75-5.00 mm), width (0.40-0.80mm), anther length (3.50-4.50mm), width (0.50-0.80mm), pollen diameter (41.25-45.00 micron), ovary length (4.00-8.00 mm), diameter (2.50-5.00), style length (1.00-1.50 mm), width (1.50-2.50mm), stigma length (2.00-3.50 mm) and width (2.00-3.00 mm) and exhibited wide variations in their floral organs. Pollen viability was found to be significantly highest 98% in NB-7 and NB-9, whereas rest of the varieties has 95% pollen viability or more than it. Bud length (13.00 mm) and breadth (9.70 cm) were found maximum in NB-17 and CISH-B-2, whereas bud length was the minimum in Pant Aparna and NB-9, NB-16, however bud width was measured the minimum in Pant Shivani (7.50 mm) followed by Pant Sujata, NB-16 and in NB-9 and NB-5 exhibited equal bud width (8.00 mm).Flower size with respect to length and width was measured highest in CISH-B-2(19.00 mm) and NB-7(35.00 mm), respectively and same was recorded minimum in GomaYashi followed by NB-9, NB-16. Pedicel length (10.50 mm) and pedicel width (2.50 mm) were observed the maximum in NB-5 followed by Pant Aparna and Pant Sujata among the varieties of bael tested under rainfed conditions. Flower petal length (19.00 mm) and petal width (10.00 mm) were the maximum in NB-7 and Pant Aparna, respectively, whereas minimum petal length (11.00 mm) and width (7.00 mm) were recorded in NB-9 followed by NB-16 and CISH-B-2.

Fruit characters

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

Quantitative

Fruit weight was recorded the highest in NB-7 (4.25 kg) followed by Pant Urvashi (2.90 kg), CISH-B-2 (2.58 kg) and Pant Shivani (2.45 kg), whereas the lowest fruit weight was recorded in NB-16 (0.43kg) followed by CISH-B-1 (0.96 kg). Fruit length (19.59cm) was found to be highest in CISH-B-2 and Pant Shivani followed by NB-9 and Pant Urvashi whereas the same was recorded the lowest in NB-16 (10.61) followed by Pant Aparna and Pant Sujata. Fruit width (22.00 cm) was measured the maximum in NB-7 followed by Pant Urvashi(19.40 cm), CISH-B-2(17.50 cm) and Pant Shivani(16.30cm) and it was the minimum in NB-16 (9.40cm) followed by CISH-B-1, Pant Aparna and Pant Sujata. The maximum fruit girth (70.00 cm) was exhibited by NB-7 followed by Pant Urvashi (61.70 cm) and CISH-B-2 (54.17 cm), while the minimum fruit girth was observed in NB-16 (29.10cm) followed by CISH-B-1 (34.53cm), Pant Sujata (41.25cm), Pant Aparna (43.30cm), NB-5 (43.20cm) and Goma Yashi (44.20cm).

Physical composition

Among the varieties, shell weight (610.75g) was measured conspicuously very high in Pant Urvashi and the lowest in NB-16 (115.25g) followed by Goma Yashi (146.09 g) and NB-5 (146.47g.) Shell thickness (0.31 cm) was recorded maximum in NB-7 (0.31 cm) and the least thickness was observed in Goma Yashi (0.16cm) followed by NB-5 (0.17 cm) and CISH-B-1 (0.18cm). The pulp content was maximum in NB-7 (3.67 kg) followed by Pant Urvashi (2.16 kg), CISH-B-2 (2.00 kg) and the minimum pulp content was obtained from the variety NB-16 (0.27 kg) followed by CISH-B-1 (0.73 kg) and Pant Aparna (0.80 kg).Total number of seed per fruit was counted the maximum in NB-17 (212) followed by CISH-B-1 (191), Pant Shivani, (171),NB-7(160) and CISH-B-2 (140) while the seeds were recorded minimum in Goma Yashi (90) followed by Pant Urvashi (103) and NB-5 (114). Total seed sacs per fruit were recorded highest in NB-9 (19) and it was lowest in CISH-B-1(10) followed by NB-16 and Pant Sujata having similar seed sacs in both the varieties (13.00). Fresh seed weight/fruit was recorded the maximum in Pant Urvashi (0.22g) and minimum in NB-16 (0.15g) as well as NB-9 (0.15g). Total fresh seed weight/fruit was recorded the highest in NB-17 (43.41g) followed by CISH-B-1 (38.44 g) and same was observed the lowest in Goma Yashi (17.34 g) followed by Pant Urvashi (18.18g). Fresh fibre weight was obtained

highest in NB-17 (106.50g) followed by Pant Shivani (101.50 g) and it was lowest in NB-16 (15.91 g) followed by CISH-B-1 (22.70g), NB-5 (25.24 g) and Goma Yashi (28.50g). The physical composition of bael fruit consisted of shell, seed, fibre and pulp percentage varied between 11.76-26.80, 0.80 - 5.05, 2.23-4.14 and 63.45- 85.14, respectively in different varieties of bael. The highest percentage of shell and total seed were computed 26.80 and 5.05 in NB-16, whereas the shell and seed percentage was minimum in Goma Yashi (11.76) and CISH-B-2 (0.80), respectively. The minimum fibre(2.23) and maximum pulp (85.14) percentage were obtained in the Goma Yashi, while the maximum fibre (4.14%) and minimum pulp (63.45%) were recorded in NB-17 and NB-16, respectively in all the varieties studied for physical composition.

Qualitative

Among the varieties, fruit acidity was estimated highest in Pant Urvashi (0.49%) followed by NB-16, Pant Shivani and CISH-B-2 and it was lowest in Goma Yashi (0.30%) followed by NB-17 and NB-9, however the minimum Vitamin 'C' content was found in Goma Yashi (21.03mg/100g) followed by NB-5 (20.63 mg/100 g) and NB-7 (19.78 mg/100 g) and the same was observed the minimum in Pant Sujata (17.13 mg/100g) followed by Pant Aparna (17.15 mg /100g). Total phenol was estimated highest in CISH-B-1 (2.75%) followed by CISH-B-2 (2.65%) and the lowest in Pant Urvashi (2.34%). The total soluble solids in pulp were recorded highest in Goma Yashi (37.45°brix) followed by Pant Urvashi (36.44° brix), NB-5 (36.21°brix) and NB-16 (35.90°brix) and the lowest TSS of pulp was recorded in NB-7 (30.57°brix) followed by CISH-B-2(31.00°brix) and CISH-B-1 (31.20°brix). The total soluble solids in mucilage were recorded highest in Pant Urvashi (49.50°Brix) followed by NB-7 (49.00^0 brix), Pant Shivani (48.65^0 brix) and NB-17 (48.52°brix) and the minimum in Pant Aparna (37.00° brix). Total sugar was found maximum in NB-9 (19.98%) followed by Pant Aparna (19.93%), whereas the same was recorded the minimum in Pant Urvashi, NB-7 (16.15%) and NB-17 (16.60%). Reducing sugar was estimated highest in Pant Aparna (4.95%) followed by CISH-B-1, NB-9 and NB-5 and the same was lowest in NB-7 (3.30%) followed by Pant Sujata, Pant Shivani. Non reducing sugar was recorded maximum in NB-9 (15.13%) followed by Goma Yashi and the non reducing sugar was found minimum in NB-7 (12.85%). TSS/Acid ratio was computed the maximum in Goma Yashi (124.83) followed by NB-5 (113.15) and NB-17 (112.51) whereas it was minimum in NB-16 (74.79) followed by Pant Shivani (75.31) and Pant Sujata (75.56).

10. Characterization of aonla varieties for developing DUS test guidelines

Co-Nodal Centre

Co-PI: Dr. A. K. Singh

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 Kanchan, tall drooping in Francis and tall semi-spreading in NA-7 under rainfed conditions of western India. Plant height was maximum (5.67m) in Anand-2 followed by Anand-1 (5.52m) while it was found to be minimum in Chakaiya (3.78 m) followed by Krishna (3.86m).The foliage in Banarasi, Chakaiya, Krishna, Kanchan, Anand-1 and Anand-2 was sparse whereas in Francis, NA-7 and NA-10 it was dense foliage. The tree trunk colour of different varieties was 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 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 of same trait was minimum in Chakaiya (1.24cm) followed by

Anand-2(1.25 cm), Anand-2 (1.27cm), NA-10 (1.28cm) and Krishna (1.29 cm). The leaf width was measured maximum in Banarasi (0.37 cm) followed by Francis and Kanchan (0.32 cm), whereas same was recorded minimum in Anand -1 (0.23 cm) followed by Anand-1 (0.26 cm).

Fruit set and retention

Results of study on fruit set and fruit retention revealed that the fruit set was noticed during the 1st fortnight of March in Krishna, Francis, Chakaiya, Kanchan and 2nd fortnight of February in Banarasi, NA-7 and NA-10 whereas it was recorded in 2nd fortnight of March in Anand-1 and Anand-2. The percentage of fruit set (51.95 %) and fruit retention (26.40%) were recorded the maximum in NA-7 followed by Krishna for fruit set (49.50 %) and fruit retention (20.78%), and the minimum fruit set and fruit retention were recorded in Banarasi (36.21%) and in Francis (11.43%), respectively among all the varieties. The time of fruit maturity was last week of October in Banarasi, Francis, NA-10 and the same was observed during mid to last week of November in Krishna, Chakaiya, Kanchan , Anand-1 and Anand-2. Days of maturity of different varieties ranged between 208 -222 days under rainfed conditions.

Physical fruit characters

Among 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-1 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, Aanand-1 and Anand-2. Fruit stem end cavity was noticed 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 coloure flesh excluding Krishna which had yellowish green colour under rainfed semi arid environment of western India.

Fruit weight ranged between 25.94-33.90g being maximum in Banarasi (33.90 g) followed by NA-7 (33.76 g) and it was measured the minimum in Kanchan (25.94 g).The fruit length ranged between 3.07-3.82 cm whereas it was observed the maximum in Kanchan (3.82 cm) followed by Banarasi (3.73 cm) and Krishna (3.70 cm) and the same was observed the minimum in Francis (3.07 cm) followed by Anand-1(3.10 cm) and Anand -2 (3.12 cm). Among the varieties, fruit width varied between 3.40-4.37cm and the maximum width was observed in Banarasi (4.37 cm) followed by NA-7 and Chakaiya (4.00 cm) whereas it was minimum in Francis (3.40 cm) followed by Anand-2 (3.41 cm) and Anand -1 (3.45 cm) under hot semi arid ecosystem.

Qualitative characters of fruits

Among the varieties, the maximum (64.45%) juice content was recorded in NA-7 followed by Krishna (61.60%) and lowest in Chakaiya (40.00%) followed by Banarasi (41.34%). The astringency level was highest in Krishna, Chakaiya and NA-10, and it was least in NA-7, but the rest of the varieties had medium astringency. The acidity ranged between 2.03-2.21 % being the maximum in Banarasi (2.21%) followed by Krishna (2.16 %) whereas it was recorded the minimum (2.03 %) in Kanchan. The pulp content ranged between 23.95-31.91g /100 g of fruit and it was recorded the maximum in Banarasi (31.91 g) followed by NA-7 (31.79g) and Krishna (31.51g) whereas the minimum pulp content was recorded in Kanchan (23.95 g) followed by Anand-2 (24.59g) and Anand-1 (26.48 g). The estimated ascorbic acid content among all the varieties ranged between 334.12- 453.20 mg /100g. It was observed maximum in NA-7 (453.20 mg/100g) followed by Kanchan (427.27 mg/100g) and the same was found to be minimum in Banarasi (334.12mg/100g) followed by Francis (345.34 mg/100g) and Krishna (352.45 mg/100g). The total soluble solids were recorded maximum in NA-7 (11.50^{0}brix) followed by Anand-1 (11.30^{0}brix) and Anand-2 (10.25^{0}brix),

while Banarasi had the minimum value (8^{0}Brix) followed by NA-10 (8.50^0 Brix). TSS/Acid ratio varied from 3.61 to 6.74 being the maximum in Krishna (6.74) followed by NA-7(5.60) and Anand-1(5.51) whereas it was the minimum in Banarasi (3.61) followed by NA-10 ((4.00) and Francis (4.04). The value of specific gravity ranged between 1.06 -1.43 being the highest in Banarasi (1.43) followed by Anand-1 (1.39) while it was least in Francis (1.06) followed by NA-7 (1.13) in all the studied germplasm.

Seed characters

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, Krishna and NA-7 enunciated large stone and seed size whereas it was small in Chakaiya, Kanchan, Anand-1 and Anand-2 while the rest of the varieties had medium stone size. The weight of the stone was exhibited maximum (2.08%) in Francis followed by Krishna and Anand-1 (2.05 g) and it was minimum in NA-7 (1.97 g) followed by Kanchan and NA-10 (1.99 g).

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

Co-Nodal Centre

Co-PI: Dr. Sanjay Singh

Characteristics for DUS guide lines in jamun

S.N.	Characteristics	States	Notes	Example accession/ verities	State of observation	Type of assessment
1 (*) (+)	Growth habit	Spreading	3	Goma Priyanka, Gokak-1, Gokak-2,	5(a)	VS
		Semi-spreading	5	Konkan Bahadoli, Gokak-3,		
		Upright	7	CISH J-42, CISH J-37		
2	Tree foliage type	Sparse	1	-	5(a)	VS
		Dense	3	CISH J-42, CISH J-37, Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3 ,		
3 (*)	Mature Leaf Colour	Green	3	Gokak-1	5 (b)	VG
		Dark green	5	CISH J-42, CISH J-37, Goma Priyanka, Konkan Bahadoli, Gokak-2, Gokak-3		
4 (*)	Leaf Lamella Surface	Smooth	3	CISH J-42, CISH J-37, Goma Priyanka, Konkan Bahadoli	5 (b)	VG
		Wavy	5	Gokak-1, Gokak-2 Gokak-3		
5 (*) (+)	Leaf Apex	Acute	3	Konkan Bahadoli	5 (b)	VG
		Acuminate	7	CISH J-42, CISH J-37, Goma Priyanka, Gokak-1, Gokak-2, Gokak-3		

S.N.	Characteristics	States	Notes	Example accession/ verities	State of observation	Type of assessment
6 (*) (+)	Leaf Base	Acute	3	CISH J-42, CISH J-37, Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3	5 (b)	VG
		Round	7	-		
7 (*)	**Leaf length: width ratio**	Low (<2.0)	3	CISH J-42, Konkan Bahadoli, Gokak-1	5 (b)	MG
		High (>2.0)	7	CISH J-37, Goma Priyanka, Gokak – 2, Gokak – 3		
8 (*)	**Inter nodal length**	Short (<6.0 cm)	3	-	5 (b)	MS
		Medium (6.0 to 7.5 cm)	5	CISH J-42, CISH J-37, Gokak –1, Gokak-2		
		Long (>7.5 cm)	7	Goma Priyanka, Konkan Bahadoli, Gokak-3		
9 (*)	**Petiole length**	Short (<1.5 cm)	3	-	5 (b)	MG
		Medium (1.5 to 2.5 cm)	5	CISH J-37, Goma Priyanka, Gokak – 3		
		Long (>2.5 cm)	7	CISH J-42, Konkan Bahadoli, Gokak-1, Gokak – 2		
10 (*)	Newly flush color	Light pinkish brown	3	Goma Priyanka, Gokak-1, Gokak-2, Gokak-3	5 (b)	VG
		Light greenish brown	7	CISH J-42, CISH J-37, Konkan Bahadoli		
11	Initiation of bloom	Early (2^{nd} week February)	3	CISH J-42	5 (c)	MG
		Medium (3^{rd} to 4^{th} week February)	5	CISH J-37, Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		
		Late (1^{st} week March)	7	-	5 (c)	MG
12 (*)	Inflorescence length: diameter ratio	Low (<1.0cm)	3	CISH J-42, CISH J-37, Goma Priyanka,	5 (c)	MS
		Medium (1.0 to 1.2 cm)	5	Gokak-1		
		High (>1.2cm)	7	Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		

S.N.	Characteristics	States	Notes	Example accession/ verities	State of observation	Type of assessment
13 (*)	Mature fruit colour	Purple red	1	CISH J-42, CISH J-37	5 (d)	VG
		Dark purple	2	Goma Priyanka, Konkan Bahadoli, Gokak-2, Gokak-3,		
		Purple black	3	Gokak-1		
14 (*) (+)	Mature fruit shape	Oblong	3	Goma Priyanka, Konkan Bahadoli	5 (d)	VG
		Elliptic	5	Gokak –1, Gokak-2, Gokak-3		
		Ovoid	7	CISH J-42, CISH J-37		
		Round	9	-		
15 (*) (+)	Mature fruit apex	Flat	3	Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3	5 (d)	VS
		Depressed	5	CISH J-42, CISH J-37		
		Round	7	-		
16 (*) (+)	Mature fruit: stalk end	Nipple shape	3	CISH J-42, CISH J-37	5 (d)	VS
		Flattened	5	Goma Priyanka		
		Depressed	7	Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		
17	Mature fruit pulp colour	Cream white	1	CISH J-42, CISH J-37, Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3	5 (d)	VG
		Purple white	9	--		
18 (*)	Ripe fruit weight	Low (<10.0g)	3	CISH J-42	5 (d)	MS
		Medium (10.0 to 15.0 g)	5	Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		
		High (>15.0g)	7	CISH J-37, Goma Priyanka		
19 (*) (+)	Ripe fruit length	Short (<3.0 cm)	3	CISH J-42	5 (d)	MS
		Medium (3.0 to 4.0 cm)	5	Konkan Bahadoli, Gokak-2, Gokak-I, Gokak-3		
		Long (>4.0 cm)	7	CISH J-37, Goma Priyanka, Gokak-1		

S.N.	Characteristics	States	Notes	Example accession/ verities	State of observation	Type of assessment
20 (*) (+)	Ripe fruit breadth	Narrow (<2.0 cm)	1	CISH J-42	5 (d)	MS
		Medium (2.0 to 2.5 cm)	2	Konkan Bahadoli		
		Wide (>2.5 cm)	3	CISH J-37, Goma Priyanka, Gokak-1, Gokak-2, Gokak-3		
21 (*)	Ripe fruit Size	Small (<7.0 cm^2)	3	CISH J-42	5 (d)	MS
		Medium (7.0 to 11.0 cm^2)	5	Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		
		Large (<7.0 cm^2)	7	CISH J-37, Goma Priyanka		
22 (*)	Seed weight	Low (<1.7 g)	3	-	5 (d)	MG
		Medium (1.7 to 2.0 g)	5	Goma Priyanka, Gokak-1, Gokak-2, Gokak-3		
		High (>2.0g)	7	CISH J-37, Konkan Bahadoli		
23 (*)	Pulp Content	Low (<80%)	3	-	5 (d)	MG
		Medium (80 to 90%)	5	Goma Priyanka, Konkan Bahadoli, Gokak-1, Gokak-2, Gokak-3		
		High (>90%)	7	CISH J-42		
24 (*)	Seed	Absent	1	-	5 (d)	MG
		Rudimentary	5	CISH J-42		
		Present	9	CISH J-37, Goma Priyanka, Gokak-1, Gokak-2, Gokak-3, Konkan Bahadoli		
25 (*)	Pulp TSS	Low (<12.0 ^{0}B)	3	CISH J-42, Gokak –1, Gokak –2, Gokak –3	5 (d)	MG
		Medium (12.0 to 15.0 ^{0}B)	5	Konkan Bahadoli,		
		High (>15.0 ^{0}B)	7	CISH J-37, Goma Priyanka		
26 (*)	Pulp: Seed Ratio	Low (<10.0)	3	Konkan Bahadoli	5 (d)	MG
		Medium (10.0 to 16.0)	5	Goma Priyanka, Gokak-1, Gokak-2, Gokak-3,		
		High (>16.0)	7	CISH J-37		

12. Validation of DUS descriptors for chironji and tamarind.

Nodal Centre

PI: Dr. Sanjay Singh

Co-PI: Dr. A. K. Singh

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 42.10, 43.20, 40.10, 43.40, 40.10, 41.10, 43.00, 45.00, 38.10 and 34.60 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 12.10 cm, 10.20 cm,13.50 cm, 11.30 cm, 12.40 cm, 14.10 cm, 10.20 cm, 12.10 cm, 14.30 cm and 15.40cm 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 descriptor. 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 semi tall type, while CHESC-14, CHESC-15, CHESC-19and CHESC-20 were found tall type. Foliage was dense and leaf was elliptical lanceolate. Leaves thickly coriaceous, broadly oblong, obtuse, reticulately veined in all genotypes.

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,

Characteristics of tree and leaves of different chironji genotypes

Characters	CHESC-16	CHESC-17	CHESC18	CHESC-19	CHESC-20
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

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Compendium

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Sharma, B. D. and Sharma, S. K. (2016) ICAR-AICRP on Arid Zone Fruits: At a glance, ICAR-CIAH 8p.

RADIO TALK

Dr Sanjay Singh

Radio talk delivered at Godhra Radio station, Godhra on water management in fruit crops.

Radio talk delivered at Godhra Radio station, Godhra on management of mango.

Dr A. K. Singh

Delivered radio talk on the topic Uttam bagayati Pakoni mavjat, 28th March, 2015, AIR, Godhra

Delivered radio talk on the topic Ochha paniye Pak Kontha 17th December, 2015, AIR, Godhra

Delivered radio talk on the topic Bili nu aushdhiya mahatva, 16th March, 2016, AIR, Godhra

Dr L. P. Yadav

Radio talk delivered at Godhra Radio station, Godhra on production technology of drumstick on 17-10-2015

9. RESEARCH PROJECTS

Code	Title	Investigators
CIAH: 1	**Introduction, collection, characterization, conservation and evaluation of germplasm of arid and semi-arid fruit and vegetable crops.**	**Dr. S. K. Sharma (Project Leader)**
(a)	*Ber*	Dr. Hare Krishna
(b)	Pomegranate	Mr. Ramesh Kumar Dr. S. K. Maheshwari
(c)	Date palm	Dr. R. S. Singh Dr. R. Bhargava Dr. B. D. Sharma
(d)	*Aonla*	Dr. A. K. Singh Dr. P. P. Singh Mr. Ramesh Kumar
(e)	Indigenous and exotic underutilized fruit crops (Lasora, ker, pilu, karonda, phalsa, cactus pear, fig, mulberry and dragon fruit).	Dr. Hare Krishna Dr. R. S. Singh Dr. Dhurendra Singh Dr. Pinaki Acharyya
(f)	*Bael*	Dr. R. S. Singh Mr. Jagan Singh Gora Dr. A. K. Singh Dr. Sanjay Singh
(g)	Wood apple and custard apple.	Dr. A. K. Singh
(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 Dr. R. Bhargava Dr. S. K. Maheshwari Dr. S. M. Haldhar
(j)	Jamun, tamarind, mahua, chiraunji, karonda, phalsa, khirni and manila tamarind.	Dr. Sanjay Singh Dr. A. K. Singh Dr. R. Bhargava 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 Dr. S. M. Haldhar Dr. P. N. Sivalingam
(b)	Genetic improvement of ridge gourd (*Luffa acutangula*) under arid environment.	Dr. B. R. Choudhary Dr. S. K. Maheshwari Dr. S. M. Haldhar

Code	Title	Investigators
(c)	Identification of Institute germplasm through biotechnological interventions :	
(i)	Development of phyto-chemical markers in arid horticultural crops for varietal identification and assessment of phylogenetic relationship.	Dr. R. Bhargava Dr. R. S. Singh Dr. B. D. Sharma Dr. Dhurendra. Singh
(d)	Alleviation of climatic constraints on growth of vegetable crops under hot arid regions with an understanding on its seed physiology.	Dr. Pinaki Acharyya Dr. R. Bhargava Dr. P. N. Sivalingam
(e)	Development of aonla varieties against frost resistance.	Dr. P. P. Singh Dr. R. Bhargava Dr. R. S. Singh
(f)	Breeding for abiotic stress tolerance in solanaceous crops.	Dr. P. P. 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 Dr. R. Bhargava Dr. S. R. Meena 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 Dr. R. S. Singh Dr. B. D. Sharma
(d)	Technological interventions for arid horticulture development and its impact assessment.	Dr. S. R. Meena Dr. R. S. Singh Dr. D. K. Samadia Dr. Dhurendra Singh
(e)	Standardization of integrated nutrient management in arid horticultural crops.	Dr. B. D. Sharma Dr. R. Bhargava Dr. R. S. Singh Dr. S. K. Maheshwari
(f)	Standardization of production technology of mango and sweet orange.	Dr. Sanjay Singh Dr. A. K. Singh Dr. V. V. Appa Rao
(g)	Value addition in semi-arid fruit crops.	Dr. Sanjay Singh Dr. V.V. Appa Rao
(h)	A study on rural wisdom and resources of arid horticultural importance.	Dr. S. R. Meena Dr. B. D. Sharma Dr. S. K. Maheshwari
(i)	Exploitation of arid fruits and vegetables for value addition and commercialization.	Mr. Ramesh Kumar Dr. R. S. Singh Dr. S. R. Meena Dr. Pinaki Acharyya

Code	Title	Investigators
(j)	Standardization of production technology of *bael* under rainfed semi-arid conditions of western India.	Dr. A. K. Singh Dr. Sanjay Singh Dr. R. S. Singh Dr. V. V. Appa Rao
(k)	Nutrients management in vegetables (mateera, kachri, snap melon and cluster bean,) of hot arid region of Rajasthan.	Dr. M. K. Jatav Dr. B. D. Sharma Dr. S. R. Meena Dr. D. K. Samadia
(l)	Nutrient management in chironji, custard apple, jamun and tamarind.	Dr. V. V. Appa Rao Dr. Sanjay Singh Dr. A. K. Singh
(m)	Intensification of research on tissue cultured date palm in hot arid region.	Dr. B. D. Sharma Dr. R. S. Singh Dr. R. Bhargava
CIAH: 4	**Plant health management studies in arid and semi-arid fruit and vegetable crops.**	**Dr. S. K. Sharma (Project Leader)**
(b)	Survey of insect-pests, their natural enemies and pest management strategies for cucurbits in arid region of Rajasthan.	Dr. S. M. Haldhar Dr. B. R. Choudhary Dr. R. Bhargava
(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 Dr. R. Bhargava Dr. R. S. Singh Dr. Hare Krishna
Concluded Projects		
CIAH- 4 (a)	Integrated disease management in cucurbits (watermelon and bottle gourd) and fruit (pomegranate) under arid zone of Rajasthan.	Dr. S. K. Maheshwari Dr. Dhurendra Singh Dr. B. R. Choudhary
Closed Project		
CIAH- 4 (d)	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 Dr. B. D. Sharma Dr. R. S. Singh Dr. Rajkumar
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 Dr. R. Bhargava
EF 3	Validation of DUS descriptor for date palm (*Phoenix dactylifera*).	Dr. R. S. Singh Dr. R. Bhargava
EF 4	Validation of DUS descriptor for *bael.*	Dr. A. K. Singh
EF 5	Characterization of *aonla* varieties for developing DUS testing guidelines.	Dr. A. K. Singh (Co-Nodal Centre: CHES, Godhra)
EF 6	Development of morphological descriptor and DUS testing guidelines for jamun.	Dr. Sanjay Singh (Co-Nodal Centre: CHES, Godhra)

Code	Title	Investigators
EF 7	Validation of DUS descriptors for chironji and tamarind	Dr. Sanjay Singh (Nodal Centre: CHES, Godhra)
EF 8	Production and demonstration of tissue culture raised plants under three locations and collection and maintenance of elite germplasm of date palm.	Dr. Dhurendra Singh
EF 9	Borers management in arid and semi-arid horticulture crops under consortium research platform (CRP) on borers in network mode.	Dr. S. M. Haldhar Dr. R. Bhargava Dr. R. S. Singh Dr. Hare Krishna Dr. A. K. Singh
EF 10	Network project on organic farming in horticultural crops.	Dr. B. D. Sharma Dr. R. Bhargava Dr. S. K. maheshwari Dr. B. R. Choudhary
EF 11	Network project on micro-nutrient management in horticultural crops for enhancing yield and quality.	Dr. B. D. Sharma Dr. R. Bhargava Dr. B. R. Choudhary
Concluded Externally Funded Project		
EF 4	Enhancement of livelihood of tribal farm households of Panchmahals district in Gujarat State through agricultural diversification.	Dr. S. S. Hiwale
New Research Project Proposal		
1.	Studies on compatibility and adaptability of citrus rootstock under hot arid environment of Rajasthan.	Mr. Jagan Singh Gora Mr. Ramesh Kumar Dr. B. D. Sharma
2.	Studies on flowering regulation, cracking management, root stock adaptability and value addition in pomegranate under hot arid environment of Rajasthan.	Mr. Ramesh Kumar
3.	Management of different diseases of arid horticultural crops through botanicals and inorganic salts under hot arid conditions of Rajasthan.	Dr. S. K. Maheshwari Dr. Hare Krishna Dr. B. R. Choudhary
Flagship Project		
1.	Development of *khejri* based cropping models under rainfed conditions.	Dr. D. K. Samadia Dr. B. D. Sharma 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
NRC on Seed Spices, Ajmer

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

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

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

Director
CIAH, Bikaner

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

Member Secretary

Dr. B. D. Sharma
Head, Division of Crop Production
CIAH, Bikaner

The meeting of RAC was held on 27-28 July, 2015.

INSTITUTE RESEARCH COMMITTEE (IRC)

Chairman

Dr. S. K. Sharma
Director
CIAH, Bikaner

Members

All Scientists of the Institute

Member Secretary

Dr. S. K. Maheshwari
Sr. Scientist (Plant Pathology)

IRC meeting was held on 16-17 April, 2015

INSTITUTE MANAGEMENT COMMITTEE

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

S. No.	Name of Members	Term	
1	ADG (H-1), ICAR, New Delhi	28.8.2014	27.8.2017
2.	Director (Horticulture) Government of Rajasthan, Jaipur (Rajasthan)	27.7.2015	26.7.2018
3.	Director of Horticulture Gujarat State, Krsihi Bhavan, Sector No.10-A, Gandhinagar (Gujarat)	27.7.2015	26.7.2018
4.	Director of Research, Swami Keswanand Rajasthan Agricultural University Bikaner	27.7.2015	26.7.2018
5.	Shri 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 Central Arid Zone Research Institute, Jodhpur	27.7.2015	26.7.2018
8.	Dr. Sanjay Singh P.S. & I/c Head, CHES, Vejalpur, Godhra	28.8.2014	27.8.2017
9.	Dr.R.Bhargava, Principal Scientist, CIAH, Bikaner	28.8.2014	27.8.2017
10.	Dr.Kishan Kant, Principal Scientist, NRCSS, Ajmer	28.8.2014	27.8.2017
11.	Dr.N.D.Yadava, P.S. & Head, CAZRI, RS, Bikaner	28.8.2014	27.8.2017
12	Administrative Officer & Member Secretary	Ex-officio whole time	

No meeting of IMC meeting held during 2015-16

11. MEETING, CONFERENCE, LECTURE, ETC.

MEETING

Dr. S. K. Sharma

Chaired SAC meeting at KVK, Godhra and monitored the progress of CHES, Godhra on 13.05.2015.

Attend meeting in Horticulture Science Division on 14.05.2015 under the chairmanship of DDG (Hort. Sci.)

Attended Vice Chancellors and Directors meeting on 15-16 May, 2015 at New Delhi.

Attend meeting of the tenure renewal committee at Krishi Bhawan at KAB-II on 24 August, 2015.

Attended 2nd Hailstorm Task Force Meeting held on 21.11.2015 at ICAR- NRCG, Pune.

Attended Assessment Committee Meeting for CAS under the revised CAS for promotion from Senior Scientist to Principal Scientist on 17.12.2015.

Attended Director and Vice-Checellor's conference at NASC Complex, ICAR, New Delhi from 22.01.2016 to 24.01.2016

Brainstorming on IPM in major crops at NASC Complex, Todapur, New Delhi on 17.02.2016.

Attended conduct the Annual Review Meeting of Date Palm Tissue Culture Project at Anand (Gujarat) on 18.02.2016.

Participated in the CRP-AB Northern Cluster Review Meeting at ICAR-CISH, Lucknow on 17.03.2016.

Dr. B. D. Sharma

Annual Group Meeting of AICRP on AZF at SKRAU, Bikaner on 04-06th February 2016.

Attended Institute Management Committee meeting of DRMR, Bharatpur on 05-11-2015.

Attended Institute Management Committee meeting of NRC on Seed Spices, Ajmer, on 18-01-6

Attended Institute Management Committee meeting of NRC on Camel, Bikaner, on 19-12-2015

Attended Institute Management Committee meeting of NRC on Camel, Bikaner, on 22-03-2016

Institute Technology Management Committee meeting as member at CIAH, Bikaner on 10-09-2015.

Attended Institute Variety Identification Committee of CIAH, Bikaner on 06-02-2016.

Attended as member of IJSC meetings held at CIAH Bikaner on 24-06-2015, 11-09-2015, 30-12-2015 and 30-03-2016.

Attended PG Committee meeting of the Institute on 16-08-2015, 12-12-2015 and 23-03-2016.

Attended as member of Project Monitoring Committee on 13-04-2015 at ICAR-CIAH, Bikaner

Attended as Member Secretary of RAC of ICAR-CIAH, Bikaner on 27-28th July 2015.

Attended IRC meeting of the Institute from 16-17 April 2015.

Attended RAC meeting of CIAH, Bikaner held on 26-27th July 2015.

Attended ICAR Industry Meet at CIAH, Bikaner as Chairman on 18-12-2015.

Attended meeting of Committee for implementation Official languages and Hindi Karyashala on 17-06-2015,18-09-2015, 30-03-2016 and organization of Hindi Diwas programme on 14 September, 2015.

Attended meeting of Germplasm Identification committee of Institute on 31-07-2015 03.09.2015 and 6.2.2016.

Annual Rate Contract for Chemical, Glasswares and Plasticwares held at CIAH, Bikaner on 15-05-2015.

Attended workshop on Improving Crop Water productivity in IGNP-Expanding Dimensions held at DHRD, SKRAU, and organized by CAZRI, RRS, Bikaner 02-03-2016.

Attended ICAR- Foundation Day programme organized by ICAR Institutes at Kalasar village, Bikaner on 16.7.2015.

Attended as Chairman of committee for DPC on 18.04.2015, 21.04.2015, 25.08.2015 29.08.2015, 11.02.2016 as member on 12.02.2016 for different staff of CIAH, CHES and KVK

Attended as Chairman of Selection Committee on 05-10-2015, 06.10.2015 at CIAH, Bikaner

Attended as Chairman of Screening Committee for MACPS of the staff of CIAH, Bikaner.

Attended as member of Selection committee at ICAR-NRCC, Bikaner on 21-03-2016.

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 09-10-2015.

Acted as Chief Guest On valedictory function of Hindi Week at CAZRI, RRS, Bikaner on 20-09-2015.

Attended Soil Health Card Committee meeting as member at Office of Joint Director, Agriculture (Extension), Bikaner on 09 -02-2016.

Attended workshop on "Climate Change: Mitigation and adaptation in hot arid regions" at DHRD, SKRAU, Bikaner organized by CAZRI, RRS, Bikaner on 26th February 2016.

Attended Launch function of Mera gaon mera Gaurav scheme in village Kalasar on 3-10-2015.

Attended workshop on Agriculture Development for western Dry Region at ICAR-CAZRI, Jodhpur on 06-11.2015

Attended Midterm Review Meeting of the recommendation of Regional Committee held at AAU, Anand at ICAR-CAZRI, Jodhpur on 07-011-2015.

Attended the meeting of watershed Development in Bikaner district at the office of CEO, Bikaner on 10-01-2016.

Attended as member of Selection Committee for T-6 at ICAR-NRCC, Bikaner 0n 24-06-2015.

Dr. Sanjay Singh

Participated in the National seminar on " Dynamics of smart horticulture for livelihood and rural development organised by ASM foundation at MGCGV, Chtrakoot from 28 to 30 May, 2015.

Participated in the International seminar on indigenous technologies for sustainable agriculture and better tomorrow during 9-10th January,2016 at NBRI, Lucknow, organized by Samagra Vikas Welfare Society, Lucknow.

Participated in the Annual Group Workers Meeting of AICRP on Arid fruits from 4-2-2016 to 6-2-2016 at SKRAU, Bikaner, Rajasthan.

Participated in the second World Noni Congress from 19-3-2016-20-3-2016 at SRM University, Chennai.

Participated in the national seminar on potential of dry land horticulture in semi arid ecosystem on 7-12-2015, organized by N M Sadguru water and development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

Attended the workshop on fruit cracking and soil health management in pomegranate on 3-10-2015 at NRC Pomegranate, Solapur.

Attended workshop on 12-10-2015 to make road map of horticultural in hills and plains of Gujarat held at DMAPR,Boriavi,Anand.

Participated in Kisan goshthi organized by N M Sadguru water and development Foundation, Dahod, on 7-12-2015.

Dr. R. S. Singh

Attended ICAR Industry Day meet programme at Khara Industrial Area,Bikaner on18th Decenber,2015..

Attended Annal Group meet of AICRP on AZF at SKRAU, Bikaner from 4-6 February, 2016.

Attended workshop of NICRA held at IABM,SKRAU,Bikanerorganized by CAZRI on 26.2.2016.

Attended IMC meeting ATARI as member, at ZPD, Zone –VI, CAZRI Campus Jodhpur on 29.2.2016.

Attended Institutes Variety Identification Committee meeting as Member Secretary held on 24.6.2015 and 6.2.2016 at CIAH,Bikaner.

Attended one day Workshop on Crop- water productivity in IGNP areas held at IABM, SKRAU

and organized by CAZRI, RRS, Bikaner on 02.3.2016.

Attended one day seminar on Patenting & Biodiversity in India held at NRCC, Bikaner on 26.9.2015.

Attended Reviw monitoring meeting of CRP on Agrobiodiversity at ICAR-CISH,Lucknow on 17.3.2016 and presented the progress report of the project for 2015-16.

Dr. R. Bhargava

Annual Workshop of AICRP on AZF at Bikaner 4-6 March, 2016

ICAR-DAC meeting at Krishi Bhawan, Jaipur on 5.6.2015.

IMC meeting on 8th September, 2015.

Dr. S. K. Maheshwari

Member Secretary (Dr. S. K. Maheshwari)–IRC Meeting held on 16-17th April, 2015.

Dr. S. K. Maheshwari attended meeting of Project Monitoring & Evaluation Committee (PMC) of ICAR-CIAH, Bikaner as 'Invitee Member' on 13-4-2015 for approval of status report of RPP-I.

Dr. S. K. Maheshwari acted as Member, ITMC meeting which was held on 8th September, 2015.

Dr A. K. Singh

Attended task Force meeting DUS bael at SKUAT, Dantiwada on 13/07/2015 for presenting DUS guide lines of bael.

Attended task Force meeting DUS aonla at CHES, Vejalpur on 15/10/2015 for presenting DUS guidelines of aonla.

Participated Research Workers group annual meet, AICRP on AZF from 12 to 14 December, 2016 at KNAU, Bikaner, Rajasthan

Attended task Force meeting DUS bael at SKUAT, Dantiwada on 13/07/2015 for presenting DUS guide lines of bael.

Attended task Force meeting DUS aonla at CHES, Vejalpur on 15/10/2015 for presenting DUS guidelines of aonla.

Participated in First World Noni Congress, Noni for Global Wellness, 19th – 21st March, 2016 at Chennai.

CONFERENCE/SEMIMAR-SYMPOSIUM/ WORKSHOP/ETC

Dr. S. K. Sharma

Attended ICAR-AICR on AZF 20th Research Workers Group Meeting-2016 held at SKRAU, Bikaner during 4-6 Feb. 2016

Dr. Dhurendra Singh

Attended International Conference on vertical farming at Bengaluru during 2-3 November 2015.

Attended Zonal Research Advisory Committee meeting for Rabi 2015-16 of Zone 1c organised by ARS, SKRAU, Bikaner on 1-2 Sept., 2015

Attended national seminar on ground water recharge and development organized by Govt. Dungar College, Bikaner on 17-18 , December 2015.

Attended Research management training programme on application of tissue culture techniques for micropropagation and crop improvement of date palm, AAU, Anand during 05.05.2015-03.06.2015

Participated in 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 18-02-2016 and presented 03 years progress of of project

Attended ICAR-AICR on AZF 20th Research Workers Group Meeting-2016 held at SKRAU, Bikaner during 4-6 Feb. 2016

Attended national round table meet of use of biotechnology for climate resilient agriculture organized by State Institute of Agriculture Management, Jaipur on 26.02.2016Attended National Seminar on Agriculture Resource Management for Sustainability and Eco-Restoration organised by Society for Agriculture and Arid Ecology at ICAR-CIAH, Bikaner during March 11-13, 2016

Dr. Sanjay Singh

Participated in the National seminar on "Dynamics of smart horticulture for livelihood and rural development organised by ASM foundation at MGCGV, Chtrakoot from 28 to 30 May, 2015.

Participated in the International seminar on indigenous technologies for sustainable agriculture

and better tomorrow during 9-10th January,2016 at NBRI, Lucknow, organized by Samagra Vikas Welfare Society, Lucknow.

Participated in the Annual Group Workers Meeting of AICRP on Arid fruits from 4-2-2016 to 6-2-2016 at SKRAU, Bikaner, Rajasthan.

Participated in the second World Noni Congress from 19-3-2016-20-3-2016 at SRM University, Chennai.

Participated in the national seminar on potential of dry land horticulture in semi arid ecosystem on 7-12-2015, organized by N M Sadguru water and development Foundation, Dahod, Gujarat in collaboration with CHES, Vejalpur.

Attended the workshop on fruit cracking and soil health management in pomegranate on 3-10-2015 at NRC Pomegranate, Solapur.

Attended workshop on 12-10-2015 to make road map of horticultural in hills and plains of Gujarat held at DMAPR,Boriavi,Anand.

Participated in Kisan goshthi organized by N M Sadguru water and development Foundation , Dahod, on 7-12-2015.

Dr A. K. Singh

Participated Research Workers group annual meet, AICRP on AZF from 12 to 14 December, 2016 at KNAU, Bikaner, Rajasthan

Participated in First World Noni Congress, Noni for Global Wellness, 19th – 21st March, 2016 at Chennai.

Dr. Ramkesh Meena

Attended and presented reports of varietal evaluation of*Bael* and Pomegranate in the Annual Workshop of AICRP on AZF held at CIAH, Bikaner during 4-6th Febuary, 2016.

Dr. P. P. Singh

Attended "National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" scheduled to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District- Satna (M.P.).

Attended National Symposium on Vegetables Legumes for Soil and Human Health scheduled to held February 12-14, 2016 at ICAR-IIVR, Varanasi.

Dr. S. K. Maheshwari

Attended "11th National Symposium on Dynamics of Crop Protection: Challenges in Agri-horticultural Ecosystems Facing Climate Change" scheduled to held during 23-25th April, 2015 at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan).

Attended "National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" scheduled to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District- Satna (M.P.).

Dr. M. K. Jatav

Attended International Conference on "Agriculture, Food Engineering and Environmental Sciences- Sustainable Approaches" (AFESA- *2015) Organized by* Jawaharlal Nehru University, New Delhi during 9th and 10th May, 2015.

Attended National Symposium on Sustaining Agricultural Productivity in Arid Ecosystems: Challenges & Opportunities (SAPECO-2015) During August 19-22, 2015 at Leh, RRS, ICAR-CAZRI.

Attended National Conference On Innovative Research in Agriculture, Food Science, Forestry, Horticulture, Aquaculture, Animal Sciences, Biodiversity, Environmental Engineering and Climate Change (AFHABEC-2015) Organized by "Krishi Sanskriti" On 17th and 18th October, 2015 Organized by Jawaharlal Nehru University, New Delhi

Dr. Pinaki Acharyya

Attended and participated in the National Workshop on " Sustainable ground water development and management" organized by Department of Geology and Geo-Ventures, Govt. Dungar College, Bikaner and delivered a talk on "Closed soilless growing systems" on 22nd December, 2015.

Dr. B. R. Choudhary

Participated in 33rd workshop of AICRP on Vegetable Crops held at ICAR-IIVR, Varanasi from 21-24 May, 2015.

Attended an International Conference 'Agriculture, Aquaculture, Food Technology,

Environment Dynamics and Climate Change' organized by Krishi Sanskriti on 17-01-2016 at JNU, New Delhi.

Attended an International Conference 'Natural Resource Management: Ecological Perspective' held at SKUAST-J, Jammu (J&K) from 18-20 February, 2016.

Attended a workshop on "Climate change mitigation and adaptation in hot arid region" organized by CAZRI RSS, Bikaner on 26-02-2016.

Attended a workshop on "Improving Water Productivity in IGNP- Expanding Dimensions" under ICAR-ICARDA Collaborative Project No. 8 organized by CAZRI RSS, Bikaner on 02-03-2016.

Dr. S. R. Meena

Attended the National Symposium on " Modern agro- technologies for nutritional security and health" organized by society for advancement of human and nature at YSPUSH, Solan, HP, India during 21 - 23 April, 2015 and gave oral presentations of two research papers entitled as (i) Land races of /Traditional fruits and vegetables in *Thar* desert area of Rajasthan: Major sources of food stuff, nutritional and livelihood security for the masses, authored by *S. R. Meena, B. D. Sharma, S. K. Sharma and S. K. Maheshwari* (ii) Reaching the masses/farmers with recent innovations in arid horticulture : Problems and prospects , authored by *S. R. Meena, B. D. Sharma, R. S. Singh and D. Singh.*

Attended 4th Jammu and Kashmir Agricultural Science Congress on " technological innovations, opportunities and challenges for sustainable rainfed agriculture and livelihood security" held at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu, during 28 - 30 October, 2015 and gave oral presentations of two research papers entitled as (i) A study on farming systems and crop diversification through horticultural crops for livelihood security in hot arid region of the Western Rajasthan, India, authored by S. R. Meena, R. S. Singh, B. D. Sharma and D. Singh (ii) Production and consumption systems of cucurbitaceous arid vegetables in the hot arid zone of the western Rajasthan: Evaluation, authored by S. R. Meena, R. S. Singh, D. Singh and B. D. Sharma.

Dr. D. K. Samadia

Attended 33rd Group Meeting of AICRP on Vegetable Crops and Brain Storming Session on Vegetable Seeds: Requirements and Gaps, organized at ICAR–IIVR, Varanasi from 21–24 May 2015.

Attended and presented vegetable research work in ZREAC (Zonal Research Extension Advisory Committee meeting – Rabi 2015–16 of Zone Ic), organized at ARS, SKRAU, Bikaner from 01–02 September 2015.

Attended and Acts as Vice–President and Co–convener of National Seminar – Agriculture resource management for sustainability and eco-restoration. Society for Agriculture and Arid Ecology Research, ICAR–CIAH, Bikaner from 11 – 13 March 2016.

Dr. Hare Krishna

Attended and presented an oral paper in National Symposium on Modern Agro-technologies for Nutritional Security and Health (MANUSH) held on 21-23 April, 2015 at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230 Himachal Pradesh, India.

Attended and presented an oral paper in 3rd International Symposium on Minor Fruits, Medicinal & Aromatic Plants (ISMF&MAP)', held on 20-21 May, 2015 at Bangladesh Agricultural University campus, Mymensingh, Bangladesh.

Attended and delivered a lecture during a workshop on 'Fruit cracking and soil health management in pomegranate' at ICAR-NRC on Pomegranate, Solapur on October 3, 2015.

Attended and presented an oral paper in *International Conference on Natural Resource Management: Ecological Perspectives* on 18-20 February, 2016 at Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu Chatha-Jammu (J&K) – 180 009, India.

Attended Workshop on 'Improving water productivity in IGNP- Expanding Dimensions' organized by CAZRI-RRS, Bikaner on March 2, 2016 at IIBM, SKRAU, Bikaner.

Dr. Jagan Singh Gora

Participate in Rajasthan State Government workshop on mandarin conducted by SIAM, Depart. of Agriculture, Jaipur. A lecture delivered

on "Status, constraints and strengthen of citriculture in Rajasthan" in Mandarin Workshop at Jhalawar Rajasthan dated 02 -04 feb. 2016.

Dr. S. M. Haldhar

National symposium on 'Sustaining agricultural productivity in arid ecosystems: challenges & opportunities (SAPECO-2015)' during August, 19-22, 2015 at CAZRI, Leh

25th National Conference on 'Natural resource management in arid and semi-arid ecosystem for climate resilient agriculture and rural development' organized by SKRAU, Bikaner during 17-19, February, 2016.

National Conference on 'Agriculture Resource Management for Sustainability and Eco-Restoration' organized by ICAR-CIAH, Bikaner during 11-13, March, 2016

Workshop on 'Climate change mitigation and adaptation in hot arid region' under NICRA project organised by CAZRI, RRS, Bikaner in 26th February, 2016.

LECTURE

Dr. B. D. Sharma

B. D. Sharma (2016) Increasing Water Productivity in Indira gandhi Canal Command Area. In: Workshop on Improving water productivity in IGNP-Expanding Dimension on 2nd march organized by CAZRI, RRS, Bikaner.

B. D. Sharma (2016) Evolving-Horticulture Production Systems in Climate Change of Arid Region. In: Workshop on Climate change: mitigation and adaptation in hot arid regions organized by CAZRI, Jodhpur on 26th February 2016.

B. D. Sharma (2016) Drip irrigation in horticultural crops with special reference arid region. In: Model training course on Horticulture based farming system for arid region held at CAZRI, RRS, Pali during 22-29th February 2016.

B. D. Sharma (2016) Integrated Nutrient management and Role of Bio-Fertilizers for sustainable Production of Underutilized Fruit Crops. In Short course on Exploitation of underutilized horticultural crops for sustainable production during 11-20th February 2016 at CHES, Godhra.

B. D. Sharma (2016) Micro-Irrigation System in Arid Horticulture In: Short course on Exploitation of underutilized horticultural crops for sustainable production during 11-20th February 2016 at CHES, Godhra.

B. D. Sharma (2016) Impact of soil health management practices on productivity of arid fruit crops. In Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 147-154.

B. D. Sharma (2015) Role of calcium and potassium in managing stress in plants. In: Winter School on Management of Abiotic and Biotic Stresses in Agriculture from 01-20th December at DHRD, SKRAU, Bikaner.

B. D. Sharma (2015) Soil health management in arid and semi-arid regions In: Winter School on Management of Abiotic and Biotic Stresses in Agriculture from 01-20th December at DHRD, SKRAU, Bikaner.

B. D. Sharma (2016) Bagwani Phaslon mein Jal Prabhandhan. In: farmers training on Sushak Kshetron mein Krishi Utpadakta Vradhi Hetu Navachar. (Hindi) at CAZRI, RRS, Bikaner during 8-12 March 2016.

S. K. Sharma and B. D. Sharma (2015) Post harvest handling and utilization of dryland fruits. In: Model training course at ICAR-CIPHET, Abohar during 17-24th November 2015.

Meena, S. R., B. D. Sharma, S. M. Haldhar and B. R. Choudhary (2016) Traditional vegetables of the hot arid region and their agro-economic importance. In: Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 199-203.

Sharma, S. K. and Sharma, B. D. (2016) precision farming in arid horticultural crops: status and prospects. In: Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 95-101.

Jatav, M. K., Acharyya, P., Krishna, Hare, Maheshwari, S. K., Sharma, B. D. and Meena, S. R. (2016). Micro irrigation in arid fruit and vegetable crops: Status and Prospects. Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 74-81.

Krishna, Hare, Jatav, M. K., Maheshwari, S. K., Singh, P. P., Haldhar, S. M. and Sharma, B. D. (2016). Principles and practices of good agricultural practices for arid fruit crops. Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 102-108.

Meena, S. R., Jatav, M. K., Maheshwari, S. K., Singh, D. and Sharma, B. D. (2016). Traditional approaches of water and nutrient management in horticultural crop production. Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 128-133.

Meena, S. R., Jatav, M. K., Maheshwari, S. K., Singh, D. and Sharma, B. D. (2016). Water and nutrient management: Role of indigenous technological knowledge in horticulture crop production in hot arid region. Chapter published in compendium (Edited by Jatav *et al.*) of ICAR Short Course in "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner, Rajasthan, p. 184-189.

Dr. R. S. Singh

Importance of Fruits production in Agriculture Education Day programme on 22.7.2015 at CIAH, Bikaner in which more than 106 students teachers were participated.

Production technologies of fruits in arid region in World Soil Health Day programme organized by CIAH at SareRupayat village ,Bikaner on 5.12.2015

Date palm – an ideal crop for arid conditions in Winter school entitiled, Management of biotic and abiotic stress in Agriculture" organized by Directorate of HRD, SKRAU,Bikaner on 9th December,2015.

Date palm and Lasoda cultivation in arid region in short course on Exploitation of Horticultural crops at CHES, Godhra on 12.2.2016.

Prospects of Exotic under utilized fruits in arid region in Short course on Exploitation of Horticultural crops at CHES, Godhra on 13.2.2016.

Good Management Practice for Date palm production and post harvest management in Short Course entitiled , "Good management practices for arid horticultural crops to combat current Agrarion crisis" held at CIAH, Bikaner on 27.2.2015.

Improved technology for Pomegranate Cultivation in Arid region in Farmers trainingprogramme of ATMA, on 10.3.2016 at CAZRI, RRS, Bikaner

Dr. Dhurendra Singh

Delivered a lecture on integerated production of horticulture crops . In farmer training under TSP organized by NRCC, Bikaner on 18.03.2016

Delivered a lecture on integerated production of horticulture crops . In farmer training under TSP organized by ARS-CSWRI, Bikaner on 27.03.2016

Delivered a lecture of khejri propagation and nursery establishment in World Soil Day at Sarayrupayat village (7, 8 &9 JMD) of Bikaner on 05.12.2015 organised by CIAH, Bikaner

Delivered a lecture of management of arid fruit crops in Farmer Fair organised by RAJUVAS and ATMA, Bikaner

Delivered a lecture and Practical training to newly recruited scientist DR L P Yadav and Vikas Yadav on biotechnology for crop improvement on 26.10.2015

Delivered a lecture and Practical training to newly recruited scientist Mr Gangadhar K and Dr V K Reddy on biotechnology for crop improvement on 26.10.2015

Delivered 03 lectures on kitchen gardening In Training programme on gardening for families of army personnels. Organised by Abhiruchi Hobby Centre, Bikaner cantonment during 14-28 Sept. 2015

Delivered a lecture on Production of disease free planting material on 26.02.2016 in Short course on Good management practices for arid horticultural crops to combat current Agrarian Crisis conducted at Central Institute for Arid Horticulture, Bikaner during February 25th to March 5th, 2016

Delivered a presentation on Prospectus of mulberry cultivation in peri-urban areas of arid region in Zonal Research Advisory Committee meeting for Rabi 2015-16 of Zone 1c organised by ARS, SKRAU, Bikaner on 1-2 Sept., 2015

Delivered lecture on nursery raising of khejri at village Bichhasar , FLD organized ov Khejri, CIAH Bikaner

Delivered lecture on on Potato as intercrop with kinnow orchard in Field Day organized by o ATMA, Bikaner 16.0.2016

Delivered a lecture on Importance of micropropagation in arid fruit crops in national round table meet of use of biotechnology for climate resilient agriculture organized by State Institute of Agriculture Management, Jaipur on 26.02.2016

Dr. R. Bhargava

Bhargava, R. 2016. Arid Horticulture-way forward. In National Science Day celebration at Department of Botany, University of Jammu, Jammu on 8th March, 2016.

Bhargava, R. 2016. Impact of climate change on production of arid horticultural crops. In National Conference on Biodiversity, Conservation and pollution Control- Challenges and Strategies" held at Department of Environmental Sciences, University of Jammu, Jammu on 9th March, 2016.

Bhargava, R. 2016. Impact of water stress on growth, development and photosynthetic activity in water melon and mateera. In. National Seminar on New Vistas in Plant and microbial Sciences" Department of Botany, University of Jammu, Jammu on 12th March, 2016.

Dr. D. K. Samadia

Delivered lecture - Status, strategies and scope of improvement in vegetable crops under abiotic stresses of hot arid and semi-arid sub-tropic climate. In winter school: "Management of biotic and abiotic stresses in agriculture" Organized by DHRD, SKRAU, Bikaner from 01–21 December 2015.

Delivered lecture - Status, strategies and scope of improvement in fruit crops under abiotic stresses of hot arid and semi-arid sub-tropic climate. In winter school: "Management of biotic and abiotic stresses in agriculture" Organized by DHRD, SKRAU, Bikaner from 01–21 December 2015.

Delivered lecture - Vegetable based integrated framing systems for arid and semi-arid areas. In model training course: "Integrated farming systems in arid and semi-arid regions" Organized by Directorate of Extension, SKRAU, Bikaner from 22–29 February 2016.

Delivered lecture - Innovative concepts, techniques and practices for managing vegetable culture under environmental stresses of hot sub-tropic climate. In short course: Good management practices for arid horticultural crops to combat current agrarian crises. Organized by ICAR–Central Institute for Arid Horticulture, Bikaner from 25 February – 05 March 2016.

Delivered lecture - Breeding strategies for enhancing vegetable production under environmental stresses of hot agro-climate. In short course: Good management practices for arid horticultural crops to combat current agrarian crises. Organized by ICAR–Central Institute for Arid Horticulture, Bikaner from 25 February – 05 March 2016.

Delivered scientific training lecture – Orientation regarding the research programme in vegetable / perennial vegetable / seed production. Professional training programme of Mr. L. P. Yadav and V. Yadav, CIAH: Bikaner on 27/04/2015.

Delivered scientific training lecture – Orientation regarding genetic resources, research on arid vegetables / seed production / work on khejri. Professional training programme of Mr. K. Gangadhara and V. R. Reddy, CIAH: Bikaner on 02/11/2015.

Delivered talk – Innovative arid zone vegetable culture. Farm Innovations Day, Organized by CIAH at village - Sarayrupayat on 09/10/2015.

Dr. M. K. Jatav

A Lecture was delivered on Micro-irrigation in arid fruit and vegetable crops: status and prospects in ICAR sponsored 10 days training programme on Good management practices for arid horticultural crops to combat current Agrarian Crisis conducted at Central Institute for Arid Horticulture, Bikaner during February 25th to March 5th, 2016

A Lecture was delivered on Soil and nutrient management for enhancing productivity of *kachari* and snap melon in Off campus farmers training programme on Nutrient management of *kachari* and snap melon" at Khinchiya village of Bikaner district on 18/11/2015

A Lecture was delivered on Soil health care, its testing and soil health card importance for farmers in Off campus farmers training programme on Nutrient management of *kachari* and snap melon" at Khinchiya village of Bikaner district on 18/11/2015.

A Lecture was delivered on Soil health care, its testing and soil health card importance for farmers in Off campus farmers training programme on Nutrient management of clusterbean and mateera in the arid region" in Khinchiya village of Bikaner district on 30/11/2015.

A Lecture was delivered Soil and nutrient management for enhancing productivity of clusterbean and mateera in Off campus farmers training programme on Nutrient management of clusterbean and mateera in the arid region" in Khinchiya village of Bikaner district on 30/11/2015.

A Lecture was delivered on Soil health care, its testing and soil health card importance for farmers in World Soil Day at Sarayrupayat village (7, 8 &9 JMD) of Bikaner on 05.12.2015.

A Lecture was delivered on Nutrient management in vegetable crops in Farm Innovators Day at Sarayrupayat village (7, 8 &9 JMD) of Bikaner on 09.09.2015.

A Lecture was delivered on Nutrient management in vegetable crops in Farmers-Scientists Interface Workshop on Agriculture Resource Management for Sustainable Production in arid region during (March 11-13, 2016) At ICAR-Central Institute for Arid Horticulture, Bikaner-334006, Rajasthan Supported Agricultural Technology Management Agency (ATMA).

A Lecture was delivered on Soil and water conservation/use of micronutrients in Orientation/ Induction programme of Dr Lalu Prasad Yadav, Scientist on 29.04.2015.

A Lecture was delivered on Soil and water conservation/use of micronutrients in Orientation/ Induction programme of Mr Gangadhara K and Dr Vijay Rakesh Reddy on 31.10.2015.

A Lecture was delivered on Nutrient management in vegetable crops in Farmers-Scientists Interface Workshop on Agriculture Resource Management for Sustainable Production in arid region during (March 11-13, 2016) At ICAR-Central Institute for Arid Horticulture, Bikaner-334006, Rajasthan Supported Agricultural Technology Management Agency (ATMA).

A Lecture was delivered on soil and nutrient management in Khejri in Off campus farmers training programme on Improved agro-techniques of establishing orchard of khejri "thar shobha at a farmers (Sh NK Kiradu) fielf situated in Khajuwala Tehsil of Binaker

Dr. B. R. Choudhary

Delivered lectures on 'Gardening of fruit and vegetables' in a training programme organized by Ranbankura Division of Army, Bikaner from 14-28 Sept., 2015.

Delivered a lecture in Farm Innovators Day organized by ICAR-CIAH, Bikaner on 09-10-2015 in Sarayrupayat village of Bikaner district.

Delivered a lecture on 30-11-2015 in an Off Campus training programme organized by ICAR-CIAH, Bikaner in Khinchiya village of Bikaner district.

Delivered oral presentation on 'Sources of variation in sponge gourd breeding' in International Conference in Agriculture, Aquaculture, Food Technology, Environment Dynamics and Climate Change organized by Krishi Sanskriti on 17-01-2016 at JNU, New Delhi.

Delivered a lecture on 'Low tunnel cultivation of cucurbitaceous crops in arid region' during a short course organized by ICAR-CIAH, Bikaner from Feb. 25, 2016 to March 5, 2016.

Delivered a lecture on 'Improved cultivation practices of *rabi* season vegetable crops' in a training programme organized by ICAR-CAZRI RSS, Bikaner from 8-12 March, 2016.

Dr. Hare Krishna

Delivered lecture on 'बेर उत्पादन एवं प्रसंकरण' on 11-03-16 organized by ICAR-CAZRI-RRS, Bikaner.

Delivered lecture on topic 'Agri-horti based production system: potential and prospects in arid and semi arid regions' during Model Training Course on 'Integrated farming system in arid and semi-arid regions' on 23-02-15 organized at Directorate of Extension Education, SKRAU, Bikaner.

Delivered lectures on 'Fruit based diversified cropping system under arid ecosystem', 'Minor fruits: mines of antioxidants' and 'DUS guidelines for Indian jujube (*ber*)' during ICAR sponsored short course on "Good management practices for arid horticultural crops to combat current agrarian crisis" held on 25th February-5th March, 2016 at ICAR-CIAH, Bikaner.

Delivered lectures on topics 'Antioxidant properties of arid fruits' and 'Physiology of canopy management of underutilized fruits' on 13.02.2016 during the ICAR sponsored short course on "Exploitation of underutilized horticultural crops for sustainable production" held at CHES (ICAR-CIAH), Vejalpur, Godhara.

Delivered a talk on the topic 'Physiology of fruit cracking and its management through application of cling film' during a workshop on 'Fruit cracking and soil health management in pomegranate' at ICAR-NRC on Pomegranate, Solapur on October 3, 2015.

Dr. Pinaki Acharyya

Delivered lecture on "Closed soilless growing systems" on 22nd December,2 015 in the National Workshop on "Sustainable ground water development and management" organized by Department of Geology and Geo-Ventures, Govt. Dungar College, Bikaner.

Dr. S. K. Maheshwari

Delivered an oral presentation entitled: "Management of shoe-string disease of watermelon/ *mateera* in Rajasthan" in "11th National Symposium on Dynamics of Crop Protection: Challenges in Agri-horticultural Ecosystems Facing Climate Change" scheduled to held during 23-25th April, 2015 at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan).

Delivered an oral presentation of research paper entitled: "Response of different genotypes/varieties of ridge gourd for resistance to mosaic disease under field conditions of Rajasthan" in "National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" scheduled to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District- Satna (M.P.).

Dr. S. K. Maheshwari delivered a lecture on "Disease management in arid fruits" in one day off campus farmer's training programme entitled: "Improved horticultural practices *vis-à-vis* arid fruit production" on 24-11-2015 at Sarairupayat village of Bikaner district.

Dr. S. K. Maheshwari delivered a lecture on "Disease evasion of arid horticultural crops through good agricultural practices and optimal use of fungicides" in 10 days ICAR sponsored Short Course entitled "Good Management Practices for Arid Horticultural Crops to Combat current Agrarian Crisis" held on 25th February-05th March, 2016 at ICAR-CIAH, Bikaner.

Dr. S. K. Maheshwari delivered a lecture on "Disease management in horticultural crops" in 05 days farmers training programme on "Shushk Cshetron mein Krishi Utpaadakta Vardhi hetu Navachar" during 08-12 March, 2016 at ICAR-CAZRI, RRS, Bikaner.

Dr. P. P. Singh

Delivered an oral presentation of research paper entitled: "Variability Studies in Aonla wild Genotype for fruit character from the North Eastern Region of India" in "National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development" scheduled to held during 28th-31st May, 2015 at Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya (MGCGV), Chitrakoot, District- Satna (M.P.).

Delivered an oral presentation of research paper entitled: Prospects and Potential of under Utilized

leguminous crops of Hot Arid Region in National Symposium on Vegetables Legumes for Soil and Human Health scheduled to held February 12-14, 2016 at ICAR-IIVR, Varanasi.

Dr. S. M. Haldhar

Report of *Digama hearseyana* (Noctuidae: Lepidoptera) on Karonda (*Carissa carandus*) Plant in Rajasthan, India: Incidence and Morphological Analysis *National Conference on 'Agriculture Resource Management for Sustainability and Eco-Restoration' organized by ICAR-CIAH, Bikaner during 11-13, March, 2016.*

Integrated pest management and optimal use of pesticides in arid fruit and vegetable crops10 days short coarse programme on 'Good management practices for arid horticultural crops to combat current agrarian crisis' during February 25 to March 05, 2016.

Pioneer white butterfly, *Belenois aurota* (Lepidoptera: Pieridae) a new threat to ker (*Capparis decidua*) plant in arid region of India: incidence and morphological evidence *25th National Conference on 'Natural resource management in arid and semi-arid ecosystem for climate resilient agriculture and rural development' organized by SKRAU, Bikaner during 17-19, February, 2016.*

Antixinotic and allelochemical resistance traits of ridge gourd [*Luffa acutangula* (Roxb.) L.] against melon fruit fly (*Bactrocera cucurbitae* (Coquillett)) in arid region *National symposium on sustaining agricultural productivity in arid ecosystems: challenges & opportunities (SAPECO-2015) during August, 19-22, 2015 at CAZRI, Leh*

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*

Insect-pests management of arid fruits and vegetable crops *Farmers-Scientist interaction workshop organized by ICAR-CIAH, Bikaner during 11-13, March, 2016*

IMPOARTANT EVENTS

Celebration of Week/day

Celebration of Foundation of the Institute: Foundation Day of the Institute was celebrated on 01.04.15 at the Institute.

Celebration of Farm Innovators Day: Farm Innovators Day held on 09.10.15 at Sarehrupayat village of Bikaner District in which more than 100 innovative farmers were participated. They 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 Industry Day: The ICAR Industry Day was Celebrated at the Institute on 18.12.2015 during which several industrialist and clients were participated and there were held various discussions on industrial aspects of arid horticultural crops.

Celebration of Agriculture Education Day: On 22.07.15 the Agriculture *Education Day* was celebrated in the Institute in which > 100 students and teachers from different school of Bikaner participated. Technological film of the Institute for the technical knowledge of arid horticultural technologies was shorn. The students and other participants were visited to the Museum of the Institute to acquaint them with latest technologies displayed in the museum.

Organization of Communal Harmony Campaign and the Fund Raising Week: During the reported period the Communal Harmony Campaign and the Fund Raising Week" (Under NFCH, New Delhi.) was carried out in the Institute from 19-25 November, 2015.

Celebration of World Soil Day : World Soil Day was celebrated at Sarayrupayat village of Bikaner district. In this programe 110 farmers were participated and the distribution of soil health card was initiated.

12. DISTINGUISHED VISITORS

BIKANER

- Dr. B. R. Chhipa, Vice Chancellor, SKRAU, Bikaner on 31.03.2016
- Dr. Govind Singh, Director of Research, SKRAU, Bikaner on 31.03.2016
- Dr. T. Janakiram, Asstt. Director General (Hort. Sci,.), ICAR, New Delhi on 06.03.2016
- Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture Science), ICAR, New Delhi visited on 05.03.2016.
- Dr. A. D. Pathak, Director, ICAR-IISR, Lucknow. on 21.03.2016.

GODHRA

- Smt. P. Bharthi I.A.S. Distt. Collector, Panchmahals (18/06/2015)
- Dr. S. B. Dandin, Formar V.C.U.H.S. Bogalkot & Presently Liaison Officer (08/07/2016)
- Anil Rao, Khareta Polyhouses and Farms Alwar, Raj. (21/07/2015)
- Dr. A. K. Sangwan and Dr. Navprem Singh (19/08/2015)
- Dr. V. Parthsarthi, Formar Director ICAR-IISR (19/08/2015)
- Prof. R. R. Hanchinal Chair person, Protection of plant, varieties and farmer's right (19/08/2015)
- Dr. H Ravishankar PS (Hort) I/C ATIC, IIHR, Bangaluru. (15/10/2015)
- Dr. Kirti Singh, Former V. C. NDUA&T, Faizabad, Ex-Chairman ASRB,(ICAR), New Delhi (15/10/2015) and Chair Person , WNRF, Chennai
- Dr. S.L.Mehta Ex D.D.G. Edu. Ex V.C. MPUAT, Udaipur (15/10/2015)
- Dr. B.S.Chundawat, Formar V.C.SDAU, Dantiwada Gujarat, Udaipur (16/02/16)

13. RAJBHASHA

हिन्दी चेतना सप्ताह का आयोजन

भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान बीकानेर, में दिनांक 14 से 19 सितम्बर, 2015 तक हिन्दी चेतना सप्ताह का आयोजन किया गया। इस दौरान हिन्दी सामान्य व्याकरण ज्ञान प्रतियोगिता, हिन्दी शब्द लेखन प्रतियोगिता और हिन्दी में वैज्ञानिक शोध पत्र पोस्टर प्रतियोगिता का आयोजन किया गया। इन आयोजित विभिन्न प्रतियोगिताओं में विजेताओं को अतिथियों ने पुरस्कार वितरित किए। **हिन्दी सामान्य व्याकरण ज्ञान प्रतियोगिता** में प्रथम श्री भोजराज खत्री, तकनीकी अधिकारी, द्वितीय डॉ. उदयवीर सिंह, वरिष्ठ तकनीकी अधिकारी और तृतीय डॉ. सुशील कुमार महेश्वरी, वरिष्ठ वैज्ञानिक रहे। **हिन्दी शब्द लेखन प्रतियोगिता** में वर्गवार पुरस्कार वितरित किए गये। प्रशासकीय वर्ग में प्रथम श्री स्वरूप चंद राठौर, उ.श्रे. लिपिक, द्वितीय श्री कुलदीप पान्डे, सहायक और तृतीय श्री रावत सिंह, उ.श्रे. लिपिक, तकनीकी वर्ग में प्रथम श्री पृथ्वीराज सिंह, वरिष्ठ तकनीकी सहायक और द्वितीय श्री संजय पाटिल, वरिष्ठ तकनीकी अधिकारी तथा वैज्ञानिक वर्ग में प्रथम डॉ. बालूराम चौधरी, वरिष्ठ वैज्ञानिक, द्वितीय डॉ. पुष्पेन्द्र प्रताप सिंह, वरिष्ठ वैज्ञानिक और तृतीय डॉ. रमेश कुमार, वैज्ञानिक रहे। **हिंदी में वैज्ञानिक शोध पत्र पोस्टर प्रतियोगिता** में प्रथम स्थान पर डॉ. हरे कृष्ण, वरिष्ठ वैज्ञानिक और द्वितीय स्थान पर डॉ. श्रवण एम. हलधर, वैज्ञानिक रहे। वर्ष 2014 के दौरान **हिन्दी में सर्वाधिक कार्य** के लिए श्री राकेश कुमार स्वामी, सहायक को रू. 500/– का नकद पुरस्कार दिया गया।

हिन्दी चेतना सप्ताह का समापन समारोह दिनांक 19 सितम्बर, 2015 को आयोजित किया गया था। इस अवसर पर वरिष्ठ हिंदी साहित्यकार और केन्द्रीय विद्यालय, बीकानेर की पूर्व प्राचार्या **डॉ. (श्रीमती) प्रभा खत्री** ने समापन समारोह की अध्यक्ष की। उन्होंने कहा कि हिन्दी रूप से सुदृढ़ व्याकरणीय भाषा है। इसे जैसे बोला जाता है वैसे ही लिखा भी जाता है। विश्व में आज हिंदी का प्रचलन बढ़ रहा है उसका श्रेय हम सबों को जाता है। समारोह में राजुवास, बीकानेर के सूक्ष्म जीवविज्ञान प्राध्यापक **डॉ. बृजनंदन श्रृंगी** विशिष्ठ अतिथि थे। हमें अपनी उन्नत और प्रभावशाली भाषा को न केवल अपनाना है बल्कि इसका विदेशों में भी प्रचार करना है।

इस अवसर पर संस्थान के निदेशक **डॉ. सतीश कुमार शर्मा** ने अतिथियों का स्वागत करते हुए संस्थान के क्रिया कलापों के बारे में बताया। संस्थान में हिंदी का प्रयोग बढ़ाने के लिए भारत सरकार के प्रेरणा और प्रोत्साहन कार्यक्रम की प्रशंसा की। उन्होंने कहा कि अपनी भाषा, अपनी वेष–भूषा और अपने देश पर हम सबको गर्व करना चाहिए। इसमें वैज्ञानिक साहित्य की रचना करके हमें किसानों तक इसे पहुँचाना चाहिए ताकि कृषि के क्षेत्र में हुए तकनीकी विकास को किसान अपनी भाषा में समझ सके।

हिन्दी कार्यशालाओं का आयोजन

पहली तिमाही की कार्यशाला दिनांक 24 जून 2015 को आयोजित की गयी। दूसरी तिमाही की कार्यशाला का आयोजन दिनांक 21 अगस्त, 2015 को किया गया। इसमें परिषद मुख्यालय के राजभाषा विभाग के उप मुख्य तकनीकी अधिकारी श्री मनोज कुमार ने 'राजभाषा–नियमावली और क्रियान्वयन' विषय पर व्याख्यान दिया। वर्ष 2015 की अंतिम तिमाही की कार्यशाला का आयोजन दिनांक 31 दिसम्बर, 2015 को किया गया। इसमें भाकृअनुप–राष्ट्रीय डेयरी अनुसंधान संस्थान, करनाल (हरियाणा) के पूर्व प्रशासनिक अधिकारी श्री संतोख सिंह ने 'कार्यालय में हिंदी का प्रयोग कैसे बढ़ाएं' विषय पर व्याख्यान देकर संस्थान के अधिकारियों एवं कर्मचारियों को हिंदी में कार्य करने को प्रेरित किया। चौथी तिमाही की कार्यशाला दिनांक 30 मार्च 2016 को आयोजित की गयी थी।

हिन्दी चेतना सप्ताह के समापन अवसर पर उपस्थित अतिथिगण एवं पुरस्कार ग्रहण करते हुए प्रतिभागी

राजभाषा कार्यान्वय समिति की बैठक

संस्थान राजभाषा कार्यान्वयन समिति की बैठक प्रत्येक तिमाही में आयोजित की गयी हैं। पहली तिमाही की बैठक दिनांक 24 जून 2015 को, दूसरी तिमाही की बैठक दिनांक 18 सितम्बर, 2015, तीसरी बैठक दिनांक 30 दिसम्बर 2015 और चौथी तिमाही की बैठक दिनांक 30 मार्च 2016 को आयोजित की गयी थी।

14. PERSONNEL

STAFF POSITION AS ON 31.03.2016

CIAH (including CHES)

No.	Designation	Sanctioned Posts	Posts filled	Posts vacant
1.	Director (RMP)	01	01	--
2.	Scientific	35	25	10
3.	Technical	42	36	06
4.	Administrative	23	17	07
5.	Skilled Support Staff	33	26	07
Total		134	105	30

*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. M.K. Jatav	Senior Scientist (Soil Science)
9.	Dr. P.P. Singh	Senior Scientist (Vegetable Science)

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from previous page

S. No.	Name	Designation/Discipline
10.	Dr. Pinaki Acharya	Senior Scientist (Vegetable Science)
11.	Dr. B. R. Chaudhary	Senior Scientist (Vegetable Science)
12.	Dr. S.R. Meena	Senior Scientist (Agril. Extension)
13.	Dr. D. K. Sarolia	Scientist (Vegetable Science)
14.	Dr. S. M. Haldhar	Scientist (Agri. Entomology)
15.	Sh. Ramesh Kumar	Scientist (Floriculture)
16.	Dr. Ramkesh Meena	Scientist
17.	Dr. Jagan Singh Gora	Scientist (Fruit Science)
18.	Dr. Vijay Rakesh Reddy S.	Scientist (Fruit Science)
19.	Sh. Gangadhara K.	Scientist (Vegetable Science)
	III. ADMINISTRATIVE	
1.	Shri Ramdeen	Administrative Officer
2.	Shri Raj Kumar	Finance & Accounts Officer
3.	Sh. Kuldeep Pandey	Asstt. Admn. 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
6.	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. A.K. Singh	Senior Scientist
3.	Dr. V.V. Appa Rao	Senior Scientist
4.	Dr. Vikas Yadav	Scientist
5.	Dr. Lalu Prasad Yadav	Scientist
6.	Dr. D. S. Mishra	Scientist
	II. ADMINISTRATIVE	
1.	Sh. Rajesh Daiya	Asstt. Admn. 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 (Official Language)
4.	Sh. A.V.Dhobi	Sr. Technical Officer (Civil)
6	Sh. K. K.Vankar	Technical Officer (Field)

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S. No.	Name	Designation/Discipline
7	Sh. G.R.Baria	Technical Officer (Field)
8	Sh. B.J.Patel	Technical Officer(Artist cum Photography)
9	Sh. R.B.Baria	Technical Officer (Field)
10	Sh. R.D.Rathva	Technical Officer (Lab.)
11	Sh. C.S.Chamar	Technical Officer (Field)
12	Sh. K.V.Parmar	Technical Officer (Lab.)
13	Sh. D. C.Joshi	Technical Officer (Field)

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 Khadda	Sr. Technical Officer - (Animal Hus.)
3	Dr. Ajay Kr. Rai	Sr. Technical Officer - (Soil Sci.)
4	Dr. Raj Kumar	Sr. Technical Officer - (Hort.)
5	Dr. Shakti Khajuria	Sr. Technical Officer - (Plant Prot.)

NEW ENTRANTS

1. Dr. Lalu Prasad Yadav, Scientist (Veg. Science) joined on 08.04.2015.
2. Dr. Vikas Yadav, Scientist (Fruit Science) joined on 10.04.2015.
3. Dr. Deepak Kumar Sarolia, Sr. Scientist (Veg. Science) joined on 07.10.2015.
4. Sh. Gangadhara K., Scientist (Veg. Science) joined on 12.10.2015.
5. Dr. Vijay Rakesh Reddy, Scientist (Fruit Science) joined on 12.10.2015
6. Dr. Daya Shankar Mishra, Sr. Scientist (Fruit Science) joined on 02.03.2016.
7. Sh. Kamlesh Kumar, Scientist (Hort.) (Fruit Science) joined on 11.04.2016.
8. Sh. Ajay Kumar Verma, Scientist (Veg. Science) joined on 11.04.2016.

PROMOTION

ADMINISTRATIVE

No.	Name/Designation	Grade/post to which promoted	Date of Promotion
1.	Sh. K.F. Kharkhariwala, Assistant	Assistant Administrative Officer	01.01.2016
2.	Sh. Rajesh Daiya, Assistant	Assistant Administrative Officer	05.01.2016
3.	Sh. Kuldeep Pandey, Assistant	Assistant Administrative Officer	14.03.2016
4.	Sh. H.S. Patel, U.D.C.	Assistant	23.01.2016

TECHNICAL ASSESSMENT

N.	Name and Present Grade/ Designation	Promoted to Grade/Scale	Date of merit Promotion	Present Place of Posting
1.	Shri D.C. Joshi Senior Technical Assistant (Field)	Technical Officer (Field) PB-2/Rs.9300-34800 with Grade Pay of Rs.4600	01.01.2011	CHES, Godhra
2.	Shri C.S. Chamar Senior Technical Assistant (Field)	Technical Officer (Field) PB-2/Rs.9300-34800 with Grade Pay of Rs.4600	01.01.2014	CIAH, Bikaner
3.	Shri D.P. Patel Technical Assistant (Field)	Sr. Technical Assistant (Field) PB-2/Rs.9300-34800 with Grade Pay of Rs.4200	01.01.2010	CHES, Godhra
4.	Shri A.J. Solanki Technical Assistant (Field)	Sr. Technical Assistant (Field) PB-2/Rs.9300-34800 with Grade Pay of Rs.4200	01.07.2010	CHES, Godhra
5.	Shri K.M. Parmar Technical Assistant (Mechanic)	Sr. Technical Assistant (Mechanic) PB-2/Rs.9300-34800 with Grade Pay of Rs.4200	02.11.2010	CHES, Godhra
6.	Shri P.G. Vankar Sr. Technician (Field)	Technical Assistant (Field) PB-1/Rs.5200-20200 with Grade Pay of Rs.2800	21.09.2014	CHES, Godhra
7.	Shri N.B. Varia Technician (Driver)	Sr. Technician (Driver) PB-1/Rs.5200-20200 with Grade Pay of Rs.2400	29.07.2014	CHES, Godhra

MODIFIED Assured Career Progression scheme (MacpS)

S. No.	Name of Official with designation	Financial Up-gradation granted	Effective Date
1.	Sh. D.U. Chauhan	II Financial Up-gradation PB-1/ Rs 5200-20200 + GP Rs 2800.00	22.07.2015
2.	Sh. D.B. Yadav, SSS	III Financial Up-gradation . PB-1/ Rs 5200-20200 + GP Rs 2400.00	02.04.2014

PROBATION CLEARANCE

No.	Name and Designation	Post/Grade	Date of appointment	Date of clearance of Probation
1.	Sh. Rakesh Kumar Swami	Assistant Pay Band-2/Rs.9300-34800 with Grade Pay of Rs.4200/-	02.04.2012	01.04.2014

PROBATION CLEARANCE & CONFIRMATION

No.	Name and Designation	Post/Grade	Date of appointment	Date of clearance of Probation	Date for confirmation in ICAR service
1.	Smt. Pooja Joshi	Stenographer Grade-III Pay Band-1/Rs.5200-20200 with Grade Pay of Rs.2400/-	25.05.2012	24.05.2014	25.05.2014

JOINING ON TRANSFER/PROMOTION

Sl. No.	Name/Designation	Date of joining
1.	Sh. D.U. Chauhan, L.D.C.	29.10.2015
2.	Dr. Ramkesh Meena, Scientist (Fruit Science)	17.12.2015 (A.N.)
3.	Sh. K.F. Kharkhariwala, AAO	01.01.2016
4.	Sh. H.S. Patel, Assistant	23.01.2016

RELIEVING ON PROMOTION/TRANSFER

1. Dr. Rajkumar, Scientist (Fruit Science) relieved on 25.04.2015 (A.N.) on transfer to ICAR-CSSRI, Karnal.
2. Sh. Satpal, Senior Technical Assistant (Driver) relieved on 30.05.2015 (A.N.) on transfer to CIRB, Hisar.
3. Dr. Lalu Prasad Yadav, Scientist (Veg. Science) relieved on 24.08.2015 (A.N.) on transfer to CHES, Vejalpur, Godhra.
4. Dr. Vikas Yadav, Scientist (Fruit Science) relieved on 24.08.2015 (A.N.) on transfer to CHES, Vejalpur, Godhra.
5. Sh. B.K. Panchal, L.D.C. relieved from the Institute on 30.11.2015 on transfer to CHES, Vejalpur, Godhra.
6. Dr. P.N. Sivalingam, Scientist (Plant Biotechnology) relieved from the Institute on 30.01.2016 for joining the post of Sr. Scientist (Agricultural Biotechnology) at ICAR- NIBSM, Raipur (Chhattisgarh).
7. Sh. K.V. Parmar, Technical Officer - Lab. relieved from the Institute on 15.03.2016 on transfer to CHES, Vejalpur, Godhra.
8. Sh. C.S. Chamar, Technical Officer - Field relieved from the Institute on 15.03.2016 on transfer to CHES, Vejalpur, Godhra.
9. Sh. Gangadhara K., Scientist (Veg. Science) relieved from the Institute on 30.04.2016 on transfer to CHES, Vejalpur, Godhra.

SUPERANNUATION/RETIREMENT

1. Dr. S.S. Hiwale, Principal Scientist retired on superannuation from the Council's service in the afternoon of 31.03.2015.
2. Sh. B.H. Patel, Technical Officer - Field retired on superannuation from the Council's service in the afternoon of 31.05.2015.
3. Sh. A.D. Vankar, SSS retired on superannuation from the Council's service in the afternoon of 30.06.2015.
4. Smt. R.K. Shah, AAO retired on superannuation from the Council's service in the afternoon of 31.10.2015.
5. Sh. N.A. Patel, AAO retired on superannuation from the Council's service in the afternoon of 31.10.2015.
6. Sh. K.F. Kharkhariwala, AAO retired on superannuation from the Council's service in the afternoon of 29.02.2016.

OBITUARY

1. Sh. K.S. Chauhan, SSS, CHES, Vejalpur, Godhra expired on 17.09.2015.
2. Sh. R.K. Solanki, Personal Assistant, CHES, Vejalpur, Godhra expired on 29.01.2016.
3. Sh. P.G. Vankar, Technical Assistant - Field, CHES, Vejalpur, Godhra expired on 21.02.2016

15. BUDGET

Rs. In lakhs

No.		HEAD	CIAH BIKANER	CHES GODHRA	TOTAL	CIAH BIKANER	CHES GODHRA	TOTAL
A.		Grant in Aid – Salary						
	a	Salary				430.26	309.72	739.98
	b	Wages				0.00	194.58	194.58
		Total (A)	**0.00**	**0.00**	**0.00**	**430.26**	**504.30**	**934.56**
B.		Grants in Aid - Capital			0			0
	a	Equipment	57.57	4.19	61.76	0.13	0.91	1.04
	b	Works	326.63	105.62	432.25			0
	c	Library Books & Journals	5.34	0.62	5.96			0
	d	Furniture & Fixtures			0	0.99	1.00	1.99
	e	Others (Specify)			0			0
		Total (B)	**389.54**	**110.43**	**499.97**	**1.12**	**1.91**	**3.03**
C.		Grants in Aid - General			0			0
	a	Overtime allowance			0	0.17		0.17
	b	Travelling allowance	8.99	2.99	11.98	2.30	0.70	3
	c	Human Resource Development(HRD)	2.89	0.10	2.99			0
	d	Contingencies			0			0
	-	Research and Operational	29.22	18.67	47.89	31.89	4.80	36.69
	-	Administrative Exp	62.85	11.62	74.47	38.50	12.25	50.75
	-	Misc. Exp.			0	5.15	1.00	6.15
	-	Project on Date Palm	11.99		11.99			0
	-	Tribal Scheme Plan (TSP)*		16.77	16.77			0
		Total – (C)	**115.94**	**50.15**	**166.09**	**78.01**	**18.75**	**96.76**
D.		Others			0			0
	a.	Pension			0	25.05	83.10	108.15
	b.	P Loan and Advances			0	2.09	4.68	6.77
		Total - (D)			**0**	**27.14**	**87.78**	**114.92**
		GRAND TOTAL (A+B+C+D)	**505.48**	**160.58**	**666.06**	**536.53**	**612.74**	**1149.27**

Revenue Receipt 2015-16

No.	HEAD OF RECEIPT	CIAH	CHES	KVK	Seed Pro	TOTAL
1	Sale of farm produce	197370	1163215	4350	697344	2062279
2	Sale of Condemned items	17500				17500
3	Licence fee	42169	13735			55904
4	Water Charges	2037	0			2037
5	Tender fee	222500	9950			232450
6	Interest earned on loan & advances	177281	9669			186950
7	Leave salary and penbsion contribution					0
8	Guest House	66625				66625
9	Interest earned on short term deposits	1681627				1681627
10	Recoveries of Loans & Advances	286680	492685			779365
11	Miscellaneous Receipts	1251742	88843			1340585
	TOTAL RECEIPT	**3945531**	**1778097**	**4350**	**697344**	**6425322**

16. METEOROLOGICAL DATA

METEOROLOGICAL DATA FOR THE YEAR 2015-16 (BIKANER)

S.No.	Month	Temperature (°C)		RH %		Rainfall (mm)	Wind Speed (km/hr)	Sunshine hrs	Evaporation (mm)
		Max.	Min.	I	II				
1.	April, 2015	40.15	25.21	43.10	16.60	52.20	4.03	8.69	6.3
2.	May, 2015	44.31	29.66	38.39	16.10	73.10	17.83	5.49	11.6
3.	June, 2015	41.08	29.68	56.30	35.40	54.60	6.19	7.06	8.7
4.	July, 2015	37.30	27.82	73.23	47.81	118.70	7.15	7.38	7.6
5.	August, 2015	37.35	27.29	71.58	45.00	128.10	6.70	6.72	8.2
6.	September, 2015	30.58	20.27	62.83	35.37	0.00	3.92	7.49	7.7
7.	October, 2015	34.98	18.40	54.94	30.68	0.00	2.90	9.04	5.3
8.	November, 2015	29.32	12.34	62.93	33.70	0.00	1.74	8.54	3.1
9.	December, 2015	24.60	7.40	65.90	28.50	0.00	1.10	7.71	1.4
10.	January, 2016	23.8	6.2	06.2	57.9	0.00		-	1.1
11.	February, 2016	27.4	0.6	70.2	49.2	4.9	4.8	-	1.7
12.	March, 2016	33.7	15.9	72.1	44.5	21.0	5.0	-	3.6

METEOROLOGICAL DATA FOR THE YEAR 2015-16 (CHES, GODHRA, GUJARAT)

S.No.	Month	Temperature (°C)		RH %		Rainfall (mm)	Rainy days	Sunshine hrs	Evaporation (mm)
		Max.	Min.	I	II				
1.	April, 2015	37.04	23.32	75.55	32.03	0.0	0.0	9.42	--
2.	May, 2015	39.92	26.23	69.50	32.17	0.0	0.0	9.83	--
3.	June, 2015	36.15	26.54	87.74	64.90	129.4	5.0	4.50	--
4.	July, 2015	31.78	26.05	91.17	73.25	263.8	8.0	2.42	--
5.	August, 2015	31.77	24.78	92.33	72.97	54.0	4.0	3.93	--
6.	September, 2015	33.41	23.70	91.55	65.18	38.8	3.0	6.60	--
7.	October, 2015	35.35	19.12	85.25	50.03	0.0	0.0	6.64	--
8.	November, 2015	32.12	17.53	84.40	47.95	0.0	0.0	8.13	--
9.	December, 2015	29.53	09.20	84.18	62.23	0.0	0.0	8.58	--
10.	January, 2016	27.65	11.32	83.24	33.91	0.0	0.0	7.54	--
11.	February, 2016	33.62	12.35	79.73	31.83	0.0	0.0	8.92	--
12.	March, 2016	36.08	15.30	78.60	25.97	0.0	0.0	8.40	--

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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