An ISO 9001:2008 Certified Institute

2019

Annual Report







ICAR-Central Institute for Arid Horticulture
Bikaner-334 006 (Rajasthan)

ANNUAL REPORT

2019

ICAR-Central Institute for Arid Horticulture
Beechwal, Bikaner-334 006, Rajasthan
(An ISO 9001:2008 Certified Institute)

Published by
Prof. (Dr.) P. L. Saroj
Director
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.icar.gov.in

Compiled and edited by
Prof. (Dr). P. L. Saroj
Dr. B. D. Sharma
Dr. R. S. Singh
Mr. Ramesh Kumar
Dr. Chet Ram
Mr. P. P. Pareek

Correct Citation
Annual Report 2019
ICAR-Central Institute for Arid Horticulture, Bikaner-334 006, Rajasthan

Laser setting, designing and photography
Sh. Bhoj Raj Khatri
Sh. Mahaveer Kumar Jain
Sh. Sanjay Patil

Printed at
M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028

Prof. (Dr.) P.L. Saroj
Director

ICAR-Central Institute for Arid Horticulture
Beechwal, Bikaner-334 006

PREFACE

It gives me immense pleasure in bringing out the Annual Report 2019 of the ICAR-Central Institute for Arid Horticulture, Bikaner. Owing to their strength such as vast land resource, ample solar radiation, low incidence of diseases and pests, arid and semi-arid regions are bestowed with potential to become the horticultural bowl of India provided adequate technologies are developed. Ever since its inception on 1st April 1993, ICAR-Central Institute for Arid Horticulture, Bikaner is dedicated to serve the farmers and stake holders of arid and semi-arid regions by developing technologies, introduction of genotypes of crops from iso-climatic conditions, package and practices of arid horticultural crops under adverse climatic condition with limited resources, handling and value addition technologies of the horticultural produce, development of quality planting materials for the farmers and capacity building programmes etc.

The present report highlights glimpses of 4 mega research projects and 8 externally funded projects. The research accomplishments, 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 are given in succeeding pages. I express my sincere appreciation to all the members of the Research Advisory Committee and Institute Research Committee 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. Mohapatra, Secretary, DARE and Director General, ICAR for his constant support in executing the mandate of the institute. I also express my gratitude to Dr. A. K. Singh, Deputy Director General (Horticultural Science) and to Dr. W. S. Dhillon, ADG (Hort.-I) for their critical 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. B. D. Sharma, Dr. R. S. Singh, Mr. Ramesh Kumar, Dr. Chet Ram and Sh. P. P. Pareek for their sincere and whole-hearted support in bringing out the Annual Report 2019. The technical support in terms of computerization and photograpy by Sh. Bhoj Raj Khatri, Sh. M.K. Jain and Sh. Sanjay Patil is also appreciated.

पी.एल.सरोज

Dated: January 2020, Bikaner

(पी. एल. सरोज)

(P. L. Saroj)

Contents

1. EXECUTIVE SUMMARY

Plant Genetic Resources and Crop Improvement

The rich germplasm of various arid fruits including twelve new germplasm of *ker*, four of ber, one of lasoda, four of guava and two of acid lime were collected and being conserved at the field gene bank of ICAR-CIAH, Bikaner, Rajasthan and its regional station CHES, Godhra, Gujarat during 2019. The exiting germplasm were evaluated for various morphological, physiological and agronomical attributes during 2019. Two elite germplasm of white fleshed guava and two acid lime germplasm were collected from Rewa and two white fleshed genotypes of guava were also collected from AAU, Anand (Gujarat). In *ker*, twelve elite type genotypes having distinct characteristics were collected from different arid districts of Rajasthan and based on this survey; one elite type lasoda germplasm (extra-large fruit size) was collected from Katrathal (Sikar), Rajasthan. An extensive survey was conducted for aonla in the Satna and Rewa district of Madhya Pradesh. Twenty nine fruit samples were collected and analyzed which exhibited a wide variation in physico-chemical characters.

Bael germplasm were evaluated under hot arid ecosystem of western Rajasthan. The fruit number and yield per plant were ranged from 12.60 to 42.00 and 7.60 to 33.00 kg/plant, respectively. At CHES, Godhra, sixteen genotypes were found superior for their morphological, quantitative and qualitative characters. Among the sixteen genotypes of wood apple evaluated for different morphological traits at CHES, Godhra, the maximum fruit weight was recorded in CHESW-4 (Thar Gaurav) [450.33 g] followed by CHESW-6 (385.00 g). The highest yield was recorded in CHESW-6 (148.00 kg/plant) followed by CHESW-4 (125.25 kg/plant). Out of ten tamarind varieties evaluated at CHES, Godhra, Goma Prateek was found superior for maximum fruit yield (32.10 kg/plant), pod length (14.59 cm) and pulp content (51.82%), while maximum TSS and total sugar was recorded in Urigum.

Thar Gaurav, a newly identified variety of wood apple, produced big size fruit (450.25 g) with better shelf-life under rain-fed conditions of western India. It gives 124.36 kg/plant yield in 12th year. The fruit is rich in pectin (1.76%) and protein (pulp 18.13% and seed 24.38%), phosphorous (0.07%), potassium (1.73%), calcium (0.30%) and iron (16.72 mg) content. Forty seven custard apple germplasm were evaluated at Godhra, which showed significant variations regarding qualitative and quantitative attributes such as fruit weight (110.12-370.36 g), pulp (46.23-66.51%), TSS (22.27-30.45 ^{o}Brix), acidity (0.24-0.55%), and yield (6.27-22.58 kg/tree). Among the evaluated germplasm, CHESCA-4, CHESCA-13, CHESCA-23 and CHESCA-27 were found superior in terms of fruit quality and yield. Among evaluated germplasm of guava, significantly maximum number of fruits/tree was observed in CHESG-15 (161) followed by MPUAT-1 (115) and CHESG-21 (110). Whereas, the maximum fruit yield/tree was recorded in CHESG-15 (25.55 kg) followed by CHESG-21 (19.30 kg) and L-49 (14.50 kg). The maximum fruit weight was observed in MPUAT-2 (287.35 g) followed by CHESG-28 (275.65 g). Twenty genotypes of acid lime evaluated under semi-arid conditions at CHES, Godhra. Among them, CHESL-12 accession recorded highest average fruit weight (38.29 g), peel thickness (1.78 mm), acidity (8.71%) and ascorbic acid (50.15 mg/100g) with 47.34% juice. However, the highest average yield/tree was observed in CHESL-32 (15.22 kg) followed by CHESL-10 (14.68 kg) and CHESL-12 (13.85 kg).

In pomegranate, maximum number of fruits per plant was obtained in Mridula (28.67) followed by Saharanpur (25.50), Tujetis EC4347 (22.00) and Jodhpur collection (21.50). Maximum fruit weight was recorded in Jalore Seedless (269.45g) followed by G-137 (265.50 g). The fruit cracking was varied significantly among different cultivars and recorded maximum (41.17%) in Saharanpur followed by Mridula (39.51%). Interestingly, very less cracking was observed in sour types of deciduous germplasm like Gul-e-Shah, Gul-e-Shah Red and Gul-e-Shah Rose Pink, etc. Similarly, five promising pomegranate selections namely CIAH PG-1, CIAH PG-2, CIAH PG-3, CIAH PG-4 and CIAH PG-5 were evaluated for growth and yield attributes. Among them, the CIAH PG-1 found highly suitable for anardana purpose due to high yield, more anardana recovery and high acidity while CIAH PG-2 found suitable for table purpose. In sweet orange varieties, Satgudi was found significantly superior as compared to other varieties under arid climatic conditions. Mandarin hybrid cv. Fremont was evaluated under field conditions on four different rootstocks namely Rough lemon, Karna Khatta, Pectinifera and Troyer rootstocks. Karna Khatta and Rough lemon found suitable for fast orchard formation and higher yield while Pectinifera for high planting density and better fruit quality traits under hot arid region.

In date palm, early fruit maturity was recorded in cultivars Tayer, Dhamas and Nagal. Exotic cultivars Siwi and Ahmat started fruiting with low yield per plant. The berry of Ahmat was greenish yellow with medium size while, it was yellow in Siwi with long size. The *doka* fruits in late maturing rain tolerant and red colour berry genotype (CIAH/DP/S-01) were harvested in first week of September and fruit yield was observed 46 kg/tree. Among the six male date palm germplasm evaluated for pollen production, one elite male date palm (CIAH/DP/M-01) was marked promising for more pollen production (672.7 g/tree) and number of spathes per plant (25-30). The IC No. 0632315 of this elite male genotype was obtained from ICAR-NBPGR, New Delhi. The maximum fruit yield (50 kg) was recorded in Shamran followed by Khuneizi and Braim (40-47.2 kg/tree). The maturity of fruits (*doka* stage) was recorded in maximum varieties in the second week of July. The cultivars Medjool, Dayari and Siwi were harvested late. In varietal evaluation of date palm, maximum fruit yield/tree was observed in cv. Khalas (40.0 kg/tree) followed by Zahidi (36 kg/tree). Aonla varieties were studied for their growth, flowering and fruiting characters under semi-arid condition and fruit weight ranged between 27.25 to 38.20 g with maximum fruit weight in Banarasi (38.20 g) followed by NA-7 (30.80 g). Hybridization in ber was carried out to obtain superior progeny in Thai ber and fruit fly resistance in commercial varieties (Gola, Thar Bhubhraj & Umran). A total of 911 crosses were made and out of which only 28 were set fruits.

The improved germplasm of arid vegetable crop (500) mainly consisted of desert melons (125), non-dessert melons (161), gourds (60), cluster bean and beans (35) were being conserved *ex-situ* in gene-bank (–20 ºC deep freeze) facilities at ICAR-CIAH, Bikaner. In addition, germplasm of *khejri*, *kumat*, *sehjan*, aloe vera, curry-leaf, ivy gourd, spiny gourd and other perennial vegetables were being maintained in field repository. Seed of *khejri* (Thar Shobha and Selection–2) was deposited to ICAR-NBPGR, New Delhi and IC number 632064 and 632065, respectively were obtained during 2019. In vegetable cowpea, germplasm were evaluated and plant height (47.8-210.6 cm), days to first harvest of tender pods (37-69 DAS), pod length (11.2-31.1 cm) and weight (2.4-7.7 g) were recorded at vegetable use stages. The line AHCP-1-4-1 and AHCP-2-3 were studied for their performance in comparison to popular varieties (RCV-7, Arka Garima, Kashi Nidhi and Kashi Kanchan) both under rainfed and irrigated conditions.

In ivy gourd, one accession (IC-632331) was identified as promising line with maximum fruit weight (29.40 g) and yield (38.96 kg/plant/year) under semi-arid conditions. Similarly, the attractive fruit appearance was identified in two ivy gourd accessions namely IC-632334 and IC-

632328. The average fruit weight and length was recorded 14.20 g and 4.70 cm, respectively, with total yield 21.10 kg/plant in IC-632334 and maximum fruit yield (2.81 kg/plant) was observed in case of IC-632328 accession. In bottle gourd, the LS-4xLS3-2 line was found superior with maximum number of fruit (17.60/plant) and yield (13.20 kg/plant) with 75.00 g average fruit weight in round shape. A promising heat tolerant tomato variety, Thar Annant was developed through induced mutation followed by selection. It has high flesh thickness (0.85 cm), deep red fruit colour and rich in lycopene content (7.9 mg/100g) with medium acidity (0.42%) under semi-arid conditions. It showed high tolerance to heat and drought stress having high yield potential (4.2 to 4.9 kg/plant). Each fruit weight about 120-130 g with attractive deep red colour fruits with round shape. In drumstick, a medium dwarf and drought tolerant genotype (CHESD-40) was identified as promising lines under rainfed semi-arid conditions with 2.74 m plant height, 248 no. of pods, 218 g average fruit weight, 8-10 seed per pod and TSS 8.9 °Brix. The fruit length was recorded 38-42 cm at tender stage with vitamin C (258.9 mg/100 g), acidity (0.017%) and TSS (9.5 °Brix). In Indian bean, CHESIB-50 genotype was found promising with good pods attributes and yield (4.1 kg/plant). In vegetable cowpea, pole types genotypes like CHESVC-01, CHESVC-10, CHESVC-15, CHESVC-22 and CHESVC-45 and bush types *viz.*, CHESVC-33 and CHESVC-20 were found superior with respect to fresh number pods and pod yield. In cluster bean, the genotypes CHESCB-25 and CHESVC-24 were found superior with respect to fresh number pods and pod yield (1.2 and 1 kg/plant, respectively) under semi-arid condition. In potato, Kufri Chipsona-4 gave highest yield (534.8 q/ha) followed by Kufri Frysona (479.7 q/ha) and Kufri Jyoti (465.1 q/ha), Kufri Garima (430.9 q/ha), Kufri Surya (398.6 q/ha) and Kufri Khyati (387.6 q/ha) under sprinkler system. Similarly, dry matter content was found highest (22.22%) in Kufri Frysona and minimum in Kufari Khayati (15.09%) at 90 days of harvesting. Based on performance, potato varieties like Kufri Chipsona-4 and Kufri Frysona were found suitable for processing purpose while Kufri Garima and Kufri Jyoti for table purpose cultivation.

In water melon, one advance line, YF 5-2-7 was identified which possess characteristics such as entire leaf (non-lobed), dark green rind colour with very narrow stripes and blackish brown colour of seed coat. The flesh of YF 5-2-7 recorded 3.92-4.14 µg/g FW carotenoid content and 0.25 mg AAE/g total antioxidant activity (TAA). In muskmelon, AHMM/BR-35 produced round fruits with netted rind (0.4 cm thick) and salmon orange flesh. Seed cavity is small (5-5.5 cm), thick flesh (3-3.2 cm) and TSS ranges from 11.5-12.2%. AHMM/BR-47 of muskmelon produced first harvesting in 75-80 days after sowing, bear 3-4 fruits/plant weighing 750-900 g, netted rind with sutures, TSS 11.2-12%, rind 0.3-0.4 cm thick, seed cavity 5.4-5.7 cm and flesh thickness 2.8-3.2 cm of salmon orange colour. It is characterized by deep lobing of leaves. Identified an andromonoecious plant (AHW/BR-5) from segregating population in water melon which have stable andromonoecious sex form and able to set fruits under net house conditions without pollinators and produced viable seeds. AHW/BR-5 produced round, red fleshed fruits having light green rind (1.38-1.92 cm thick) which is devoid of stripes. It was registered with ICAR-NBPGR, New Delhi under INGR 19081 for stable andromonoecious trait. During the year, the varietal release proposal of Thar Sheetal (longmelon) and Thar Karni (ridge gourd) was submitted which have been accepted for release and notification for Rajasthan State by State Seed Sub Committee for Agricultural and Horticultural Crops.

The advanced breeding material of round melon progenies AHRM-1/2017/17-a/ whitish-green-Bikaneri type was compared with base line AHRM-1/a Bikaneri type. Both the lines exhibited good initial vine growth and fruiting. Two selections of long fruited bottle gourd were tested for fruit quality and yield attributes. Line AHLS/2017/01 was at par to AHLS/2017/02 and both exhibited superiority for growth and

marketable fruit yield under temperature range 38-42 °C in August-September. On average, both the selection exhibited earliness for first picking (62.5 DAS) and yield was 3.17 kg/plant. Fourteen elite genotypes were conserved in *khejri* germplasm plot. *Khejri* variety Thar Shobha and *Khejri* Selection–2 were compared in reference to growth, pod yield and biomass production over the years under rainfed conditions. Similarly, comparative study in two advanced material of round melon (AHRM-1/2017/17-a/whitish-green-Bikaneri type series) was done.

Physiological, Biochemical and Bio-technological Interventions

Low cost hardening techniques for tissue cultured date palm plants was standardized. Maximum (70%) plant survival during primary hardening in Halawy was recorded in vermiculite based medium and minimum (15%) in sand + vermiculite media. Similarly, in cultivar Khalas, maximum plant survival (60%) was noticed in vermiculite and minimum (10%) in sand + vermiculite media. During secondary hardening under greenhouse condition, maximum plant survival (57.14%) was recorded in cultivar Halawy with vermiculite medium while minimum in sand + vermiculite + perlite (20%). In cultivar Khalas, maximum plant survival (58.33%) was observed in vermiculite and minimum (22.22%) in sand + vermiculite + perlite + cocopeat media. Biochemical mechanism of abiotic stress tolerance in *khejri* and ber under different seasons were studied. A quick and significant enhancement was observed in these metabolite accumulations during severe winter (December-January) as well as under severe summer (May to June). The quick metabolic responses towards different environmental conditions make this plant a wonder tree with highest extent possible tolerance towards all abiotic stresses. In *Z. nummularia* and *Z. mauritiana*, a significant difference was observed in all antioxidant metabolite accumulation (total phenol, flavonoids and antioxidant activity) with seasons. It was observed that the absolute values for all metabolites assay were higher in *Z. nummularia* than *Z. mauritiana* at each point of time.

In field evaluation of tissue cultured date palm plants cvs. Halawy and Khalas, plant heights in cvs Halawy and Khalas were recorded 66.12 and 69.97 cm, respectively. Average plant spread (NS and EW) in cultivar Halawy was noted 62.65 and 67.58 cm while in Khalas 77.20 and 74.93 cm, respectively. DNA fingerprinting of Thar Sheetal and Thar Karni varieties of long melon and ridge gourd, respectively were done by using functional (ScoT and CBDP) and random (RAPD and ISSR) markers. Additionally, bioinformatics analysis was also done for characterization of watermelon genomic database for identification of AP2/ERF transcription factor gene family.

Crop Management and Agro-techniques

In production system management in ber under hot arid ecosystem, maximum canopy spread and stem diameter were recorded in cv. Gola. The fruit set and bearing density were found maximum in cv. Goma Kirti and minimum in Thai ber. Fruit drop was observed maximum in Thai ber. In different training systems of ber, espalier system was better with bearing density, branch distribution and minimum fruit drop over rest of the treatments and fruit set was higher in Y-shape training system. In different planting densities, higher density at 3x3 m was found better with respect to fruit set and bearing density over other spacing. In mango cv. Kesar, maximum plant height (4.30 m), plant spread east-west (3.50 m), north-south (3.40 m) and scion girth (62.90 cm) was recorded in FYM + standard dose of NPK + *Azotobactor* + PSB closely followed by castor cake + standard dose of NPK + *Azotobactor* + PSB. Maximum fruit yield (44.20 kg/plant), TSS (20.80 ^{0}Brix) was also recorded in FYM + standard dose of NPK + *Azotobactor* + PSB closely followed by castor cake + standard dose of NPK + *Azotobactor* + PSB. In different mulches treatments in sweet orange cv. Sathgudi, maximum fruit yield (27.00 kg/plant) was recorded in paddy straw mulch

followed by grasses (22.20 kg/plant), black polythene mulch (18.00 kg/plant). Maximum fruit weight (242.20 g) and TSS (13.30 °Brix) was also recorded in paddy straw mulch, followed by grasses and black polythene mulch. In standardization of seed germination methods in drumstick, it was found that seed without wing kept in between paper (rolled towel method-BP) produce healthy and vigorous seedling with highest germination (66%) followed by seed with wing-BP (48%) while, the lowest germination (22%) was found in seed without wing-TP followed by seed with wing-TP (42%) with poor seedling growth.

In bael, efficacy of plant growth regulator and chemicals were evaluated to reduce fruit drops and sun scald. The minimum fruit drop (95.13%) and sun scald (19.52%) and the highest fruit retention (3.15%) were recorded with grass mulch + NAA (15 ppm) + course cotton cloth followed by grass mulch + NAA (15 ppm) + ascorbic acid (96.50, 25.30 and 3.00%), respectively. In different pruning treatments in bael cv. Goma Yashi, highest yield was recorded with 3 m plant height + 25% pruning (67.19 kg/plant) followed by 2.5 m plant height + 25% pruning (59.00 kg/plant). Fruit size and TSS was recorded maximum in the plants where height maintained at 3 m and pruned at 25% annual growth extension. In bael, effect of age of scion shoot and time of budding (*in-situ*) on success and survival was studied. The plants grafted in May recorded 94.47, 89.20 and 60.20 per cent success through patch budding (1-1½ month old shoots), softwood grafting (4-6 month old shoots) and softwood patch budding, respectively. The May month found ideal time for multiplication of bael in hot rainfed semi-arid conditions of western India. Maturity indices in bael varieties were standardized and variety Thar Divya acquired full maturity in January and ripening initiated from the first week of February (260-270 day from fruit setting) while ripening in NB-7, NB-9, NB-16, NB-17, Pant Aparna, Pant Urvashi was observed 300-320 days from fruit setting whereas ripening in NB-5 and CISHB-2 was observed in 310-330 days from fruit setting under rainfed semi-arid conditions.

In standardization of sowing date and covering material in longmelon, the sowing on 20th December with polythene covering recorded maximum fruit yield per hectare (163.68 q) followed by sowing on the same date with non-woven covering (157.65 q). Use of tunnels resulted in 50 days earlier harvesting. Net income and cost benefit ratio of sowing under low tunnel was significantly higher than the sowing under open field condition and the highest economics (C:B ratio of 2.16) was achieved by sowing the crop on 20th December under tunnel with non-woven cloth followed by polythene sheet. Similarly in water melon, low tunnel had significantly higher yield than open field condition and the maximum fruit yield was recorded with sowing on 10th January, 2019 with polythene covering followed by sowing on the same date with non-woven covering in the first year of experiment.

In ridge gourd, predominantly gynoecious line AHRG-15-4-1 was studied based on uniqueness for several generations. Two types of sex form i.e. predominantly gynoecious and absolute gynoecious sex forms were observed. It exhibited earliness for days to first tender fruit harvest (45 days after sowing). Whereas, plants with absolute gynoecious sex form had female flowers only and cluster bearing in nature. Selected plants with potential trait were isolated, selfed and seeds were harvested separately for further evaluation. In protected condition of vegetable under hot arid condition, tomato fruit development with higher number of fruits per plant (37-65) was observed under shade net condition in contrast to open field crop where plant height was 33.5 cm and less fruiting (18-42) was observed. In brinjal, days to first fruit harvest was recorded 67-72 DAP under shade net, whereas, it took 75-79 DAP under open condition. In chilli, genotype had higher number of fruits per plant (46-84) under shade net condition in contrast to open field crop over the season where less number of fruits per plant (28-48) was observed. In standardization of propagation technique in ivy gourd, raised bed recorded 71.4% sprouting in comparison to portray which had 45.7% sprouting and hard/

semi-hard wood cuttings of about 18-24 cm length are found suitable for multiplication of ivy gourd both during rainy and winter season. In evaluation of fruit based diversified cropping models for arid region, in aonla based cropping system, highest yield was recorded in aonla-*khejri* (66.58 kg/plant) followed by aonla-ber (63.24 kg/plant) and aonla-karonda (61.82 kg/plant).

Integrated Water and Nutrient Management

In management practices for saline soil and water for crop production in arid region, leafy vegetables performance was good except coriander crop under saline water (4ECIW dSm^{-1}). The fresh yield of fenugreek crop was 113.03 q/ha, 77.18 q/ha and 51.87 q/ha in saline, conjunctive water and canal water treated plots, respectively. The highest spinach yield was recorded in saline water treated plot 378.33 q/ha followed by 184.33 q/ha, 164 q/ha in conjunctive water, canal water treated plots, respectively. The performance of coriander crop was not goods in saline water treated plot and highest yield was recorded in canal water treated plot (75.27 q/ha) and in saline water and conjunctive water yield was 51.37 q/ha and 50.28 q/ha, respectively.

In *kachri* integrated nutrient management, application of organic and inorganic sources of nutrients significantly increased growth parameters and yield of *kachri* as compared to control. Maximum vine length, no. of branches, fruits/plant and fruit yield/plant were observed 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. In integrated nutrient management of kinnow, fruit yield was recorded maximum (22.50 t/ha) in RDF of N, P, K + FYM + PSB + azotobactor + VAM treatment and minimum (7.80 t/ha) yield was estimated in control. The addition of FYM, inorganic fertilizers increased the TSS content. The juice recovery was ranged from 45 to 52 per cent and maximum juice (52%) was recorded in those treatments where FYM was the component of the treatment. The maximum benefit cost ratio (3.96) was recorded in treatment RDF of N, P, K + FYM + PSB + azotobactor + VAM and minimum (2.10) was in control treatment. The adding of FYM with recommended dose of NPK was increased the benefit cost ratio while adding of AMF not increased the income. In nutrient management in chironji, custard apple, jamun and tamarind, leaf samples were collected from Vejalpur, forest area of Godhra and Jambughoda area of Gujarat. The nitrogen (4.62 %), phosphorus (0.15 %), potassium (0.83 %), calcium (1.81%), magnesium (1.12%), sulphur (0.20 %), iron (233 ppm), manganese (244 ppm), zinc (44 ppm) and copper (21 ppm) varied from place to place in different villages of Gujarat.

Plant Protection

In muskmelon, *Fusarium* wilt was found with ranging from 14.29-39.58% disease index in the field. Among 11 treatments, carbendazim (0.1%) was found the most efficient treatment against *Fusarium* wilt with minimum per cent disease index of 14.29% and 63.90% disease control, followed by neem leaf extract (10%) with per cent disease index (19.67%) and 50.30% disease control. Next best treatments were tumba fruit extract (10%) and aak leaf extract (10%) with per cent disease index of 22.35% and 26.84% as well as 43.53% and 32.19% disease control, respectively. In ridge gourd, mosaic disease was found with ranging from 15.13-39.74% disease index. Among 11 treatments, imidacloprid (0.05%) was found the most efficient treatment against mosaic disease with minimum per cent disease index of 15.13% and per cent disease reduction (61.93%). Next best treatment was neem leaf extract (10%) with per cent disease index of 18.27% and per cent disease reduction (54.03%), followed by *tumba* fruit extract 10% (20.0% PDI and 49.67% disease reduction) for management of mosaic disease in ridge gourd. Maximum disease index (39.74%) was found in case of control. The different pomegranate cultivars were screened

against mite, *Tenuipalpus punicae* and very low incidence was recorded in Gul-e-Shah Rose Pink (6.50%), Speen Sacarin (7.17%) and Bassin Seedless (8.83%). Significantly greater incidence of mite was registered in Kajaki Anar (54.50%), IC-318712 (55.17%), Basin Seedling (56.83%) and Bedana Suri (63.00%).

Noval biopesticide (Thar Jaivik 41 EC) from *tumba* (*Citrullus colocynthis*) was developed and its formulations were analyzed against *Helicoverpa armigera*, *Spodoptera exigua*, *Diphania indica,* etc. and vectors (aphid and white fly). The bio-efficacy of Thar Jaivik 41 EC @ 3 ml per litre of water was found most effective against *Helicoverpa armigera*. The neem based formulations, *viz.,* NSKE and neem oil were proved to be the least effective in reducing the borer, *H. armigera* as compared to Thar Jevik 41 EC. The bio-efficacy of biopesticide was also tested against aphids in arid horticultural crops and Thar Jaivik 41 EC @ 3 ml per litre of water was found most effective. The bio-efficacy of biopesticide/insecticide were tested against coccinellids in arid horticultural crops which revealed that Thar Jaivik 41 EC @ 3 ml per litre of water was proved to be best safer for biocontrol agents and at par with Thar Jaivik 41 EC @ 2 ml per litre of water.

Post-harvest Management and Value addition

The protocol for preparation of wood apple RTS and powder was standardized and one liter RTS was prepared with best recipe *viz.,* 10 % fruit pulp, 13% TSS and 0.25% acidity. The wood apple powder have good aroma and light brown color, it gives excellent taste with addition of adequate amount of salt. The 1.0 to 1.5 kg mature wood apple fruits is sufficient for making of 200-220 g powder. It can be used as preparation of wood apple *serbat* and wood apple drink.

In standardization of pre-treatments for browning reduction in dry dates (*chhuhara*), 2% SFS was found to be effective among various treatments. This treatment was found to have significant impact on the browning reduction in the date cv. Barhee and Zahidi with little impact on the cv. Medjool. However, there was no significant effect on the recovery percentage of the dry dates with the imposed pre-treatments. Sour type pomegranate were screened for anardana purpose and fruit weight was found maximum in the cv. Tujetis EC-104347 (208.28 g) followed by cv. P-21 (194.25 g). The aril recovery was maximum in the cv. Bedana Seedless (69.21%) followed by CIAH-PG-1 (68.14%) and Khog (68.03%). The dehydration ratio was maximum in cv. CIAH-PG-A6 (4.17) followed by Khog (4.02) while anardana recovery percentage from fresh aril was maximum in cv. CIAH-PG-A3 (46.82%). Maximum TSS (°B) was noted in the cv. SaihSirin (19.2 °B) and minimum was observed in the cv. Sirin (11.2 °B). The acidity was found to be maximum in the cv. Tujetis EC-104347 (3.6%) followed by Khog and CIAH-PG-1 (3.5%) while minimum acidity was observed in the cv. Malta (0.78%). In phalsa methods for extraction of juice was standardized, among various methods, freezing followed by thawing was found superior with highest recovery followed by manual mashing. The reduction of recovery percentages in other extractions might be due to evaporation of water during heating process. However, the amounts of anthocyanins in the extracted juice were more in the microwave assisted extraction methods followed by heat processing techniques.

Technological Impact Assessment

In *kachri*, the area and production of AHK-119 was increased significantly during 2007 to 2019. The area in 2007 under the improved variety AHK-119 was 2057 ha and production was 18.30 thousand tonnes which is estimated more than 8 thousand ha and more than 60 thousand tonnes in the year of 2019, respectively in hot arid region of India. The estimated gross return from improved variety of *kachri* (AHK-119) alone was Rs. 28.19 crores in 2007 which increased to more than Rs. 85 crores in 2019. In snap melon, the area under variety AHS-82 was 969 ha and production was 14.34 thousand tonnes in 2007 which is estimated more than 4 thousand ha and more than 60 thousand

tonnes, respectively in the year of 2019. The gross return from this improved variety AHS-82 alone was Rs. 11.76 crores in 2007 which increased to Rs. 50 crores in 2019.

Potato cultivation is popularized in non-traditional area of arid region. FLDs/method demonstration/result demonstration were conducted among the farmers of adopted villages under MGMG scheme and others villages for popularization of arid horticultural technologies and varieties at different locations of Bikaner districts. *Kachri* variety AHK-119 technology was also demonstrated at KVK's of Lunkaransar, Nagaur and Sardarshahar as research trial and seed production. During 2019, seed of improved varieties were produced which includes seed production of snap melon (AHS-82, 12.20 kg), *kachri* (AHK-119, 101 kg), sponge gourd (Thar Tapish, 28 kg), cluster bean (Thar Bhadavi, 58 kg), *palak* (Thar Hariparna, 37 kg), brinjal (Thar Rachit, 0.650 kg) and other arid vegetable crop varieties. About 236 kg seed of arid vegetables 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.

2. INTRODUCTION

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

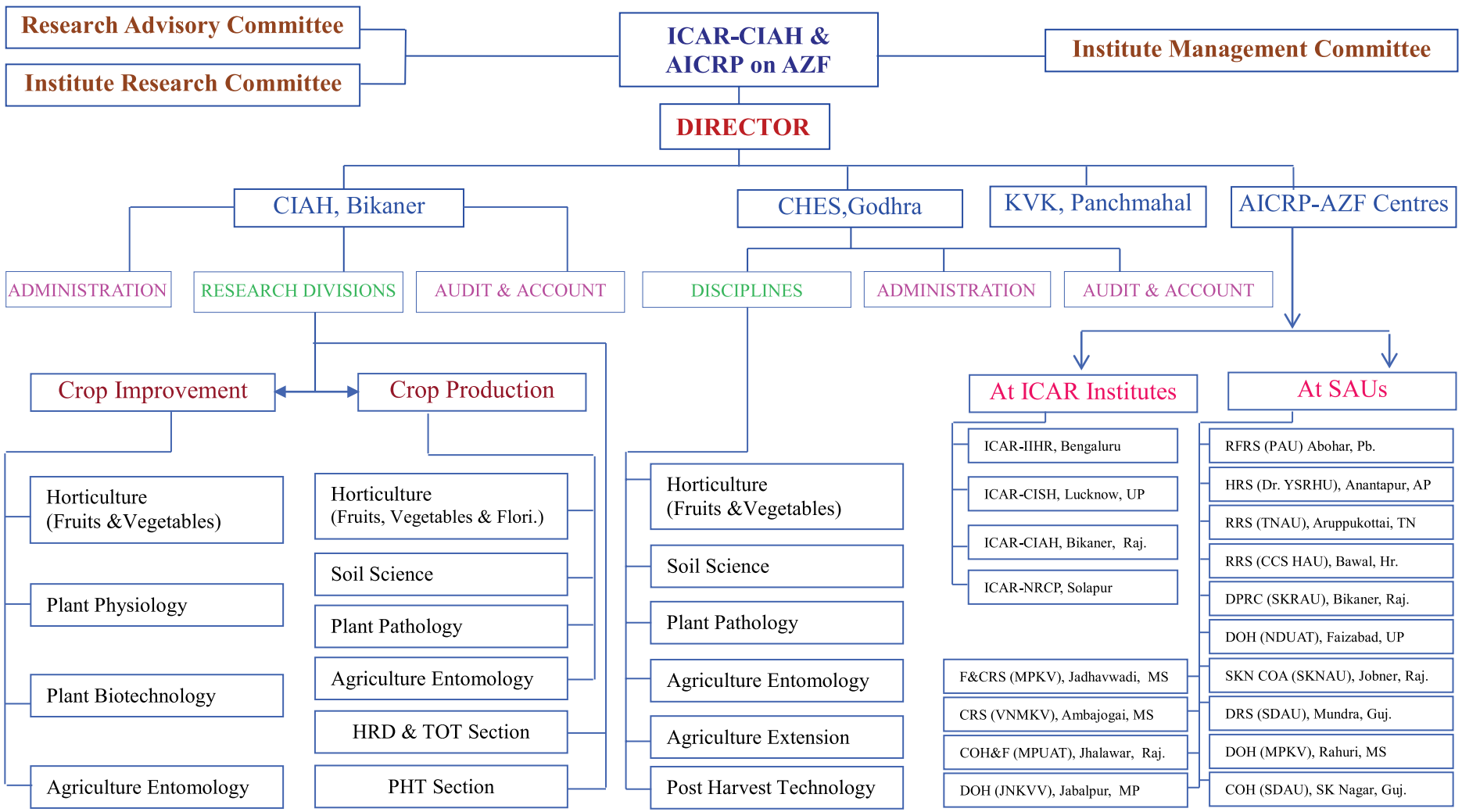
- Basic, strategic and applied research to enhance sustainable productivity, quality and utilization of horticultural crops of arid and semi–arid regions.
- Repository of genetic resources and scientific information on horticultural crops of arid and semi-arid region.
- Transfer of technology, capacity building and impact assessment of technologies.
- Coordinate research and validation of technologies on fruit crops of arid and semi-arid regions.

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, bael, 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 agro–techniques 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 Jan.-Dec., 2019 and the significant results obtained in different projects are presented hereunder.

ORGANIZATIONAL SETUP



3. RESEARCH ACHIEVEMENTS

Genetic Resources

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

Evaluation of ber (*Ziziphus mauritiana*) genotypes under hot arid region

A field observation trial was conducted on ber cv. Gola genotypes collected from different sources and planted at varied locations. Fruit quality of Gola (CAZRI) recorded higher TSS content (31.60 °B), TSS/acid ratio (83.16), total sugar (16.40%), reducing sugars (7.55%) and non-reducing sugars (9.71%) closely followed by Gola MPKV and Gola Kakrola, Rahuri. The minimum values of fruit quality traits *viz*., TSS (25 °B), total sugar (13.08%), reducing sugars (6.02%) were recorded in Gola Laddu. No significant difference with acidity and ascorbic acid content were observed (Table 1 to 2).

Table 1. Evaluation of ber cv. Gola genotypes for fruit quality traits

S. No.	Genotype	GPS location	Evaluated characters						
			TSS (°B)	Acidity (%)	TSS/Acidity ratio	Total sugar (%)	Reducing sugars (%)	Non reducing sugars (%)	Ascorbic acid (mg/100g)
1	Gola CAZRI (S1-1)	N-28°6'3 E-73°20'4 Elevation 194.8 m	31.60	0.38	83.16	16.40	7.55	9.71	78.80
2	Gola , Jodhpur (S1-21)	N-28°6'4 E -73°20'4 Elevation 211.7m	25.50	0.42	60.71	13.23	6.09	7.84	82.20
3	Gola Gudgaon, (S3-5)	N-28°6'4 E-73°20'5 Elevation 201.9m	27.10	0.41	66.10	14.06	6.48	8.33	80.60
4	Gola Kakrola (S4-6)	N-28°6'4 E-73°20'5 Elevation 206.1m	28.80	0.40	72.00	14.95	6.88	8.85	79.00
5	Gola in Nursery-1	N-28°7'2 E-73°21' Elevation 197.3 m	27.40	0.41	66.83	14.22	6.55	8.42	80.60
6	Gola by cuttings in nursery -2	N-28°6'4 E- 3°21' Elevation 203.6 m	29.10	0.40	72.75	15.10	6.95	8.94	80.00
7	Gola in nursery-3	N-28°6'1 E-73°20' Elevation 196.3 m	26.30	0.40	65.75	13.65	6.29	8.08	79.00
8	Gola near (Diggi No.1)	N-28°6'9 E-73°21' Elevation 217.3 m	28.10	0.40	70.25	14.58	6.72	8.64	78.70

S. No.	Genotype	GPS location	Evaluated characters						
			TSS (°B)	Acidity (%)	TSS/Acidity ratio	Total sugar (%)	Reducing sugars (%)	Non reducing sugars (%)	Ascorbic acid (mg/100g)
9	Gola HAU	N-28°6'1 E-73°20'3 Elevation 198.6 m	28.70	0.40	71.75	14.90	6.86	8.82	78.60
10	Gola Laddu (S2-28)	N-28°6'4 E-73°20'4 Elevation 190.5m	25.20	0.41	61.46	13.08	6.02	7.74	80.60
11	Gola in Reference	N-28°6' 1 E-73°20'3 Elevation 199.6 m	27.20	0.41	66.34	14.12	6.50	8.36	80.60
12	Gola Kakrola, (Rahuri S4-7)	N-28°6' 4 E-73°20'5 Elevation 204.7 m	29.80	0.39	76.41	15.47	7.12	9.16	77.40
13	Gola popular-Hisar (S6-9)	N-28°6' 4 E-73°20'5 Elevation 206 m	28.00	0.40	70.00	14.53	6.69	8.60	79.00
14	Gola MPKV (S6-13)	N-28°6' 4 E-73°20'5 Elevation 197.7m	31.10	0.38	81.84	16.14	7.43	9.56	76.80
15	Gola Kakrola (Badurgarh S8-17)	N-8°6' 4 E-73°20'5 Elevation 204.4m	28.50	0.40	71.25	14.79	6.81	8.76	79.00
16	Gola IARI (S9-17)	N-28°6' 4 E-73°20'5 Elevation 203.4m	26.00	0.41	63.41	13.49	6.21	7.99	80.60
SEm±			2.07	0.02	3.78	1.07	0.49	0.61	2.09
CD (5%)			6.21	NS	11.34	3.22	1.48	1.83	NS

Table 2. Observations on time of anthesis in different ber varieties

S. No.	Variety	Anthesis time	S. No.	Variety	Anthesis time
1	Gola	2-2.30 PM	14	Chhuhara Bawal	1.30-2.30 PM
2	Seb	9-10.30 AM	15	Narma	2.0-3.0 PM
3	Banarasi Karaka	2-2.30 PM	16	Kismis	10.0-11.0 AM
4	Banarasi Pewandi	9.30-10.30 AM	17	Safeda Rohtak	10.30-11.0 AM
5	Chhuhara	1.30-2.30 PM	18	Mehrun	10-11 AM
6	Kaithali	2.15-3.0 PM	19	Kala Gola	2.0-3.0 PM
7	Mundia	2.0-3.0 PM	20	Katha Phal	9.30-11.0 AM
8	Illaichi	9.30-10.30 AM	21	Dharki No.1	2.0-3.0 PM
9	Reshmi	10-11 AM	22	Lakhan	2.0-3.0 PM
10	Sanur-5	2.0-3.0 PM	23	Gularvasi	10.0-11.0 AM

S. No.	Variety	Anthesis time	S. No.	Variety	Anthesis time
11	Umran	2.0-3.0 PM	24	Safeda Selection	2.0-3.0 PM
12	ZG-3	2.0-3.0 PM	25	Tikadi	2.0-3.0 PM
13	Jogia	10-11 AM			

Evaluation of pomegranate (*Punica granatum*) germplasm under hot arid climate

During 2019, pomegranate germplasm were evaluated and characterized for growth and fruit quality characteristics. In plant growth attributes, observations were recorded on plant height, canopy spread, number of stems and growth habit during December. The maximum plant height (221 cm) and canopy spread (216 N-S and 204 cm E-W) was recorded in Uthkal, followed by Yercaud with plant height (201 cm) and canopy spread (195 N-S and 198 cm E-W) while minimum plant height (122 cm) and canopy spread (112 N-S and 117 cm E-W) was observed in AHPG-C4. Number of stems was ranged from maximum (5.33) in MR 599 followed by AHPG-C3 (5.00), Jodhpur coll. (5.00), Bedana Sedana (5.00) and minimum (1.33) in both P-23 and Boseka Link. Growth habit varies from very dwarf to very vigorous among different germplasm and germplasm Uthkal found very vigorous (Table 3).

Table 3. Plant growth characteristics of pomegranate germplasm under hot arid climate

S. No.	Germplasm	Plant height (cm)	Canopy spread (cm)		No. of stems	Growth habit
			N-S	E-W		
1	Jalore Seedless	160	152	146	3.00	Vigorous
2	Jodhpur Red	181	168	175	2.33	Very vigorous
3	Kajaki Anar	135	122	123	1.67	Dwarf
4	Ganesh	142	155	140	1.67	Dwarf
5	Dorsata Malus	163	165	170	2.33	Vigorous
6	Saharanpur	155	163	168	2.67	Vigorous
7	G-137	129	125	121	3.00	Dwarf
8	Kabul	167	159	145	3.33	Vigorous
9	Basein Seedling	147	149	154	2.67	Vigorous
10	Banaras collection	159	136	138	3.00	Vigorous
11	Bassin Seedless	149	172	153	2.67	Vigorous
12	Alah	175	138	142	3.00	Very Vigorous
13	Kandhari	163	145	133	2.33	Vigorous
14	Bedana Suri	137	136	146	2.00	Semi dwarf
15	GK VK-1	132	129	133	1.67	Dwarf
16	Speen Sacarin	173	155	147	3.33	Vigorous
17	IIHR 12/1	176	174	163	3.50	Vigorous
18	Muskat	162	153	146	1.67	Vigorous
19	Dholka	178	168	175	1.67	Vigorous
20	IIHR 19/10	134	135	148	2.33	Dwarf
21	Jalore Red	189	181	185	2.67	Very vigorous
22	Uthkal	221	216	204	2.00	Very vigorous
23	Kalisirin	193	172	181	5.00	Very vigorous
24	AHPG-C1	175	159	158	3.33	Semi dwarf
25	Khog	165	122	128	2.67	Dwarf
26	Coimb. White	163	155	142	2.00	Semi dwarf

S. No.	Germplasm	Plant height (cm)	Canopy spread (cm)		No. of stems	Growth habit
			N-S	E-W		
27	Saih Sirin	172	148	152	2.67	Vigorous
28	MR 599	182	177	163	5.33	Very vigorous
29	AHPG-C3	190	189	191	5.00	Very vigorous
30	Yercaud	201	195	198	4.33	Semi dwarf
31	Jodhpur coll.	177	170	165	5.00	Semi dwarf
32	Bedana Thin Skin	152	157	162	3.67	Very dwarf
33.	AHPG-C4	122	112	117	2.67	Semi dwarf
34	AHPG-C4b	172	173	155	2.33	Vigorous
35	P-23	166	178	189	1.33	Vigorous
36	P-21	185	164	160	2.67	Very vigorous
37	A K Anar	163	123	121	3.33	Vigorous
38	P-26	153	161	152	3.00	Vigorous
39	Crenedode Elecho	159	136	122	2.33	Vigorous
40	Kabul Kohinoor	158	128	124	2.67	Vigorous
41	EC-62812	161	145	143	2.33	Vigorous
42	Ruby	142	149	146	1.67	Semi dwarf
43	Mridula	143	155	142	2.00	Semi dwarf
44	Tujetis EC 4347	176	163	158	3.33	Vigorous
45	Sirin	154	143	128	2.67	Vigorous
46	AHPG-H1	189	152	158	2.00	Very vigorous
47	Boseka Link	176	147	149	1.33	Vigorous
48	Yercaud Local	158	158	163	1.67	Vigorous
49	Tebest	159	164	152	4.67	Vigorous
50	Gul-e-Shah Red	193	181	175	2.33	Vigorous
51	Speen Danedar	189	154	145	2.67	Very vigorous
52	AHPG-H2	155	149	146	2.50	Vigorous
53	Patna-5	143	131	128	3.33	Dwarf
54	Sur Sukker	183	162	157	2.33	Very vigorous
55	Malta	135	133	129	4.00	Semi dwarf
56	Gul-e-Shah Red	132	128	122	3.33	Semi dwarf
57	AH-PG-H3	189	162	157	2.67	Very vigorous
58	Gul-e-Shah	175	152	146	4.33	Vigorous
59	Surat Anar	164	143	137	4.00	Vigorous
60	Gul-e-Shah R. Pink	176	132	139	3.33	Vigorous
61	Kurvi	181	158	161	3.67	Very vigorous
62	Bedana Sedana	153	144	140	5.00	Vigorous
63	PG-C	145	122	138	3.33	Semi dwarf
64	P-13	172	128	117	1.67	Vigorous
65	Agah	157	129	118	3.33	Dwarf
66	EC-12613	143	128	134	2.67	Very vigorous
67	AHPG-H4	149	128	122	2.50	Vigorous
68	Achikdana	137	124	123	3.33	Semi dwarf
69	Surkh Anar	141	125	131	4.67	Vigorous
	CD (5%)	9.46	12.74	11.37	0.527	

Data were recorded on fruit quality attributes of pomegranate germplasm under hot arid condition (Table 4). Significant variations were recorded in number of fruits, cracked fruit per plant, fruit weight and size with wide range of rind colour among the germplasm. Rind colour varied from yellow green, light red, bright red, yellow red to yellow with red tinge. Maximum number of fruits per plant was obtained in Mridula (28.67) followed by Saharanpur (25.50), Tujetis EC 4347 (22.00) and Jodhpur collection (21.50). Maximum fruit weight was recorded in Jalore Seedless (269.45 g) followed by G-137 (265.50 g). Fruit cracking was varied significantly among different cultivars and recorded maximum (41.17%) in Saharanpur followed by Mridula (39.51%) and no or less cracking was observed in some of the sour type deciduous germplasm like Gul-e-Shah, Gule-e-Shah Red and Gule-e-Shah Rose Pink, etc.

Table 4. Fruit quality attributes of pomegranate germplasm under hot arid climate

S. No.	Germplasm	No. of fruits/ plants	No. of cracked fruits/plants	Fruit Av. weight (g)	Fruit size (cm)		Rind colour[1]
					Length	Diameter	
1	Jalore Seedless	20.33	4.33	269.45	8.10	7.45	YRT
2	Jodhpur Red	20.00	7.00	215.31	7.12	6.95	YRT
3	Kajaki Anar	15.67	3.50	148.45	7.24	6.34	YR
4	Ganesh	15.25	4.50	196.18	8.05	7.64	YRT
5	Dorsata Malus	10.50	2.50	128.35	5.68	5.81	R
6	Saharanpur	25.50	10.50	145.36	6.31	5.58	YRT
7	G-137	15.33	3.67	265.50	7.45	7.21	YRT
8	Kabul	9.50	2.50	125.23	5.34	5.20	R
9	Basein Seedling	6.50	2.67	175.54	7.29	7.24	YR
10	Banaras collection	8.00	2.00	148.18	6.24	6.08	YR
11	Bassin Seedless	6.50	2.33	186.64	8.02	7.34	R
12	Kandhari	8.50	2.00	100.33	5.11	4.85	BR
13	Bedana Suri	12.50	3.00	145.96	6.11	5.31	YRT
14	GKVK-1	15.33	4.50	210.26	7.58	7.29	YRT
15	Speen Sacarin	12.50	3.00	145.25	5.81	5.64	R
16	IIHR 12/1	12.00	3.50	180.25	6.34	5.87	R
17	Muskat	14.25	3.33	160.78	7.15	6.85	R
18	Dholka	12.50	3.00	225.65	8.11	7.47	YG
19	IIHR 19/10	10.33	2.50	210.43	7.42	7.25	BR
20	Jalore Red	18.50	4.50	224.37	7.34	7.27	YRT
21	Uthkal	8.33	2.00	198.57	6.14	6.30	YRT
22	Kalisirin	5.50	0.00	133.01	5.57	5.48	BR
23	Khog	5.00	0.00	196.25	7.06	6.57	BR
24	Coimb. White	6.00	2.50	147.85	6.11	5.68	YRT
25	Saih Sirin	8.33	2.00	166.31	7.34	6.37	YRT
26	MR 599	5.00	0.00	95.12	5.40	4.61	BR
27	AHPG-C3	5.33	1.50	185.33	6.68	5.03	BR
28	Yercaud	10.50	2.33	94.80	7.33	6.31	LR
29	Jodhpur collection	21.50	2.67	255.32	7.85	7.22	YR
30	Bedana Thin Skin	15.33	3.00	146.05	7.23	7.32	R

S. No.	Germplasm	No. of fruits/ plants	No. of cracked fruits/plants	Fruit Av. weight (g)	Fruit size (cm)		Rind colour[1]
					Length	Diameter	
31	P-23	5.67	0.00	182.07	6.42	6.25	YR
32	P-21	10.33	0.00	125.25	8.07	7.51	YR
33.	A K Anar	12.50	1.00	142.37	6.89	6.11	BR
34	P-26	10.25	0.00	155.67	6.58	6.23	R
35	Crenedo de Elecho	5.00	2.00	85.22	5.33	4.27	BR
36	EC-62812	7.50	0.00	85.09	5.78	5.45	BR
37	Ruby	18.50	3.67	211.47	7.33	6.98	BR
38	Mridula	28.67	11.33	149.68	6.48	5.55	R
39	Tujetis EC 4347	22.00	2.00	211.50	8.07	7.93	BR
40	Sirin	8.00	0.00	173.18	8.51	7.82	BR
41	AHPG-H1	7.33	2.33	137.02	6.21	5.32	LR
42	Yercaud Local	18.67	3.33	96.67	6.15	5.17	YRT
43	Tebest	8.00	2.00	85.67	5.45	4.36	R
44	Gul-e-Shah Red	10.25	0.00	210.69	7.33	6.75	BR
45	Speen Danedar	11.67	0.00	115.08	5.57	4.31	YRT
46	AHPG-H2	8.00	0.00	175.25	6.28	5.67	YR
47	Patna-5	6.50	1.50	155.12	6.05	5.27	YRT
48	Sur Sukker	7.00	0.00	96.47	6.09	5.12	BR
49	Malta	12.33	2.50	133.18	6.34	5.27	BR
50	Gulsa Red	6.33	0.00	185.47	6.57	6.67	BR
51	AH-PG-H3	8.00	1.67	200.37	6.58	6.11	BR
52	Gul-e-Shah	7.50	0.00	185.67	6.51	5.96	BR
53	Gule-e-Shah Red Pink	8.00	0.00	198.30	7.24	5.31	RR
54	Kurvi	11.25	2.33	142.55	6.05	5.12	LR
55	Bedana Sedana	18.50	2.00	196.67	7.69	7.32	BR
56	PG-C	5.00	1.00	158.38	5.65	5.24	R
57	P-13	6.50	1.00	147.63	5.21	5.08	R
58	Agah	7.50	0.00	137.20	5.15	4.31	R
	CD (5%)	3.64	---	13.38	1.16	0.85	

([1]Note: R-Red, LR-Light red, BR-Bright red, RR-Rose red, YR-Yellow red, YG-Yellow green and YRT-Yellow with red tinge)

Matured fruits were harvested during December and analyzed for aril attributes. Total soluble solids were ranged from 11.45 to 17.36 °Brix among different germplasm and highest TSS was found in Saih Sirin (17.36 °Brix) followed by Jalore Seedless (15.65 °Brix) and G-137 (15.60 °Brix). Maximum acidity was recorded in Tujetis EC 4347 (3.87 %), followed by Khog (3.67 %) and Crenedo de Elecho (3.59 %) while minimum acidity was found in Ganesh (0.67%) and Jalore Seedless (0.70%). Arils colour was observed light pink, whitish pink, dark pink, red, dark/ blood red and pink (Fig. 1) while mellowness of seed varies from very soft, soft, slightly hard, medium hard to very hard (Table 5). Desirable characters like attractive rind colour–bright red/purple, aril colour-pink/blood red, bold arils, low incidence of cracking and mite attack, low spines and suckers were observed in some germplasm, which can be utilized as breeding lines for development of varieties for different purpose like table, anardana and rootstock purpose and tolerance to cracking and mite.

Table 5. Aril attributes of pomegranate germplasm under hot arid climate

S. No.	Germplasm	TSS (°Brix)	Acidity (%)	Aril color	Taste	Seed mellowness
1	Jalore Seedless	15.65	0.70	Light pink	Sweet	Very soft
2	Jodhpur Red	12.25	0.93	Pink	Sweet	Very hard
3	Kajaki Anar	13.11	1.58	Pink	Sour	Hard
4	Ganesh	14.35	0.67	Dark pink	Sweet	Very soft
5	Dorsata Malus	13.85	3.55	Dark pink	Very sour	Very hard
6	Saharanpur	12.10	1.25	Light pink	Slightly sweet	Very hard
7	G-137	15.60	0.72	Light pink	Sweet	Very soft
8	Kabul	12.24	0.95	Red	Sweet	Very hard
9	Basein Seedling	11.45	0.97	Whitish	Sweet	Hard
10	Banaras collection	12.25	1.25	Light pink	Slightly sweet	Soft
11	Basein Seedless	13.41	1.12	Pink	Slightly sour	Very hard
12	Kandhari	13.21	1.32	Light pink	Sweet	Hard
13	Bedana Suri	12.54	1.04	Bright red	Sweet	Soft
14	GK VK-1	14.26	0.97	Light red	Sweet	Hard
15	Speen Sacarin	13.51	2.45	Bright red	Very sour	Hard
16	IIHR 12/1	15.12	3.46	Bright red	Very sour	Hard
17	Muskat	14.84	0.98	Pink	Sweet	Medium hard
18	Dholka	14.12	0.87	Whitish pink	Sweet	Hard
19	IIHR 19/10	14.85	0.74	Bright red	Sweet	Soft
20	Jalore Red	14.45	0.71	Light pink	Sweet	Medium hard
21	Uthkal	12.80	2.33	Light pink	Sour	Hard
22	Kalisirin	12.91	3.12	Bright red	Very sour	Very hard
23	Khog	14.90	3.67	Bright red	Very sour	Hard
24	Coimb. White	11.80	0.85	Light pink	Sweet	Hard
25	Saih Sirin	17.36	2.11	Pink	Sour	Hard
26	MR 599	15.25	3.25	Pink	Very sour	Hard
27	AHPG-C3	11.57	3.50	Whitish pink	Very sour	Hard
28	Yercaud	15.37	0.89	Red	Sweet	Hard
29	Jodhpur collection	14.80	3.28	Bright red	Very sour	Hard
30	Bedana Thin Skin	14.24	0.89	Bright red	Sweet	Hard
31	P-23	12.11	0.71	Whitish pink	Sweet	Soft
32	P-21	12.07	0.88	Pink	Sweet	Very hard
33.	A K Anar	15.00	3.01	Bright red	Very sour	Very hard
34	P-26	12.61	0.82	Whitish pink	Sweet	Very hard
35	Crenedo de Elecho	15.45	3.59	Whitish pink	Very sour	Hard
36	EC-62812	12.24	2.45	Pink	Sour	Hard
37	Ruby	14.02	0.95	Dark pink	Sweet	Soft
38	Mridula	14.57	0.81	Blood red	Very sweet	Soft
39	Tujetis EC 4347	11.55	3.87	Bright red	Very sour	Very hard

S. No.	Germplasm	TSS (°Brix)	Acidity (%)	Aril color	Taste	Seed mellowness
40	Sirin	11.98	2.71	Pink	Sour	Very hard
41	AHPG-H1	12.71	2.24	Bright red	Sour	Hard
42	Yercaud Local	13.57	1.95	Light pink	Slightly sour	Hard
43	Tebest	12.07	3.44	Dark red	Very sour	Very hard
44	Gul-e-Shah Red	15.71	2.65	Pink	Sour	Very hard
45	Speen Danedar	12.94	2.55	Pink	Sour	Hard
46	AHPG-H2	14.71	1.33	Light pink	Slightly sweet	Hard
47	Patna-5	13.53	1.27	Light pink	Sweet	Hard
48	Sur Sukker	12.01	3.24	Dark pink	Very sour	Very hard
49	Malta	13.34	0.36	Dark pink	Sweet	Hard
50	Gulsa Red	14.05	3.24	Dark red	Very sour	Very hard
51	AH-PG-H3	12.21	2.41	Dark pink	Sour	Very hard
52	Gul-e-Shah	11.75	3.50	Red	Very sour	Very hard
53	Gule-e-Shah Red Pink	14.25	3.24	Pink	Sour	Very hard
54	Kurvi	11.54	1.37	Light pink	Slightly sweet	Hard
55	Bedana Sedana	12.35	1.89	Dark pink	Slightly sweet	Hard
56	PG-C	14.28	0.75	Light pink	Sweet	Soft
57	P-13	13.89	0.81	Light pink	Sweet	Medium hard
58	Agah	14.64	2.47	Pink	Very sour	Very hard
	CD (5%)	1.09	0.179			

Fig. 1. Variability in fruit shape, rind and aril colour of pomegranate germplasm

Evaluation of pomegranate germplasm under semi-arid condition

Pomegranate germplasm were evaluated under semi-arid condition. The maximum plant height (2.75 m), canopy spread in N-S (2.56 m) and E-W (2.62 m) directions and stem girth (4.65 cm) were recorded in Yercaud while the minimum plant height (1.65 m), plant spread (1.46 m) and (1.68 m) and stem girth (3.11 cm) were recorded in anardana cv. Goma Khatta. Among evaluated genotypes, Yercaud was found most vigorous while Khog was found least vigorous.

Collection, conservation and evaluation of date palm (*Phoenix dactylifera* L.) under hot arid environment

Conservation and maintenance of sixty four date palm varieties/genotypes including exotics was carried out during 2019. Seed of *Phoenix sylvestris* (12 germplasm) was collected from Dattiwada, Banaskantha (Gujarat) during June, 2019 and fruit characters were studied. Seedlings were raised in the nursery for evaluation. Variation in germination of seeds was also noted from 50-100%. The offshoots of a male genotype was collected from DRS, Mundra and planted for evaluation. The fruit samples of early maturing 19 germplasm was collected from Mundra, Gujarat and variation in number of fruits/strand (8-34), fruit size, weight (4.9 to 15.4 g), stone size and TSS (13.2–36.8° Brix) were observed. The seeds were sown in the nursery for further evaluation.

Evaluation of date palm germplasm

The spathe emergence was started in second week of January and completed in first week of March. Delay in emergence of spathe and flowering was observed in male and female palm due to change in climatic conditions. The flowering/fruiting were observed in 35 genotypes of 64 germplasm during the year 2019. Early flowering/fruiting and fruit maturity was recorded in cvs. Tayer, Dhamas and Nagal. In 3-4 genotypes, fruit drop was also observed just after setting of fruits. Exotic cultivars Siwi and Ahmat started flowering /fruiting. However, fruiting was low in both cultivars. The berry of Ahmat was greenish yellow and medium in size. The length of strand in cv. Siwi was long (60-65 cm) with 10-13 berry/strand. The berry colour was yellow in Siwi, berry weight 10-12 g and sweet in taste while in Ahmat, fruit weight was 4.69 g and less sweet.

The *doka* stage of fruits in late maturing, rain tolerant and red colour berry genotype (CIAH/DP/S-01) was also harvested in first week of September with fruit yield (46 kg/tree) during 2019. The fruits were not affected by rains and can be used for fresh consumption and processing. Among 6 male date palm evaluated for pollen production, one elite male date palm (CIAH/DP/M-01) was marked promising for more pollen production (672.7 g/tree) and number of spathes (25-30). The IC No. 0632315 was obtained from ICAR-NBPGR, New Delhi. The vegetative growth of plants was almost same (130-143 cm height) in 03 germplasm introduced from ICARDA, Jordan after three year of planting while the spathe emergence/ flowering were observed in few plants in MHN/B and MRKS germplasm and fruiting (2-4 bunch/plant) was observed during the year.

The maximum length of bunch was observed in Shamran and Siwi (140 cm) followed by Bikaner local and Sayer (123 cm). Similarly, number of berries/strand varied from 7 to 24. The maximum number of bunches/ plant (13) were observed in cv. Sewi followed by Sharman, Braim and Sabiah (10-12). The maximum number of berries (24 per strand) was recorded in cv. Zahidi and Sayer followed by Khadrawy, Abdul Rehman, Bint-a-isha (20-22) while minimum was in Gulchati variety (5). Fruit drop was also observed in few genotypes during this year. The bigger size and fruit weight (10.5 g) was observed in cv. Braim, Punjab Red, Medjool and minimum fruit weight (3.33 g) was recorded in cv. Muscat. Variation in stone weight and size were also noticed. The early maturity of fruits (*doka*) was observed in cvs. Nagal, Khuneizi, Surya, Halawy and Tayer which were harvested during mid June to first week of

July. Fruit yield varied from 2 to 50 kg per tree among the germplasm. The maximum fruit yield (50 kg) was recorded in Shamran followed by Khuneizi and Braim (40- 47.2 kg) per tree. The maturity of fruits (*doka* stage) was recorded in maximum varieties in the second week of July. However, cvs. Medjool, Dayari and Siwi were harvested late.

Varietal evaluation of date palm

The growth performance was vigorous in Halawy and Khalas as compared to Zahidi, Khadrawy and Medjool. Flowering/fruiting was observed in all varieties however, fruit drop was noted in cv. Halawy. As intercrop, mustard was grown during *rabi* season between inter spaces of trees for proper utilization of land. The maximum fruit yield/tree was observed in cv. Khalas (40.0 kg) followed by Zahidi (36 kg) and Medjool. The variation in fruit weight (10.8-17.3 g), number of berries/strand (10-15) and TSS (34.0 to 38.5 °Brix) were recorded among the varieties.

Evaluation of tissue cultured plants of date palm

Tissue cultured plants of cv. Barhee and KCS-143 were evaluated and observed better growth, flowering and fruiting in Barhee cultivar. Maximum number of bunch/plant was observed in Barhee (6) which was more than KCS-143 (4). The berry weight was 8.5 g in Barhee and 11.40 g in KCS plant. At *doka* stage of maturity yellow colour was noted in the first week of August. TSS was varied from 33-34.4 °Brix.

Effect of stored and fresh pollens on fruiting of date palm

The effect of stored pollens under different temperature conditions was carried out with the objective to find out effect on fruiting in date palm cv. Halawy. The fruit set was observed however, dropping of fruits was more possibly due to poor viability of pollen and improper pollination besides environmental conditions. Under fresh pollen, 80-85 per cent fruit set was observed.

Response of date palm cultivar to pollen sources, pollen quality, quantity and suitability under hot arid ecosystem

Collected the pollen from the fresh spathe opened on male plants (Ghanami, M1, M3 and elite male) available in field repository. The harvested male pollen grains were collected on the clean plastic shilpoline sheet and air dried for 3-4 hrs. After that pollen was stored in vials and sealed air tight. The pollen vials were stored at -20 °C, referigrator, -80 °C and ambient room temperature to assess the viability of fresh and stored pollen for pollination.

Survey, collection and evaluation of aonla (*Emblica officinalis* Gaertn) genotypes under semi-arid condition

An extensive survey was made to identify and collect the elite genotypes to determine variability for physical and biochemical traits and find out the promising genotypes having bold size fruits with quality. A total of twenty nine fruit samples were collected from Satna and Rewa district of Madhya Pradesh and subjected to qualitative and quantitative evaluation (Fig. 2). Wide range of variability with respect to fruit weight (12.39- 60.25 g), fruit length (1.97- 3.97 cm), fruit breadth (2.27-4.12 cm), fruit girth (3.16 to 8.10 cm), stone weight (0 .45 to 1.50 g), specific gravity (1.00-1.42), TSS of juice (10.00-20.30 °Brix), pH of fruit juice (2.48-3.41), acidity (1.80-4.84%), total sugar (7.50-13.68%), vitamin C (375.00-1428.50 mg/100 ml), phenol (944.85-4969.50 mg/100g) and TSS/acid ratio (2.64-9.72) were observed among the studied genotypes. The genotype T_{12}, T_{17} and T_{21} was found superior with respect to fruit weight, fruit girth, fruit length and breadth, whereas $T_{9,}$ T_{24}, T_{27} and T_{29} were found superior for vitamin C, total soluble solids and total sugar among the genotypes. A wide variation in physico-chemical characters of aonla genotypes indicated the enormous scope of selection based on their quantitative and qualitative characters and its genetic improvement.

Fig. 2. Aonla germlasm for bold size fruits earmarked in Rewa, Satna (MP) & Pratapgarh (UP)

Varietal evaluation of aonla

Aonla varieties namely Chakaiya, Banarasi, Francis, Krishna, Kanchan, NA-6, NA-10, Anand-1, Anand-2, NA-7, Goma Aishwarya, BSR-1, Laxmi-52 and BSR-2 were studied for their morphomatrix, yield and qualitative attributes of fruits during the year 2019. Genotypes CHESA-1 to CHESA-12 were studied for their growth, flowering and fruiting characters. Tree growth 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. The dense foliage was observed in Francis, NA-7, BSR-1 and NA-10, while Banarasi, Chakaiya, Krishna, Kanchan, Anand-1, BSR-2 and Anand-2 had sparse foliage. The tree trunk colour of varieties were grey in Banarasi, Krishna, Francis, Chakaiya, Anand-1 and Anand-2 and whitish grey in Kanchan, Goma Aishwarya, 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.

Fruit shape was observed triangular in Banarasi and Krishna; flattened round in Francis, NA-7, Goma Aishwarya, Chakaiya, Kanchan and NA-10, and flattened oval in Anand-1 BSR-1 and BSR-2 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 in Francis, Chakaiya, Kanchan, Anand-1 and Anand-2. Fruit stem end cavity was noticed shallow in Banarasi, Francis, Chakaiya, Kanchan, Anand-1 and Anand-2, whereas deep in Krishna, NA-7 and NA-10. Styler end cavity 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 occasionally. Most of the varieties showed whitish green colour flesh excluding Krishna which had yellowish green colour. The highest fruit set was recorded in the NA-7 (52.20%) followed by Goma Aishwarya (50.10%), Krishna (44.72%), NA-10 (41.27%), Kanchan (35.28%) and lowest was in Banarasi (22.00%) followed by Chakaiya (31.73%). The fruit weight was ranged between 27.25-38.20 g, being maximum in Banarasi (38.20 g) followed by NA-7 (30.80 g) and it was measured minimum in BSR-1 (13.08 g) and Kanchan (24.72 g). The fruit length ranged between 3.13-3.50 cm, whereas it was observed maximum in Banarasi (3.69 cm) followed by Krishna (3.40 cm) and NA-7 (3.65 cm). Fruit breadth ranged between 3.40-4.24 cm and the maximum breadth was observed in Banarasi (4.24 cm) followed by NA-7 and Chakaiya (4.10 cm), while it was minimum in BSR-1 (1.90 cm). The percentage of fruit retention was recorded maximum (28.19%) in NA-7 followed by Krishna (25.67%) and minimum (18.19%) in Banarasi among the evaluated varieties.

The juice content was observed maximum in NA-7 (57.23%) followed by Goma Aishwarya (48.13%), however Chakaiya had the lowest juice content (40.28%) followed by Banarasi (39.10%). The acidity ranged between 1.97-2.23% being the maximum in BSR-1 (2.23%) followed by

Krishna (2.14%), whereas it was observed the lowest (1.97%) in Kanchan followed by Anand-1 (2.12%). The vitamin C content ranged between 350.63- 499.00 mg/100 g. It was observed the highest in NA-7 (499.00 mg/100 g) followed by Kanchan (471.50 mg/100 g) and the same was found lowest in Banarasi (339.07 mg/100 g) followed by Francis (349.23 mg/100 g) and Krishna (351.70mg/100 g). The total soluble solids were recorded maximum in NA-7 (10 °Brix) followed by Anand-1 (9.50 °Brix) and Anand-2 (9.20 °Brix) while Banarasi had the minimum TSS (8.70 °Brix) followed by NA-10 (9.00 °Brix). The value of specific gravity ranged between 1.02-1.40 being the highest in Banarasi (1.40) followed by Anand-1 (1.38), and it was least in Francis (1.02) followed by NA-7 (1.22). The weight of the stone was exhibited the highest in Francis (2.10 g) followed by Krishna (2.01 g) and Anand-1 (2.50 g) and it was least in NA-7 (1.97 g) followed by Kanchan and NA-10 (198.20 g) among the varieties.

Evaluation of aonla genotypes

Among the 12 genotypes, maximum plant height (3.48 m) was recorded in CHESA-4 followed by CHESA-7 (3.35 m) and it was recorded least in CHESA-1 (2.89 m) followed by CHESA-2 (2.45 m), whereas yield per plant was recorded maximum in CHESA-4 (15.05 kg) under rainfed semi-arid conditions. Among the genotypes, flowering and fruiting was not observed in CHESA-1 and CHESA-2 which were collected from north eastern region during 2014. Among the genotypes, tree growth was semi-spreading in CHESA-1 and CHESA-2; tall upright in CHESA-7 and CHESA-8; tall spreading in CHESA-5 and CHESA-6 and semi-drooping in CHESA-4 under rainfed conditions of western India.

Evaluation of bael (*Aegle marmelos* Correa.) genotypes under hot arid condition

Evaluation of 450 bael germplasm under hot arid ecosystem of western Rajasthan was conducted during the year 2019. The morphometric parameters of the seedling plant height was ranged from (2.6-5.6 m), canopy spread (E-W 2.7-5.2 m x N-S 2.7-5.3 m) and plant girth (34.2- 70.2 cm). The maximum fruit weight, length and width was ranged (6.90 – 14.04 cm and 7.70 – 14.70 cm) and maximum number of fruit and yield per plant ranged from (12.6 to 42 and 7.6 – 33 kg). Differences in growth yield and fruit quality behavior among evaluated varieties might be due to the genetical constitution of the individual genotype and their acclimatization under hot arid agro climatic conditions (Table 6 to 9).

Table 6. Evaluation of bael germplasms for growth and fruit parameters

Seedlings	Plant height (m)	Stem girth (cm)	Plant spread (m)		Fruit weight (kg)	Fruit length (cm)
			E-W	N-S		
1	4.8	53.2	4.4	4.5	0.427	9.66
2	5.6	53.4	5.0	5.0	0.451	8.88
3	4.8	65.8	5.2	5.1	0.432	7.68
4	4.5	70.2	4.4	4.5	1.903	11.34
5	3.8	54.6	3.8	3.7	0.454	9.62
6	4.2	60.6	4.6	5.3	0.471	10.18
7	4.2	52.2	4.1	4.9	0.763	11.48
8	3.8	59.4	4.3	3.8	0.738	11.46
9	4.6	60.2	4.5	4.4	1.735	13.86
10	3.6	59.4	4.5	4.0	0.440	8.68
11	2.6	54.4	4.5	3.6	1.341	14.04
12	3.4	34.8	2.7	2.6	0.484	9.44
13	4.1	52.2	4.0	3.6	0.431	9.08

Seedlings	Plant height (m)	Stem girth (cm)	Plant spread (m)		Fruit weight (kg)	Fruit length (cm)
			E-W	N-S		
14	2.8	58.6	4.2	3.7	0.493	9.54
15	4.2	51.8	3.0	3.7	0.604	9.38
16	4.8	53.2	3.4	3.4	0.451	10.06
17	5.5	57.0	4.4	3.9	0.498	7.96
18	5.2	75.0	5.4	4.7	0.434	8.06
19	5.0	38.6	4.5	4.4	0.531	8.88
20	4.2	58.0	3.3	3.2	0.487	7.94
21	4.6	34.4	2.7	2.8	0.632	10.28
22	4.9	44.2	3.7	3.4	0.465	7.04
23	4.2	47.8	3.5	3.7	0.470	9.12
24	4.0	60.2	3.9	3.7	0.482	6.90
25	3.8	37.4	3.2	3.6	0.488	9.68
SEM±	0.19	1.80	0.25	0.21	0.072	0.378
CD (5%)	0.54	5.06	0.71	0.59	0.202	1.062

Table 7. Evaluation of bael germplasm for fruit parameters

Seedlings	Width (cm)	Shell thickness (mm)	No. of fruit / plant	Yield/ plant (kg)	TSS of pulp (°Brix)	TSS of mucilage (°Brix)
1	8.76	0.95	22.6	9.6	47.1	54.3
2	8.14	2.35	24.8	11.4	57.0	59.8
3	9.14	1.60	25.6	11.4	41.6	53.9
4	14.70	2.40	12.6	24.1	48.1	52.9
5	9.26	2.34	20.4	9.0	52.1	52.5
6	9.12	2.09	18.6	9.2	55.4	58.5
7	10.70	1.77	16.8	12.7	50.7	47.1
8	10.80	1.76	19.0	13.7	56.1	55.3
9	13.82	2.39	18.6	33.2	37.6	54.1
10	9.72	2.40	34.6	15.3	46.6	48.0
11	13.04	2.37	19.4	25.7	38.1	44.7
12	9.62	1.59	15.2	7.5	44.4	52.9
13	9.64	2.38	20.4	8.8	49.2	58.7
14	9.72	2.22	33.2	16.4	50.2	59.9
15	10.60	1.54	20.8	12.7	44.5	58.1
16	9.00	1.66	16.6	7.6	46.6	57.7
17	8.86	2.24	31.0	15.3	50.3	52.3
18	8.56	2.21	30.0	12.8	51.9	49.1
19	8.72	2.34	32.2	17.3	56.1	62.7
20	9.18	1.66	25.0	12.2	57.1	50.9
21	10.56	2.34	28.0	17.9	48.9	48.1
22	8.92	2.34	18.4	8.6	54.1	58.3
23	9.66	1.67	21.0	9.9	46.5	51.4
24	7.70	1.42	42.2	21.0	58.1	54.3
25	9.44	2.36	29.6	14.3	55.1	61.5
SEM±	0.281	0.078	2.88	2.37	1.12	1.14
CD (5%)	0.791	0.219	8.10	6.68	3.15	3.21

Table 8. Evaluation of bael germplasm for fruit parameters

Seedlings	Fruit colour	Fruit shape	Pulp colour	Styler end cavity
1	Yellowish green	Globose	Dark yellow	Shallow
2	Yellowish green	Round	Yellow	Shallow
3	Greenish Pale yellow	Round	Dark yellow	Shallow
4	Greenish Pale yellow	Round	Yellow	Highly depressed
5	Yellowish green	Pumpkin Shape	Yellow	Shallow
6	Greenish Pale yellow	Globose	Dark yellow	Shallow
7	Greenish Pale yellow	Round	Yellow	Shallow
8	Greenish Pale yellow	Round	Yellow	Shallow
9	Greenish pale yellow	Round	Yellow	Depressed
10	Greenish pale yellow	Round	Yellow	Highly depressed
11	Greenish pale yellow	Globose	Yellow	Shallow
12	Yellowish green	Globose Round	Yellow	Shallow
13	Greenish pale yellow	Globose	Yellow	depressed
14	Greenish pale yellow	Globose	Dark Yellow	Shallow
15	Greenish pale yellow	Round	Dark Yellow	Highly depressed
16	Yellowish Green	Elliptical	Yellow	Shallow
17	Yellowish Green	Round	Dark Yellow	Shallow
18	Yellowish Green	Round	Dark Yellow	Shallow
19	Greenish pale yellow	Globose	Yellow	Shallow
20	Greenish yellow	Round	Yellow	Depressed
21	Greenish pale yellow	Round	Yellow	Depressed
22	Greenish pale yellow	Globose	Dark yellow	Shallow
23	Greenish pale yellow	Round	Dark yellow	Shallow
24	Greenish pale yellow	Round	Dark yellow	Shallow
25	Yellowish Green	Round	Dark yellow	Depressed

Table 9. Evaluation of bael germplasm for fruit parameters

	Fruit surface	Stem end cavity	Seed shape	Locule arrangement
1	Smooth	Depressed	Oblong	Scattered
2	Smooth	Flattered	Round	Centric
3	Smooth	Depressed	Oblong	Centric
4	Smooth	Depressed	Round	Centric
5	Rough	Depressed	Oblong	Scattered
6	Smooth	Depressed	Oblong	Centric
7	Smooth	Depressed	Oblong	Centric
8	Smooth	Depressed	Oblong	Centric
9	Rough	Flattered	Round	Highly centric
10	Smooth	Flattered	Round	Centric
11	Smooth	Depressed	Round	Centric
12	Smooth	Shallow	Oblong	Centric
13	Rough	depressed	Oblong	Centric
14	Smooth	Flattered	Oblong	Scattered
15	Rough	Depressed	Oblong	Scattered
16	Rough	Depressed	Oblong	Centric

	Fruit surface	Stem end cavity	Seed shape	Locule arrangement
17	Rough	Flattered	Oblong	Scattered
18	Smooth	Depressed	Oblong	Scattered
19	Rough	Depressed	Oblong	Centric
20	Rough	Depressed	Oblong	Centric
21	Rough	Depressed	Oblong	Centric
22	Smooth	Depressed	Oblong	Scattered
23	Smooth	Shallow	Round	Centric
24	Smooth	Depressed	Oblong	Centric
25	Smooth	Depressed	Oblong	Scattered

Collection, conservation and evaluation of bael germplasm under semi-arid condition

A total of 213 germplasm has been established through *in-situ* patch budding at the field gene bank of station. Among the genotypes, flowering and fruiting was noticed in 79 genotypes during the year 2019. Genotypes exhibited wide range of variability in terms of yield/plant (49.13-108.80 kg), fruit weight (0.75-2.70 kg), fruit length (7.11-22.27 cm), fruit circumference (27.75- 54.10 cm), shell thickness (1.4-3.10 mm), seed number/fruit (60.14-254), number of seed sacs (09.47-11.32), seed weight (0.10-0.20 g), shell weight (109.70-435.00 g) and pulp weight (0.38-2.29 kg). The chemical composition including TSS in pulp (32.30- 41.75 °Brix), TSS in mucilage (40.17-54.50 °Brix), acidity (0.31-0.52%), vitamin C (13.09-21.77 mg/100 g), total phenol contents (1798-2678 mg/100 g) and total sugar (13.17-17.17%) exhibited wide variation (Fig. 3). Among the germplasm, considerable variability with regards to physical composition of fruit *viz.,* pulp (45.33-76.00%), shell (13.97-25.22%), fibre content (2.52-6.15%), mucilage (10.07-15.41%) and seed content (1.75-5.35%) were recorded under dryland conditions of western India. Genotypes showed wide variation in ripening period (February to June). Based on the observation on various aspects particularly fruiting pattern and quality attributes, genotypes *viz.,* CHESB-11, CHESB-16, CHESB-21, CHESB-27, CHESB-29 , CHESB-31, CHESB-42, CHESB-48 CHESB-59, CHESB-60, CHESB-62, CHESB-69, CHESB-71, CHESB-73, CHESB-77 and CHESB-78 were found to be superior under rainfed semi-arid ecosystem. Details of striking features of promising genotypes, CHESB-11, CHESB-16, CHESB-21, CHESB-27 and CHESB-29 are as follows:

CHESB-11 (IC-0629384): This genotype has been identified promising which was collected from Anand, Gujarat in 2010. Average yield per plant was 108.80 kg in 11th year, fruit weight 1.40 kg, fruit size 14.03 cm x 15.00 cm, fruit girth 43.75 cm, shell thickness 0.14 cm, total number of seed 60.25, seed weight 0.19 g, total seed weight 15.00 g, fibre weight 27.42 g, shell weight 180.30 g, locules in cross section 14-17, TSS pulp 37.50 °Brix, TSS mucilage 51.35 °Brix, acidity (0.31%) and vitamin C 21.80 mg/100 g pulp were recorded. It is comparatively small in stature and belong to late maturing group (1stweek of May). The fruits of this genotype are attractive having good flavour and aroma. It is highly suitable for *sharbat*, *murabba* and powder making.

CHESB-16 (IC-0629385): It is identified promising based on horticultural traits, which was collected from Vidyanagar, Anand, Gujarat during 2010. Average yield per plant 97.00 kg in 10th year, fruit weight 1.45 kg, fruit size 14.10 cm x 15.14 cm, fruit girth 43.87 cm, shell thickness 0.19 cm, total number of seed 75.32, seed weight 0.20 g, total seed weight 18.50 g, fibre weight 35.00 g, shell weight 190.21 g, locules in cross section 14-17, TSS pulp 37.10 °Brix, TSS mucilage 50.80 °Brix, acidity (0.33%) and vitamin C 20.40 mg/100 g pulp were recorded. It belongs to late maturing group (3rd week of May). It is rich in antioxidants activity CUPRAC (micro MTE/g) was recorded 129.35 in mucilage and 62.18 in

fruit pulp. The fruits of this genotype are having good flavour and aroma. Drooping branches, whitish green fruit surface colour and curved petals are identical and distinct characters of this genotype. It is highly suitable for powder making.

CHESB-21 (IC-0629386): It was collected from Pansora village, Anand, Gujarat during the year 2011. Recorded average yield per plant 91.50 kg in 10th year, fruit weight ranged between 1.35-1.75 kg, fruit size 21.0 0 cm x 14.00 cm, fruit girth 43.53 cm, shell thickness 0.20 cm, total number of seed 98.15, seed weight 0.20 g, total seed weight 20.51 g, fibre weight 49.32 g, shell weight 200.00 g, locules in cross section 14-16, TSS pulp 36.58 °Brix, TSS mucilage 51.50 °Brix, acidity (0.35%) and vitamin C 20.00 mg/100 g pulp. It is medium maturing variety (3rd week of April). Highly centric locule arrangement, thorny, odourless and lemon colour of fruit surface after ripening are identical and distinct characters. It is highly suitable for pickle, squash, candy and powder making.

CHESB-27 (IC-06293867): It was collected from Undel village, Anand, Gujarat during the year 2011. Average yield per plant 105.80 kg in 10th year (heavy yielder), fruit weight ranged between 1.2-1.45 kg, fruit size 14.32 cm x 13.38 cm, fruit girth 41.77 cm, shell thickness 0.24 cm, total number of seed 57.10, seed weight 0.20 g, total seed weight 29.59 g, fibre weight 43.12 g, shell weight 203.12 g, locules in cross section 15-17, TSS pulp 42.15 °Brix, TSS mucilage 45.50 °Brix, acidity (0.33%) and vitamin C 20.80 mg/100 g pulp were recorded. It is mid maturing variety (4th week of April). Compact canopy, cluster bearing, deep yellow colour of fruit. It is having excellent shelf life (15 days) after harvesting. It is highly suitable for pickle, candy and powder making.

CHESB-29 (IC-0629388): It was collected from Undel village, Anand, Gujarat during the year 2012. Average yield per plant 62.25 kg in 7th year (heavy yielder), fruit weight ranged between 0.77 kg, fruit size 11.17 cm x 10.25 cm, fruit girth 39.27 cm, shell thickness 0.18 cm, total number of seed 52.24, fibre weight 43.12 g, shell weight 203.12 g, locules in cross section 15-17, TSS pulp 35.15 °Brix, TSS mucilage 48.50 °Brix, acidity (0.35%) and vitamin C 23.70 mg/100 g pulp were recorded. It is mid maturing variety (4th week of April). Compact canopy, cluster bearing, deep yellow colour of fruit. It is having excellent shelf life (15 days) after harvesting. It is highly suitable for making *sharbat* and slice.

Evaluation of sweet orange varieties in arid region of western Rajasthan

Nine sweet orange cultivars were evaluated for growth, yield and fruit quality attributes under hot arid region of Rajasthan (Fig. 4). Sweet orange cultivars namely Washington Navel, Blood Red, Newhall Navel, Jaffa, Satgudi, Hamlin, Mosambi, Pineapple and Valencia Olinda on rough lemon rootstock were evaluated at 6x6 m spacing and uniform intercultural operations were followed. The plant height (262.12 cm), canopy spread N-S (286.83 cm) and E-W (287.84 cm), canopy diameter (287.34 cm), canopy volume (15.78 m^3), scion diameter (83.17 mm) and rootstocks diameter (89.27 mm) were found maximum in Satgudi followed by Hamlin and Jaffa. The S:R ratio (0.96) was found highest in Newhall Navel however, it was recorded lowest in Washington Navel, Blood Red and Pineapple. During third year, maximum average number of fruits per plant was recorded (12.25) in Satgudi followed by Mosambi (10.20) as compared to lowest (5.20) in Jaffa while no fruiting was observed in Washington Naval variety. Fruit weight was ranged from maximum (235.40 g) in Satgudi to minimum 175.68 g in Newhall Navel. Highest TSS was recorded in Satgudi (12.45 °Brix) followed by Hamlin (11.90 °Brix) and Pineapple (11.80 °Brix). Acidity was found minimum (0.42%) in Satgudi and maximum (0.68%) in Hamlin. Ascorbic acid content varied from 31.05 to 45.26 mg/100 g among different varieties. In conclusion, Satgudi was found significantly superior as compared to other cultivars of sweet orange varieties under hot arid climatic conditions (Table 10 &11).

CHESB-11 CHESB-16 CHESB-21 CHESB-27 CHESB-29

Fig. 3. Evaluation of elite bael germplasm

Fig. 4. Fruit quality attributes of sweet orange cultivars

Table 10. Growth attributes of sweet orange cultivars under hot arid climate

Varieties	Plant height (cm)	Canopy spread N-S (cm)	Canopy spread E-W (cm)	Canopy dia. (cm)	Canopy volume (m^3)	Scion dia. (mm)	Rootstock dia. (mm)	S:R ratio
Washington Navel	225.40	255.45	251.32	253.39	11.97	73.11	81.65	0.90
Blood Red	220.38	246.21	240.15	243.18	11.23	65.25	71.34	0.91
Newhall Navel	232.50	260.38	257.39	258.89	12.61	78.57	82.18	0.96
Jaffa	244.13	264.12	255.90	260.01	13.30	75.24	80.69	0.93
Satgudi	262.12	286.83	287.84	287.34	15.78	83.17	89.27	0.94
Hamlin	248.50	275.55	268.12	271.84	14.15	84.12	87.12	0.95
Mosambi	202.40	221.49	211.38	216.44	9.18	69.27	73.85	0.94
Pineapple	206.40	208.47	210.39	209.43	9.06	58.19	63.19	0.92
Valencia Olinda	191.50	226.80	229.09	227.95	9.15	64.97	68.19	0.95
SEm ±	6.10	7.60	8.12	8.20	0.8	2.51	2.49	0.02
CD (5%)	18.30	22.90	24.37	24.70	2.41	7.54	7.47	0.05

Table 11. Yield and quality attributes of sweet orange cultivars under hot arid climate

Varieties	Number of fruits /plant	Fruit dia. (mm)	Fruit weight (g)	Fruit yield (kg/plant)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100 g)
Blood Red	8.33	7.54	198.26	1.65	10.30	0.58	38.45
Newhall Navel	6.50	7.33	175.68	1.14	11.10	0.62	36.14
Jaffa	5.20	7.21	186.45	0.97	10.80	0.51	40.95
Satgudi	12.25	8.25	235.34	2.88	12.45	0.42	42.18
Hamlin	6.33	6.95	184.13	1.17	11.90	0.68	32.15
Mosambi	10.20	8.11	227.18	2.32	10.20	0.45	45.23
Pineapple	6.67	7.30	215.72	1.44	11.80	0.60	45.26
Valencia Olinda	6.70	7.80	258.14	1.73	8.8	0.54	31.05
SEm ±	0.71	0.6	4.11	0.1	0.41	0.01	1.10
CD (5%)	2.20	1.80	12.33	0.3	1.20	0.02	3.32

Evaluation of interspecific hybrid Mandarin cv. Fremont on different rootstocks under hot arid region

The performances of interspecific mandarin hybrid cv. Fremont were evalauted on four different rootstocks under arid region for enhancing production and improving quality of fruits. The three years old Fremont plants budded on Rough lemon, Karna Khatta, Pectinifera and Troyer rootstocks were evaluated under field conditions. Results revealed significant effect of rootstocks on growth, yield and fruiting attributes. Tree height (1.76 m), canopy diameter (1.78 m), canopy volume (6.84 m^3) and canopy projection area (2.60 m^2) were found highest on Karna Khatta followed by Rough lemon (Table 12). The stonic difference and scion rootstock ratio were found highest in Troyer Citrange (7.58 mm) and Pectinifera (0.92), respectively. The trunk cross sectional area was recorded highest on Karna Khatta (265.46 cm^2) and Rough lemon (239.15 cm^2) rootstocks as compared to other rootstocks. Karna Khatta and Pectinifera rootstocks were regulated in higher fruiting density, while it was lowest on Troyer citrange. Whereas, Karna Khatta produced highest fruits (123.73 g), maximum numbers of fruit (131.79/tree) and fruit yield (17.28 kg/tree), while all these parameters were found lowest in Troyer (96.03g, 47.80/tree and 5.40 kg/tree), respectively (Table 13). Technology index and production efficiency were recorded highest on Pectinifera (2.90) and Karna Khatta (2.32 kg/m^3), respectively. All desirable fruit quality parameters were observed highest in Pectinifera as juice percentage (59.27), TSS (12.56 °B), acidity (0.98 mg/100 ml), ascorbic acid (64.14 mg/100 ml), rind thickness (2.95 mm) and organoleptic score (8.92) as compared to other rootstocks

Table 12. Effect of rootstock on growth and compatibility index of Fremont mandarin

Rootstocks	Canopy parameters				Compatibility index			
	Plant height (m)	Canopy dia. (m)	Canopy volume (m^3)	CPA (m^2)	Stonic difference (mm)	S:R ratio	TCSA (cm^2)	Fruiting density /cm^2 TCSA
Rough lemon	1.61	1.48	5.50	2.08	6.11	0.89	239.15	0.63
Karna Khatta	1.76	1.78	6.84	2.60	6.09	0.88	265.46	0.85
Pectinifera	1.33	1.26	3.83	1.44	2.26	0.92	169.54	0. 71
Troyer citrange	1.49	1.32	4.22	1.52	7.58	0.82	168.66	0.46
SEm±	0.04	0.04	0.26	0.09	0.84	0.02	11.54	0.05
CD (5%)	0.11	0.10	0.73	0.27	2.40	0.05	33.10	0.15

Table 13. Effect of rootstocks on fruit yield attributes of Fremont mandarin

Rootstocks	No. of fruits /tree	Fruit weight (g)	Fruit diameter (mm)	Fruit yield (kg /tree)	Fruit index	TI	PE (kg/ m³)
Rough lemon	105.58	114.67	385.08	13.16	0.80	2.58	2.27
Karna Khatta	131.79	123.73	440.43	17.28	0.75	2.60	2.32
Pectinifera	69.99	114.60	389.27	8.83	0.72	2.90	2.08
Troyer citrange	47.80	96.03	290.74	5.40	0.75	2.83	1.07
S Em±	3.20	1.54	8.60	0.45	0.01	0.04	0.08
CD (5%)	9.17	4.43	24.67	1.30	0.04	0.12	0.23

Table 14. Fruit quality attributes of Fremont mandarin as affected by rootstocks

Rootstocks	Fruit juice (%)	TSS (°Brix)	Acidity (mg/100 ml)	Ascorbic acid (mg/100 ml)	Rind thickness (mm)	Ripening index	Organoleptic score
Rough lemon	52.11	10.88	1.18	51.10	3.19	9.23	7.42
Karna Khatta	52.69	11.12	1.24	31.48	3.35	9.00	7.22
Pectinifera	59.27	12.56	0.98	64.14	2.95	12.81	8.92
Troyer citrange	52.71	11.57	1.10	52.95	3.06	10.51	7.67
S Em±	0.57	0.09	0.01	0.60	0.02	0.13	0.07
CD (5%)	1.63	0.27	0.04	1.72	0.07	0.38	0.21

(Table 14). Troyer citrange appeared poor performer in terms of growth, compatibility and fruit yield parameters. A positive significant correlation was found in Karna Khatta and Rough lemon for higher growth and yield parameters and fruit quality parameters in Pectinifera. Hence, based on these observations, Karna Khatta and Rough lemon were found suitable for quick orchard development and higher yield, whereas Pectinifera found suitable for high planting density and better fruit quality traits for Fremont mandarin under arid region.

Evaluation of wood apple (*Feronia limonia*) germplasm under semi-arid condition

Sixteen genotypes of wood apple were evaluated for different morphological traits (Table 15). The fruit colour of genotypes varied from dull white to grayish. Genotypes CHESW-1, CHESW-2, CHESW-7, CHESW-8, CHESW-9, CHESW-10, CHESW-11 and CHESW-13 had dull white fruit colour while genotypes CHESW-3, CHESW-4, CHESW-5, CHESW-12, CHESW-14, CHESW-15 and CHESW-16 exhibited to grayish colour. Genotypes, CHESW-1, CHESW-3, CHESW-5, CHESW-6, CHESW-7, CHESW-8, CHESW-9, CHESW-11, CHESW-13 and CHESW-16 were observed with round fruit shape while CHESW-2, CHESW-4 and CHESW-15 showed to oblong fruit shape. The genotype CHESW-10 has flat fruit shape. Fruit pulp colour also showed much variability among the genotypes such as brown pulp colour in CHESW-1, CHESW-3, CHESW-4, CHESW-6, CHESW-7, CHESW-10, CHESW-13 and CHESW-16 and toffee brown colour in CHESW-5, CHESW-8, CHESW-9 and CHESW-11, whereas CHESW-2, CHESW-12, CHESW-14 and CHESW-15 have pale gold colour. Among all the genotypes, the maximum fruit weight was recorded in CHESW-4 (Thar Gaurav) (450.33 g) followed by CHESW-6 (385.00 g) while, it was minimum in CHESW-7 (165.57 g) followed by CHESW-8 (227.0 g). The fruit length was estimated highest in CHESW-4 (Thar Gaurav) (102.67 mm) whereas it was least in CHESW-7 (60.29 mm). The fruit breadth varied from 96.66 mm to 66.35 mm among all genotypes. The highest fruit breadth was observed in CHESW-4 (96.66 mm) followed by CHESW-2 (87.56 mm).

The pulp percentage of fruit in wood apple is very important quality parameter and it is directly related to seed numbers and shell weight of fruit. Among all genotypes, CHESW-6 genotype was observed maximum fruit pulp (58.27%) followed by CHESW-15 (55.62%). The highest yield per plant was recorded in CHESW-6 (148.0 kg) followed by CHESW-4 (125.25 kg), CHESW-10 (115.97 kg) and CHESW-15 (105.23 kg), whereas, it was recorded minimum in CHESW-1 (50.45 kg). The moisture content of wood apple genotypes varied from 70.12 to 72.92% and it was found maximum in CHESW-10 (72.92%), whereas maximum juice content was recorded in CHESW-6 (18.20%). The highest total soluble solid (TSS) was recorded in genotype CHESW-6 (20.30) in pulp and 29.21°Brix. The fruit acidity varied from 3.54 to 7.31% in pulp among the genotype. The highest ascorbic acid was recorded in CHESW-11(32.38 mg) in fruit pulp and it varied 21.36-32.18 mg. The maximum reducing and total sugars were estimated in CHESW-4 i.e. 1.42 and 3.07% respectively. The highest pectin content was estimated in CHESW-16 (1.92%) and it ranged from 1.04-1.92%.

CHESW-6: The genotype CHESW-6 having average fruit weight (385.00 g) with round shape, and TSS (20.30% °Brix). The fruits start ripening from 2nd fortnight of December and belong to late maturity group. The average fruit yield per plant was recorded 148.00 kg/plant during 13th year.

CHESW-10: The average physical attributes of genotype CHESW-10 in terms of fruit weight (350.23 g), total number of seed (518.10), pulp per cent (52.23%), TSS (17.00% °Brix), fruit shape is oblong. Ripening starts in the first week of December and fruit yield per plant was recorded 115.97 kg/plant during 13th year of planting under rainfed conditions of semi-arid ecosystem (Table 15).

Table 15. Fruit and yield attributes of wood apple genotypes

Genotypes	Fruit weight (g)	Fruit shape	Fruit colour	Pulp colour	Pulp (%)	T.S.S. (°Brix)	Shell thickness (mm)	Fruit yield (kg)/ plant
CHESW-1	239.43	Round	Dull white	Brown	43.95	15.60	3.15	50.45
CHESW-2	392.00	Oblong	Dull white	Pale gold	51.30	18.00	3.32	108.23
CHESW-3	312.00	Round	Grayish	Brown	46.90	12.00	3.52	58.50
CHESW-4 (Thar Gaurav IC-0629365)	450.33	Oblong	Grayish	Brown	50.92	14.12	3.25	125.25
CHESW-5	276.33	Round	Grayish	Toffee brown	51.06	14.60	3.45	68.60
CHESW-6 (IC-0629366)	385.00	Round	Greenish-Dull white	Brown	58.27	20.30	3.18	148.00
CHESW-7	165.57	Round	Dull white	Brown	47.66	12.50	3.55	77.75
CHESW-8	237.00	Round	Dull white	Toffee brown	45.08	13.00	3.68	72.88
CHESW-9	312.20	Round	Dull white	Toffee brown	46.64	12.30	3.65	60.52
CHESW-10 (IC-0629368)	350.23	Flat	Dull white	Brown	52.23	17.00	3.18	115.97
CHESW-11	293.33	Round	Dull white	Toffee brown	47.54	12.30	3.34	81.98
CHESW-12	285.35	Triangular	Grayish	Pale gold	45.75	15.27	3.61	62.15
CHESW-13	275.65	Round	Dull white	Brown	45.44	15.60	3.46	56.23
CHESW-14	283.43	Triangular	Grayish	Pale gold	45.12	15.86	3.62	72.56
CHESW-15	320.45	Oblong	Grayish	Pale gold	55.62	18.12	3.24	105.23
CHESW-16	268.32	Round	Grayish	Brown	42.67	17.23	4.10	72.54
C.D.(5%)	015.23	-	-	-	3.64	1.32	0.17	7.20

The growth parameters and fruiting traits recorded in new germplasm of wood apple, which were planted in 2015. The plant growth character and yield was recorded in 4th year age plant (Fig. 5). The plant root stock diameter, scion diameter, plant height, plant spread, total fruit and fruit weight were recorded 8.32-39.12 cm, 6.50-37.53 cm, 1.42-3.89 m, 0.49-3.39 m EW & 0.55-3.36 m NS, 8.12-60.23 and 247.21-317.53 g, respectively (Table 16).

Table 16. Growth parameters of new germplasm of wood apple

Genotypes	Root stock dia. (cm)	Scion dia. (cm)	Plant height (m)	Plant spread (m)		Total fruit (no.)	Fruit weight (g)
				EW	NS		
CHESW-17	18.32	16.42	2.45	02.25	02.58	No fruiting	
CHESW-18	35.25	32.15	3.89	03.17	03.08	11.53	278.85
CHESW-19	27.17	25.11	2.68	02.57	02.52	No fruiting	
CHESW-20	15.24	14.12	1.95	00.95	00.89	No fruiting	
CHESW-21	36.26	35.42	3.38	02.56	02.53	8.92	302.36
CHESW-22	31.68	28.15	3.47	02.28	02.19	22.63	305.63
CHESW-23	39.12	36.13	4.29	02.93	03.36	21.13	294.36
CHESW-24	18.65	15.36	2.39	01.55	01.79	No fruiting	
CHESW-25	34.28	32.45	3.34	03.15	02.89	24.00	311.32
CHESW-26	8.320	06.50	1.42	00.49	00.59	No fruiting	
CHESW-27	38.18	37.53	3.85	03.39	03.15	60.13	317.53
CHESW-28	18.23	16.23	2.27	01.64	01.88	No fruiting	
CHESW-29	22.25	20.33	2.69	01.98	02.19	13.12	261.56
CHESW-30	24.74	24.23	2.87	01.89	01.95	16.38	292.13
CHESW-31	21.53	22.25	2.39	01.99	01.87	14.27	247.21
CHESW-32	14.39	12.62	1.87	01.39	01.49	No fruiting	
CHESW-33	13.56	13.12	1.73	01.21	01.23	9.36	278.23
CHESW-34	14.52	14.36	1.65	01.41	01.45	9.26	291.56
CD (5%)	03.56	02.17	0.18	00.17	00.90	1.52	19.23

Fig. 5. Fruits of wood apple genotype CHESW-10

Evaluation of custard apple (*Annona squomosa*) germplasm under semi-arid condition

The existing forty seven custard apple germplasm were evaluated for their qualitative and quantative characters and significant variation was recorded. The qualitative and quantative attributes varied like fruit weight (110.12-370.36 g), fruit length (6.42-8.26 cm), fruit diameter (5.42-8.61 cm), pulp weight (48.36-245.38 g), rind weight (43.28-125.27 g), pulp (46.23-66.51%), rind thickness (2.23-4.47 mm), fruit pulp colour (creamy white to dull white), fruit core length (1.24-3.49 cm), pulp texture (soft to gritty), total sugars (13.25-17.27%), reducing sugars (11.36-15.39%), ascorbic acid (16.73-38.28 mg/100 g), no. of flakes (41.87-98.29), no. of flakes with seed (41.15-84.52), no. of flakes without seed (5.82-56.88), firmness of flesh (firm to medium), TSS (22.27-30.45 °Brix), acidity (0.24-0.55%), pulp aroma (mild to strong), eating quality (good and very good), shelf life

(3-6 days) and yield (6.27-22.58 kg/tree). Among the evaluation of existing germplasm, CHESCA-4, CHESCA-13, CHESCA-23 and CHESCA-27 was found superior in terms of fruit quality and yield under field condition (Fig. 6).

The newly selected genotypes were planted in field during 2017. The plant root stock and scion diameter varied from 19.30 to 36.50 mm and 16.50 to 34.80 mm, respectively. The maximum plant stock and scion diameter were recorded in genotype CHESCA-26, 36.53 mm and 34.80 mm, respectively (Table 17). The plant height recorded 92.24-168.24 cm, the maximum plant growth was observed in CHESCA-24 (168.24 cm) and minimum in CHESCA-37 (92.24 cm). The maximum primary branches per plant were also recorded in CHESCA-24 (9.14). The secondary branches per plant were found highest in CHESCA-10 followed by CHESCA-32 and CHESCA-24 and CHESCA-2. The fruit weight ranged from 138.23-290.00 g while fruit pulp was observed 32.30-121.23 g. The pulp percentage was recorded maximum in CHESCA-21 (49.52%) and it varied from 36.74-49.52. The highest seed number (76.23) was observed in CHESCA-32 (Table 18).

Table 17. Plant growth and fruits attributes of custard apple genotypes

Genotypes	Root stock dia. (mm)	Scion stock dia. (mm)	Plant height (cm)	Primary branches	Secondary branches
CHESCA-1	18.33	15.36	099.00	4.00	4.62
CHESCA-2	27.33	22.36	140.67	5.67	7.36
CHESCA-3	31.66	26.13	146.00	5.66	2.43
CHESCA-4	32.00	26.35	155.23	7.00	6.85
CHESCA-5	32.33	29.12	158.33	6.60	2.69
CHESCA-6	27.22	26.30	130.00	5.01	3.46
CHESCA-7	32.66	27.36	145.34	5.33	3.25
CHESCA-8	30.33	25.63	132.00	6.35	1.63
CHESCA-9	32.02	24.69	148.33	9.44	2.16
CHESCA-10	34.35	29.86	165.33	5.66	7.56
CHESCA-11	32.67	28.36	152.00	6.67	3.20
CHESCA-12	33.68	29.36	143.67	7.10	4.20
CHESCA-13	30.00	27.36	125.33	6.00	1.60
CHESCA-14	26.34	21.18	123.00	5.76	2.30
CHESCA-15	32.08	26.34	142.00	6.10	3.10
CHESCA-16	30.33	27.38	136.67	6.34	2.56
CHESCA-17	28.67	23.45	115.00	6.20	4.23
CHESCA-18	31.67	26.34	135.00	6.10	2.30
CHESCA-19	27.00	26.86	133.34	6.40	4.12
CHESCA-20	23.54	19.30	120.12	6.12	4.23
CHESCA-21	20.72	19.50	98.12	3.45	2.30
CHESCA-22	25.55	23.70	105.12	7.51	3.26
CHESCA-23	30.51	25.40	136.36	6.36	4.36
CHESCA-24	35.58	25.50	168.24	9.41	7.36

Genotypes	Root stock dia. (mm)	Scion stock dia. (mm)	Plant height (cm)	Primary branches	Secondary branches
CHESCA-25	31.60	27.30	117.21	4.52	2.10
CHESCA-26	36.53	34.80	152.27	5.43	6.45
CHESCA-27	34.45	31.30	135.64	6.28	2.36
CHESCA-28	34.50	27.50	147.86	8.23	3.15
CHESCA-29	26.54	24.70	137.45	6.28	3.45
CHESCA-30	25.30	21.30	157.23	6.43	1.36
CHESCA-31	27.44	23.70	134.27	5.46	2.86
CHESCA-32	34.50	29.30	155.29	6.49	7.45
CHESCA-33	30.70	29.70	131.43	7.24	3.69
CHESCA-34	28.60	24.50	150.43	3.49	6.42
CHESCA-35	20.30	18.70	143.29	5.69	5.02
CHESCA-36	31.60	28.30	160.48	4.63	4.26
CHESCA-37	19.30	16.50	92.24	5.63	4.75
C.D. (5%)	02.72	01.81	011.42	0.27	0.31

Table 18. Fruits attributes of custard apple genotypes

Genotypes	Fruits/ plant	Fruit weight (g)	Pulp weight (g)	Shell weight (g)	Seed no./ fruit	Total soluble solids (°Brix)	Fruit pulp (%)
CHESCA-1	5.62	212.23	78.17	80.25	65.00	30.12	39.15
CHESCA-2	6.35	215.23	81.13	83.45	52.23	27.36	39.04
CHESCA-3	6.25	197.23	73.26	75.43	45.26	24.13	39.13
CHESCA-4	7.60	214.00	32.30	81.00	56.00	30.00	43.13
CHESCA-5	6.23	138.23	52.31	65.12	25.12	28.00	38.68
CHESCA-6	6.35	155.43	62.23	70.12	34.23	24.00	40.68
CHESCA-8	5.16	153.15	62.31	68.23	43.13	27.16	40.69
CHESCA-9	6.23	162.48	58.42	59.23	38.12	27.12	38.31
CHESCA-10	8.35	290.00	121.23	110.21	58.00	29.00	43.30
CHESCA-11	6.53	257.23	112.23	82.23	52.31	31.12	43.63
CHESCA-12	9.24	198.23	60.12	95.45	34.12	26.12	36.74
CHESCA-13	5.24	140.23	65.12	57.00	44.00	27.13	46.44
CHESCA-14	5.31	211.25	85.23	87.36	52.13	26.31	42.35
CHESCA-15	5.87	288.23	105.23	120.23	63.25	30.10	37.82
CHESCA-17	4.58	240.23	92.36	100.12	57.23	26.12	38.45
CHESCA-21	10.25	197.23	97.56	85.63	36.46	28.74	49.52
CHESCA-26	9.24	185.65	89.23	73.26	44.12	28.69	48.07
CHESCA-32	7.26	276.36	120.36	125.26	76.23	30.13	44.35
CHESCA-35	6.53	249.29	109.42	110.54	68.12	29.16	43.89
CHESCA-37	4.53	215.36	86.42	96.58	56.27	29.56	40.13
C.D. (5%)	0.38	17.320	09.45	08.42	06.25	01.51	03.75

CHESCA-4 CHESCA-27 CHESCA-10 CHESCA-15

Fig. 6. Custard apple genotypes

Survey, collection, conservation and evaluation of guava (*Psidium guajava*) under semi-arid condition

Diversity rich areas of Satna and Rewa in Madhya Pradesh were surveyed. During the visit of different locations, two elite germplasm of white fleshed guava were collected from Rewa. Two white fleshed genotypes of guava were also collected from AAU, Anand. All the collected guava germplasm were successfully established in the field gene repository and they are surviving well.

The maximum number of fruits/tree was observed in CHESG-15 (161) followed by MPUAT-1 (115) and CHESG-21 (110) and it were found minimum in Dhawal (25.16). Whereas the maximum fruit yield/tree was recorded in CHESG-15 (25.55 kg) followed by CHESG-21 (19.30 kg) and L-49 (14.50 kg) while the minimum fruit yield (2.52 kg) was found in Dhawal (Fig. 7).

The maximum fruit weight was observed in MPUAT-2 (287.35 g) followed by CHESG-28 (275.65 g). However, the minimum fruit weight was recorded in Dhawal (98.85 g) followed by MPUAT-1 (118.37 g). The maximum fruit length was recorded in CHESG-21 (7.85 cm) followed by Thai guava (7.12 cm) while the maximum fruit width was found in MPUAT-2 (8.55 cm). However, the minimum fruit length and width were observed in MPUAT-1 (5.28 cm) and Dhawal (5.46 cm), respectively. MPUAT-2 recorded the maximum seed core diameter (5.60 cm) and pulp thickness (1.60 cm). The highest 100 seed weight was noted in Thai guava (1.87 g) followed by CHESG-2 (1.58 g) while it was found minimum in CHESG-15 (0.95 g).

The highest TSS was recorded in MPUAT-1 (15.60 °Brix) followed by CHESG-15 (14.50 °Brix) while the minimum TSS was observed in MPUAT-1 (12.85 °Brix) followed by CHESG-1 (13.30 ^{0}Brix). The maximum acidity (1.20%) was recorded in CHESG-21 while the minimum acidity (0.29%) was observed in MPUAT-2. The maximum ascorbic acid (267.98 mg/100 g) was found in CHESG-15 while it was recorded minimum in CHESG-28 (88.85 mg/100 g).

CHESG-15: Trees are moderately tall with good spreading loose canopy. It bears heavy in bunches, round shaped fruits, medium in size weighing around 150-230 g. Fruit peel colour is yellow with slight pink blush at base with deep red pulp colour at ripening. Keeping quality of fruits is good. At ripened mature stage fruit pulp was firm with less number of seeds of small size, having pleasant aroma and have good taste with TSS:acidity ratio of around 30. It is soft seeded with 100 seed weight of 0.95 g. Fruit pulp is rich in lycopene (0.43 mg/100g), total antioxidants (534.56 mg AAE/100g) and ascorbic acid (267.98 mg/100g). It ripens early in the season *i.e.* in second week of November with extended harvesting period till the last of December. Yield potential is high (25-30 kg/tree in 3rd year). Rainy season fruits are sweet in taste with good keeping quality.

Fig. 7. Fruit bearing tree, harvested fruits and deep red pulp colour of CHESG-15

Survey, collection, conservation and evaluation of acid lime under semi-arid condition

Various acid lime growing areas of Panchmahals, Gujarat and Rewa in Madhya Pradesh were explored for collection of elite germplasm. During reporting period, two acid lime genotypes were collected from Rewa while scion shoot of NRCC-7, NRCC-8 and Balaji were also collected for *in-situ* budding on Rangpur lime rootstock in the month of August. Initially, all the grafts shown good sprouting but later on died except NRCC-7. In field gene bank of citrus, 37 genotypes of acid lime, 6 genotypes of lemon and one genotype each of white and purple flowering type *Citrus medica* are conserved.

The maximum plant height was recorded in Pramalini (3.60 m) followed by Sai Sarbati (3.50 m) and CHESL-30 (3.35 m) while Ganganagar-1 was found most dwarfing (1.65 m) followed by CHESL-16 (2.33 m). Canopy spread in both the direction was found maximum in CHESL-12 (3.48 & 3.40 m) followed by Pramalini (3.42 & 3.39 m) while the minimum canopy spread was observed in Ganganagar-1 (1.88 & 1.93 m). The maximum stem girth was recorded in Pramalini (7.72 cm) followed by CHESL-10 (6.90 cm) and Sai Sarbati (6.85 cm).

During reporting period, fruiting was observed in 20 genotypes. Acid lime accession CHESL-12 recorded the highest average fruit weight (38.29 g), peel thickness (1.78 mm), acidity (8.71%) and ascorbic acid (50.15) with 47.34% juice. However, ≥ 33 g fruit weight, length and width ≥ 35 mm were noted in CHESL-3, CHESL-6, CHESL-10, CHESL-13, CHESL-15, CHESL-31, Vikram and Sai Sarbati. A minimum peel thickness of 0.95 mm was observed in CHESL-13 which was followed by 1.08 mm in Ganganagar-1. In most of the genotypes, number of seeds was found to be 10 or lesser than that except Ganganagar-1 (13.88) and CHESL-17 (14.35). However, the highest juice percentage was recorded in CHESL-3 (56.72 %) followed by CHESL-13 (56.43%), CHESL-10 (50.33%) and CHESL-9 (48.81%). Fruit juice TSS was recorded maximum in Pramalini (10.10 °Brix) followed by CHESL-12 (9.53 °Brix) while CHESL-3 recorded the minimum TSS (6.75 °Brix). Ganganagar-1 recorded the minimum acidity (5.17%). The highest number of fruits/tree was recorded with CHESL-10 (442.66) followed by Sai Sarbati (422.33) and CHESL-12 (421.66). However, the highest average yield/tree was observed in CHESL-32 (15.22 kg) followed by CHESL-10 (14.68 kg) and CHESL-12 (13.85 kg).

Survey, collection, conservation and evaluation of underutilized fruit crops under hot arid and semi-arid condition

Evaluation of jamun (*Syzigium cuminii*) germplasm under semi-arid condition

Twenty six promising genotypes of jamun were evaluated for growth, fruiting and fruit quality attributes under rainfed conditions of semi-arid ecosystem. Peak period of panicle emergence was recorded in the month of February. Peak period of flowering and fruit set was recorded in the month of March in all genotypes. Peak period of ripening was recorded in the month of May-June in all the genotypes. Goma Priyanka ripened in the first week of June and recorded 54.00 kg fruit yield, 19.90 g fruit weight, 86.00% pulp and 16.50 °Brix TSS, 0.39% titratable acidity, 11.30% total sugar, and 48.00 mg/100 g vitamin C. Thar Kranti variety ripened in the last week of May and recorded 52.00 kg fruit yield per plant, 20.60 g fruit weight, 84.00 % pulp and 17.30 °Brix TSS. 0.43% titratable acidity, 12.60% total sugar and 49.00 mg/100 g vitamin C. 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. CHESJ-30 was found promising with 85.20% pulp, 17.40 °Brix TSS, it matures after Goma Priyanka and Thar Kranti.

Jamun CHESJ-30: It was collected from Ode, district Anand. It ripens during third week of June. It recorded 20.60 g fruit weight, 85.0 per cent pulp, 17.40 °Brix TSS, 0.40% titratable acidity, 12.60% total sugar and 52.00 mg/100 g vitamin C under rainfed conditions of semi-arid ecosystem.

Varietal trial on jamun

Four varieties of jamun were evaluated and maximum plant height was recorded in CISHJ-37 (5.10 m) followed by Goma Priyanka and CISHJ-42 (Table 19). Stock and scion girth was found to be maximum in CISHJ-37 closely followed by CISHJ-42. Maximum fruit weight and pulp content was recorded in Goma Priyanka closely followed by CISHJ-37 (Table 20).

Tamarind (*Tamarindus indica*)

Twenty four promising genotypes of tamarind were evaluated for growth, flowering, fruiting and fruit quality attributes. On the basis of fruit yield and quality attributes, CHEST-10 was found promising.

Tamarind CHEST-10: It has upright growth habit, thick trunk and drooping branches. It recorded 72.20 kg fruit per plant. Peak period of ripening time was last week of March. It recorded 52.00 per cent pulp and 70.00 °Brix TSS during ripening.

Varietal trial on tamarind

Ten tamarind varieties namely Pratisthan, T-263, PKM-1, Ajanta, DTS-1, Red Type, Sweet Type, Bantoor, Urigum and Goma Prateek were evaluated and observations on growth pattern and fruit quality attributes were recorded. Plant height of Ajanta was observed maximum i.e. 5.73 m while least plant height was recorded in Sweet Type (3.40 m). The stock girth was found to be least (50.10 cm) in Bantoor. Plant spread (E-W and N-S) was also found maximum in Ajanta. Maximum fruit yield was noted in Goma Prateek (32.10 kg/plant). Maximum pod length (14.59 cm) and pulp content (51.82 %) was recorded in Goma Prateek, while maximum TSS and total sugar was recorded in Urigum (Table 21 to 23). Plants are performing well under semi-arid condition of western India.

Table 19. Growth pattern of jamun varieties under semi-arid condition

Varieties	Stock girth (cm)	Scion girth (cm)	Plant height (m)	Plant spread (E-W)	Plant spread (N-S)
Goma Priyanka	40.10	37.10	4.10	3.90	3.70
CISHJ-37	46.10	42.00	5.10	4.90	3.80
CISHJ-42	45.14	40.10	4.00	3.70	3.60
Konkan Bardoli	38.20	31.00	3.90	3.80	3.70
CD (5%)	0.38	0.22	0.30	0.11	0.11

Table 20. Fruit quality attributes of jamun varieties under semi-arid condition

Varieties	Fruit weight (g)	Pulp weight (g)	Pulp (%)	TSS (°Brix)	Acidity (%)	Total sugar (%)	Vitamin C (mg/100g)
Goma Priyanka	19.60	16.70	87.43	16.50	0.40	10.50	45.60
CISHJ-37	19.10	16.40	85.86	16.50	0.38	10.40	44.32
CISHJ-42	10.60	9.10	85.84	16.24	0.36	10.20	42.50
Konkan Bardoli	15.60	12.20	78.20	15.60	0.34	9.60	43.20
CD (5%)	1.20	1.10	1.30	0.13	0.01	0.30	1.11

Table 21. Growth pattern of tamarind varieties under semi-arid condition

Varieties	Stock girth (cm)	Scion girth (cm)	Plant height (m)	Plant spread (E-W)	Plant spread (N-S)	Fruit yield (kg/plant)
Pratisthan	52.10	46.10	3.50	3.70	3.73	20/00
T-263	54.20	53.10	3.62	3.40	3.45	8.00

Varieties	Stock girth (cm)	Scion girth (cm)	Plant height (m)	Plant spread (E-W)	Plant spread (N-S)	Fruit yield (kg/plant)
PKM-1	68.10	66.00	3.73	3.20	3.40	10.00
Ajanta	82.10	70.00	5.73	5.10	5.50	18.40
DTS-1	71.20	64.00	4.93	5.00	5.30	14.10
Red Type	68.00	63.34	5.70	4.67	4.80	10.12
Sweet Type	60.10	57.10	3.40	3.30	5.40	08.00
Bantoor	50.10	47.23	3.83	3.20	3.30	09.00
Urigum	59.00	57.12	4.20	4.50	3.60	9.50
Goma Prateek	67.10	63.12	4.50	3.70	3.80	32.12
CD (5%)	0.19	0.22	0.21	1.12	1.21	1.32

Table 22. Fruit quality attributes of tamarind varieties under semi-arid condition

Varieties	Pod length (cm)	Pod breadth (cm)	Pod weight (g)	Seed weight (g)	Shell weight (g)	Pulp weight (g)	Pulp (%)
Pratisthan	11.78	2.30	16.79	4.90	5.24	6.70	39.90
T-263	11.69	2.26	15.69	4.32	4.40	6.96	44.36
PKM-1	10.98	2.70	18.63	6.40	5.69	6.54	35.10
Ajanta	12.67	2.25	17.89	6.48	5.24	6.20	34.65
DTS-1	12.13	1.90	11.58	3.79	3.30	4.56	39.38
Red Type	11.59	2.35	14.79	4.56	4.45	5.89	39.82
Sweet Type	10.49	2.49	16.46	5.48	5.34	5.75	34.93
Bantoor	10.56	2.57	19.48	4.45	5.40	9.69	49.74
Urigum	12.00	2.70	19.00	5.69	5.46	8.20	43.16
Goma Prateek	14.59	2.49	20.80	4.87	5.23	10.78	51.82
CD (5%)	0.40	0.43	1.30	0.63	0.41	0.51	0.61

Table 23. Fruit quality attributes of tamarind varieties under semi-arid condition

Varieties	T.S.S. (°Brix)	Acidity (%)	Total sugar (%)	Vitamin C (mg/100g)
Pratisthan	64.55	12.43	49.00	12.70
T-263	53.20	13.32	43.92	13.40
PKM-1	64.70	13.42	50.10	15.10
Ajanta	61.50	12.50	47.54	15.90
DTS-1	61.65	12.40	45.80	20.70
Red Type	60.85	10.25	44.80	22.90
Sweet Type	59.10	8.42	43.70	21.20
Bantoor	60.95	10.74	44.60	20.60
Urigum	65.40	11.95	49.90	21.10
Goma Prateek	65.10	12.79	47.80	25.00
CD (5%)	1.11	1.10	0.70	1.12

Manila Tamarind (*Pithecellobium dulce*)

Twenth eight germplasm evaluated and peak period of flowering was noted in January-February in all genotypes. Earliest flowering took place in CHESM-4, while it was noted at the last in CHESM-12. Maximum panicle length, fruit weight (30.70 g) with 74.10 per cent pulp was recorded in CHESM-4, while, highest TSS was recorded in CHESM-12 (25.60 °Brix). During the year 2019, one genotype (CHESM-29) from Dakore, Gujarat was collected.

Evaluation of mulberry (*Morus alba*) germplasm under hot arid condition

Fruit characteristics of mulberry

Mulberry cvs. Thar Harit and Thar Lohit significantly varied with different fruiting parameters *i.e.* fruit weight, size (length & width), TSS and acidity. Variety Thar Lohit showed early withdrawal of harvesting compared to Thar Harit and this variety has higher mean fruit weight, length, thickness and acidity content, but low in TSS content (Table 24). Among successive harvesting period desirable attributes were recorded in second and third pickings only.

Phenological growth study in mulberry

Mulberry is winter deciduous plant and new flushes started in February with flowering from 24 days (catkins emerge to sessile flower took 24 days) and initiated harvesting on 1st April with peak period during 2nd to 3rd week of April. Further, heat unit in degree days hours from flowering to fruiting was calculated over base temperature (10 °C) was 565.7 °C, heliothermal unit was 5123.7, photothermal temperature was 1030° and nycto-temperature was 730.43 °C recorded during the year 2019 (Table 25). However, mulberry var. Thar Lohit was shown early withdrawal of harvesting over Thar Harit (Fig. 8).

Table 24. Periodical fruit characteristics of mulberry varieties at different harvest

Fruit parameters	Thar Harit					Thar Lohit				CD 5% (A x B)
	I (April-1st Week)	II (April-2nd Week)	III (April-3rd Week)	IV (April-4th Week)	Mean value	I (April-1st Week)	II (April-2nd Week)	III (April-3rd Week)	Mean value	
Fruit weight (g)	3.67	5.00	4.56	3.34	4.14	5.30	6.80	6.50	6.20	0.27
Fruit length (cm)	5.90	5.80	5.70	5.00	5.60	6.00	5.90	8.85	6.92	0.62
Fruit thickness (cm)	0.93	0.75	0.81	0.75	0.81	0.82	0.81	0.78	0.80	0.05
Fruit TSS (°Brix)	20.8	23.30	27.20	22.40	23.43	21.60	24.65	21.08	22.44	0.73
Acidity (%)	0.29	0.27	0.27	0.22	0.26	0.74	0.92	1.05	0.90	0.05

Table 25. Weather parameters during flowering and fruiting phenophases of mulberry

S. No.	Phenophases	Date/period	Temperature (°C) (Max./Min.)	RH (%) (Max./Min.)	Evap. (mm)
1	Plant in dormancy	January	25.4/5.3	78.6/29.5	2.5
2	Date of initiation of catkin	1 Feb.	29.8/12	48/28	3.0
3	Bloom period	25 Feb.	29/12.5	92/43	5.0
4	Flowering span	24 days	28.68/9.79	68.79/27.08	4
5	Date of first harvest	1 April	41/22	39/16	10

S. No.	Phenophases	Date/period	Temperature (°C) (Max./Min.)	RH (%) (Max./Min.)	Evap. (mm)
6	Date of peak harvest	8 April	41.5/22.5	40/17	8
7	Date of last harvest	29 April	45.6/24.5	29/14	16
8	Last residual harvesting (Harit)	6 May	41.6/25.4	34/21	10
9	Harvesting period	28 days	39.85/21.59	41.96/18.68	9.64
10	Heat unit	313.7^0 days (17 ^{0}C base temp)		565.7 ^{0}days (10 ^{0}C base temp)	
11	HTU	5123.67 (Mean 142.32)			
12	Photothermal temperature (PHT)	1030.98 (Mean 28.64)			
13	Nycto-temperature (NCT)	730.43 (Mean 20.29)			

Fig. 8. Fruiting branches of mulberry cv. Thar Harit

Survey and collection of elite germplasm of *ker and lasoda*

A survey was conducted at Bikaner, Churu, Sikar and Nagaur districts of Rajasthan and collected fruit samples and cuttings of 12 elite type genotypes of *Ker*. A germplasm has typical violet coloured fruit was collected from Laxmangarh area, district Sikar and a rare germplasm with late blooming was collected from 'Kaladi' village of Nagaur district (Fig. 9). Cuttings of all 12 germplasm were planted in vermiculite based rooting media and placed under green house for multiplication of germplasm for further utilization. During survey also found one elite type lasoda germplasm (extra large fruit size) from Katrathal, Sikar. Scion bud wood from this lasoda plant was collected and budded on seedling rootstocks is nursery (Fig. 10). Bud sprout obtained in 10 rootstocks which are growing well under nursery condition.

Fig. 9. Voilet colour and late blooming *ker* germplasm

Fig. 10. Elite lasoda germlasm collected during survey

Identification of rare occurring orange and yellow flower coloured *ker* germplasm

Two rare occurring *ker* germplasm were identified (Table 26) from a locality called Lunol (orange flowered), district Sirohi and Lalavas (yellow flowered), district Nagaur, Rajasthan. In orange flowered germplasm, thorn were observed long and more while very small and less thorn in yellow flowered germplasm (Fig. 11). Wood sticks in the form of cuttings from both the germplasm were collected and planted in pots containing vermiculite based rooting media for multiplication of germplasm under green house condition.

Fig. 11. Orange (left) and yellow (right) flower coloured ker germplasm

Table 26. Characteristic features of surveyed elite germplasm of *ker*

S. N.	Character	Orange flowered *ker*	Yellow flowered *ker*
1.	Locality	Lunol, Sirohi, Rajasthan	Lalavas, Nagaur, Rajasthan
2.	Foliage colour	Green	Light green
3.	Thorn	More, long	Less, minute near to thornless
4.	Thorn length	5-9 mm	1-2 mm
5.	Flower colour	Orange	Yellow
6.	Flowers per node	3 to 6	4 to 14
7.	No. of stamens/ flower	12	16 to 18
8.	Flowering	Sparse	Profuse
9.	Length of flower stalk	8-12 mm	14-19 mm

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

Monitoring of arid vegetable germplasm/ lines (500) was done for their safe conservation in gene-bank (–20 ^{0}C deep freeze) facilities at ICAR-CIAH, Bikaner. In addition, germplasm of *khejri*, *kumat*, *sehjan*, *guarpatha*, curry-leaf (meetha-neem), ivy gourd, spine gourd and other perennial vegetables were maintained in field repository. As per maintenance work-plan, cowpea was taken during 2019 and sufficient quantity seed of line AHCP-3-1 was produced. Likewise, seed enhancement of *khejri* - Thar Shobha and Selection–2 was done, seeds were deposited to ICAR-NBPGR and IC number 632064 and 632065 were obtained, respectively. Similarly, seed enhancement of sponge gourd- Thar Tapish, brinjal - Thar Rachit, palak - Thar Hariparna, Indian bean - Thar Kartiki & Thar Maghi and *sehjan* - AHMO–1–4s was done to fulfill national indents.

Germplasm evaluation and maintenance in vegetable cowpea under hot arid region

In traditional mixed cropping of arid region, cowpea (*Vigna unguiculata*) was grown for grain production but its pre-mature pod and seed is also used in vegetable culinary. The indigenous germplasm of vegetable and multi-purpose pod types was initially collected from arid, semi-arid and tribal areas of Rajasthan and Gujarat during 2001 and 2002 as regional diversity. Potential germplasm were used in breeding for purification over the years and 10 genotypes were maintained at Bikaner. During rainy season of 2019, 28 diverse cowpea germplasm from wide geographical areas covering state of Rajasthan, Gujarat, Karnataka, Kerala and Uttar Pradesh were studied with two production situations (rainfed and irrigated) for quantifying component of genetic variability and performance under hot arid environment at ICAR-CIAH, Bikaner.

The germplasm was characterized for growth, maturity, quality and yield component and good amount of variations were recorded

Fig. 12. Pod bearing pattern and marketable stage pod in cowpea selection AHCP-1-4-1 and AHCP-2.

for plant height (47.8-210.6 cm), days to first harvest of tender pods (37-69 DAS), pod length (11.2-31.1 cm) and weight (2.4-7.7 g) at vegetable use stages. The line AHCP-1-4-1 and AHCP-2-3 were studied (Fig. 12) for their performance in comparison to popular varieties (RCV-7, Arka Garima, Kashi Nidhi and Kashi Kanchan) both under rainfed and irrigated situations. AHCP-1-4-1 is purified line producing vegetable type pod and is selected from germplasm collected from local market (*Haatt*) of village Limkheda and Jhalod of district Daahod (Gujarat). The purified line AHCP–2–3 is multi-purpose type, locally known as *bindodi-chawala* and is trait specific for rainfed cultivation. It is very early in tender pods harvesting (47 DAS), high yielding and drought tolerant.

Evaluation of brinjal germplasm

During the summer season of 2019, seven progenies of selected brinjal genotypes were evaluated at ICAR-CIAH, Bikaner for growth, fruit yield and quality. These lines were also screened to find out genotype giving superior performance over the season and years under high temperature condition. The seed content in the fruits was higher in the month of June as compared to the fruit set in the month of March-April. In the growth parameter, the highest plant height was found in (L_6) and minimum plant height was observed in (L_5). In the case of primary branches, the highest number of primary branches was observed in (L_5) followed by (L_6) and lowest in (L_1). The fruit length was observed maximum in L_7 closely followed by (L_5) and the lowest in (L_1). The fruit width was observed maximum in L_7 and the lowest was observed in L_6 (1.61 cm). The fruit yield per plant was observed highest in L_3 (2.37 kg) followed by L_2 (1.80 kg). The maximum yield per hectare was found in L_3 (519.20 q/ha), whereas minimum yield was found in L_6 (354.20 q/ha). All the lines were shown homogeneous and did not show any segregation for morphological traits. Selection and selfing on individual plant was done from lines showing marketable quality fruits and stable performance over the season.

Evaluation of spine gourd under semi-arid condition of Gujarat

A total of 24 germplasm of spine gourd were collected from different parts of the country on the basis of their morphological characters from diversity rich areas. The evaluation of twenty four lines of spine gourd for various horticultural traits at ICAR-CHES (CIAH), Vejalpur, Gujarat exhibited wide range of variability with respect to growth, yield and quality attributes under field condition of dryland semi-arid region. Based on various desired horticultural traits, IC-632328 was found superior with attractive dark green colour, medium round shape fruit having very small and soft spines. The maximum fruit yield (2.81 kg per plant) was observed among all the genotypes with average fruit weight (23.8 g), and recorded 122 fruits per vine under the semi-arid conditions.

Evaluation of ivy gourd under semi-arid condition of Gujarat

Twenty eight germplasm of ivg gourd were evaluated and data were recorded for vine length, fruit length, days to male flower emergence, days to female flower anthesis, days to fruit set to edible maturity, fruit diameter, fruit length, number of fruits/plant, yield/plant, TSS, vitamin C and acidity. The various parameters of superior genotypes are as below:

IC-632331: This accession was identified as a promising line having high yield potential with the maximum fruit weight (29.4 g) and

yield (38.96 kg/plant/year) as compared to other genotypes with identical appearance in form of attractive dark green shining colour with discontinuous stripes, round oblong fruit shape without neck under the dryland semi-arid conditions (Fig. 13).

IC-632334: Idenified a unique ivy gourd genotype having attractive shining dark green stripeless fruit appearance, trilobe leaf shape, small-medium size and pointed styler end character. The total number of fruits per vine was 1489. The average fruit weight and length of fruit was recorded 14.2 g and 4.7 cm, respectively, with total yield of 21.1 kg per plant. This genotype was found tolerant to both powdery mildew and fruit fly under field conditions (Fig. 13).

Fig. 13. Extra large fruits with discontinuous strips (IC-632331) and stripeless soft texture fruits (IC- 632334) of ivy gourd

Germplasm evaluation of bottle gourd

Seven promising lines including VRBG-88, Baina and derivatives of LS-4xLS3-2, LS-20-1xLS14-1, LS-28xLS-20-2, LS3xLS-2 and LS42xLS32-2 along with checks (Thar Samridhi, Pusa Naveen and Arka Bahar) were tested and evaluated on the basis of horticultural traits under replicated trial at CHES (ICAR-CIAH), Vejalpur. In LS-4xLS3-2, the number of fruit 17.6 and yield (13.2 kg per plant) was recorded with 750 g average fruit weight having round shape (Fig. 14).

Fig. 14. Tender fruit of derivative LS-4xLS3-2 of bottle gourd

Evaluation of drumstick germplasm

A total of 45 genotypes of drumstick were assessed for their horticultural traits. The evaluation of five genotypes of drumstick exhibited wide range of variability with respect to growth, yield and qualitative parameters. A medium dwarf drought tolerant genotype (CHESD-40) with 2.74 m plant height, 248 pods, average fruit weight 218 g, fruit length of 38-42 cm at tender stage (45-48 cm at mature edible stage), 8-10 seed per pod and TSS 8.9 °Brix was identified as promising lines during the evaluation under rainfed semi-arid conditions. The fruit length was recorded 38-42 cm at tender stage with vitamin C 258.9 mg/100 g, acidity 0.017% and TSS 9.5 °Brix. The colour of the pods at tender stage remains light purple and change to green colour at mature edible stage.

Introduction, collection, characterization, conservation and evaluation of dolichos bean, cluster bean and cowpea under rainfed semi-arid condition

Dolichos bean/ Indian bean

The experiment was carried out to assess the variability in 60 genotypes of pole type Indian bean (*Lablab purpureus* var. *typicus*). The 60 genotypes were grown in a RCBD with three replications at Central Horticultural Experimental Station (ICAR-CIAH) Vejalpur, Gujarat. The crop was raised in three replications at 2.5 m x 2.5 m spacing between rows and plants, respectively. The data were recorded for plant height, number of branches, days to 50% flowering, No. of pods/plant, pod weight, pod length, pod girth and pod yield/plant. The variable quantitative parameters of superior genotypes are as given below (Fig. 15).

CHESIB-50: The pods were very attractive green with length of 17.6 cm and an average pod girth of 5.2 cm with pod weight of 15.2 g. The fresh green pods were harvested at 98 to 105 days after sowing. The total number of pods per plant was 420-430 with an average yield of 4.1 kg/plant of fresh green pods.

CHESIB-07: The pods were very attractive dark pink in colour. The pods are medium having an average pod length of 10.6 cm and an average pod girth of 4.6 cm with pod weight of 07.0 g. The fresh green pods harvest was started at 110 to 115 days after sowing. The total number of pods per plant was 460- 470 with an average yield of 4.0 kg/plant of fresh pink pods.

CHESIB-31: The pods are attractive light greenish white in colour. The pods are long having an average pod length of 15.0 cm and an average pod girth of 4.2 cm with pod weight of 8.8 g. The fresh pods were harvested at 115 to 120 days after sowing. The total number of pods per plant was 425 with an average yield of 3.2 kg/plant of fresh pods.

CHESIB-01: The pods were broad long having an average pod length of 13.5 cm and an average pod girth of 5.5 cm with pod weight of 10.0 g. The fresh green pods were harvested at 90 to 95 days after sowing. The total number of pods per plant was 356-380 with an average yield of 3.0 kg/plant of fresh green pods.

CHESIB-10: The creamy white pods were broad, having an average pod length of 16.00 cm and an average pod girth of 6.2 cm with pod weight of 11.5 g. The fresh pods were harvested at 115 to 120 days after sowing. The total numbers of pods per plant were 320 with an average yield of 2.7 to 3.0 kg/plant of fresh pods.

Vegetable Cowpea/ Yard long bean

The experiment was carried out to assess the variability in 60 genotypes were grown in a RCBD with three replications at Central Horticultural Experimental Station (ICAR-CIAH) Vejalpur, Godhra, Gujarat. The data were recorded for plant height, number of branches, days to 50% flowering, number of pods/plant, pod weight, pod length, pod girth and pod yield/plant. Among them, the genotypes (pole types) like CHESVC-01, CHESVC-10, CHESVC-15, CHESVC-22 and CHESVC-45 and bush types *viz*., CHESVC-33 and CHESVC-20 were found superior with respect to fresh number pods and pod yield. The quantitative parameters of superior genotypes are as follows (Fig. 16).

Fig. 15. Germplasm evaluation of Indian bean

Fig. 16. Germplasm evaluation of cowpea

CHESVC-01: The parrot green pods were long having an average pod length of 66 cm and an average pod girth of 3.4 cm with pod weight of 45.2 g. The fresh tender green pods were harvested at 55-60 days after sowing. The total number of pods per plant varied 60-70 pods/plant with an average yield of 1.8 to 2 kg/ plant of fresh green pods.

CHESVC-10: The light green pods were long having an average pod length of 56 cm and an average pod girth of 3.2 cm with an average pod weight of 27.0 g. The fresh tender green pods were harvested at 64-65 days after sowing. The total number of pods per plant varied 50-55 with an average yield of 1.2 to 1.3 kg/ plant of fresh green pods.

CHESVC-15: The red coloured pods having an average 48-50 cm of pod length with 2.2 cm of pod girth as well as 14.8 g of pod weight. This genotype produced 45 to 50 individual red pods/plant with an average yield of 600-700 g of fresh red pods.

CHESVC-22: The red coloured pods were long having an average pod length of 36.8 cm and pod girth of 2.6 cm with pod weight of 13.2 g. The fresh tender red pods were harvested at 64-65 days after sowing. The total number of pods per plant was varied 55-60 with an average yield of 0.7 to 0.75 kg/plant of fresh red pods.

CHESVC-45: The pods were attractive red in colour and cluster bearing genotype with four pods/cluster. The pods were medium long having an average pod length of 31.0 cm and an average pod girth of 2.5 cm with pod weight of 9.2 g. The fresh tender pods were harvested at 60-62 days after sowing. The total number of pods per plant varied from 120-150 with an average yield of 1.1 to 1.5 kg/plant of fresh red pods was harvested.

CHESVC-33: This genotype is photo-insensitive with attractive green colour pods, having an average pod length of 26.50 cm and an average pod girth of 2.5 cm with pod weight of 9.65 g and days taken for first flowering is 42-45 days. The total number of pods per plant varies 140-150 with an average yield of 1.4 kg/ plant of fresh pods. This genotype is photo insensitive.

CHESVC-20: This genotype is also photo-insensitive with pale green colour pods, having an average pod length of 17.50 cm and an average pod girth of 2.3 cm with pod weight of 5.8 g and days taken for first flowering is 43-45 days. The total number of pods per plant varies 120-130 with an average yield of 14 kg/plant of fresh pods.

Cluster bean

The experiment was carried out to assess the variability in 60 genotypes of clusterbean which were grown in a RCBD with three replications at Central Horticultural Experimental Station (ICAR-CIAH), Vejalpur, Gujarat. The data were recorded for plant height, number of branches, days to 50% flowering, no. of pods/plant, pod weight, pod length, pod girth and pod yield/plant. Among them, the genotypes like CHESCB-25 and CHESCB-24 are superior with respect to number of fresh pods and pod yield.

CHESCB-25: It is single stem growth behavior with green colour pods, having an average pod length of 11.00 cm and an average pod girth of 2.5 cm with pod weight of 3.93 g. The total number of pods per plant varies 280-320 with an average yield of 1.2 kg/plant of fresh pods.

Fig. 17. Improved cluster bean genotype CHESCB-24

Fig. 18. Evaluation of onion varieties under hot arid condition

CHESCB-24: It is single stem growth behavior with green colour pods, having an average pod length of 11.02 cm and an average pod girth of 2.8 cm with pod weight of 3.12 g. The total number of pods per plant varies 300-320 with an average yield of 1 kg/plant of fresh pods (Fig. 17).

Evaluation of cluster bean varieties under hot arid condition

Twelve varieties of cluster bean were evaluated during *kharif* season of 2019 to identify the most suitable variety under hot arid conditions. The varieties comprised of HG-563, HG-2-20, HG-365 from HAU, Hisar, Thar Bhadavi from ICAR-CIAH, Bikaner, Guar Kranti from RARI, Durgapura, Pusa Navbahar from ICAR-IARI, New Delhi, CO-1 from TNAU, Tamil Nadu and five other local ones. A wide range of diversity was observed for growth, yield and pod characters among different varieties. Plant height at maturity ranged from 52.14-107.68 cm among the varieties. It was found that days to 50% flower and days to first harvest ranged from 37-51 and 54-78 days, respectively. The varieties had significant difference with respect to plant growth, flowering, fruiting and pod quality. Based on overall performance, potential varieties and lines were identified for cultivation under hot arid condition.

Evaluation of onion varieties under hot arid condition

The soil of arid region is sandy in nature which creates scope for cultivation of bulb crops. Different varieties of onion *viz*., Bhima Subhra, Bhima Raj, Bhima Super, Bhima Kiran, Bhima Shakti, Bhima Safed, Bhima Shweta, Bhima Red and Bhima Dark Red were evaluated (Fig. 18) during *rabi* season of 2018-19 under hot arid conditions to identify the suitable variety and develop production technology under hot arid agro-ecosystem. A wide range of diversity was found among varieties with respect to growth and yield contributing traits such as bulb length, diameter and dry weight (Table 27).

Table 27. Performance of onion varieties on bulb parameters

Variety	Bulb length (cm)	Bulb diameter (cm)	Dry bulb weight (g)
Bhima Subhra	3.66	4.86	45.25
Bhima Safed	2.24	3.16	65.12
Bhima Super	4.82	5.94	32.00
Bhima Kiran	6.30	8.10	70.83
Bhima Light Red	5.45	6.84	57.14
Bhima Dark Red	5.82	7.22	55.83
Bhima Raj	5.61	6.80	40.63
Bhima Shakti	6.26	6.90	68.75
Bhima Red	5.72	7.34	59.38
Bhima Shweta	5.70	7.34	35.42

Performance of sweet potato germplasm in arid region of north western Rajasthan

An investigation was carried out at Experimental Farm of ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan) to assess the performance of sweet potato cultivars under hot arid region with cuttings of three sweet potato cultivars *viz*., CO 3-4, Sree Bhadra, sweet potato Gouri, sweet potato ST, sweet potato-1 and Local-1 were planted on the 1st week of July (Fig. 19). In this experiment, 1/3rd of N was applied through neem coated urea

and SSP in side-band along with a uniform dose of 80 kg P_2O_5 through single super phosphate and 100 kg/ha K_2O through muriate of potash during planting time. The dose 1/3rd of N was applied through neem coated urea at 40 days after planting *i.e.* at the time of earthing up and the remaining 1/3rd N at 60 days after planting *i.e.* at the time of bulking stage.

Various growth parameters *viz*., vine length (cm), number of leaves/plant and number of vines/plant for all the varieties grown has been recorded at different days after planting. The highest tuber yield was recorded in CO-3-4 (412 q/ha) followed by Local-1 (325 q/ha) and minimum yield in sweet potato Gouri, sweet potato ST, sweet potato-1 was recorded. These observations suggest that CO-3-4 and Local-1 were high yielder while Sweet potato Gowry, sweet potato ST, sweet potato-1 were low yielder and long roots were observed and looked threads like structure. These cultivars were not suitable under hot arid region. It can be concluded that yield of sweet potato can be improved markedly by exploiting varietal differences in sweet potato. Sweet potato cultivars showed wide variation in yield in western Rajasthan (Table 28 to 30).

Table 28. Growth parameters of sweet potato in non-traditional areas of western Rajasthan

Cultivars	Growth parameters at 35 days		
	No. of branches	No. of leaves/plant	Vine length (cm)
sweet potato-1	3.50	25.30	73.60
sweet potato ST-14	3.80	35.90	90.90
sweet potato CO 3-4	3.80	36.10	88.10
Sweet potato Gouri	3.80	36.10	88.10
Local-1	3.65	30.60	82.25
Mean	3.71	32.80	84.59

Table 29. Growth parameters of sweet potato in non-traditional areas of western Rajasthan

Cultivars	Growth parameters at 50 days			Growth parameters at 100 days		
	Vine length	No. of leaves/ vine	No. of node	Vine length	No. of leaves/ vine	No. of node
Sweet potato-1	62.5	10	3.5	98	18.5	5
Sweet potato ST-14	67.5	14	4.5	90	17.5	3.5
Sweet potato CO 3-4	73.5	15.5	5.5	114.5	22	5
Sweet potato Gouri	76.5	13	6.5	116	18.5	4
Local-1	-	-	-	102	20	5

Table 30. Growth and yield parameters of sweet potato in non-traditional areas of western Rajasthan

Cultivars	No. of tuber/ha				Yield (q/ha)			
	Large	Medium	Small	Total no. of tuber /ha	Large	Medium	Small	Total yield/ha (q/ha)
Sweet potato-1	-	-	-	-	-	--	-	51.45
Sweet potato ST-14	-	-	-	-	-	-	-	26.59
Sweet potato CO 3-4	31950	38700	136800	207450	195	127	91	412
Sweet potato Gouri	-	-	-	-	-	-	-	38
Sree Bhadra	-	-	-	-	-	-	-	-
Local-1	52700	161500	102000	316200	145	141	39	325

Sweet potato CO 3-4 Local-1

Fig. 19. Evaluation of sweet potato germplasm under hot arid region

Performance of greater yam (*Dioscorea alata* L.) in arid region

A field experiment was carried out at the ICAR-CIAH, Bikaner to found out performance of greater yam (Fig. 20) under different conditions i.e. open field, partially shade (grown under aonla plantation 8 x 8 m) and fully shade (under Lasoda plantation). Greater yam setts of 250-300 g size were cut and dipped in solution of Dithane M-45 (0.2%) in order to prevent soil borne fungi. Yam was planted as main crop at a spacing of 90 x 75 cm. The greater yam setts were planted on ridges at a depth of 15 cm. Setts were covered properly with soil and each plot was irrigated immediately after sowing/planting. Vermicompost @ 1.5 t/ha and NPK @ 80:60:80 kg/ ha were applied. Phosphorus was given as basal dose. Nitrogen and potash were applied in four equal doses at one month interval started from 3rd month. Greater yam cultivars differ in their growth and yield potential under three conditions i.e. under aonla plantation (8 x 8 m), fully shade and open field conditions. Various growth parameters *viz.,* main shoots, primary branches, secondary branches and tertiary branches have been recorded at 100 days after planting. All vegetative growth parameters were higher in open field conditions followed by grown under aonla based cropping system and lower growth parameters were recorded under shade conditions (Table 31 to 34).

Table 31. Days to sprouting, sprouting, survival and rate of emergence (%) in greater yam

Greater yam grown in different conditions	Days to sprouting	Sprouting percentage	Survival percentage	Rate of emergence (%)
Between aonla plantation (8x8 m)	21.45	97.65	100	62.45
Grown under fully shade condition	18.14	86.45	100	50.12
Open field condition	23.25	100.00	100	71.78
Mean	20.95	94.70	100	61.45

Table 32. Vegetative attributes of greater yam after 4 months

Greater yam grown in different conditions	Number of leaves per vine	Girth of vines (cm)	Length of vines (cm)	Leaf area (cm^2)
Between aonla plantation (8x8 m)	92.67	3.87	178.12	7284
Grown under fully shade condition	52.97	4.12	106.78	2898
Open field condition	96.12	5.25	189.78	8984
Mean	80.59	4.41	158.23	6388

Table 33. Main shoot and branching attributes of greater yam in western Rajasthan

Greater yam grown in different conditions	Main shoots	Primary branches	Secondary branches	Tertiary branches
Between aonla plantation (8x8 m)	3.80	3.64	3.12	2.41
Grown under fully shade condition	2.48	2.10	1.40	1.10
Open field condition	4.10	4.78	4.30	3.55
Mean	3.46	3.51	2.94	2.35

Table 34. Tuber attributes of greater yam under arid condition

Greater yam grown in different conditions	No. of tuber/ plant	Tuber length (cm)	Tuber diameter (cm)	Weight of tuber/vine (g)	Total weight / vine (g)	DM (%)
Between aonla plantation (8X8 m)	4.5	27.2	18.1	526.5	1800.0	22.14
Grown under fully shade condition	1.0	19.0	15.0	197.9	197.9	18.45
Open field condition	5.5	18.2	20.6	447.0	2428.2	23.86
Mean	3.7	21.5	17.9	390.4	1475	21.48

The tuber yield per vine (2428.2 kg), tuber diameter (20.6 cm) and number of tubers per vine (5.5) were also recorded higher when greater yam was grown under open field followed by between aonla plantation (8 x 8 m).

Introduction and evaluation of *Colocasia* in hot arid region

The experiment was carried out under three conditions using taro cultivar with three treatments and six replications under Randomized Complete Block Design (Fig. 21). The sprouted cormels were planted at 45x45 cm spacing. Subsequent irrigations, weeding, interculturing and suitable plant protection measures were employed as and when required as per the recommended package of practices. Vermicompost @ 1.5 t/ha and NPK @ 80:60:80 kg/ ha were applied. The observations were recorded for growth, yield and quality related traits. The observations for growth and yield related traits were petiole length (cm), number of petioles, number of side shoots, number of cormels and yield per plant, length (cm), diameter (cm) and weight (g) of corm and cormels and yield (t/ha). The observation for quality traits were dry matter (%) content. The dry matter (%) was estimated based on fresh and dry weight basis (Table 35 to 37).

Table 35. Growth attributes of *Colocasia* in arid region at 45 days after planting

Colocasia grown in different conditions	Plant height (cm)	No. of leaves	Leave length (cm)	Leave width (cm)
Between aonla plantation (8x8 m)	31.1	2.5	21.6	20.2
Grown under full shade condition	31.2	2.7	17.4	13.1
Open field condition	12.5	1.1	7.0	5.3
Mean	24.9	2.1	15.3	12.8

Table 36. Performance of yield attributes of *Colocasia* in arid region

Colocasia grown in different conditions	No. of cormels/ plant	Corm length (cm)	Corm diameter (cm)	Average corm weight (g)	Cormel length (mm)	Cormel diameter (mm)	Cormel weight (g)
Between aonla plantation (8x8 m)	5.6	6.2	9.2	32.0	4.3	8.1	18.9
Grown under fully shade condition	3.4	3.7	5.5	19.2	2.6	4.9	11.3
Open field condition	1.3	1.5	2.2	7.7	1.0	1.9	4.5
Mean	3.4	3.8	5.6	19.6	2.6	5.0	11.6

Table 37. Yield and quality of *Colocasia* in arid region

Colocasia grown in different conditions	No. of tuber/plant	Yield/plant (g)	Yield (t/ha)	DM (%)
Between aonla plantation (8X8 m)	8.1	287.0	13.1	20.00
Grown under fully shade condition	4.8	172.2	7.9	18.16
Open field condition	1.9	68.9	3.1	21.15
Mean	5.0	176.0	8.0	19.77

Fig. 20. *Colocasia* performance under open field condition

Fig. 21. *Colocasia* performance under shade condition

The vegetative growth characteristics, yield attributes and quality attributes like dry matter percentage were recorded superior when *Colocasia* was grown under aonla plantation (8x8 m) followed by *Colocasia* grown under 100% shade condition and lower yield was observed under open conditions (Fig. 22). From the present study, it can be concluded that there is a good scope for cultivation of *Colocasia* in hot arid region of north-western Rajasthan as intercrop in orchard.

Fig. 22. Yield performance of *Colocosia* under arid region

Evaluation of mustard variety Pusa Sag-1

The seeds of new vegetable mustard variety i.e. Pusa Sag-1, developed by Indian Agricultural Research Institute, Pusa, New Delhi were procured and evaluated under ber based cropping system. The crop was sown during the last week of October at ICAR-CIAH, Bikaner. The variety bears large green hairy leaves, which are consumed as a green vegetable (Fig. 23). Observations on various growth and yield parameters were recorded which revealed that it reaches a height of 60-80 cm. Mature plants can produce about 20-35 leaves, which are soft, fleshy and broad. The crop was harvested

in 55-60 days after sowing. An average leaf length, leaf width and weight per leaf ranged from 22.4-36.7 cm, 12.5-20.5 cm and 12.5-16.3 g, respectively. The crop attained 50% flowering in 80-90 days after sowing.

Crop Improvement

Hybridization in ber

Hybridization in ber was carried out to obtain superior progeny in Thai ber and fruit fly resistance in commercial varieties *viz*., Gola, Thar Bhubhraj and Umran (Fig. 24). The crosses were made for improvement in TSS (parent Reshmi) and fruit shape and colour (parent Kathaphal) in Thai ber and commercial varieties fruit fly resistance (Tikadi & Illaichi). During the reporting period, 911 total crosses were made and out of which 28 fruits were set. No fruit set was recorded in Gola x Illaichi and Tikadi x Gola cross combination (Table 38).

Fig. 23. Mustard variety Pusa Sag-1

Fig. 24. Hybridization in ber for quality improvement and fruit fly resistance

Table 38. Parental lines and fruit set of ber under different hybrid combinations

S. No.	Cross combination	Crossing time	No. of crosses made	No. of fruit set	Per cent fruit set
1	Thai x Reshmi	10 AM to afternoon	90	01	1.11
2	Thai x Kathaphal	9.30 AM to afternoon	103	02	1.94
3	Reshmi x Thai	3.30 PM to evening	118	06	5.08
4	Kathaphal x Thai	3.30 PM to evening	80	01	1.25
5	Selfing of Thai	Full day	150	13	8.67
6	Umran x Illaichi	9.30 AM to afternoon	32	02	6.25
7	Thar Bhubhraj x Illaichi	9.30 AM to afternoon	45	01	2.22
8	Thar Bhubhraj x Kathaphal	9.30 AM to afternoon	133	02	1.50
9	Gola x Illaichi	9.30 AM to afternoon	118	00	0.00
10	Tikadi x Gola	3.30 PM to evening	26	00	0.00
Total			**911**	**28**	**3.07**

Elite germplasm of pomegranate for anardana and table purpose

CIAH PG-1: Plants are vigorous, evergreen and semi spreading type. It has fruit weight 237 g, fruit length 8.61 cm, fruit diameter 7.22 cm, aril weight 34.50 g/100 arils, aril length 11.38 mm, aril width 8.82 mm and TSS 16.20 °Brix. It has 12.50 kg/plant fruit yield on fourth year. Fruits are light reddish in colour, aril very bold with bright red colour (Fig. 25). It found highly suitable for anardana purpose due to high yield, more anardana recovery and high acidity.

Fig 25. Pomegranate CIAH PG-1 fruits and arils

CIAH PG-2: Plants are dwarf, evergreen and semi spreading type. It has fruit weight 210 g, fruit length 7.25 cm, fruit diameter 7.05 cm, aril weight 25.26 g/100 arils, aril length 8.78 mm and aril width 6.22 mm, TSS 15.30 °Brix and juice 45.06 % on fruit basis. Fruits are round in shape, bright reddish in colour and aril colour dark pink (Fig. 26). It has fruit yield 8.25 kg/plant on fourth year. It found highly suitable for table purpose.

Fig. 26. Pomegranate CIAH PG-2 fruit bunch and fruit cross section

Thar Gaurav: An improved variety of wood apple

It is developed through selection method. It is precocious bearer having dense canopy, and starts bearing in 4th year. It has bigger size fruit (450.25 g) with better self life under rain-fed conditions of western India (Fig. 27). It is used as table purpose and for value added products like pickle, RTS, chutney and powder. It is drought hardy and capable to give economic yield

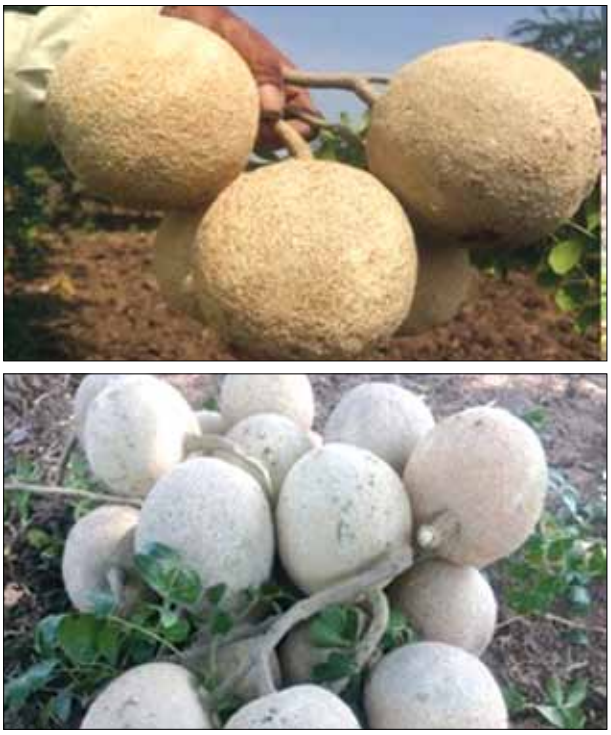


Fig. 27. Fruits of improved variety of wood apple 'Thar Gaurav'

during aberrant agro-climate condition. Fruits emit strong pleasing aroma at full maturity. It matures in month of November. It gives high yield 124.36 kg/plant in 12th year under rain fed semi-arid condition. The fruit is rich in pectin (1.76%) and protein (pulp, 18.13% and seed, 24.38%), phosphorous (0.07%), potassium (1.73%), calcium (0.30%) and iron (16.72 mg) content.

Hybridization studies in custard apple

The attempt was made to cross between the elite gemplasm and superior variety (Table 39). Crosses were made among the genotypes and varieties. The crossed fruits were harvested after horticultural maturity and seeds were kept in storage for sowing in next year.

Table 39. Hybridization studies in custard apple

Female parent	Male parent	Fruit set no.	Fruit weight (g)	Seed harvested/ fruit	Fruit TSS (°Brix)
HS-1	Balanagar	7	169.24	28.25	27.26
Hs-1	Balanagar	2	135.25	12.36	17.50
HS-2	Balanagar	3	326.12	19.50	23.45
Balanagar	Sindhan	2	230.12	42.36	27.62
Sindhan	Balanagar	3	228.23	36.36	28.10
Apk-1	Balanagar	7	375.65	30.12	24.36
Balanagar	Apk-1	2	265.23	43.26	27.36
Balanagar	Arka Sahan	2	224.36	32.23	29.23
Arka Sahan	Balanagar	3	192.56	23.50	28.50
G.S	Arka Sahan	3	189.23	19.23	29.36
Arka Sahan	G.S	9	280.23	28.56	28.24

Hybridization and evaluation of F1 hybrids of guava

Successful crosses were made between Thai guava x Taiwan Pink, Thai guava x CHESG-30, MPUAT-2 x CHESG-15, CHESG-23 x Taiwan Pink, Taiwan Pink x CHESG-28, CHESG-31 x Purple guava, CHESG-31 x Taiwan Pink, Lalit x CHESG-28, CHESG-28 x CHESG-32 and CHESG-32 x CHESG-28 during July-August, 2019 and seeds from ripened fruits were harvested in the month of December, 2019.

F1 progeny of four different cross combinations (CHESG-15 x Thai guava, Thai guava x CHESG-15, MPUAT-1 x Thai guava and CHESG-19 x Thai guava) were planted in field in last fortnight of December 2019.

F1 progeny of CHESG-28 × Lalit which was planted during August, 2017 flowered and set fruits in the Feb.-March, 2019 in most of the plants and fruits were harvested in the rainy season of July-Aug. 2019. All the plants also flowered in the month of August, 2019 and winter season crop is evaluated. Detailed characters of some promising hybrids are given below.

Hybrid 4/3: Trees are moderately tall, with semi-spreading loose canopy. Precocious and prolific bearer, fruits roundish in shape, medium in size weighing around 215-275 g. Fruit peel is yellowish pink while pulp is deep pink at mature ripened stage (Fig. 28). Keeping quality of fruits was good at ambient storage (5-6 days). At ripened mature stage fruit pulp was firm with less seeds of small size, having pleasant aroma and have good taste with TSS:acidity ratio of around 21.66. It was soft seeded with

Fig. 28. Fruit attributes of Hybrid 4/3

100 seed weight of 1.04 g. Fruit pulp is rich in β-carotene (0.27 mg/100 g), lycopene (4.33 mg/100g), antioxidants (417.43 mg AAE/100 g) and ascorbic acid 266.50 mg/100 g pulp. It ripens early in the season i.e. in second week of November with extended harvesting period.

Thar Annant: An improved heat tolerant tomato variety

The tomato variety Thar Annant was developed through induced mutation followed by selection of desired phenotypic traits in the mutation induced populations. The mutant having superior phenotypic traits was identified and homogenized based on the horticultural attributes and performance. It is having high flesh thickness (0.85 cm), deep red fruit colour rich in lycopene content (7.9 mg/100 g) with medium acidity (0.42%) under semi-arid conditions (Fig. 29). It is highly vigorous in growth with dark green dense foliage. It is distinguished by indeterminate plant habit, fruit size, fruit color and yield potential over the parent. It is highly tolerant to heat stress and drought having high yield potential (4.2 - 4.9 kg/plant) under semi-arid conditions. The each fruit weight about 120-130 g with attractive deep red colour fruits of round shape. The variety is highly suitable for table, processing and export purposes.

Fig. 29. Thar Annant laden with fruits

Improvement, maintenance and selection in watermelon and muskmelon

Twenty lines of watermelon and muskmelon were evaluated and conserved during 2019 for horticultural traits. The generation advancement of selected advance lines has been done through inbreeding. Multiplied and maintained the seed of selected promising advance lines and reference varieties for further utilization. The purified advance line, YF 5-2-7 of watermelon is distinct from Durgapura Kesar in three qualitative traits (Table 40). The distinguishing traits of YF 5-2-7 consisted of entire leaf (non-lobed), dark green with very narrow stripes rind colour and seed coat blackish brown in colour (Fig. 30). The flesh of YF 5-2-7 and Durgapura Kesar were analysed for different bio-chemical compounds and recorded 0.25 mg AAE /g total antioxidant activity (TAA) and 9.15 µg/g carotenoids in YF 5-2-7. Durgapura Kesar had 0.19 mg AAE /g TAA and 6.39 µg/g carotenoids content.

Table 40. Performance of selected advance lines of watermelon

Genotype	Fruit weight (kg)	TSS (%)	Marketable fruit yield (q/ha)	Flesh colour
AHW/BR-5	2.80	11.40	232	Red
AHW/BR-22	2.20	11.90	210	Red
AHW/BR-37	3.00	11.00	256	Red
AHW/BR-40	2.70	12.20	280	Red
YF 5-2-7	2.50	11.00	260	Saffron
Durgapura Kesar	2.70	11.00	220	Saffron
Sugar Baby	2.20	11.20	200	Red

Fig. 30. Characteristics of watermelon advance lines

AHMM/BR-35 produced round fruits with netted rind (0.4 cm thick) and salmon orange flesh (Fig. 31). Seed cavity was small (5-5.5 cm), thick flesh (3-3.2 cm) and TSS ranged from 11.5-12.2%. AHMM/BR-47 of muskmelon produced first harvesting in 75-80 days after sowing, bear 3-4 fruits/plant weighing 750-900 g, netted rind with sutures, TSS 11.2-12%, rind 0.3-0.4 cm thick, seed cavity 5.4-5.7 cm and flesh thickness 2.8-3.2 cm of salmon orange colour. It is characterized by deep lobing of leaves.

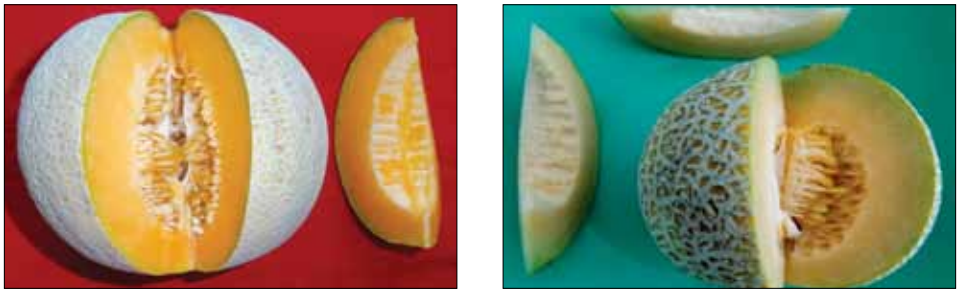


Fig. 31. Characteristics of muskmelon advance lines

Fig. 32. Characteristis of advance line of watermelon YF 5-2-7 (Carotenoid rich watermelon)

Development of watermelon for high carotenoid content

Watermelon being highly cross pollinated crop possess varying flesh colour *viz*., red, white, yellow and saffron having different profile of nutrients. Keeping in view, a saffron coloured genotype of watermelon (YF5-2-7) was identified and homogenized and evaluated over the years and seasons (Fig. 32). YF5-2-7 was high in carotenoid content (7.00-9.60 µg/g FW) in comparison to popular red fleshed varieties which have 3.92-4.14 µg/g FW carotenoid content. It is characterized by entire (non-lobed) leaves, round fruits having dark green rind with very narrow stripes, saffron flesh and blackish brown seeds. YF5-2-7 produced round fruits weighing 2.5-3 kg, rind thickness 1.0-1.3 cm, TSS 10-11% and bear 3-4 fruits/plant. Fruits ready for harvesting in 80-85 days after sowing.

Watermelon germplasm registration

Watermelon is mainly monoecious in sex expression, however, andromonoeciuos sex form is also found rarely in nature. An andromonoecious plant from segeregating population was identified and homogenized through repeated inbreeding. The developed material (AHW/BR-5; IC-0627526) possessed

unique traits i.e. stable andromonoecious sex form and able to set fruits under net house conditions without pollinators and produced viable seeds. AHW/BR-5 produced round, red fleshed fruits having light green rind (1.38-1.92 cm thick) which was devoided of stripes (Table 41 & Fig. 33). Fruits were ready for harvesting in 80-85 days after sowing. Fruit weight varied from 2.08-2.78 kg. It produced 3-4 fruits per plant with 10.80-11.74% TSS. This material (AHW/BR-5; IC-0627526) was registered with ICAR-NBPGR, New Delhi under INGR 19081 for stable andromonoecious trait.

Table 41. Salient characteristics of AHW/BR-5 (IC-0627526)

S. No.	Trait	Description
1.	Days taken to produce 50% pistillate flowers after sowing	45-50
4.	Node number at which first female flower appeared	9-12
5.	Days to first fruit harvest after sowing	80-85
6.	Fruit weight (kg)	2.08-2.78
7.	Fruit diameter (cm)	14.68-17.80
8.	Rind thickness (cm)	1.38-1.92
9.	TSS (%)	10.80-11.74
10.	Sex form	Andromonoecious
11.	Leaf shape	Pentalobate
12.	Fruit shape	Round
13.	Rind colour	Light green devoid of stripes
14.	Flesh colour	Red

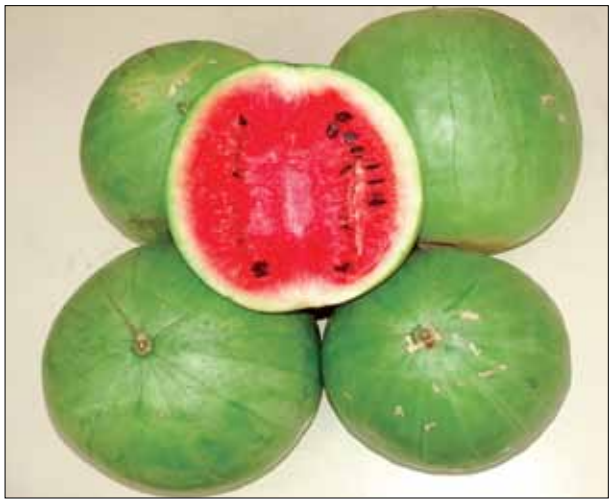


Fig. 33. Fruits of watermelon andomonoceous line AHW/BR-5 (IC-0627526; INGR 19081)

Varietal proposals recommended by State Variety Release Committee

During the year, submitted the proposal of Thar Sheetal (longmelon) and Thar Karni (ridge gourd) which have been accepted for release and notification for Rajasthan State during 33rd meeting of State Seed Sub Committee for Agricultural and Horticultural Crops held at Jaipur on 23-08-2019 (Fig. 34).

Thar Sheetal (longmelon) | Thar Karni (ridge gourd)

Fig. 34. Identified variety of longmelon and ridge gourd

Evaluation/adaptive trials of muskmelon and watermelon

Conducted evaluation/adaptive trial of advance lines of muskmelon and watermelon during summer season of 2019 at different KVKs. AHMM/BR-40 of muskmelon produced maximum yield at KVK, Phalodi (225 q/ha) followed by KVK, Gudamalani (190 q/ha) which was 11-25% higher over RM-50 (Check). AHW/BR-40 of watermelon gave maximum yield at KVK, Gudamalani (204 q/ha) followed by KVK, Phalodi (185 q/ha) which was 14-16% higher over Sugar Baby (Check).

AVT-I varietal trial of ridge gourd

Conducted AVT-I varietal trial of ridge gourd during summer season of 2019 comprising six entries. Maximum fruit length (27.33 cm), fruit weight (117.28 g), number of fruits/plant (16.50) and marketable yield (144.43 q/ha) was recorded in 2017/RIGVAR-4 (Table 42).

Table 42. AVT-I varietal trial of ridge gourd conducted during summer 2019

Name of entry	Days to first picking	Fruit weight (g)	Fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Marketable yield (q/ ha)
2017/RIGVAR-1	56.25	98.48	12.25	22.43	2.84	120.03
2017/RIGVAR-2	61.50	87.45	11.30	20.08	2.76	113.63
2017/RIGVAR-3	64.00	70.48	10.60	19.38	2.33	108.60
2017/RIGVAR-4	49.75	117.28	16.50	27.33	3.00	144.43
2017/RIGVAR-5	51.50	102.73	14.10	15.58	3.78	135.25
2017/RIGVAR-6	53.75	93.75	12.90	23.53	2.93	124.00
CD (5%)	4.89	10.54	1.94	2.58	0.40	12.37
CV (%)	5.78	7.44	9.97	8.02	8.94	6.60

IET hybrid trial of ridge gourd

Seven entries of ridge gourd were evaluated during summer season of 2019. The entry 2018/RIGHYB-1 produced maximum marketable yield (165.47 q/ha) followed by 2018/RIGHYB-6 (162.03 q/ha). Maximum fruit weight (131.00 g), fruit length (31.00 cm) and fruits/plant (19.20) were also recorded in 2018/RIGHYB-1.

IET varietal trial of longmelon

Entry 2018/LGMVAR-4 of longmelon produced maximum marketable yield (152.73 q/ha) among six entries in IET varietal trial conducted during summer 2019. The maximum fruit weight (156.04 g), fruit length (38.13) and fruits/plant (20.55) were also recorded in 2018/LGMVAR-4 (Table 43).

Breeding for high temperature tolerance and fruit quality improvement in round melon (*Praecitrullus fistulosus*)

During rainy season of 2019, advanced breeding material of round melon progenies AHRM-1/2017/17-a whitish-green-Bikaneritype was compared with base line AHRM-1/a Bikaneri type (Fig. 35). Both the lines exhibited good initial vine growth and fruiting, and detailed observation were recorded. Based on first marketable harvest (44 DAS) and fruit quality attributes, individuals were selected and bi-parental mating was done for further advancement in the progeny.

Table 43. IET varietal trial of longmelon conducted during summer 2019

Name of entry	Days to first picking	Fruit weight (g)	Fruit/ plant	Fruit length (cm)	Fruit girth (cm)	Marketable yield (q/ ha)	Crop duration (days)
2018/LGMVAR-1	52.45	144.33	17.90	37.08	8.85	136.30	96.25
2018/LGMVAR-2	57.33	128.85	16.95	27.90	10.10	128.88	80.30
2018/LGMVAR-3	52.78	146.10	18.90	36.23	9.25	142.23	84.00
2018/LGMVAR-4	49.75	156.05	20.55	38.13	7.40	152.73	92.05
2018/LGMVAR-6	57.85	123.95	14.50	34.65	11.70	118.80	88.48
CD (5%)	3.83	19.02	1.85	5.28	1.22	13.69	7.99
CV (%)	4.60	8.83	6.77	9.86	8.36	6.54	5.88

Fig. 35. Field view of advanced breeding material of round melon evaluation

Breeding for high temperature tolerance and marketable yield in long fruited bottle gourd (*Lagenaria siceraria*)

During rainy season of 2019, two selections of long fruited bottle gourd developed at CIAH were tested for fruit quality and yield attributes. Line AHLS/2017/01 was at par to AHLS/2017/02 and both exhibited superiority for growth and marketable fruit yield under temperature range 38-42 ^{0} C during August to September. On average, both the selection exhibited earliness for first picking (62.5 DAS) and yield was 3.17 kg/plant.

Maintenance breeding and seed production in *kachri* (*Cucumis melo* var. *callosus*)

Kachri variety AHK-119 was taken for varietal maintenance breeding and seed production programme (Fig. 36 to 37). The variety AHK-119 was assessed for number of fruits/plant, maturity and yield characters adopting rainfed and drip technology of crop production. No significance differences were recorded for days to first harvesting (65 & 68 DAS) and fruit yield (94 & 98 q/ha), respectively. During report period, 101 kg seed of AHK-119 was produced and about 1000 farmer's benefited with the variety. *Kachri* variety AHK-119 was also demonstrated at KVK's of Lunkaransar, Nagour and Sardarshahar as research trial and seed production.

Fig. 36. Maintenance breeding and seed production in *kachri* variety AHK-119

Fig. 37. Field view of seed crop of *kachri* (AHK-119)

Germplasm utilization and technological advancement in *sehjan* (*Moringa oleifera*) for dry-lands

Sehjan (*Moringa oleifera*) popularly known as moringa or drum-stick and native to India is versatile crop-plant due to its diverse uses and eco-restoration. During 2019, seed propagated progeny AHMO–1–4s developed at ICAR-CIAH, Bikaner was studied for growth, pod setting and yield potential (Fig. 38). The progeny is also under performance trials at farmer's field with varying production situations and adopting training-pruning and management practices to sustain under low temperatures and frost conditions in arid region.

Fig. 38. *Sehjan* AHMO-1- 4s orchard and brances laden with pods

Maintenance and evaluation of *khejri* (*Prosopis cineraria*) genotypes

Fourteen elite genotypes identified by CIAH from 2000–2005 and multiplied clonally for *ex-situ* conservation in *khejri* germplasm plot were maintained with good management practices. *Khejri* variety Thar Shobha and *Khejri* Selection–2 were compared in reference to growth, pod yield and bio-mass production over the years under rainfed conditions (Fig. 39 to 40). *Khejri* Selection–2 was also studied for picking intervals and *sangri* yield.

In maintenance of *khejri* based crop production site trial, annual plant growth and total bio-mass harvest component was studied in native crop-plant species for horticultural significance. *Phog* was studied in response to training - pruning for monsoon support bio-mass harvest including vegetable use *phogla* (Fig. 41). Boundary side and naturally maintained *kheep* shrubs were studied for growth, flowering and tender pod (*khipoli*) harvesting. With good management practices, *kheep* shrubs exhibited prolonged period of flowering and tender pod harvesting. The seedlings of native crop-plant species such as *ker*, *jharber*, *rohida*, *lasora*, *kumat* and *khejri* were observed as inter-crop/boundary side plantation, and studied with HBCPSMA concept to promote desert horticulture. During 2019, about 1,000 bud-sticks of *khejri* variety Thar Shobha were supplied to nursery unit for commercial multiplication.

Fig. 39. Plant growth and pod yield characters of *Khejri* Selection-2


Fig. 40. Shri Kailash Choudhary, Union Minister for State Agriculture and Farmers Welfare, interacting with scientists


Fig. 41. *Phog* and *kheep* cultivation under *khejri* based cropping system

Physiological, Biochemical and Bio-technological Interventions

DNA fingerprinting of longmelon cv. Thar Sheetal

For DNA fingerprinting of Thar Sheetal variety, PCR profiling of 15 ISSR, 10 ScoT (Start codon Targeted polymorphism) and 10 CBDP (CAAT Box-derived Polymorphism) markers was done (Fig. 42). For assessing the fidelity of varietal specific bands, Punjab Long melon-1 cultivar was used as comparative control. Leaf samples were collected at seedling stage and DNA was isolated from the sample. Subsequently, ISSR, ScoT and CBDP markers were profiled using PCR amplification. Consequently, ten ISSR markers produced specific bands and differentiated Thar Sheetal variety to Punjab Long Melon-1. Similarly, three ScoT and 7 CBDP markers were produced Thar Sheetal-specific bands and clearly differentiated the Thar Sheetal variety to Punjab Long Melon-1. The varietal-specific DNA fingerprints of Thar Sheetal are given in Table 44.

Table 44. Thar Sheetal-specific DNA fingerprints and their distribution and size

S. No.	Molecular marker	Specific bands (bp)	No. of specific bands	Occurrence of bands
1	ISSR1	400	1	Presence
2	ISSR3	300	1	Presence
3	ISSR4	800	1	Presence
4	ISSR5	450	1	Presence
5	ISSR13	1100	1	Presence
6	ISSR14	600, 950, 1100	3	Presence
7	ISSR23	800	1	Absence
8	ISSR25	550, 900	2	Presence
9	ScoT2	1500	1	Presence
10	ScoT12	750, 1150, 3000	3	Presence
11	ScoT16	1500	1	Absence
12	CBDP13	300, 650, 1100	3	Presence
13	CBDP14	700, 850, 1400	3	Presence
14	CBDP15	300, 750, 3000	3	Presence
15	CBDP17	1100	1	Presence
16	CBDP18	400, 800, 1200	3	Presence
17	CBDP19	200, 400, 1000	3	Presence
18	CBDP20	600	1	Presence

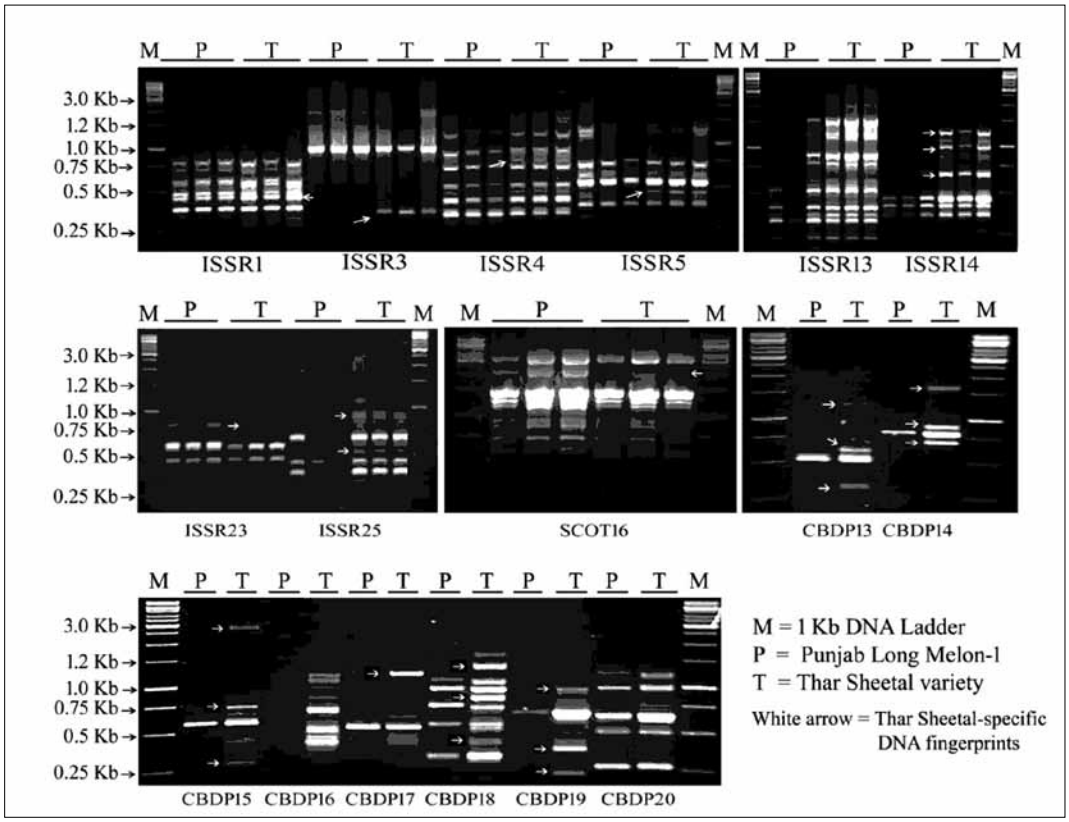


Fig. 42. PCR profiling of ISSR, ScoT and CBDP markers in Thar Sheetal variety

DNA fingerprinting of ridge gourd cv. Thar Karni

To assess the varietal-specific DNA fingerprints of Thar Karni variety, twelve CBDP and 6 ISSR markers were profiled on DNA of Thar Karni (Fig. 43). For identification of Thar Karni variety, Pusa Nutan, Pusa Nasdar and AHRG-57 (improved line) were used as comparative controls. As a result of PCR amplification, five CBDP and two ISSR markers were differentiated Thar Karni variety to comparative controls by amplifying varietal-specific DNA fingerprints.

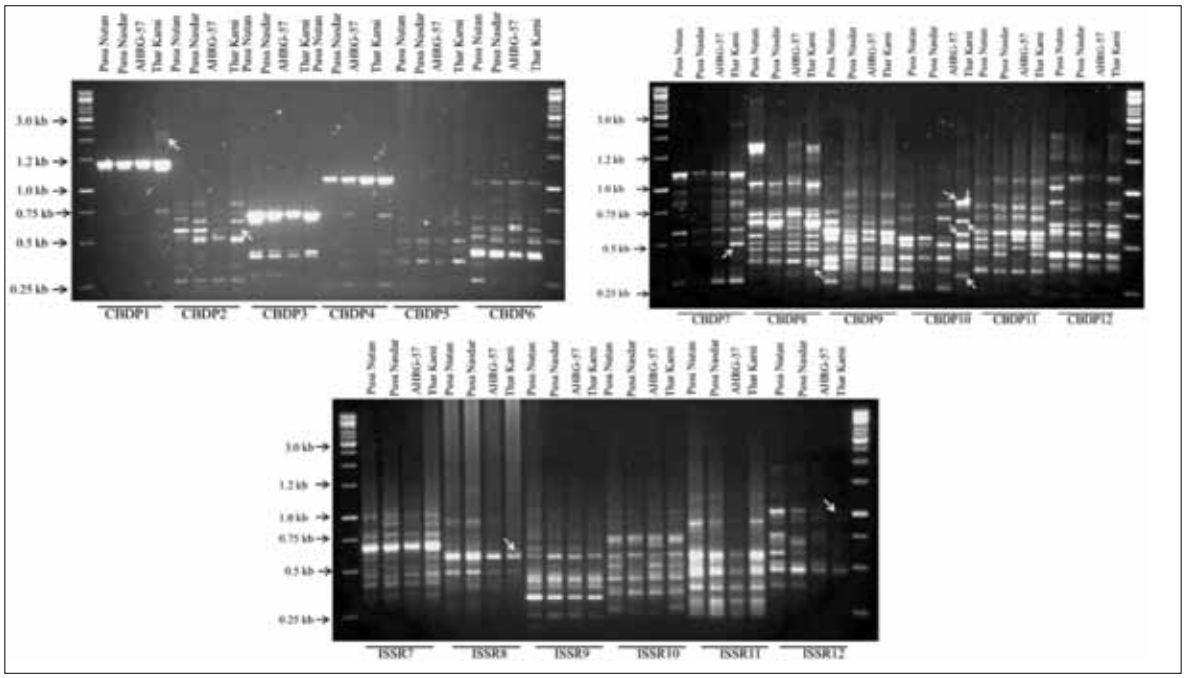


Fig.43. CBDP and ISSR marker profiling of Thar Karni variety

Identification and characterization of AP2/ERF gene family in watermelon

To identify the AP2/ERF transcription factor gene family in watermelon, BLAST search was performed in the watermelon database using AP2/ERF domain (59 amino acids) of the *Arabidopsis* AP2/ERF protein as a query sequence. As a result of the blast search, 146 putative AP2/ERF transcription factor gene family were identified in watermelon. Based on divergence in number and structure in AP2 domain, the gene family was further classified into 56 ERF, 63 DREB, 20 AP2, 4 RAV and 3 soloists. The evolutionary relationship among the AP2/ERF transcription factor gene family was demonstrated by phylogenetic analysis in MEGA 7.0 software. The phylogenetic tree constructed with deduced amino acid sequences of AP2/ERF transcription gene family classified them into 4 major groups consisting of AP2, ERF, DREB and RAV (Fig. 44).

The chromosomal position of each gene family was assigned using blast search analysis against watermelon genome using each AP2/ERF transcription factor gene family. The analysis revealed that AP2/ERF transcription factor gene family distributed throughout the genome of watermelon. The chromosome 5 presented maximum number of gene family (25 gene family) followed by chromosome 1 (20 gene family), whereas chromosome 0 (pseudomolecule) was presented only one gene family. Out of 146 AP2/ERF transcription gene family, twenty eight gene family showed tandem duplication. The chromosome 0, 3, 4 and 11 were not shown any duplicated gene family (Fig. 45).

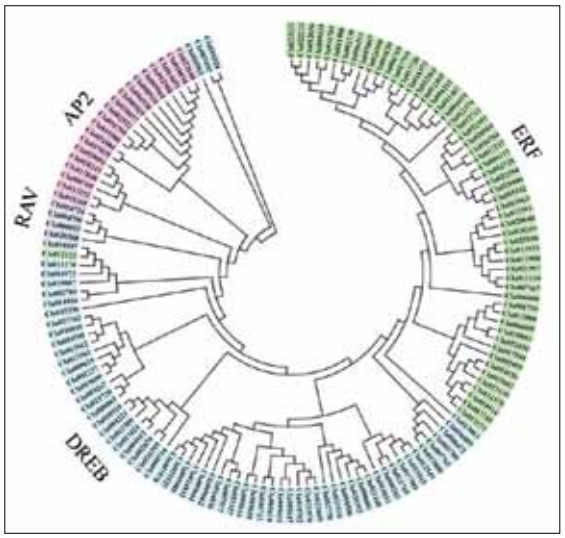


Fig. 44. Phylogenetic tree of AP2/ERF gene family of watermelon

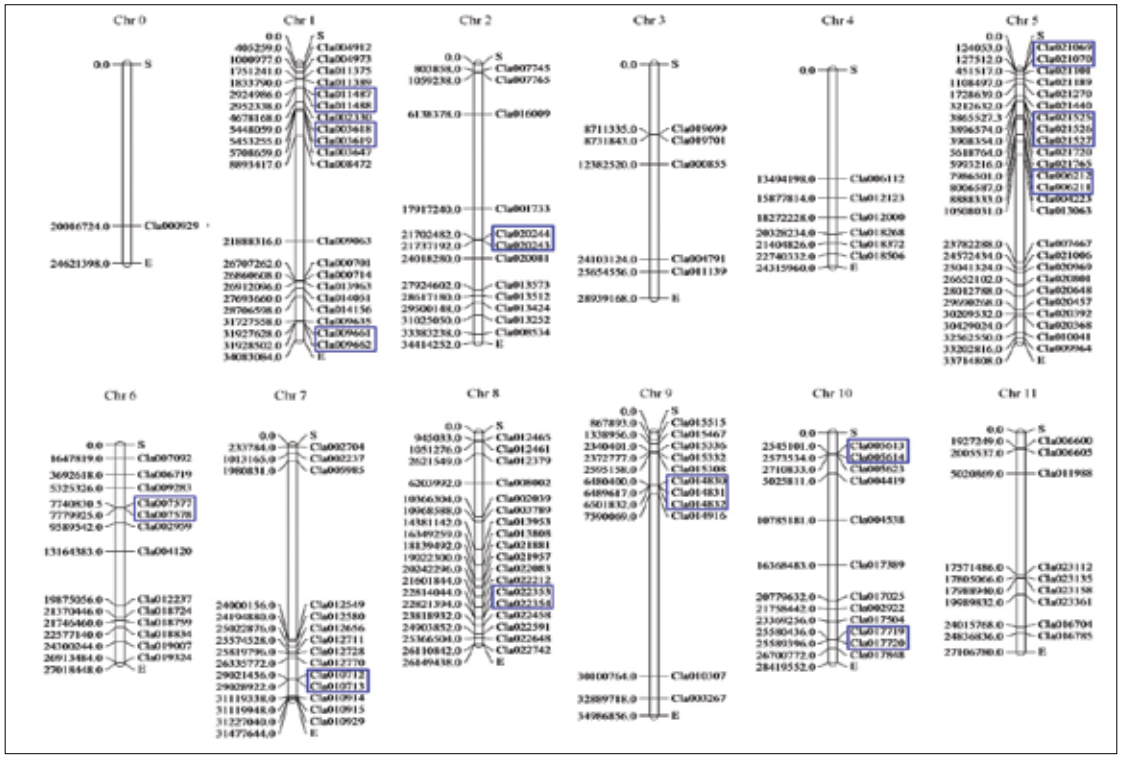


Fig. 45. Physical distribution of AP2/ERF gene family on watermelon chromosomes

To know the functions governed by AP2/ERF transcription factor gene family of watermelon, the functional annotation (gene ontology) of each gene family was done by using Blast2go analysis. The gene ontology (*GO*) analysis of AP2/ERF transcription factor gene family revealed that majority of the gene family (100%) were involved in transporter activity and other DNA binding proteins (100%). Similarly, when categorized on the basis of biological processes, majority of the genes were involved in transcription, endogenous stimulus and cellular process. Further, based on cell components, majority of them were found (100%) residing in the nucleus (Fig. 46).

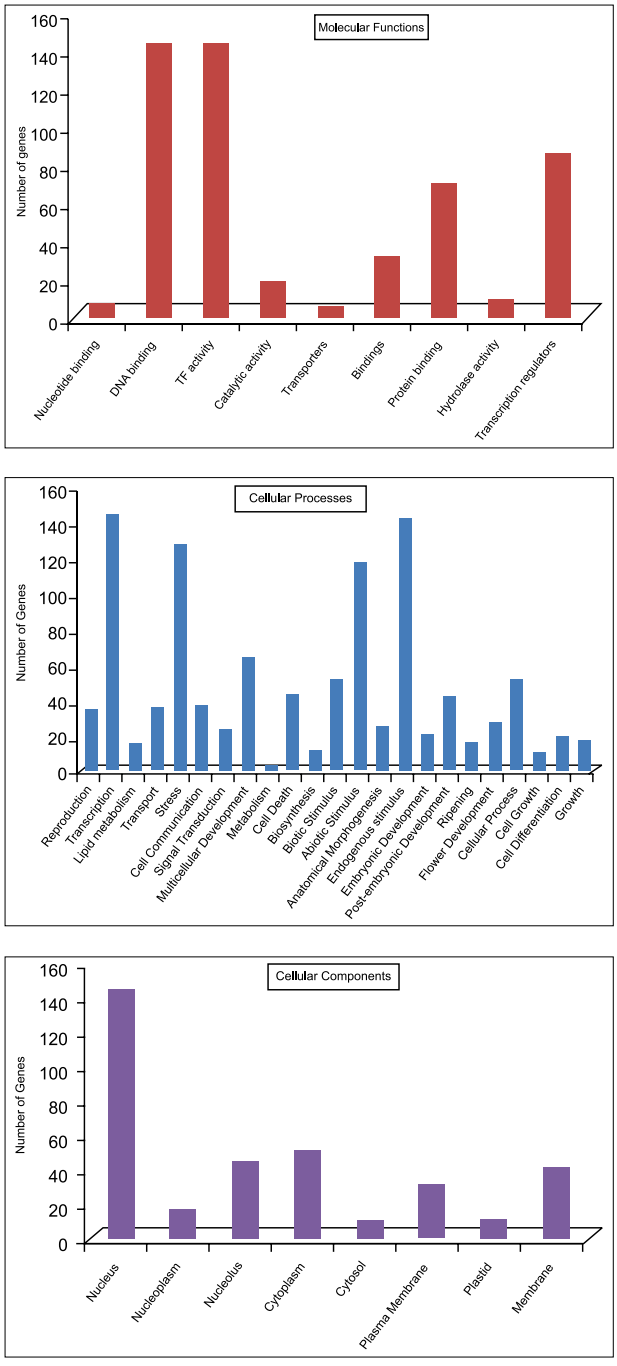


Fig. 46. Functional annotation of AP2/ERF transcription factor gene family of watermelon.

Identification of *dehydrin* gene from EST database of *Ziziphus nummularia*

To identify *dehydrin1* gene from *Z. nummularia* EST sequences, three thousand twenty four EST sequences were retrieved from NCBI EST database (https://www.ncbi.nlm.nih.gov/nuccore=*Z.nummularia*). The redundancy and vector backbone in EST sequences were removed using EGassembler software (https://www.genome.jp/tools/egassembler/). The analysis revealed 1954 non-redundant EST sequences. Finally, these 1954 non-redundant ESTs were assembled into 75 contigs (contiguous sequences). Further, the Blast2go analysis (https://www.blast2go.com/) was done for functional annotation of contigs. For getting expressivity of each contig, all 75 contigs were analyzed against drought responsive transcriptome study of *Z. nummularia* (SRX1118834) using SRA (Sequence Read Archive) blast analysis (https://blast.ncbi.nlm.nih.gov/Blast.cgi?program=blastn&page_type=BlastSearch&BLAST_spec=sra&link_loc=blasttab). Consequently, contig 72 represented maximum no. of SRA reads (Fig. 47). At final, when this contig was analyzed for mining of gene, it resulted into a full length drought-responsive *Dehydrin1* (*DHN1*) gene which named as *ZnDHN1* gene (Fig. 48).

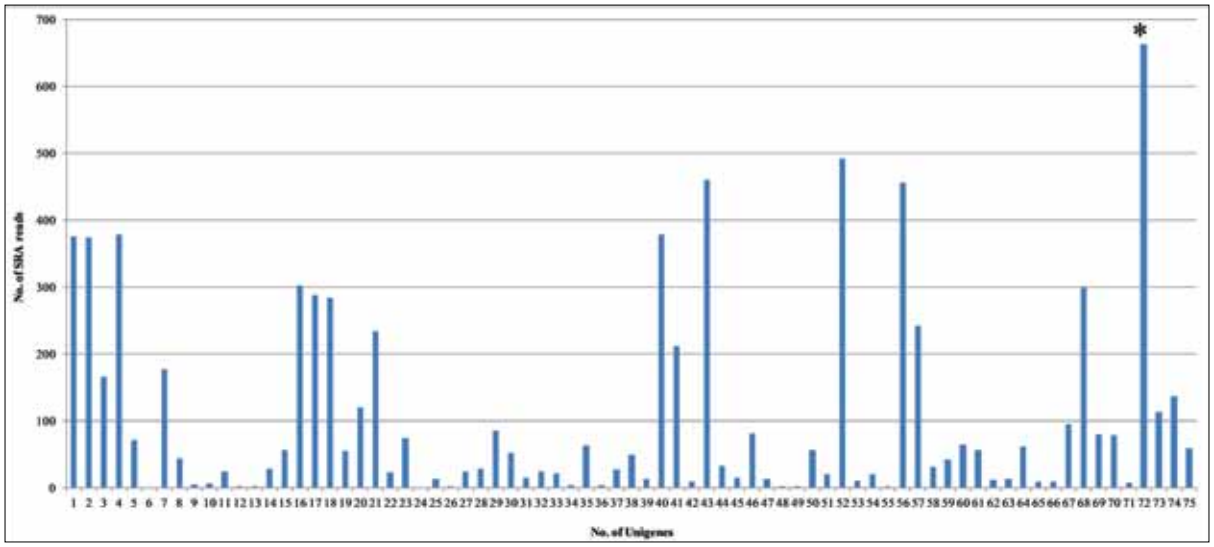


Fig. 47. SRA Blast analysis of 75 contigs for their expression level in transcriptome study Asterisk (*) indicates the highly expressive contig

>ZnDHN1(Contig72)

GTGGTTGCGGCCGAGGTACATGGGGAACTACAAAAACATCTTTTACTTCCATTAGCAAGACAACAGTTAATACCGG
CCTTTGTTACATCAATTTCTTCAGCTCACTAAGTTTATTACCTATTTCCTACTTGTTTTTCGCCCAAAAAATCAGAAAA
AAATGGCGCATTACCAGAACCAATATGGTGCAACAGGCCAAACCGATGAATATGGCAACCCAATTCGCCACACCG
ACGAGTATGGCAACCCAGTTAATCGCACCGACACCACTGGCGCCTATGGAACTGGAGGGTATGGCACCACCACGG
GACATGGTACTGCCACCACTGGTACCGGCGTTGGCGGTGATTATGTCCAGACCCAGCAGCACAAGGAACACGGCC
ATGGTGGTACTGGAGTGCTGCATCGCTCTGGTAGCTCAAGCTCTAGCTCTTCGGAGGATGATGGTCAAGGCGGGA
GGAGGAAGAAGGGACTAAAAGAGAAGATAAAGGAGAAGATGCCTGGCGGACACAGGGATGACCAGACTCATAC
AAATGCCGCTACGACTCCTGGAGGAGGAGGTTACTACGATGCATCGGGGGAGACCCATGAGAAAAAGGGAATGA
TGGACAAGATCAAGGAGAAGCTTCCTGGACACCACTAGGTTGTCTTAGATAATATCTATGTCTGTATGTACGTAAA
TATATGGTGGTTAATAAGAAGGGTGTAAAGGTAATATAAACTCTTGTTTGTCAGTGACGAGCTGAAATGGCCTGG
AGGTTTATTATTGCAAACAAGCTCATATGTTGTGTACAATAAGTGATGCTTGCTCCTCTTTGGTGCACATCATGGTG
CTTTAGATTTTGTCGTATGTGCTTCGCAGGCTTTGTTATGTGCTCTGTTGGGCACAACTTCATTGTAACGTGGTTTGT
GAAAGTTCTATTTCATACTAATACGTATTTCTAGAGTTTCTATTTTAAAACA

Fig. 48. Genomic sequence of *ZnDHN1* gene

Biochemical mechanism of abiotic stress tolerance in arid horticultural crops

Biochemical response of *khejri* cv. Thar Shobha under different seasons

Under this experiment, seasonal changes in accumulation of antioxidant defense metabolites (total phenolics, flavonoids and total antioxidant activity by CUPRAC assay) and proline content was estimated in *khejri* leaves at two month interval from January to December, 2019. A significant difference was observed in all the metabolites in response to different seasons. When the trend of these metabolites accumulation was observed (Fig. 49), a quick enhancement was observed in these metabolite accumulation during severe winter (December-January) as well as under severe summer months (May to June). Both these environment are creating severe oxidative stress in plant metabolism and to scavenge the stress, its defense system boost up the stress responsive metabolites. Under non-stress conditions like February-March and July to October, the accumulation of these metabolites observed at lower amount. From the data, it can be concluded that the quick metabolic response towards different environmental conditions make this plant a wonder tree with highest extent possible tolerance towards all abiotic stresses.

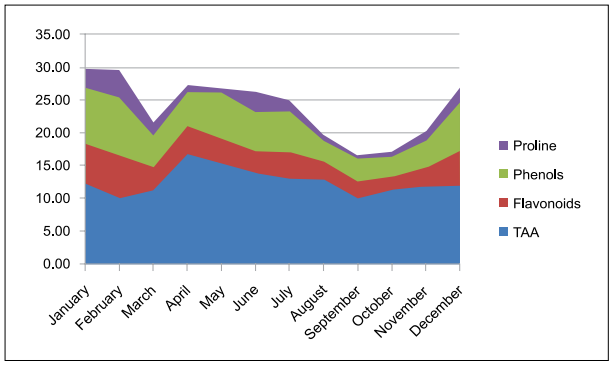


Fig. 49. Seasonal trend of phenol, flavonoids, TAA and proline content in *khejri* leaves

Behavior of antioxidant defense system against natural abiotic stresses in ber

The seasonal changes in accumulation of antioxidant defense metabolites (total phenolics, flavonoids and total antioxidant activity by CUPRAC assay) was estimated in *Ziziphus nummularia* and *Z. mauritiana* leaves at monthly interval basis from January to December, 2019. A significant difference was observed in all antioxidant metabolite accumulation with seasons. It was observed that the absolute values for all metabolites assayed were higher in *Z. nummularia* than *Z. mauritiana* at each point of time (Fig. 50 to 52). When the trend of antioxidant metabolites

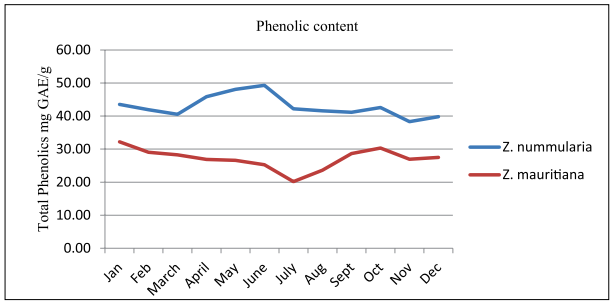


Fig. 50. Seasonal trend of total phenolic accumulation in *Z. nummularia* and *Z. mauritiana*

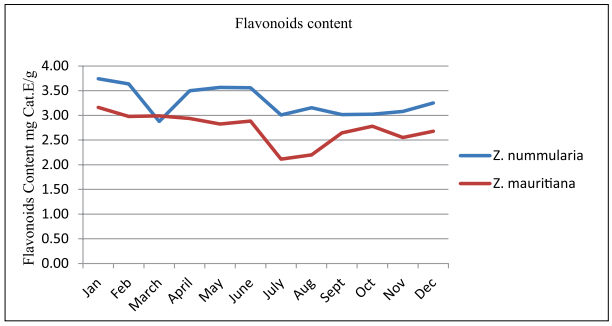


Fig. 51. Seasonal trend of total flavonoids accumulation in *Z. nummularia* and *Z. mauritiana*

accumulation was observed in *Z. nummularia,* it showed an increasing trend of all metabolites during abiotic stressed environmental conditions (under severe winter and summer months) while at the same time, *Z. mauritiana* exhibited almost stagnant or decreasing trend for all metabolites.

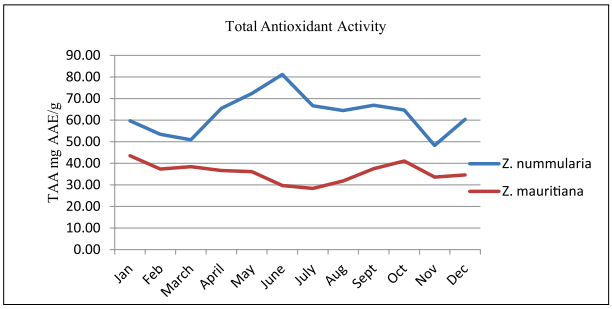


Fig. 52. Seasonal trend of total antioxidant activity in *Z. nummularia* and *Z. mauritiana*

The trend of antioxidant metabolites in *Z. nummularia* and *Z. mauritiana* exhibited their tolerance level towards abiotic stresses. Since *Z. nummularia* is known for its higher tolerance to abiotic stresses than *Z. mauritiana,* it might be due to quick response to stresses and produce more osmolites and antioxidant compounds.

Standardization and commercialization of micro-propagation techniques of horticultural crops: Date palm cvs. Halawy and Khalas

Low cost hardening strategies for tissue cultured date palm plantlets

Plants after successful primary hardening under 27 ± 2 ^{0}C temperatures and 3000 lux light intensity, transferred into hardening unit for secondary hardening with three step hardening process under environment regime of 30±2 ^{0}C temperature, 60-70% relative humidity and 10000-15000 lux light intensity. Different potting media were used for the purpose and observations were recorded with respect to plant survival per cent and number of days taken during hardening of both the cultivars (Table 45). There were five different steps involved during secondary hardening of plantlets. Primary hardened plantlets were placed under greenhouse near to cooling pad and polybags remain covered for 20 days. Thereafter, polybags were removed and after one month plantlets

were shifted in small plastic pots containing with soil and vermicompost (70:30). Hardening solution (MS macro salt 50 ml/l, MS micro salt 5 ml/l, $CaCl_2.2H_2O$ 5 ml/l, KI 2.5 ml/l, glutamine 50 mg/l, inositol 50 mg/l and Fe.EDTA 32.5 mg/l) was given twice in a week to plantlets up to 3 months. Then plants were shifted to medium and big sized plastic pots for optimum growth and development during secondary hardening. The plants have been attained 25-35 cm height after 6 months during hardening under green house.

The minimum days (60) required for primary hardening in vermiculite medium in Halawy followed by sand + vermiculite + perlite + cocopeat and maximum (94 days) in sand+vermiculite media. Similar trend was also observed in cultivar Khalas. Maximum plant survival (70%) during primary hardening in Halawy was recorded in vermiculite based medium and minimum (15%) in sand+vermiculite media. Similarly in cultivar Khalas, maximum plant survival (60%) was noticed in vermiculite and minimum (10%) in sand + vermiculite media. During secondary hardening under green house condition, maximum plant survival (57.14%) was recorded in cultivar Halawy with vermiculite medium while minimum in sand + vermiculite + perlite (20%). In cultivar Khalas, maximum plant survival (58.33%) was observed in vermiculite and minimum (22.22%) in sand + vermiculite + perlite + cocopeat media (Table 46).

Field evaluation of tissue cultured date palm plants cvs. Halawy and Khalas

Tissue culture derived plants of Halawy (09) and Khalas (07) were transplanted in open field condition during 2017-18 for studying establishment, survival and other growth and development related parameters. After two years of transplanting, 12 plants were established and survived in the field condition. Average plant heights in cvs. Halawy and Khalas were recorded 66.12 and 69.97 cm, respectively. Number of fully expanded leaves in both the cultivars was varied from 4-16 and 6-14, respectively. Average plant spread (NS and EW) in cultivar Halawy was noted 62.65 and 67.58 cm while in Khalas 77.20 and 74.93 cm, respectively (Table 47 & Fig. 53).

Table 45. Effect of media on primary hardening of tissue cultured date palm plantlets

Parameters	Vermiculite	Sand+Vermiculite	Sand+Vermiculite + Perlite	Sand+Vermiculite + Perlite + Cocopeat
Date palm cv. Halawy				
Plants taken for primary hardening (PH)	20	20	20	20
Survived plants	14	03	05	08
Plant survival (%)	70	15	25	40
Required days for PH	60	94	78	72
Date palm cv. Khalas				
Plants taken for PH	20	20	20	20
Survived plants	12	02	06	09
Plant survival (%)	60	10	30	45
Required days for PH	66	90	81	76

Table 46. Effect of media on secondary hardening of tissue cultured date palm plantlets

Parameters	Vermiculite	Sand+Vermiculite	Sand+Vermiculite + Perlite	Sand+Vermiculite + Perlite + Cocopeat
Date palm cv. Halawy				
Plants taken for secondary hardening (SH)	14.00	3.00	5.00	8.00
Survived plants	8.00	1.00	1.00	3.00

Parameters	Vermiculite	Sand+Vermiculite	Sand+Vermiculite + Perlite	Sand+Vermiculite + Perlite + Cocopeat
Plant survival (%)	57.14	33.33	20.00	37.50
Required days for SH	540.00	645.00	670.00	590.00
Date palm cv. Khalas				
Plants taken for SH	12.00	2.00	6.00	9.00
Survived plants	7.00	0.00	2.00	2.00
Plant survival (%)	58.33	0.00	33.33	22.22
Required days for SH	550.00	--	680.00	605.00

Table 47. Field observations on tissue culture derived date palm

Date palm cv Khalas					Date palm cv Halawy				
Plant No.	Plant height (cm)	Plant spread (cm)		No. of leaves	Plant No.	Plant height (cm)	Plant spread (cm)		No. of leaves
		(NS)	(EW)				(NS)	(EW)	
1.	53.5	58.2	45.6	06	1.	98.6	84.4	80.3	13
2.	90.3	95	84	12	2.	70.5	65.7	73.8	12
3.	40	46	36	06	3.	43.5	30	45	03
4.	92	98	102	12	4.	30	30	32	04
5.	55	80	85	14	5.	78.8	75.4	80.7	16
6.	89	86	97	13	6.	75.3	90.4	93.7	11
Avg.	69.97	77.20	74.93	10.50		66.12	62.65	67.58	9.83

Fig. 53. Established tissue culture plants of Halawy and Khalas in the field

Crop Management and Agro-Techniques

Production system management in ber under hot arid ecosystem

In order to assess the performance of some commercial cultivars of ber on different training systems under drip, an experiment was initiated in 2017 in hot arid ecosystem of Rajashan. During second year of observations, growth and fruit bearing parameters of ber were significantly influenced by different varieties and training systems (Fig. 54). The maximum canopy spread and stem diameter was recorded in cv. Gola (Table 48). Branch intermingling and trunk cross

section area was found maximum in Thai ber, whereas minimum was found in cv. Thar Sevika due to difference in genetic makeup of the cultivar. Moreover, fruit set and bearing density was maximum in cv. Goma Kirti and minimum in Thai ber. Fruit drop was observed maximum in Thai ber probably due to lack of fertilization and physiological problems.

In general, ber grown on different training systems showed better for growth and bearing parameters over control except trunk cross section area which was more in control (Table 49). Among training systems, espalier system was superior with bearing density, branch distribution and minimum fruit drop over rest of the treatments. Fruit set was reported higher in Y shape training system (Table 50 and 51).

Y-Shape Espalier Telephone Control

Fig. 54. View of different training systems in ber

Table 48. Effect of different training systems on canopy volume and stem diameter in ber varieties

Variety	Canopy volume (m^3) after pruning					Stem diameter (cm)				
	Y Shape	Espalier	Telephone	Control	Mean	Y Shape	Espalier	Telephone	Control	Mean
Gola	5.89	4.07	3.69	4.40	4.51	5.32	5.12	5.41	5.84	5.42
Thai	3.62	2.45	3.85	3.67	3.40	4.77	5.32	5.56	5.59	5.31
Goma Kirti	2.72	1.99	2.43	2.23	2.34	4.71	5.37	5.22	5.87	5.29
Thar Sevika	1.20	0.64	0.97	1.68	1.12	3.14	3.26	3.78	3.85	3.51
Mean	3.35	2.29	2.73	2.99		4.49	4.77	4.99	5.29	
	SEm±		CD (5%)			SEm±		CD (5%)		
V	0.48		1.39			0.15		0.43		
T	0.48		NS			0.15		0.43		
VxT	0.96		NS			0.30		NS		

NS= Non-significant

Table 49. Effect of training systems on stionic differences and TCSA in ber varieties

Variety	Stionic ratio					Trunk cross-sectional area (TCSA-mm^2)				
	Y Shape	Espalier	Telephone	Control	Mean	Y Shape	Espalier	Telephone	Control	Mean
Gola	0.90	0.89	0.89	0.91	0.90	19.37	18.29	17.62	18.46	18.43
Thai Ber	0.93	0.94	0.89	0.89	0.91	10.94	19.21	21.78	21.96	18.47
Goma Kirti	0.89	0.87	0.86	0.87	0.87	18.15	15.16	10.70	24.96	17.24
Thar Sevika	0.81	0.81	0.82	0.85	0.82	6.89	7.09	7.74	8.87	7.65
Mean	0.88	0.88	0.87	0.88		13.84	14.94	14.46	18.56	
	SEm±		CD (5%)			SEm±		CD (5%)		
V	0.01		0.03			0.98		2.84		
T	0.01		NS			0.98		2.84		
VxT	0.02		NS			1.96		5.68		

Table 50. Effect of training systems on branch intermingling and bearing in ber varieties

Variety	Branch intermingling (%)					Bearing density (Fruits/m³ canopy)				
	Y Shape	Espalier	Telephone	Control	Mean	Y Shape	Espalier	Telephone	Control	Mean
Gola	24.00 (29.33)	30.80 (33.71)	18.92 (25.78)	5.30 (13.31)	19.76 (25.53)	715.03	741.51	635.58	653.24	686.34
Thai Ber	33.30 (35.24)	30.20 (33.34)	31.00 (33.83)	6.30 (14.54)	25.20 (29.24)	485.51	529.65	520.82	564.96	525.24
Goma Kirti	28.00 (31.95)	25.00 (30.00)	20.00 (26.57)	5.00 (12.92)	19.50 (25.36)	741.51	829.79	873.92	706.20	787.85
Thar Sevika	12.60 (25.40)	15.30 (23.03)	10.20 (18.63)	10.80 (19.22)	12.23 (21.57)	617.93	626.75	662.06	556.13	615.72
Mean	24.48 (30.48)	25.33 (30.02)	20.03 (26.20)	6.85 (15.00)		639.99	681.92	673.10	620.13	
	SEm±		CD (5%)			SEm±		CD (5%)		
V	1.44		4.16			37.95		113.85		
T	1.44		4.16			37.95		NS		
VxT	2.88		NS			75.91		NS		

NS= Non-significant

Table 51. Effect of training systems on fruit set and drop in ber varieties

Variety	Fruit set (%)					Fruit drop (%)				
	Y Shape	Espalier	Telephone	Control	Mean	Y Shape	Espalier	Telephone	Control	Mean
Gola	15.60	15.00	13.90	13.70	14.55	74.24	74.9	76.2	72.8	74.54
Thai	9.70	10.30	9.50	9.20	9.68	79.8	69.5	78.9	79.2	76.85
Goma Kirti	22.05	20.20	18.40	19.10	19.94	68.7	67.9	66.2	70.6	68.35
Thar Sevika	12.30	12.00	10.80	11.30	11.60	64.7	65	64.2	66.5	65.10
Mean	14.91	14.38	13.15	13.33		71.86	69.33	71.38	72.28	
	SEm±		CD (5%)			SEm±		CD (5%)		
V	0.72		2.07			1.03		2.97		
T	0.72		NS			1.03		NS		
VxT	1.43		NS			2.06		5.94		

NS= Non-significant

Performance of Thai ber at different spacing

Thai ber planted at different spacing (6 x 6 m, 6 x 3 m & 3 x 3 m) significantly influenced stem diameter, canopy spread, branch intermingling, fruit set, fruit drop and bearing density. The maximum stem diameter and canopy gain after pruning was recorded at 6 x 3 m spacing. Higher density at 3 x 3 m was better with fruit set and bearing density over other spacing. Further this 3 x 3 m spacing also observed minimum fruit drop probably reduced the wind velocity by maximum branches intermingling that slightly improved the fruit set status (Table 52).

Table 52. Effect of planting density on growth and fruit bearing parameters of Thai ber

Spacings	Plant height (m)	Stem diameter (cm)	Plant spread (m)		Canopy gain after pruning (m)	Branch intermingling (%)*	Fruit set (%)	Fruit drop (%)	Bearing density (Fruits/ m³) of canopy
			EW	NS					
6x6m	2.00	5.91	4.00	3.30	1.90	0 (0.0)	11.5	77.5	383.11
6x3m	2.30	6.95	4.20	3.70	2.40	9.5 (17.91)	13.0	60.4	551.54
3x3m	2.60	5.24	3.82	3.56	1.80	25.0 (29.94)	14.2	53.7	573.79
SEm±	0.19	0.28	0.26	0.15	0.09	0.57	0.65	1.57	48.35
CD (5%)	NS	0.88	NS	NS	0.27	1.79	2.01	4.89	150.62

* Value in parenthesis is transformation

Effect of plant architectural engineering on fruit cracking and quality of pomegranate

For cracking management and improvement in growth, yield and quality, plants were trained using different canopy management systems i.e. one, two and four stem training system and branchings were allowed at one and two feet height along with 10 and 20% pruning of growth during winter after fruit harvest. The experiment comprised of thirteen treatments i.e. T_1-Single stem branching at 1 foot + 10% pruning, T_2-Single stem branching at 1 foot + 20% pruning, T_3-Single stem branching at 2 feet + 10% pruning, T_4-Single stem branching at 2 feet+ 20% pruning, T_5-Two stem branching at 1 foot + 10% pruning, T_6-Two stem branching at 1 foot + 20% pruning, T_7-Two stem branching at 2 feet+ 10% pruning, T_8-Two stem branching at 2 feet+ 20% pruning, T_9-Four stem branching at 1 foot + 10% pruning, T_{10}-Four stem branching at 1 foot + 20% pruning, T_{11}-Four stem branching at 2 feet+ 10% pruning, T_{12}-Four stem branching at 2 feet+ 20 % pruning and T_{13}-Control without any training and pruning. Significant differences were observed on plant growth attributes (Table 53). During third year among all the treatment, maximum plant height, (1.35 m) was recorded in T_1-Single stem branching at 1 foot + 10% pruning and minimum in control (0.94 m). Canopy spread NS and EW found maximum (1.35 and 1.34 m) in treatment T_{10}-Four stem branching at 1 foot + 20% pruning and minimum

Table 53. Effect of training and pruning on growth and yield of pomegranate

Treatment	Plant height (m)	Canopy spread N-S (m)	Canopy spread E-W (m)	Canopy volume (m³)	Number of fruits /plant
T_1	1.35	1.12	1.15	0.91	10.50
T_2	1.32	1.15	1.16	0.92	8.67
T_3	1.28	0.89	0.87	0.52	8.25
T_4	1.25	0.94	0.95	0.58	6.67
T_5	1.22	1.27	1.24	1.00	13.25
T_6	1.18	1.29	1.25	0.99	10.67
T_7	1.16	1.15	1.11	0.77	9.33
T_8	1.13	1.19	1.14	0.78	7.45
T_9	1.18	1.33	1.31	0.96	15.25
T_{10}	1.16	1.35	1.34	0.94	14.67
T_{11}	1.12	1.25	1.2	0.80	12.33
T_{12}	1.1	1.28	1.23	0.79	10.45
T_{13}	0.94	1.05	1.01	0.47	6.20
CD (5%)	0.21	0.18	0.17	0.01	0.72

in control (1.05 and 1.01), respectively. Highest value for canopy volume was recorded (1.00 m^3) in T_5-Two stem branching at 1 foot + 10% pruning followed by T_6-Two stem branching at 1 foot + 20% pruning (0.99 m^3) and lowest canopy was found in control (0.47 m^3). The maximum number of fruits per plant (15.25) was recorded in T_9-Four stem branching at 1 foot + 10% pruning followed by T_{10}-Four stem branching at 1 feet + 20% pruning (14.67) and number of fruits per plant was found in control (6.20).

Flower regulation and identification of suitable bahar in pomegranate

Under hot arid climate of Rajasthan, pomegranate flowers continuously with three distinct flowering season during Feb.-April (ambe bahar), June-July (mrig bahar) and Sept.-Oct. (hasta bahar) which may not be desirable commercially due to non-synchronized maturity, inferior fruit quality with high cracking and low yield. Therefore, plants were subjected to flower regulation treatment i.e. withholding of irrigation for one month prior to bahar and ethrel (40%) 2 ml/l application for defoliation in different bahar/first bahar for standardized flower regulation treatment to reduce cracking and improve yield. There were ten treatment combinations including T_1-Ambe bahar (Jan.-Feb.), T_2-Late ambe bahar (March-April), T_3-Mrig bahar (June-August), T_4-Hasta bahar (Sep.-Oct.), T_{5-} Ambe bahar + Mrig bahar, T_6-Ambe bahar + Hasta bahar, T_7-Late ambe bahar + Hasta bahar, T_8-Mrig bahar + Hasta bahar, T_9-Ambe bahar + Mrig bahar + Hasta bahar and T_{10} Control (Natural flowering). Among all the treatments, earliest defoliation was observed in T_3-Mrig bahar (6.50 days), followed by T_4-Hasta bahar (7.37 days) and last defoliation was noticed in control (25.50 days). Per cent defoliation varied from maximum (85.26%) in T_3-Mrig bahar to lowest (20.18%) in control. Earliest sprouting of buds and flowering initiation was observed in T_3-Mrig bahar (15.23 and 37.57 days) as compared to delayed sprouting and flowering initiation in control (40.33 and 55.30 days), respectively. The shoot length was recorded maximum (38.23 cm) in T_3-Mrig bahar followed by T_4-Hasta bahar (32.15 cm) as against minimum (18.85 cm) in control (Table 54).

Table 54. Effect of flower regulation treatments on pomegranate growth attributes

Treatments	Days to defoliation	Per cent defoliation	Days to sprouting of buds	Days to flowering initiation	Shoot length (cm)
T_1	10.50	75.25	20.45	45.30	25.95
T_2	8.50	80.15	18.78	42.12	28.47
T_3	6.50	85.26	15.23	37.57	38.23
T_4	7.33	83.19	17.50	40.60	32.15
T_5	10.25	74.15	19.84	45.14	23.18
T_6	10.33	76.19	19.55	46.69	23.55
T_7	8.67	81.54	18.50	42.15	22.19
T_8	7.50	82.67	17.45	39.74	23.68
T_9	10.40	74.85	19.50	45.67	20.18
T_{10}	25.50	20.18	40.33	55.30	18.85
CD (5%)	1.29	7.54	1.81	3.05	2.23

Effect of pruning on growth, flowering, and fruit quality attributes of mango cv. Kesar

For conducting the pruning trial in mango, planting of 200 plants of Kesar mango under high density (5 x 5 m) has been done in 0.5 ha area. Treatments were imposed after harvesting of the fruits. Maximum fruit yield (40.20 kg/plant), TSS (20.30 ^{0} Brix) was recorded in (3.60 m plant height + 25% pruning). Fruit yield was recorded least in control (26.40 kg/plant).

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

Standardization of pit size

The maximum plant height (250 cm) was recorded in Khalas and Barhee cultivar with 1 x 1 x 1 m pit size while minimum plant height (100 cm) in Khuneizi cultivar with 0.5 x 0.5 x 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 and same trend was also recorded in plant spread. In cultivar Khalas, 25% plants have been flowered and first emergence was observed on 15th March 2019 and last spathe

emergence was recorded on 25th March 2019. In Barhee and Medjool cultivars also, only 25% plants have been flowered first time. In Barhee, first emergence was recorded on 22th March 2019 and in Medjool flowering started on 25th March 2019. The Ghanami cultivar (male) spathe emerged on 18th March 2019 and pollens were collected and used for pollination in all female cultivars. Fruiting in some plants have set during the report period. The effect of pit size was recorded only on the growth performance while on reproductive phase pit size did not show any effect on emergence of spathe. 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 x 6 m and 8 x 8 m was not been seen and survival, plant height and spread were not differed significantly in both the spacing.

Standardization of crop geometry

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 x 6 m and 8 x 8 m was not been seen and survival, plant height and spread were not differed significantly in both the spacing (Table 55). In cultivar Khalas and Barhee cultivars, 8-10 new leaves were emerged while in Medjool, it was 5-6 and minimum leave emergence i.e. 2-3 was in Khuneizi cultivar. In cultivar Khalas, Barhee and Medjool, 8-10, 2-3 and 5-6 suckers were emerged while in Khuneizi, 1-2 suckers were emerged. In Khalas and Barhee, spathe has been emerged in some plants in the month of February, however, same has been removed. In Khalas, 25% plants spathe emerged in the IIIrd week of February while in Barhees, 18% plants spathe emerged in Ist week of February and Ist week of March while in Medjool, 7-10th March 15% plants spathe emerged. Among all the cultivars, the overall performance was graded as Barhee > Khalas > Medjool > Khuneizi.

Studies on compatibility and adaptability of Kinnow, sweet orange, lime and lemon scions on different rootstock

Citrus is covering highest area and production among the fruit production of Rajasthan state but productivity is low due to lack of suitable varieties and rootstocks. With this view, various combinations (forty two) of scions and rootstocks were made and planted in the field as Kinnow, sweet orange cv. Mosambi and Satgudi were grafted on Pectinifera, Kharna Khatta, Rangpur lime, Volkamericana, Rough lemon, Cleopatra, Macrophylla, Sour orange and Carrizo rootstocks; lime (Sai Sarbati and Kagzi lime) and lemon cv. Pant lemon on Kharna Khatta, Rangpur lime, Volkamericana, Rough lemon and Macrophylla rootstocks. All the combinations were transplanted in the field and growing well. The compatibility and adaptability parameters are being recorded under field condition.

Standardization of production technology of bael under rainfed semi-arid condition

Efficacy of PGRs and chemicals for management of fruit drop and sun scald in bael

Various treatments combination (grass mulch + NAA 15 ppm + coarse cotton cloth, grass mulch + NAA 15 ppm + kaolin 1% , grass mulch + NAA 15 ppm + ascorbic acid 1000 ppm, grass mulch + NAA 15 ppm + KH_2PO_4 500 ppm, grass mulch + $ZnSO_4$ 1000 ppm + coarse cotton cloth, grass mulch + $ZnSO_4$ 1000 ppm + kaolin 1%, grass mulch + $ZnSO_4$ 1000 ppm

Table 55. Growth parameters of different tissue cultured varieties of date palm

Varieties	Plant height (cm)	East x West (cm)	North x South (cm)	No. of leaves	No. of spathe	No. of strand	Number of fruit per strand at pea stage
Khalash	255	234	246	14	4	12.4	8
Barhee	252	332	337	17.6	2	10.2	10.2
Medzool	190	252	266	18.8	1	2	5
Khunezi	107	112	123	11.4	-	-	-

+ KH_2PO_4 500 ppm, grass mulch + $ZnSO_4$ 1000 ppm + ascorbic acid 1000 ppm and control) were applied to control fruit drop and sunscald. The minimum fruit drop (95.13%) and sun scald (19.52%) and the highest fruit retention (3.15%) were recorded with grass mulch + NAA (15 ppm) + course cotton cloth followed by grass mulch + NAA (15 ppm) + ascorbic acid (96.50, 25.30 and 3.00%) and grass mulch + Zn SO_4 (1000 ppm) + coarse cotton cloths (97.20, 27.05 and 2.18%), whereas fruit drop and sunscald affected fruits were recorded maximum in control (98.57% and 50.28%) while fruit retention was also recorded minimum (1.98%) in control.

Effect of canopy management on growth, yield and quality of bael cv. Goma Yashi

Various pruning treatments were imposed during 2019, observations related to growth, flowering and fruiting were recorded. The maximum number of shoots (3.78) was recorded with treatment T_3 (3m plant height + 25% pruning). However the length of shoot (47.57 cm) was recorded in T_5 (3 m plant height + 50% pruning). Average yield per plant was recorded highest with 3 m plant height + 25% pruning (67.19 kg) followed by 2.5 m plant height +25% pruning (59.00 kg), whereas lowest yield per plant was observed with 2.5 m height +75% pruning among the different combination of plant height and pruning intensity. Fruit size and TSS was recorded the maximum in the plants height maintained at 3 m plant height with 25% pruning (Fig. 55).

Standardization of maturity indices in bael varieties under rainfed condition

Different bael varieties (Goma Yashi, Thar Divya, Thar Neelkanth, CISHB-1, CISHB-2, NB-5, NB-7, NB-9, NB-6, NB-17, Pant Aparna, Pant Sujata, Pant Shivani, Pant Urvashi) were studied for their maturity indices. Bael fruits remain intact on the tree for longer duration (9-11 months) which depends upon the variety and prevailing climatic condition to particular locality. In general, ripening of fruit is judged by the turning of fruit shell and flesh colour, TSS and aroma of fruits. Among the varieties, Thar Divya acquired full maturity in January and ripening initiated from the first week of February (260-270 day from fruit setting) followed by NB-7, NB-9, NB-16, NB-17, Pant Aparna, Pant Urvashi (300-320 days from fruit setting), whereas ripening in NB-5 and CISH-2 was observed very late (310-330 days) under rainfed semi-arid conditions.

Evaluation of fruit based diversified cropping models

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 were recorded in already 10 year old established plants of

Pruning of 25% annual growth extension

Flowering behaviour after pruning

Fig. 55. Canopy management in bael

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.

Higher plant height of aonla was found in sole aonla (4.81m) followed by aonla ber (4.14 m) while minimum plant height of aonla in aonla- karonda followed by aonla + moringa. Maximum plant girth of aonla was recorded in aonla + ber (48 cm) cropping system followed by aonla + bael (43 cm) aonla + *khejri* (42 cm) and while minimum plant girth was observed in sole aonla (35 cm). The average yield of aonla varied considerably in different cropping model systems with highest being recorded in aonla-*khejri* (66.58 kg/plant) followed by aonla-ber (63.24 kg/ plant) and aonla-karonda (61.82 kg/ plant), while the lowest (55.24 kg/plant) was recorded in aonla-moringa (Fig. 56). 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 16-41 kg per tree, while a single fruit weighed around 1.62 kg with maximum and minimum fruit weights recorded to be 3.96 and 0.4 kg, respectively. The average yield of karonda was recorded 13.32 kg/plant planted in between aonla plants. Likewise, the yield of ber cv. Seb was recorded 46.73 kg/plant in model M-1.

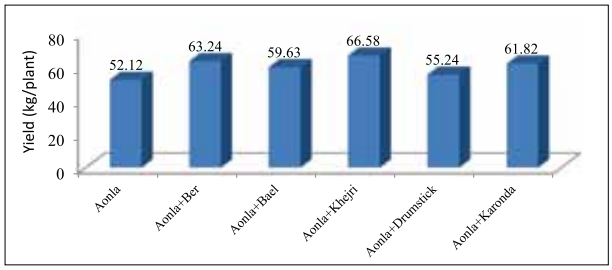


Fig. 56. Aonla yield under different cropping models

Dehydrogenate activity responded significantly across the different fruit based cropping systems and their interaction soil. Highest values obtained in August due to the presence of optimum temperature during August (wettest months) that is congenial for the growth and functioning of soil microbes. The highest increase in the value of dehydrogenase activity (5.12 µg of TPF released per gram of soil per day) was registered in aonla-*khejri* based croppings system. Alkaline phosphatase (ALP) is the key enzyme in phosphorous transformation cycle because of its role in mineralizing organic phosphorous into plant available phosphorous. The ALP enzyme activity showed significant variation among different cropping systems. The range of alkaline phosphatase activity varied from 3.72 - 6.32 µg PNP released per gram soil per hour. ALP activity depends on several factors including soil properties, organic amendments, and microbial interactions. Urease activity is widely used to assess the impact of soil management practices on soil quality. In the present study, urease activity showed a significant difference under different aonla based cropping systems. Higher urease activity was recorded under aonla *khejri* based cropping system. Higher concentration of nitrogen in soil stimulates the urease activity amended with different carbon substrates.

Standardization of plant propagation

Standardization of seed/ planting material standards of lasoda cv. Thar Bold

Seed standard

In order to produce healthy rootstocks for budding purpose, proper seed standard is required. Therefore, starting from maturity indices, seed extraction, germination, growth etc. were standardized for lasoda, as give in Table 56.

Table 56. Seed standards of lasoda cv. Thar Bold

S. No.	Description	Planting material standards
1.	Period of fruit ripening	Last week of May to 3rd week of June
2.	Stage of fruit collection	Fully ripe at pink stage
3.	Method of seed extraction	Manually by removing pulp from seeds
4.	Method of seed cleaning	By rubbing freshly extracted seed with sand
5.	Time of seed sowing	Middle of June

S. No.	Description	Planting material standards
6.	Germination medium	Vermiculite based
7.	Germination tray	Root trainer
8.	Initiation of germination	After about 15 days of sowing.
9.	Date of complete germination	First week of July
10.	Duration of germination	8 days
11.	Germination %	67.50 %
12.	Plant height after 1 week	4.10 cm
13.	Plant height after 2 weeks	6.61 cm
14.	Plant height after 3 weeks	9.05 cm
15.	Plant height after 4 weeks	11.56 cm
16.	Plant shifting	Plant shifted into polybags (15x10 cm) filled with soil and FYM (2:1)
17.	Plant height during shifting	10.7-12.3 cm
18.	Plant height after 8 weeks	20.33 cm
19.	Plant height after 12 weeks	33.3 cm
20.	Plant height after 24 weeks	52.51 cm
21.	Plant girth after 24 weeks	7.85 mm
22.	No. of leaf after 24 weeks	12.50
23.	Internodal length after 24 weeks	4.29 cm
24.	Plants ready for transplanting	5-6 months after seed sowing

Time of budding

Experiments were conducted on lasoda cv. Thar Bold for standardization of seed/planting material standards. Three different periods (16-22 May, 16-22 June and 16-22 July) of patch budding on seedling rootstocks (9-12 months old) was done to find optimum time and maximum success per cent of lasoda budding. For making budding, scion wood was taken from current season's growth of mother lasoda plant cv. Thar Bold. Budding was made on 15-22 cm from above ground level having rootstocks diameter ranging from 7.42-10.35 mm. The bud sprouted first on 7th day and completed within 9th day when budding was done during 16-22 May followed by budding during 16-22 June on 11th day and at last on 17th day budding during 16-22 July. Similar trends were also observed with maximum bud sprout success after 15th and 30th days of budding. Maximum plant success (80%) was recorded when budding was done during 16-22 May followed by (55.56%) budding during 16-22 June and least (33.33%) in 16-22 July budding. It was concluded that patch budding during 16-22 May found most suitable time for Thar Bold with highest budding success (80%). These budded plants can be transplanted in same season in the field (Table 57).

Table 57. Standardization of seed/ planting material standards of lasoda cv. Thar Bold

Budding Time	Budding height (cm)	Diameter of rootstock during budding time	Bud sprout (%) after 15 days	Bud sprouting period	Bud sprout success % after 30 days	Budded plant success % after 90 days	Plant height at 90 days (cm)	No. of leaf at 90 days
16-22.05.2019	18.80 (15-22) cm	8.20 (7.42-8.59) mm	86.67	7-14 (10.4) days	80.00	80.00	52.4-59.3 (56.25)	12-15 (12.4)
16-22.06.2019	18.00 (16-20) cm	8.59 (7.95-10.35) mm	64.4	11-22 (15.8) days	55.56	55.56	37.5-43.2 (40.8)	8-13 (10.6)
16-22.07.2019	18.60 (16-22) cm	8.50 (7.62-9.25) mm	37.78	17-25 (20.6) days	33.33	33.33	32.2-40.2 (36.6)	8-10 (8.4)

Plant standard

After standardizing the time of patch budding, the work on plant standard development was initiated. For this, further a replicated trial was initiated by performing budding on 45 rootstocks in each month. All possible parameters related to rootstock, scion and component plants were taken into consideration. The final standard is given in Table 58.

Propagation of bael

Effect of scion age and budding (*in-situ*) time

For getting vigorous and healthy scion shoots in the month of May, the branches (1-2 year old) were detopped in April during leaf less condition of the tree. The multiple axillary shoots arise below the cut portion and attain the length of 40 to 50 cm in two months; vigorous and healthy in growth were selected and used as scion shoot. Results of the study revealed that the plants grafted in May recorded 94.47, 89.20 and 60.20 per cent success through patch budding (1-1½ month old shoots), softwood grafting (4-6 month old shoots) and softwood patch budding, respectively (Fig. 57). For softwood patch budding, 70 days old rootstocks and scion shoots were collected from 20-25 days old shoots and used for budding. The maximum mean length of sprout i.e. 61.00 cm was recorded when patch budding was done in May closely followed by June (52.30 cm) and July (48.10 cm), whereas least length of sprout

Table 58. Planting material standards of lasoda cv. Thar Bold

S. No.	Planting material standards	Description
1	Age of rootstock	9-12 months old
2	Budding height (cm)	15-22 cm above ground level
3	Diameter of rootstock during budding time	8.20 mm
4	Method of vegetabe propagation	Patch budding
5	Budding time	16-22 May
6	Type of scion wood	Current season's growth
7	Bud sprouting period	7-14 days
8	Bud sprout success after 15 days	86.67%
9	Bud sprout success after 30 days	80.00%
10	Budding success % after 90 days	80.00%
11	Plant height at 90 days	52.4-59.3 cm
12	No. of leaves of budded plant at 90 days	12-15
13	Budded plants ready for transplantation	Within 90 days
14	Same season planting possible or not	Yes

Patch budding

Soft wood grafting,

Softwood patch budding

Fig. 57. Effect of scion age and budding in bael

was recorded in August (42.37cm). The highest number of trifoliate leaves (41.00) per plant was recorded from the plants when the budding was done on May followed by June (24.00) and July (23.20) and minimum was recorded in August i.e. 25 leaves. It was concluded that the May month is ideal time for multiplication of bael in hot rainfed semi-arid conditions of western India.

Multiplication of *ker* through cutting

Ker crop is very hard to propagate and prepare planting materials by any means of plant multiplication. Therefore, an experiment was conducted to multiply ker through stem cuttings. For the purpose, three types of cuttings viz., hardwood cutting, semi- hardwood cutting and soft- wood cutting were used at three different time periods (15 August, 15 September and 15 October). Three types of potting media and mixes were used i.e. sole sand, sole clay and clay + vermiculite + clay (three layers; bottom clay, middle layer vermiculite and upper layer again clay without mixing among them). The length of cuttings was 30-35 cm. All 3 types of cuttings were planted in plastic pots under green house condition and observations were recorded with respect to number of days taken to sprout, number of sprouts emerged from cuttings, sprout length, rooting success, average plant height after 6 months and average plant height after 12 months etc. (Table 59). Irrigation was given to all pots twice every day i.e. morning and evening. Success of preparing plants was obtained only in semi-hardwood stem cuttings when planting was done on 15 September with all three types of potting media and mixes. Minimum days (10-15) required to sprout cutting was observed in clay + vermiculite + clay potting media followed by sand (13-21) and maximum (17-26) in clay. Rooting success percent was recorded highest (53.33) in clay + vermiculite + clay followed by sand (40.00%) and lowest in clay (26.67%). Average plant height at 6 and 12 months was found maximum i.e. 38.56 and 73.50 cm in sand potting media followed by clay + vermiculite + clay potting media (32.14 and 47.5 cm) and minimum in clay (20.23 and 41.50 cm), respectively. On the basis of result obtained from experiment, it is recommended that September month is the optimum time for ker multiplication through semi-hardwood cutting. Total 35 rooted plants were prepared from this experiment which will be transplanted in the field condition for studying establishment, survival, growth and other necessary parameters.

Table 59. Standardization of planting material standards of *ker* through stem cuttings for multiplication of thornless (elite) germplasm

Type of stem cutting	Media & mixes	Time of planting in to pots	Days to sprout	No. of sprouts/ cutting	Sprout length after 2 months (cm)	Rooting success	Average Plant height after 6 months (cm)	Plant height after 12 months (cm)
Hard wood cutting	Sand	15.08.18	Dried	---	---	---	---	---
		15.09.18	27-32	1-3 (1.8)	Dried	Not occurred	---	---
		15.10.18	Dried	---	---	---	---	---
	Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	Dried	---	---	---	---	---
		15.10.18	Dried	---	---	---	---	---
	Clay: Vermi.: Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	24-26	1-4 (2.4)	Dried	---	---	---
		15.10.18	Dried	---	---	---	---	---
Semi- Hard wood cutting	Sand	15.08.18	Dried	---	---	---	---	---
		15.09.18	13-21	1-3 (1.8)	15-32 (20.4)	40.00%	38.56	73.50
		15.10.18	Dried	---	---	---	---	---

Type of stem cutting	Media & mixes	Time of planting in to pots	Days to sprout	No. of sprouts/ cutting	Sprout length after 2 months (cm)	Rooting success	Average Plant height after 6 months (cm)	Plant height after 12 months (cm)
	Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	17-26	1-2 (1.4)	7-21 (12.5)	26.67%	20.23	41.5
		15.10.18	Dried	---	---	---	---	---
	Clay: Vermi.: Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	10-15	2-4 (2.14)	11-26 (17.2)	53.33%	32.14	47.5
		15.10.18	Dried	---	---	---	---	---
Soft wood cutting	Sand	15.08.18	Dried	---	---	---	---	---
		15.09.18	Dried	---	---	---	---	---
		15.10.18	Dried	---	---	---	---	---
	Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	Dried	---	---	---	---	---
		15.10.18	Dried	---	---	---	---	---
	Clay: Vermi.: Clay	15.08.18	Dried	---	---	---	---	---
		15.09.18	7-10	2-4 (2.8)	7.4-18.5 (10.76)	Not occurred	Dried	Dried
		15.10.18	Dried	---	---	---	---	---

Multiplication of ivy gourd

In general, ivy gourd known as kundru (*Coccinia indica*) is propagated through cuttings during monsoon season (July-August). To standardize year the round plant multiplication technique in ivy gourd, hard/semi-hard wood cuttings of var. 'Thar Sundari' were taken for the study and also with varying situations during rainy and winter season. Both hard and semi-hard wood cuttings of July (rainy season) gave 65.8 % success and plants were ready in 30 days for transplanting. Under hot arid environment, fully developed plants may get damaged due to extremes of low temperature/frost condition. Therefore, a large number of cuttings can be taken before severity of winter as a protective measure to save the plants. Accordingly, a large number of cuttings were taken and planted under two situations i.e. raised bed and portray which were kept under coat type structure using polythene as a covering material. Raised bed recorded 71.4 % sprouting in comparison to portray which had 45.7% sprouting. Therefore, it is recommended that hard/semi-hard wood cuttings of about 18-24 cm length are found suitable for multiplication of ivy gourd both during rainy and winter season adopting low cost protective technique for quality planting materials (Fig. 58).

Fig. 58. Multiplication of Ivy gourd through cutting

Standardization of seed germination method in drumstick

Standardized seed germination methods for Thar Harsha with different treatments viz., seed with wing-top of the paper method (TP), seed without wing-top of the paper method (TP), seed with wing-between paper (BP) and seed without wing-between paper (BP). It was found that seed without wing kept in between paper (rolled towel method-BP) produce healthy and vigorous seedling with highest germination (66%) followed by seed with wing-BP (48%) while, the lowest germination (22%) was found in seed without wing-TP followed by seed with wing-TP (42%) with poor seedling growth.

Effect of mulching

Effect of different mulches on soil properties, growth, yield and quality of mango

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 varied significantly with paddy straw followed by grasses. Soil moisture content was recorded maximum with paddy straw mulch at both the depths of soil (0-15 cm and 15-30 cm). Soil moisture ranged 19.80-15.50, 21.30-17.90% in paddy straw and it was recorded 15.50-13.00, 16.90-14.50% in control at both the depths from soil surface after mulching. 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. Plants treated with paddy straw mulch recorded highest yield (48.10 kg/plant), followed by grasses (46.10 kg/plant) and black polythene mulch (42.10 kg/plant) and it was recorded minimum in control (30.10 kg/plant). Maximum TSS (20.50 ^{0} Brix) was noted in paddy straw mulch followed by grasses (20.20 ^{0} Brix) and polythene mulch (20.00 ^{0} Brix), it was recorded least in control (19.40 ^{0} Brix).

Effect of different mulches on growth, yield and quality of sweet orange cv. Satgudi

Maximum fruit yield per plant (27.00 kg) was recorded in paddy straw mulch followed by grasses (22.20 kg/plant), black polythene mulch (18.00 kg). Minimum fruit yield (13.00 kg/plant) was recorded under control. Maximum fruit weight (242.20g) and TSS (13.30°Brix) was recorded in paddy straw mulch followed by grasses and black polythene mulch.

Effect of mulches, manure, biofertilizer and fertilizer on soil properties, growth, yield and quality of bael cv. Goma Yashi

Among different combination of mulches, biofertilizer and fertilizer, plant height (3.70 m) was recorded maximum in standard dose of NPK followed by grass mulch + FYM + neem cake + 50% recommended dose of NPK + *Azotobactor* + VAM culture; grass mulch + FYM + 25% recommended dose of NPK + *Azotobactor* + PSB culture; and it was recorded minimum in FYM @ 20 kg/plant, whereas plant spread (3.50 m), stem girth (28.67 cm) and number of fruit retention (5.23 fruits/plant) was also recorded the maximum with grass mulch + FYM + neem cake + 50% recommended dose of NPK + *Azotobactor* + VAM culture under rainfed semi-arid conditions (Table 60).

Table 60. Effect of different manures, bio-fertilizers and fertilizers on plant growth of bael

Treatments	Plant height (m)	Plant spread (m)	Stem girth (cm)	Number of fruits/ plant
1. Standard dose of NPK	3.70	3.43	22.00	3.00
2.FYM (@5kg/plant) increse@5kg every year up to 10 years	3.00	2.85	24.18	3.19
3.Grass mulch + FYM + 50% recommended dose of NPK+ *Azotobactor* + PSB Culture	3.54	3.40	25.14	3.24
4.Grass mulch+ FYM + 25% recommended dose of NPK + *Azotobactor* + PSB Culture	3.55	3.35	26.87	4.15
5.Grass mulch + FYM + neem cake + 50% recommended dose of NPK + *Azotobactor* + VAM culture	3.65	3.50	28.67	5.23
6.Grass mulch + FYM + neem cake + 25% recommended dose of NPK + *Azotobactor* + VAM culture	3.97	3.65	26.20	3.67
7.Grass mulch+ FYM + neem cake + *Azotobactor* + PSB + VAM Culture	3.20	2.90	23.60	3.27

Protected cultivation of vegetables under hot arid conditions

Standardization of sowing date and covering material in longmelon

An experiment on low tunnel cultivation of longmelon was taken up to standardize the date of sowing and covering material (Fig. 59). Longmelon var. 'Thar Sheetal' was sown on four different sowing date i.e. 10th December, 20th December, 30th December and 10th January along with sowing on 10th February under open field condition. Two types of covering material i.e. biodegradable plastic sheet of 25 micron and non-woven cloth (25 gsm) were used. The covering material was removed during second week of February after gradual hardening of the plants. It was found that germination and appearance of male flower was earlier in biodegradable plastic sheet of 25 micron than non-woven cloth (25 gsm) because the temperature inside the tunnel with polythene cover was comparatively higher than the non-woven cloth. Under different treatments, days to first male flower exhibited a range of 41-50 days. The character days to first female flower exhibited a range of 44 to 55 days. Days to first harvest ranged from 50 to 62 days. The crop raised under tunnel (10th December with polythene covering) attained the harvestable maturity on 9th February in comparison to open field sowing, came in harvesting on 2nd April which was 49 days later than the tunnel. Tunnel facilitated the early harvest of crop which earn higher market price in off-season than the normal season.

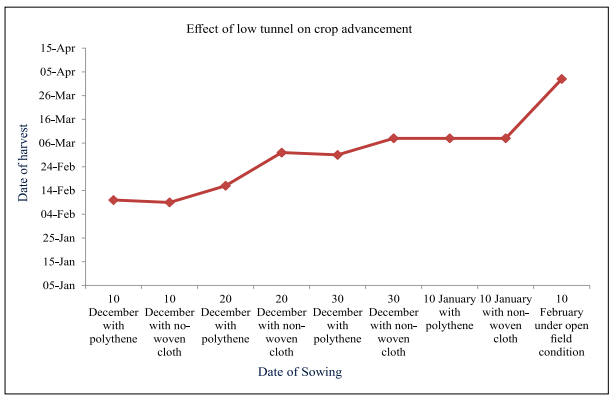


Fig. 59. Effect of sowing time on harvest time in longmelon under tunnel.

Data recorded on fruit and yield attributes revealed significantly influenced by the sowing date and covering material. Number of fruits per plant ranged from 13.6 to 18.2. Fruit length and fruit diameter ranged from 23.4 to 27.6 cm and 1.58 to 1.84 cm, respectively. The mean weight of fruit ranged from 57.3 to 75.8 g. The fruit yield per plant ranged from 1.25 to 1.96 kg. The fruit yield ranged from 103.88 to 163.68 q/ha. The sowing on 20th December with polythene covering recorded the maximum fruit yield per hectare (163.68 q) followed by sowing on the same date with non-woven covering (157.65 q) and the minimum was recorded in sowing under open condition (103.88 q). Higher yield under tunnel condition was also supported by fruiting duration as it was observed that the treatment having the highest yield had 62 days of crop duration in comparison to open field condition which had 44 days of crop duration only. With the use of tunnels, it is possible to harvest warm season crops up to 50 days earlier in the spring and extend the growing season. The low tunnel made the difference in comparison to open field because the produce harvested during second week of February from low tunnel is sold at Rs. 40-50 per kg against Rs. 10-15 per kg from the produce harvested during first week of April from open field. Net income and cost benefit ratio of sowing under low tunnel was significantly higher than the sowing under open field condition and the highest C:B ratio (2.16) was achieved by sowing the crop on 20th December under tunnel with non-woven cloth followed by polythene sheet.

Standardization of sowing date and covering material in watermelon

Water melon was sown on four different date of sowing i.e. 20th December, 30th December, 10th January under tunnel and 10th February, 2019 under open condition to standardize the sowing date and covering material under tunnel for early season harvest (Fig. 60). Two types of covering material i.e. biodegradable plastic sheet of 25 micron and non-woven cloth (25 gsm) was used. Observations on various growth and yield parameters were recorded.

In second week of February, when outside temperature increased, the covering was completely removed after gradual hardening of the plants. Under different dates of sowing and covering material, it took 7-14 days after sowing for 50% germination. Data revealed that it took 49-57 and 54-62 days after sowing for first male and female flower, respectively, whereas days to first and last harvest ranged from 83-91 and 101-109 DAS under different dates of sowing and covering material (Table 61). Low tunnel had significantly higher yield than open field condition and the maximum fruit yield was recorded with sowing on 10th January, 2019 with polythene covering followed by sowing on the same date with non-woven covering in the first year of experiment.

Fig. 60. Off season vegetable cultivation under polytunnels in arid region

Performance studies on predominant gynoecious ridge gourd for protected cultivation

During rainy season of 2019, an advance breeding material of ridge gourd, predominantly gynoecious line AHRG-15-4-1 was further studied based on uniqueness for several generations. The progeny was tested with large population and variations were recorded within the progeny for flowering, sex form and fruiting pattern. Two types of sex form i.e. predominantly gynoecious and absolute gynoecious sex forms were observed. Flowering initiated with appearance of female flower (solitary in leaf axil) first at lower nodes in plants with predominantly gynoecious sex form. Later on, male flowers were also observed in clusters at higher nodes. It exhibited earliness for days to first tender fruit harvest (45 days after sowing). Whereas, plants with absolute gynoecious sex form had female flowers only and cluster bearing in nature. Selected plants with potential trait were isolated, selfed and seeds were harvested separately for further evaluation.

Performance studies on solanacious vegetables under protected conditions

Tomato

To understand growth, fruiting and quality

Table 61. Effect of sowing date and covering material on watermelon

Date of Sowing	Covering material	Days to first male flower (DAS)	Days to first female flower (DAS)	Days to first harvest (DAS)	Days to last harvest	Fruiting duration (days)
20th December, 2018	Polythene sheet	56	62	91	107	16
20th December, 2018	Non-woven cloth	57	61	89	105	16
30th December, 2018	Polythene sheet	55	58	87	105	18
30th December, 2018	Non-woven cloth	54	59	86	102	16
10th January, 2019	Polythene sheet	51	57	83	109	26
10th January, 2019	Non-woven cloth	49	56	85	108	23
Normal sowing i.e. 2nd week of February under open condition		51	54	84	101	16

of tomato under protected condition, the genotype AHSL-1 was evaluated with two environments during spring-summer and *kharif* season of 2019 (Fig. 61). The seedlings of about 21-25 cm height were transplanted adopting drip technology of crop cultivation. Observations were recorded on growth and yield parameters during both the seasons. Under low cost and innovative shading technique of protective condition, the seedlings attained 53.0 cm height (45 DAP) and exhibited flowering at 22 days after transplanting. For days to first fruit harvest, it took 65-70 DAP under shade net, whereas, it took 75-79 DAP under open condition. Besides, fruit development with higher number of fruits per plant (37-65) was observed under shade net condition in contrast to open field crop where plant height was 33.5 cm and less fruiting (18-42) was observed. Based on preliminary observation, the genotype has the potential for cultivation under hot arid environment. Individual plant selection and generation advancement was done for further evaluation.

Fig. 61. Fruiting pattern in tomato genotype AHSL-1 during summer season

Brinjal

To understand growth, fruiting and quality in brinjal under protected condition, the genotype AHB-03 (CIAH-22) was evaluated with two environments during spring-summer season of 2019 (Fig. 62). The seedlings of about 14-16 cm height were transplanted adopting drip technology of crop cultivation. Under low cost and innovative shading technique of protective condition, the seedlings attained 28.0 cm height (45 DAP) and exhibited flowering at 46-50 days after transplanting in contrast to open field crop where plant height was 15.0 cm and flowering was observed 59-62 DAP. For days to first fruit harvest, it took 67-72 DAP under shade net, whereas, it took 75-79 DAP under open condition. Based on overall performance, individual plant selection and generation advancement was done for further evaluation.

Fig. 62. Brinjal genotype AHB-03

Chilli

To understand growth, fruiting and quality in chilli under protected condition, the genotype mathania type selection-1 was evaluated with two environments during spring-summer and *kharif* season of 2019 (Fig. 63). The seedlings of about 8-12 cm height were transplanted adopting drip technology of crop cultivation. Under low cost and innovative shading technique of protective condition, the seedlings attained 29.5 cm in contrast to open field crop plant where height was 18.0 cm (40 DAP). There was seasonal difference in performance of the genotype with respect to plant growth, flowering and fruit set. The genotype had light green fruits with typical


Fig. 63. Chilli genotype mathania type selection-1

fruit shape. The genotype had higher number of fruits per plant (46-84) under shade net condition in contrast to open field crop over the season where less number of fruits per plant (28-48) was observed. Generation advancement of selected superior plants based on plant growth, fruiting and fruit quality was done for further evaluation and improvement.

Vegetable seed production

During 2019, seed production of snap melon (AHS-82; 12.200 kg), *kachri* (AHK-119; 101 kg), sponge gourd (Thar Tapish; 28 kg), cluster bean (Thar Bhadavi; 58 kg), *palak* (Thar Hariparna; 37 kg), brinjal (Thar Rachit; 0.650 kg) and other arid vegetable crop varieties was done. About 236 kg seed of arid vegetables 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. Seed production resulted in revenue generation of Rs 3.10 lakh for the institute.

Potato cultivation in non traditional areas of India

In order to meet high demand of potato in arid region, it was thought to introduce potato in north western region of Rajasthan. However, lack of situation specific knowledge about scientific cultivation of potato hampered its introduction. Moreover, arid region is characterized as sandy soils with poor fertility and subjected to wind erosion, very low (213 mm/annum) and erratic rainfall, extremes of temperature and frost during winter, poor water resource etc. Keeping in view, to device a sustainable solution of the problem, ICAR-CIAH, Bikaner (Rajasthan) and ICAR-CPRI carried out a joint study to assess feasibility of introducing potato crop in north-western part of the country by conducting series of field experiments at ICAR-CIAH, Bikaner.

Results revealed that tuber yield varied significantly from variety to variety under sprinkler and drip irrigation system. Among both irrigation systems, in general, higher tuber yield was obtained under sprinkler system than drip system. Under sprinkler irrigation, Kufri Chipsona-4 gave highest yield (534.8 q/ha) followed by Kufri Frysona (479.7 q/ha) and Kufri Jyoti (465.1 q/ha), Kufri Garima (430.9 q/ha), Kufri Surya (398.6 q/ha) and Kufri Khyati (387.6 q/ha) while minimum yield was observed in Kufri Pukhraj (338.9 q/ha). In case of drip irrigation, Kufri Frysona gave highest yield (435.37 q/ha) followed by Kufri Chipsona-4 (428.67 q/ha), Kufri Garima (374.45 q/ha) and Kufri Jyoti (344.58 q/ha) and minimum yield was observed in Kufri Pukhraj (203.99 q/ha). The tuber yield of all varieties was also classified into large (>75 g), medium (25-75 g) and small (<25 g) categories under both irrigation systems and it was observed that >71.40% tubers were under large size category. Similarly, dry matter content was also assessed and it was found that the highest dry matter content was 22.22% in Kufri Frysona and minimum in Kufari Khayati (15.09%) at 90 days of harvesting. Based on the tuber yield, size of tuber, dry matter content and appearance of tuber, it is suggested that potato varieties like, Kufri Chipsona-4 and Kufri Frysona are suitable as processing types while

Kufri Garima and Kufri Jyoti as table types for cultivation under sprinkler system in hot arid region of Rajasthan.

The highest net return was obtained by the cultivation of Kufri Chipsona-4 under sprinkler system (Rs.117664/ha) followed by Kufri Frysona (Rs. 98403/ha) and Kufri Jyoti (Rs. 93271/ha) and minimum in Kufri Khyati (Rs. 66172/ha). Whereas, under drip system, highest net return was obtained is Kufri Frysona (Rs.82878/ha) followed by Kufri Chipsona-4 (Rs. 80536/ha) and minimum again in Kufri Khyati (Rs. 47149/ha). The B:C ratio was also found higher where net return was more. The highest B:C ratio was recorded in Kufri Chipsona-4 (2.69) followed by Kufri Frysona (2.42) under sprinkler system, whereas, Kufri Frysona (2.19) gave higher followed by Kufri Chipsona-4 (2.16) under drip irrigation system.

Integrated Nutrient and Water Management

Standardization of integrated nutrient management in arid horticultural crops

Effect of different INM treatments on microbial population

In the present study, three types of biofertilizers i.e. *Azotobactor*, PSB and AMF biofertilizers are used in the different treatments. For making standard doses of biofertilizers same were tested for their microbial load. The *Azotobactor* biofertilizer was tested for bacterial population and 5.5 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 10.5 x 10^9 bacteria population and other physico-chemical properties were also found in order.

Monitoring of microbial population at two depths (0.00 - 0.15 and 0.15 - 0.30 m) during 2019 was carried out in kinnow field. The bacterial population in different treatments ranged from 7.8 to 40 x 10^5 cfu g^{-1} soil, fungal from 2.5 to 4.8 x 10^5 cfu g^{-1} soil and actinomycetes from 16-22 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. Total population as well as individual population of different microorganism increased with involvement FYM and consortium of biofertilizers. This is because most of the soil micro-organisms are chemoheterotrophs which require organic source of carbon as food and oxidation for organic substances provides energy. Under different INM treatments, the total and individual population of different micro organisms were higher where nutrients 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 populations were higher in the surface than subsurface soil.

Effect of different INM treatments on morphological parameter of kinnow

The data revealed that significantly maximum plant height (6.00 m) was recorded in RDF of N, P, K + FYM + PSB + *Azotobactor* + VAM treatment and minimum was in control (3.00 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.

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 revealed that maximum fruit weight (230 g) was recorded in RDF of N, P, K + FYM + PSB + *Azotobactor* + VAM which was significantly at par with RDF of N, P, K + FYM + *Azotobactor* treatment. The minimum fruit weight (110 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 (7.80 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 13.50 °Brix and data revealed that addition of FYM, inorganic fertilizers increased the TSS content. The acidity content was recorded maximum in control and inorganically fertilized treatments while FYM reduced the juice acidity. The juice recovery was ranged from 45 to 52 per cent and maximum juice (52%) was recorded in those treatments where FYM was the component of the treatment.

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

The benefit cost ratio of different INM treatments was evaluated for 18 year old 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 costs 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. 10000/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 (3.96) was recorded in treatment T_{10} and minimum (2.10) was in control (Table 62). The data revealed that adding of FYM with recommended dose of NPK increased the benefit cost ration while adding of AMF did not the benefit in the income.

The soil physico-chemical properties of the soil under different INM treatments were measured periodically and data depicted 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

Table 62. Evaluation of benefit cost ratio of different INM treatments in Kinnow fruit crop

Treatments	Fixed cost ('000)	Treatment Cost ('000)	Total cost ('000)	Yield (t/ha)	Gross income ('000)	Net income ('000)	B:C ratio
Control	25	-	25	7.75	77.50	52.50	2.10
RDF of N, P and K	25	10	35	12.50	125.00	90.00	2.57
RDF + FYM	25	15	40	15.00	150.00	90.00	2.25
RDF +AZB	25	12	37	12.50	125.00	88.00	2.38
RDF + PSB	25	12	37	13.50	135.00	98.00	2.65
RDF + AMF	25	12	37	13.50	135.00	98.00	2.65
RDF+FYM +AZB	25	17	42	20.00	200.00	158.00	3.76
RDF + FYM + PSB	25	17	42	20.00	200.00	158.00	3.76
RDF + FYM + AMF	25	17	42	19.50	195.00	153.00	3.65
RDF + FYM + PSB +AZB	25	19	44	21.50	215.00	171.00	3.89
RDF + FYM + PSB + AZB + AMF	25	21	46	22.80	228.00	182.00	3.96

and recommended dose of N, P and K increased the availability of P and K_2O in the soil and their maximum status were recorded on the application of inorganic fertilizers along with FYM. Likewise, availability of zinc and iron content in the soil has also been increased over the application of FYM. The long term integrated nutrient management practices did not cause significant change in soil BD and porosity. The long term INM practices significantly reduced the soil pH of the surface soil. The contents of available N, P and K in INM treatments increased significantly as compared to inter row space. INM of orchard soils often alters soil chemical properties like pH and available fractions of nutrients due to application acid forming organic source of nutrients as well as removal of bases. INM also brought about conspicuous changes in biological and biochemical properties

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

Soil available nutrient and fruit yield

The range and mean values of soil available nutrients and fruit yield in treated and control treatments are taken into consideration. Fruit and plant leaf petiole samples were taken for estimation N, P and K contents for working out uptake by the crop. Treatment wise soil test data, nutrient doses, yield and uptake were used for obtaining NR (nutrient required to produce one tonne of kinnow fruits), % CS (per cent contribution of nutrients from treatment) and % C-OM (per cent contribution of nutrients from organic matter).

These parameters were used to develop equations for soil test based nutrient recommendations for desired yield targets of kinnow under NPK as well as NPK plus FYM. The basic data viz., NR for producing one tonne of kinnow fruits, % contribution of nutrients from soil, fertilizer and FYM have been calculated (Table 63).

Management of fruit cracking in bael under hot arid region

The experiment was conducted on 9-years old budded plants of NB-5 cultivar, planted at 8 x 8 m spacing at the ICAR-CIAH, Bikaner. The site is arid region and hot climate with average annual rainfall varies between 100-300 mm. The soil texture of the experimental field was sandy having pH 8.1; available nitrogen was 156 kg/ha, available P_2O_5 was 12.20 kg/ha and available K_2O was 220.0 kg/ha. There were 6 treatment combination applied per plant/year following RBD having three replications. The treatments were control, NPK, NPK + 30 kg FYM, NPK + 60 kg FYM, NPK + 60 kg FYM + mulching with crop residues, NPK + 60 kg FYM + mulching with black polythene. The treatments were applied in two equal split doses i.e. during 2nd week of July and 2nd week of November every year. The manure and fertilizers were applied in a circular ring of one foot wide, prepared at 3 feet apart from the plant with a depth of 10-12 cm. The plants were grown under supplementary irrigation.

Table 63. Estimation of soil test based fertilizer recommendation of kinnow in aridisols

Soil test value			Fertilizer dose (kg ha^{-1}) under NPK alone			Fertilizer doses (kg ha^{-1}) under NPK + FYM @ 40 t ha^{-1}		
SN	SP_2O_5	SK_2O	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
120	10.00	140	128	45	98	106	40	92
145	12.50	160	120	42	86	100	37	78
185	14.50	180	112	39	78	92	32	62
205	16.50	200	104	36	62	74	29	54

Table 64. Effect of nutrient and mulching on yield and quality of bael

Treatments	Fruit weight (kg/plant)	Pulp content (%)	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Yield (kg/plant)	Cracking (%)
Control	0.41	47.15	35.15	0.31	5.68	16.54	90.36
NPK	0.83	51.47	41.61	0.33	6.45	25.63	84.64
NPK + 30 kg FYM	1.18	55.74	40.25	0.33	6.78	26.78	81.78
NPK + 60 kg FYM	1.49	55.79	42.65	0.37	7.68	37.42	44.18
NPK + 60 kg FYM + mulching with black polythene	1.98	76.32	47.45	0.41	9.49	41.65	17.35
NPK + 60 kg FYM + mulching with crop residues	1.63	57.78	45.14	0.34	8.81	35.26	52.65
Mean	1.25	57.38	42.04	0.35	7.48	30.55	64.87

The data revealed that fruit weight was highest (1.98 kg) in the plant, received recommended dose of NPK + 60 kg FYM + mulching with black polythene followed by the plant (1.62 g) with 60 kg FYM + mulching with crop residues. The lowest fruit weight was recorded from the control plant (0.41 kg). There was vast difference in fruit weight between control and treated plants which may be due to different treatments (Table 64).

Leaf nutrient status, which is considered to be an indicator tool for nutrient management programme in fruit crops, was significantly varied due to different treatments. Highest foliar nitrogen content (1.90%) was measured from the plant received when recommended dose of NPK + 60 kg FYM + mulching with black polythene was applied annually. Highest fruit yield was also observed from this plant i.e., the plant that showed highest foliar N value (Table 65). The phosphorus content in leaves was measured maximum (0.73%) from the same plant; showed highest foliar N value. Potassium content in the leaves in different treatment did not tally with the corresponding plant having higher fruit yield. The control plant showed the lowest N, P, K values in the leaves (1.47, 0.41 and 1.12%, respectively).

Pulp content was maximum (76.32%) in the fruit of the plant treated with NPK + 60 kg FYM + mulching with black polythene followed by the plant (57.78%) with NPK + 60 kg FYM + mulching with crop residues. The minimum pulp content was measured from the control plant (47.15%). In bael, pulp content is one of the important parameters in respect of its utilization as fresh or processed. It is clear from the result that nutrition has positive effect on improvement in pulp content in the bael fruit.

TSS content in the fruit pulp was significantly improved due to application of organic manures and inorganic fertilizers. Highest TSS content (47.15 °Brix) was measured from the fruits treated with NPK + 60 kg FYM + mulching with black polythene and lowest (38.00 Brix) from the control plant. Acidity content in the fruit pulp did not vary significantly among the different treatments. Ascorbic acid content in the fruit pulp was significantly improved due to application of organic manures and inorganic fertilizers and mulching. Highest ascorbic acid content (9.49 mg/100 g) in the fruit pulp was

Table 65. Effect of nutrient and mulching on leaf nutrient content of bael

Treatments	N (%)	P (%)	K (%)
Control	1.47	0.41	1.12
NPK	1.63	0.62	1.26
NPK + 30 kg FYM	1.61	0.64	1.28
NPK + 60 kg FYM	1.67	0.71	1.35
NPK + 60 kg FYM + mulching with black polythene	1.92	0.73	1.51
NPK + 60 kg FYM + mulching with crop residues	1.87	0.69	1.48
Mean	1.70	0.63	1.33

noted from the fruits treated with NPK + 60 kg FYM + mulching with black polythene and lowest from the control plant (5.68 mg/100 g).

Nutrient management in custard apple

Leaf samples of custard apple were analysed for nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, iron, manganese, zinc and copper. The mean values of total 308 custard apple samples which are used for DRIS standards, which can be classified according to their variation were obtained and among them, nitrogen (4.62%), phosphorus (0.15%), potassium (0.83%), calcium (1.81%), magnesium (1.12%), sulphur (0.20%), iron (233 ppm), manganese (244 ppm), zinc (44 ppm) and copper (21 ppm) varied from place to place in different villages of Gujarat (Table 66).

Effect of organic manure and fertilizers on mango cv. Kesar

A field experiment was conducted in mango cv. Kesar. 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 (4.30 m), plant spread east-west (3.50 m), north-south (3.40 m) and scion girth (62.90 cm) was recorded in FYM + standard dose of NPK + *Azotobactor* + PSB closely followed by castor cake + standard dose of NPK + *Azotobactor* + PSB. Maximum fruit yield (44.20 kg/plant), TSS (20.80 ^{0} Brix) was also recorded in closely followed by

Nutrients management in *kachri*

Application of organic and inorganic sources of nutrients significantly increased growth parameters and yield of *kachri* as compared to control. Maximum vine length (cm), no. of branches, fruits/plant and fruit production/plant (g/plant) were observed 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 (Table 67 to 68).

Table 66. Average concentration of different nutrients of custard apple collected in the survey for developing DRIS and CND norms

S. No	Village	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
1	Baina (33)	168	272	40	24
2	Bakrol (33)	171	275	38	21
3	Bhabhar (6)	105	245	32	16
4	Chittorgarh fort (50)	491	243	53	32
5	Hathni mata (16)	216	326	42	23
6	Jaisighpur (12)	166	274	55	40
7	Jesingpur (22)	185	229	53	32
8	KVK, Chittorgarh (10) Arka Sahan	1177	354	51	30
	KVK, Chittorgarh Bala Nagar (14)	669	250	49	30
9	Labadadhara(18)	181	300	41	19
10	Nathpura (9)	118	299	47	28
11	Poyali (19)	241	299	42	25
12	Rugnathpur(22)	204	299	53	32
13	Sarasava (14)	230	270	25	26
14	Vejalpura(34)	344	301	42	24
15	Zinzari (26)	154	284	54	38
Total	**329**				

Table 67. Role of organic and inorganic source of nutrient on performance of *kachri*

Treatments	Leaves no./plant	Shoot length (cm)	Root Length (cm)	Fresh weight of plant (g)
Control	8.10	13.10	10.13	8.78
100% (I)	10.80	15.53	10.67	9.86
75% (I) + 7.5 t/ha FYM	9.45	17.55	11.21	10.13
50%(I) + 15 t/ha FYM	12.15	20.39	17.01	10.53
25%(I) + 22.5 t/ha FYM	18.90	38.75	23.36	16.07
30 t/ha FYM	24.30	34.16	20.79	15.53
Mean	13.95	23.24	15.53	11.81

Table 68. Role of organic and inorganic source of nutrient on soil temperature

Treatments	Soil temperature at 60 day
Control	45.33
100% (I)	37.66
75% (I) + 7.5 t/ha FYM	37.00
50%(I) + 15 t/ha FYM	37.33
25%(I) + 22.5 t/ha FYM	36.76
30 t/ha FYM	36.66
CD (5%)	

Soil enzymatic activity has been a real-time indicator of the functional potentiality of microorganisms. Dehydrogenate, alkaline phosphatase (ALP) and urease activity showed a significant difference among different treatments of organic and inorganic source of nutrients and higher as organic dose of nutrients were increased. Higher enzymatic activity was observed and recorded under application of 50% NPK from inorganic fertilizers and 15 t/ha FYM (Table 69 & Fig. 64).

Table 69. Effect of organic and inorganic nutrients on enzymes activity in the rhizospare

Treatments	Dehydrogenase (µg TPF g^{-1} dry soil h^{-1})	Alkaline phosphatase (µg p-NP g^{-1} dry soil h^{-1})	Urease (µg $NH3^{-1}$g dry soil-1h)
Control	4.7	4.6	162.0
100% (I)	6.4	7.4	359.5
75% (I) +7.5 t/ha FYM	5.9	7.0	263.3
50% (I) + 15 t/ha FYM	7.0	7.9	395.0
25% (I) + 22.5 t/ha FYM	5.5	5.2	292.0
30 t/ha FYM	6.8	7.2	315.6
Mean	6.0	6.6	297.9

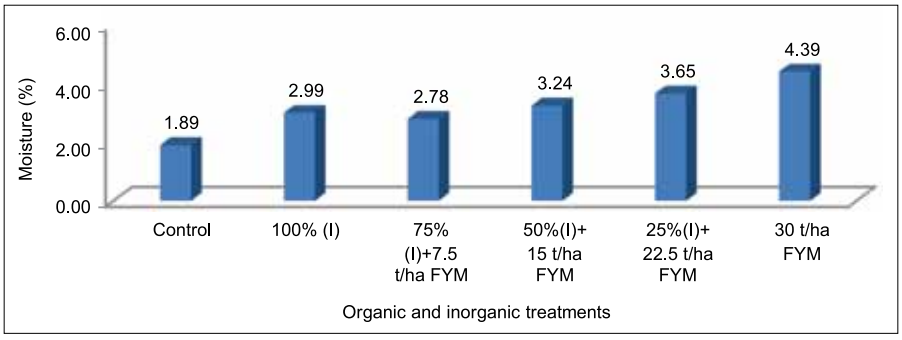


Fig. 64. Soil moisture (%) at 40 DAS under different treatments of nutrients

Soil moisture was increased with increasing doses of FYM and observed maximum where 30 t/ha FYM was applied. Whereas, soil temperature was decrease with increasing doses of FYM observed and minimum was observed where 30 t/ha FYM was applied. Maximum per cent yield response was observed where 50% (I) + 15 t/ha FYM was applied (170.48 %) followed by 25% (I) + 22.5 t/ha FYM (157.71%) as compared to control (Fig. 65 to 66).

Standardization of irrigation scheduling in date palm

The irrigation treatments were deployed on the basis of evapotranspiration considering the open pan evaporation data. The plant to plant spacing (6 x 8 m), pan factor (0.75), crop factor (0.60) was taken into account to calculate the water requirement of the treatment. The water requirements of different treatments were calculated and said amount was applied

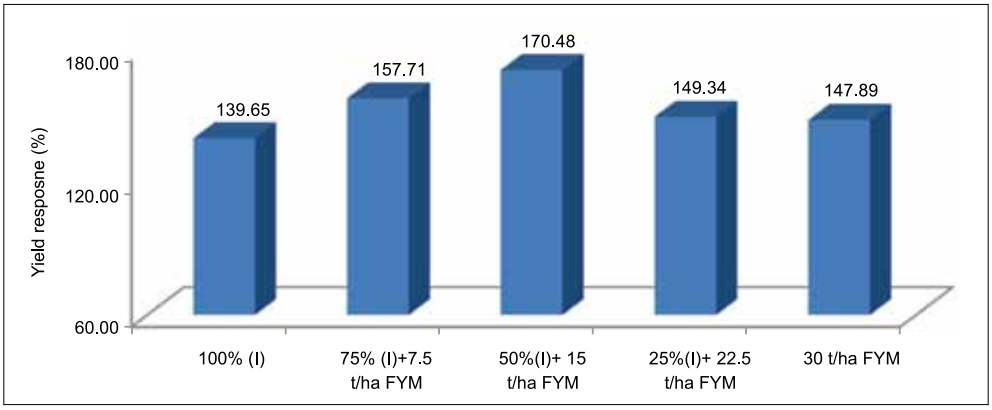


Fig. 65. Effect of organic and inorganic source of nutrient on yield response of *Kachri*

Fig. 66. Experimental view of *kachri* crop in the field.

Table 70. Standardization of nutrient requirement

S. No.	Treatments	Remarks
T1	Control (No fertilizers and No FYM)	NPK doses have been given through irrigation systems FYM has been given in trenches in the month of October Biofertilizer consortia has been mixed in the soil along with FYM
T2	100g + 100g + 100 g + 10 kg FYM/tree/year	
T3	200g + 100g + 100 g + 10 kg FYM/tree/year	
T4	200g + 100g + 200 g + 10 kg FYM/tree/year	
T5	200g + 200g + 200 g + 10 kg FYM/tree/year	
T6	200g + 100g + 100 g + 15 kg FYM/tree/year	
T7	200g + 100g + 200 g + 15 kg FYM/tree/year	
T8	200g + 200g + 200 g + 15 kg FYM/tree/year	
T9	200g + 100g + 100 g + 10 kg FYM + BF consortia/tree/year	
T10	200g + 100g + 200 g + 10 kg FYM + BF consortia/tree/year	
T11	200g + 200g + 200 g + 10 kg FYM + BF consortia /tree/year	

through drip system. The amount of water was given on 3rd day. The results revealed that 100 and 75% of ETC gave the maximum plant height (250 cm), spread (145 x 150 cm) in cultivar Barhee and Khalas. In Khalas cultivar, maximum spathe per plant (6) was recorded in 1.00 ETC irrigation level & minimum (2) in 50% ETC irrigation level. The maximum moisture (5.50%) was recorded at 45 cm depth after 8 hrs of the irrigation. The integrated nutrient management schedule were deployed in tissue cultured date palm cultivars as given in Table 70.

The above treatments were applied in the month of October, 2019 and plant height, spread, spathe emergence were recorded in different treatments in different cultivars. Growth data revealed that maximum plant height, spread after six month was recorded in T_8 treatment in Khalas cultivars where NPK (800 g each) along with 50 kg FYM were applied.

Management practices for saline soil and water for crop production in arid region

The leafy vegetables (Coriander, fenugreek, spinach and radish) were grown at field (Fig. 67). The survival percentage of all leafy vegetables was up to 100% under the saline water (4 EC_{IW} dS m^{-1}) treatment as well as in control (0.5EC_{IW} dS m^{-1}). All leafy vegetables performance was good except coriander crop under saline water (4EC_{IW} dS m^{-1}). The sequence of germination was observed like fenugreek > spinach > radish > coriander and the 100% germination was observed in fenugreek crop under saline (4 EC_{IW} dS m^{-1}) water treatment as compared to control (Fig. 68). The growth and yield parameter were recorded in fenugreek and the fresh yield of fenugreek crop was observed 113.03 q/ha, 77.18 q/ha and 51.87 q/ha in saline, conjunctive water and canal water treated plots, respectively (Table 71). The highest spinach yield was recorded in saline water treated plot that was 378.33 q/ha and 184.33, q/ha, 164 q/ha in conjunctive water, canal water treated plots, respectively. In radish crop, the root length was 29.22 cm, shoot length 28.88 cm, no. of main leaf (15), no. of root was (15/square feet) were recorded highest in saline water treated plots but yield (879.2322ha) was highest in canal water treated plot (Table 72). The performance of coriander

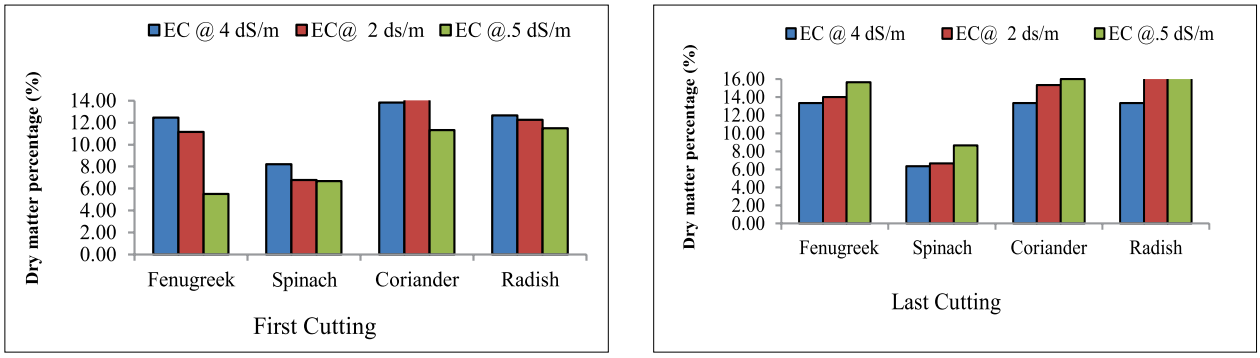


Fig. 67. Dry matter % in vegetables under different level of salinity

Table 71. Growth and yield parameter of fenugreek crop under saline irrigation water

	Treatment		
Yield parameter	**Irrigation water 4EC (dS m^{-1})**	**Irrigation water 2 EC (dS m^{-1})**	**Irrigation water 0.5 EC (dS m^{-1})**
No. of pod/plant	42	40	34
Length of pod (cm)	12.4	11.34	11
No. of seed /Pod	21	18	16
Seed yield/plot	1.62	1.5	1.42
Seed yield (q/ha)	26.67	25	23.66
Biological yield(q/ha)	57.67	51.33	48.33
Harvest Index	49.69	48.70	48.27

Table 72. Growth and yield attribute of radish crop under saline irrigation water

	Treatment		
Growth parameter	**Irrigation water 4EC (dS m^{-1})**	**Irrigation water 2 EC (dS m^{-1})**	**Irrigation water 0.5 EC (dS m^{-1})**
DM (%) at initial stage	12.63	11.47	8.22
DM (%) at harvesting stage	13.33	15.33	19.00
Root length (cm)	29.22	28.00	28.00
Shoot length (cm)	28.88	28.89	26.33
No. of leaf (main)	15	15	14
No. of leaf (secondary)	15	15	16
Length of leaf (cm)	8	8	7
Width of leaf (cm)	8	8	7
Fresh weight of root (g)	68	70	66
Fresh weight of shoot (g)	152	160	153
No. of fruits	15	11	14
Yield (q/ha)	647.67	503.00	879.23

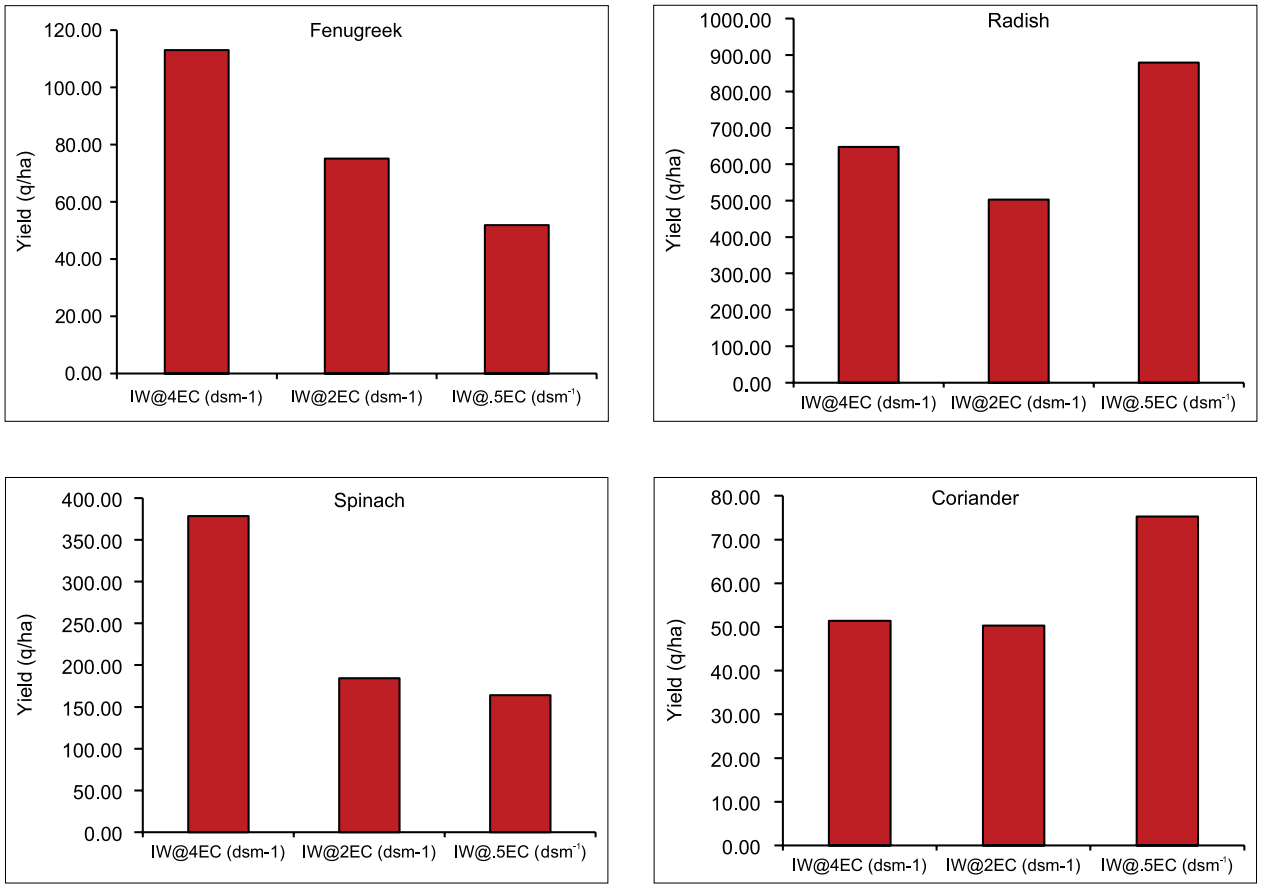


Fig. 68. Yield of fenugreek, radish, spinach and coriander crop under saline irrigation water

crop was not good in saline water treated plot and highest yield was recorded in canal water treated plot that was 75.27 q/ha and in saline water and conjunctive water was 51.37 q/ha, 50.28 q/ha, respectively. It was also observed that the dry matter percentage during first cutting in all vegetable were high under saline water treatment but it was gradually reduced under saline water treatment as compared to control treatments. Therefore, in arid region, the saline water can be an alternate source of irrigation during the scarcity of fresh water.

Plant Protection

Management of different diseases in arid horticultural crops through botanicals and inorganic salts under hot arid condition

Management of wilt disease in muskmelon

A trial was conducted for management of *Fusarium* wilt in muskmelon variety 'RM-50' under field condition during summer season of 2019 at Pathology Block of this Institute. Eleven treatments such as neem leaf extract 5%, neem leaf extract 10%, tumba fruit extract 5%, tumba fruit extract 10%, aak leaf extract 5%, aak leaf extract 10%, neem seed kernel extract (NSKE) 5%, salicylic acid 500 ppm and borex 500 ppm, carbendazim (0.1%) and control (treatment of untreated check without spray) were taken in the field trial for management of *Fusarium* wilt of muskmelon. *Fusarium* wilt was found with ranging from 14.29-39.58% disease index in the field. Among 11 treatments, carbendazim (0.1%) was found the most efficient treatment against *Fusarium* wilt with minimum per cent disease index of 14.29% and 63.90% disease control, followed by neem leaf extract (10%) with 19.67% per cent disease index and 50.30% disease control. Next best treatments were tumba fruit extract (10%) and aak leaf extract (10%) with per cent disease index of 22.35% and 26.84% as well as 43.53% and 32.19% disease control, respectively. Neem leaf extract (10%) and tumba fruit extract (10%) were statistically at par with each other. Maximum disease index of 39.58% was found in case of control (Table 73).

Management of mosaic disease in ridge gourd

Field trial was conducted for management of mosaic disease of ridge gourd for which variety 'Jaipur Long' was sown on 27th July, 2019 at this Institute. Seven botanicals such as neem leaf extract (5%), neem leaf extract (10%), neem seed kernel extract (NSKE 5%), tumba fruit extract (5%), tumba fruit extract (10%), aak leaf extract (5%), aak leaf extract (10%), 02 inorganic salts such as salicylic acid (500 ppm) and borex (500 ppm),

Table 73. Management of *Fusarium* wilt disease in muskmelon under field conditions

S. No.	Treatments	Doses	Per cent disease index	Per cent disease reduction
1.	Neem leaf extract	5%	28.73 (32.75)*	27.41
2.	Neem leaf extract	10%	19.67 (26.31)	50.30
3.	Tumba fruit extract	5%	31.18 (33.92)	21.22
4.	Tumba fruit extract	10%	22.35 (28.18)	43.53
5.	NSKE	5%	30.26 (33.34)	23.55
6.	Aak leaf extract	5%	32.67 (34.82)	17.46
7.	Aak leaf extract	10%	26.84 (31.17)	32.19
8.	Borex	500 ppm	35.12 (36.32)	11.27
9.	Salicylic acid	500 ppm	34.53 (35.95)	12.76
10.	Carbendazim	0.1%	14.29 (22.12)	63.90
11.	Control	-	39.58 (38.96)	-
CD (5%)				3.137

* Figures in parenthesis are angular transformed values.

one insecticide namely, imidacloprid (0.05%) and control (treatment of untreated check without spray) were taken for this experiment. Three sprays of each treatment were done in the crop. Weekly observations were recorded on disease incidence and per cent disease index (PDI) as well as per cent disease reduction were calculated. All the treatments were found better than control. Mosaic disease was found with ranging from 15.13-39.74% disease index. Among 11 treatments, imidacloprid (0.05%) was found the most efficient treatment against mosaic disease with minimum per cent disease index of 15.13% and per cent disease reduction (61.93%). Next best treatment was neem leaf extract (10%) with per cent disease index of 18.27 % and per cent disease reduction (54.03%), followed by tumba fruit extract 10% (20.0% PDI and 49.67% disease reduction) for management of mosaic disease in ridge gourd. Maximum disease index (39.74%) was found in case of control (Table 74).

Insect pests incidence in arid horticultural crops

The periodical observation on major insect-pests and natural enemies of arid fruits and vegetables has been carried out at fortnight intervals (Fig. 69 to 70).

Ber leaf weevil (*Amblyrrhinus poricollis* S.)- A new threat to ber

Ber leaf weevil was observed on ber, *Z. mauritiana* tree in the hot arid region of north-western India (Thar Desert) and identified as *A. poricollis*. Weevil is a polyphagous pest, regularly occurring on ber. Grubs of the weevil

Table 74. Management of mosaic disease in ridge gourd during rainy season of 2019

S. No.	Treatments	Doses	Per cent disease index	Per cent disease reduction
1.	Neem leaf extract	5%	26.32 (30.82)*	33.77
2.	Neem leaf extract	10%	18.27 (25.27)	54.03
3.	NSKE	5%	22.40 (28.21)	43.63
4.	Tumba fruit extract	5%	29.76 (33.01)	25.11
5.	Tumba fruit extract	10%	20.0 (26.49)	49.67
6.	Salicylic acid	500 ppm	33.58 (35.34)	15.50
7.	Borex	500 ppm	35.17 (36.35)	11.50
8.	Aak leaf extract	5%	31.62 (34.19)	20.43
9.	Aak leaf extract	10%	24.56 (29.63)	38.20
10.	Imidacloprid	0.05%	15.13 (22.84)	61.93
11.	Control	-	39.74 (39.05)	-
	CD (5%)	3.96		

* Figures in parenthesis are angular transformed values.

Fig. 69. Ber leaf weevil and bean thrips

Fig. 70. Identification of insect pests of arid horticulture crops

feed on roots, whereas the adult feeds on the foliage of the host plants. Weevils are active throughout the year with their peak activity during the months of July–August. The numbers of ber leaf weevil were the maximum in July-August (356.70 per plant of four years old) and the minimum in April-May (10.50 per plant of four years old). Tender/ newly leaves are more severely attacked as compared to mature leaves. Initially they cut irregular holes and gradually eat up entire leaves leaving only the midribs. Adult weevils are small, brown to blackish in colour. Their abdomen is fully coloured with black elytra. The body length varied from 1.81 to 1.96 mm and width range from 1.65 to 1.79 mm. Male and female adults can be distinguished on the basis of colour of elytra. The elytra length varied from 2.69 to 2.74 mm. The length of antennae ranged from 1.83 to 1.92 mm. The length and width of head and thorax were 0.53, 0.81, 1.03, 1.34 mm, respectively.

Table 75. Infestation of mite on different cultivars of pomegranate

Cultivars	Infestation (%)	Category	Cultivars	Infestation (%)	Category
Jalore Seedless	22.50	M	Crenedo de Elecho	12.17	L
Jodhpur Red	26.83	M	Kabul Kohinoor	13.67	L
Kajaki Anar	54.50	VS	EC-62812	30.50	M
Ganesh	27.67	M	Ruby	17.17	L
Dorsata Malus	46.83	S	Mridula	37.17	M
Saharanpur	24.67	M	Tujetis EC 4347	14.67	L
G-137	30.17	M	Sirin	11.33	L
Kabul	41.83	S	AHPG-H1	24.67	M
Basin Seedling	56.83	VS	Boseka Link	15.50	L
Banaras collect.	37.17	M	Yercaud Local	43.83	S
Bassin Seedless	8.83	VL	Tebest	18.83	L
Alah	29.67	M	Gul-e-Shah Red	13.83	L
Kandhari	15.33	L	Speen Danedar	28.83	M
Bedana Suri	63.00	VS	AHPG-H2	32.83	M
GK VK-1	11.33	L	Patna-5	37.17	M
Speen Sacarin	7.17	VL	Sur Sukker	19.67	M
IIHR 12/1	33.83	M	Malta	16.33	L
Muskat	40.17	S	Gulsa Red	21.33	M
Dholka	14.67	L	AH-PG-H3	31.83	M
IIHR 19/10	42.17	S	Gul-e-Shah	13.83	L
Jalore Red	32.17	M	Surat Anar	15.17	L
Uthkal	10.50	L	Gul-e-Shah Rose Pink	6.50	VL
Kalisirin	17.17	L	Kurvi	38.00	M
AHPG-C1	13.83	L	Bedana Sedana	21.33	M
Khog	36.83	M	Jyoti	25.50	M
Coimb. White	43.00	S	P-13	28.83	M
Saih Sirin	41.83	S	Agah	16.33	L
MR 599	15.50	L	EC-12613	20.50	M
AHPG-C3	8.00	VL	AHPG-H4	13.50	L

Cultivars	Infestation (%)	Category	Cultivars	Infestation (%)	Category
Yercaud	47.17	S	Achik Dana	17.17	L
Jodhpur coll.	37.17	M	Surkh Anar	35.17	M
Bedana Thin Skin	28.83	M	IC-318712	55.17	VS
AHPG-C4	13.83	VL	HP Collec.	5.50	VL
P-23	43.83	S	Goma Khata	13.50	L
P-21	13.83	L	Phule Arakta	36.83	M
A K Anar	22.17	M	Bhagwa	28.83	M
P-26	25.50	M			

VS: Very severe; S: Severe; M: Moderate: L: Low; VL: Very Low

Screening of pomegranate cultivars against mite under hot arid condition

The different pomegranate cultivars were taken for final screening against mite, *Tenuipalpus punicae* and significant differences were found in infestation (Table 75). The pomegranate cultivars under study indicated significantly very low incidence in Gul-e-Shah Rose Pink (6.50%), Speen Sacarin (7.17%) and Bassin Seedless (8.83%). Significantly greater incidence of mite was registered in Kajaki Anar (54.50%), IC-318712 (55.17%), Basin Seedling (56.83%) and Bedana Suri (63.00%).

Noval biopesticide compositions and formulation from tumba (*Citrullus colocynthis*) for insect control (Thar Jaivik)

The present invention describes the isolation and characterization of the novel biopesticide compositions and formulations obtained from tumba (*Citrullus colocynthis*) with desi cow urine effective against pest management and capable of surviving as effective biocontrol agent. The invention focuses on the isolation of this biopesticide compositions and formulations that are known to possess pesticidal properties and are derived from natural sources having biological origin. The patent was filed vide application number 201911012592 dated 30th March, 2019. This biopesticide compositions and formulation control the insects (*Helicoverpa armigera*, *Spodoptera exigua*, *Diphania indica etc.*) and vectors (Aphid and white fly) through repellent, deterrent, antifeedent and stop the respiration. This biopesticide compositions and formulation containing botanical plant (tumba) and deshi cow urine is eco-friendly and safe for environment.

Table 76. Efficacy of different biopesticide in arid horticultural crops

S. No.	Biopesticide	Per cent reduction in *H. armigera* larvae			
		Field condition		Laboratory condition	
		After 1 day	After 3 day	After 1 day	After 3 day
1.	Thar Jaivik 4 ml/l	75.60 (60.38)	80.70 (63.49)	85.30 (67.48)	90.93 (72.54)
2.	Thar Jaivik 2 ml/l	65.70 (54.14)	71.80 (57.91)	70.50 (57.11)	77.47 (61.66)
3.	Thar Jaivik 3 ml/l	74.93 (59.99)	82.90 (65.56)	84.17 (66.56)	90.63 (72.40)
4.	NSKE 5%	43.60 (41.31)	48.17 (43.93)	50.37 (45.19)	52.33 (46.32)
5.	Neem Oil 4 ml/l	50.20 (45.10)	54.23 (47.41)	56.40 (48.66)	58.40 (49.82)
6.	Spinosad 0.5 ml/l	65.07 (53.78)	71.63 (57.81)	68.03 (55.55)	74.27 (59.50)
7.	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm±		0.97	0.65	0.90	1.15
LSD (P = 0.05)		3.02	2.03	2.75	3.53

*Values in parenthesis are angular-transformed

Bio-efficacy of Thar Jaivik biopesticide

The bio-efficacy of six biopesticides were tested against borer, *Helicoverpa armigera* in arid horticultural crops revealed that Thar Jaivik 41 EC @ 3 ml per litre of water proved to be the most effective and that is non significant with Thar Jaivik 41 EC @ 4 ml per litre of water. The dose of Thar Jaivik 41 EC is standardized as 3 ml per litre of water as it was best for management of insect-pests. The neem based formulations, *viz.,* NSKE and neem oil were proved to be the least effective in reducing the borer, *H. armigera* (Table 76).

The bio-efficacy of six biopesticide were tested against aphids in arid horticultural crops revealed that Thar Jaivik 41 EC @ 3 ml per litre of water proved to be the most effective and that is at par with Thar Jaivik 41 EC @ 4ml per litre of water. The dose of Thar Jaivik 41 EC is standardized as 3 ml per litre of water as it was best suitable for management of aphids (Table 77).

Table 77. Efficacy of different biopesticide against aphids in arid horticultural crops

S. No.	Biopesticide	Per cent reduction in aphid population			
		Field condition		Laboratory condition	
		After 1 day	After 3 day	After 1 day	After 3 day
1.	Thar Jaivik 4 ml/l	78.33 (62.29)	86.83 (68.88)	87.46 (69.28)	94.70 (77.05)
2.	Thar Jaivik 2 ml/l	67.43 (55.21)	73.90 (59.27)	72.32 (58.26)	79.33 (62.96)
3.	Thar Jaivik 3 ml/l	78.23 (62.18)	86.13 (68.26)	87.30 (69.18)	94.40 (76.72)
4.	NSKE 5%	46.23 (42.82)	50.68 (45.37)	50.73 (45.40)	56.20 (48.55)
5.	Neem Oil 4 ml/l	52.90 (46.64)	56.23 (48.56)	58.33 (49.78)	61.50 (51.64)
6.	Neem Oil 4 ml/l	49.97 (44.96)	53.13 (46.78)	54.13 (47.35)	56.80 (48.89)
7.	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm±		0.84	1.25	0.95	1.50
LSD (P = 0.05)		2.61	3.88	2.91	4.59

*Values in parenthesis are angular-transformed

Table 78. Efficacy of different insecticide/biopesticide against coccinellids

S. No.	Biopesticide/ insecticide	Per cent reduction in coccinellids population	
		After 1 day	After 3 day
1.	Thar Jaivik 4 ml/l	30.13 (33.27)	32.07 (34.47)
2.	Thar Jaivik 2 ml/l	18.80 (25.67)	20.47 (26.88)
3.	Thar Jaivik 3 ml/l	22.57 (28.33)	23.13 (28.73)
4.	NSKE 5%	14.97 (22.69)	16.37 (23.85)
5.	Neem Oil 4 ml/l	21.47 (27.53)	23.77 (29.16)
6.	Acephate 1.5 g/l	78.83 (62.65)	85.27 (67.45)
7.	Control	0.00 (0.00)	0.00 (0.00)
SEm±		1.17	0.62
LSD (P = 0.05)		3.65	1.94

*Values in parenthesis are angular-transformed

Mortality of aphids | Mortality of *H. armigera* larvae | Mortality of white fly | Survivility of coccinellids grub

Fig. 71. Effect of Thar Jaivik 41 EC spray in field as well as laboratory conditions

The bio-efficacy of six biopesticide/insecticide were tested against coccinellids in arid horticultural crops revealed that Thar Jaivik 41 EC @ 3 ml per litre of water proved to be best safer for biocontrol agents and that is non significant with Thar Jaivik 41 EC @ 2 ml per litre of water. The effect of insecticide acephate @ 1.5 g per litre of water was having highest mortality to biocontrol agents, coccinellids (Table 78 & Fig. 71).

Post Harvest Management

Value addition in semi-arid fruit crops

Mix sweet wood apple and lemon pickle

Ingredient: Dry wood apple pulp (300 g), chilli powder (Kashmiri), lemon (200 g), salt, caraway powder, sugar (250 g).

Flow chart:

300 g dry wood apple pulp put in cold water for 8-10 hour
↓
Add 200 g lemon without seeds
↓
Mix it.
↓
Add 1 cup of water and sugar (250g)
↓
Put it on gas for 15 min.
↓
Mix it for 5 min.
↓
Cooled at room temp
↓
Add salt
↓
Add the roasted Caraway powder
↓
Add the red chilli powder (kashmiri) for colour
↓
Kept for 8 to 10 days for fermentation in room temp

Phyto-toxicity effect of Thar Jaivik biopesticide

The data on phyto-toxicity effect on plant was also recorded and found that no effect was observed on plant when applied 10 times more dose of the recommended dose of biopesticide (Thar Jaivik 41 EC). It was also observed that their no effect on fruits and vegetables after 3 days spraying of biopesticide (Thar Jaivik 41 EC) for human consumption.

Wood apple ready to serve (RTS) drink and powder

For RTS formulation, the total soluble solids and total titratable acidity are estimated in extracted pulp by hand refractometer and titration, respectively. Then calculation was done for sugar and acid present in the pulp as well as for remaining amount of sugar, citric acid, potassium metabisulphite and water required to prepare the finished RTS in different proportions according to desired recipes (Fig. 72). One liter of RTS of each recipe were prepared by mixing the calculated amount of pulp, sugar, citric acid and water in different proportions (recipes) then organoleptically evaluated on a 9.0 Point Hedonic Rating Scale to find out the best one recipe of wood apple pulp, sugar and acidity content. Finally one liter RTS was prepared with best recipe *viz.* 10% fruit pulp, 13% TSS and 0.25% acidity. The wood apple powder have good aroma and

Fig. 72. Wood apple powder and ready to serve drink

light brown color, it gives excellent taste with addition of adequate amount salt. 1.0 to 1.5 kg mature wood apple fruits is sufficient for making of 200-220 g powder. It can be used as preparation of wood apple serbat and wood apple drink.

Exploitation of arid fruits and vegetables for value addition and commercialization

Standardization of pre-treatments for browning reduction in dry dates (*chhuhara*)

Dry dates (*chhuhara*) prepared from the doka stage fruits are prone to browning resulting from enzymatic as well as non-enzymatic reactions (Fig. 73). Hence, various pre-treatments were imposed for reducing the browning reactions during drying and storage. Various chemicals used for pre-treatment include 1, 2 and 5% sodium formaldehyde sulfoxylate (SFS), 1% potassium metabisulfate (KMS) and 1% ascorbic acid. These chemicals were applied during hot water treatment during which the doka staged fruits were boiled for 8-10 minutes in boiling water. After the treatment, the fruits were well drained, fan dried and placed in tray drier at 60-65 °C for 18-20 hours. Among various treatments 2% SFS was found to be effective in obtaining good color development after drying to final product. Study indicates that the color development and browning was variable with the cultivar of the doka staged fruits. This treatment was found to have significant impact on the browning reduction in the date cv. Barhee and Zahidi with little impact on the cv. Medjool (Table 79 to 80).

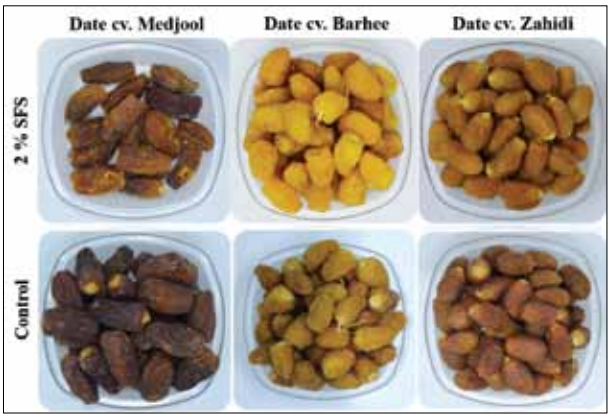


Fig. 73. Effect of SFS and variety on browing of date palm at *doka* stage

Table 79. Effect of pre-treatments on non-enzymatic browning index of dry dates cv. Medjool

Treatment	Medjool	
	Initial (0 month)	Final (6 months)
1% SFS	0.046	0.129
2% SFS	0.039	0.117
5% SFS	0.034	0.102
1% KMS	0.098	0.174
1% Ascorbic acid	0.142	0.211
Control	0.158	0.238

Table 80. Effect of pre-treatment on non-enzymatic browning index of dry dates

Cultivar	Zahidi		Barhee			
Treatment		Mature Green		Mature Yellow		
	Initial	Final	Initial	Final	Initial	Final
Control	0.048	0.154	0.054	0.164	0.049	0.175
SFS (2%)	0.018	0.084	0.024	0.097	0.022	0.090

However, there was no significant effect on the recovery percentage of the dry dates with the imposed pre-treatments.

Development of functional foods and nutraceutically rich value added products from arid horticultural crops

Screening of sour type pomegranate germplasm for anardana purpose

Anardana is an acidulant spice used in the Indian cuisines for giving sour-sweet taste. It is prepared from the dried seeds of pomegranate fruits wherein the seeds are dried along with adhering pulp. Anardana is used to add flavour to vegetables and legumes as well as meat dishes. It is known to have medicinal and smoothening effects on the stomach, as well as good for the heart. Traditionally, the sour types of wild pomegranate *viz*. daru type are being used in the preparation of anardana; however their fruit size and yield are very low. Hence, an attempt was being made to identify the sour genotypes from the total germplasm (95) available at the institute. Around 31 genotypes are being identified as sour genotypes and these are being screened for preparation of quality anardana from extracted arils (Table 81 & Fig. 74).

Among all the cultivars screened, the average fruit weight was recorded maximum in the cv. Tujetis EC-104347 (208.28 g) followed by cv. P-21 (194.25 g). The aril recovery was maximum in the cv. Bedana Seedless (69.21%) followed by CIAH-PG-1 (68.14%) and Khog (68.03 %). The dehydration ratio was maximum in cv. CIAH-PG-A6 (4.17) followed by Khog (4.02) while anardana recovery percentage from fresh aril was maximum in cv. CIAH-PG-A3 (46.82 %). Maximum TSS (°B) was noted in the cv. Saih Sirin (19.2 °B) and minimum was observed in the cv. Sirin (11.2 °B). The acidity was found to be maximum in the cv. Tujetis EC-104347 (3.6%) followed by Khog and CIAH-PG-1 (3.5%) while minimum acidity was observed in the cv. Malta (0.78%).

Fig. 74. Drying quality characteristics of different sour genotypes of pomegranate

Table 81. Drying quality characteristics of different sour genotypes of pomegranate

Accession name	Fruit Weight (g)	Aril recovery (%)	Peel percentage (%)	Dehydration ratio	Anardana recovery (%) from fresh aril	Aril color	TSS (°B)	Titratable acidity (%)	Brix: Acid ratio
SaihSirin	158.20	58.40	40.16	2.74	36.50	Pink	19.2	2.1	9.14
Uthkal	184.38	58.15	40.96	3.66	27.32	Light pink	13.4	2.5	5.36
IIHR-12/1	122.19	53.41	40.19	3.44	29.05	Dark red	16.1	3.4	4.74
Tujetis EC-104347	208.28	61.79	33.06	3.16	31.66	Dark Red	12.8	3.6	3.56
CIAH-PG-1	166.58	68.14	30.44	3.80	26.35	Dark red	13.34	3.5	3.81
Speen Sacarin	129.16	59.62	39.24	3.66	27.34	Dark red	12.5	2.6	4.81
Bedana Thin skin	162.34	53.49	45.74	3.09	32.32	Dark red	15.3	0.8	19.13
AK Anar	146.37	53.53	45.26	3.11	32.14	Dark red	16	2.8	5.71
Bedana Seedless	115.84	69.21	30.81	3.36	29.74	Light pink	15.4	1.9	8.11
Gul-e-Shah Red	169.25	63.39	35.64	3.25	30.77	Pink	14.7	2.6	5.65
Patna-5	124.12	57.37	41.28	3.37	29.71	Light pink	13.5	1	13.50
P-21	194.25	62.04	36.44	3.29	30.43	Pink	12.8	0.81	15.80
Gul-e-Shah Rose Pink	154.21	54.18	43.96	3.18	31.49	Pink	15.2	3.0	5.07
Yercaud Local	86.35	45.07	54.42	3.61	27.73	Light pink	12.5	1.8	6.94
AHPG-H3	186.14	47.90	51.31	3.58	27.94	Dark pink	12.5	2.3	5.43
Malta	118.25	61.80	36.65	3.49	28.62	Dark pink	14.3	0.78	18.33
Khog	184.32	68.03	30.57	4.02	24.88	Dark Red	16	3.51	4.56
Gul-e-Shah	164.25	52.60	45.20	3.13	31.99	Red	12.7	3.3	3.85
IC-310712	34.51	50.42	49.35	2.86	35.01	Red	13.4	2.6	5.15
Basin Seedless	175.23	50.99	41.32	3.33	30.00	pink	14.7	1.08	13.61
EC-62812	65.20	51.55	46.99	3.49	28.68	pink	12.8	2.3	5.57
Sirin	158.23	61.95	37.53	3.73	26.78	pink	11.2	2.7	4.15
Tabest	70.28	57.87	40.80	3.43	29.19	Dark red	13	3.42	3.80
AHPG-H-1	132.86	59.10	40.00	3.53	28.32	Dark red	13.7	2.1	6.52
Kalisirin	122.28	45.22	53.67	3.37	29.64	Dark red	13.9	3.2	4.34
Agah	110.23	53.11	45.13	3.36	29.80	pink	14.7	2.29	6.42
CIAH-PG-A-6	74.22	45.89	49.04	4.17	24.00	Whitish pink	12.4	2.0	6.20
CIAH-PG-A-2	74.70	56.59	42.92	3.17	31.56	Whitish pink	13.6	1.8	7.56
CIAH-PG-A-5	29.82	25.45	69.85	2.26	44.16	Whitish pink	11.2	3.2	3.50
CIAH-PG-A-4	27.44	37.61	61.59	2.28	43.94	Whitish pink	14.6	1.4	10.43
CIAH-PG-A-3	17.40	26.95	71.61	2.14	46.82	Whitish pink	12.2	2.1	5.81

Standardization of methods for extraction of phalsa juice extract

Phalsa juice is very popular due to its pleasing flavour and deep crimson-red colour. In addition, due to extremely refreshing quality of phalsa juice, it can be processed into ready-to-serve (RTS) and carbonated beverages. The juice could also be used in the preparation of syrup and squashes by mixing with appropriate amounts of sugar syrup. However, the process of extraction of juice from the phalsa fruits is highly tedious and complex process due to their minute size and bigger seed size. The recovery of juice from the fruits varies with the method of extractions such as mechanical or manual etc. Hence, an attempt was made to standardize the juice extraction methods for achieving greater quantity and quality of phalsa extracts. The methods used include manual crushing, microwave heat application (900 watt) prior to and after crushing, direct heat application (60 °C), prior to and after crushing, and freezing followed by thawing. The recovery of juice obtained by various methods was given in the Table 82.

Table 82. Juice recovery obtained through various extraction methods

Treatment	Method of extraction	Juice recovery (%)	Pomace waste (%)
T1	Mashing (Manual crushing)	68.00	25.0
T2	Mashing + Microwaving (5 min)	61.50	24.4
T3	Microwaving (5 min) + Manual crushing	67.00	24.8
T4	Heating (60°C) for 5 min + Mashing	55.00	30.8
T5	Mashing + Heating (60°C) for 5 min	51.50	33.2
T6	Freezing (-20°C) + Thawing	70.00	20.2

Among various methods, freezing followed by thawing has given highest amount of recovery followed by manual mashing. The reduction of recovery percentages in other extractions might be due to evaporation of water during heating process. However, the amount of anthocyanins in the extracted juice were more in the microwave assisted extraction methods followed by heat processing techniques (Fig. 75)

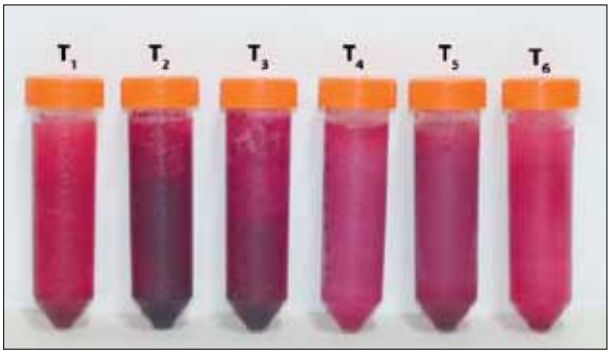


Fig. 75. Color variation in phalsa extract under different methods

Impact assessment of arid horticultural crops

During the reported period, the impact assessment on adoption of improved variety of *kachri* (AHK-119) and snapmelon (AHS-820) was carried out and the outcomes of the same are given below in brief.

Kachri (*Cucumis callosus* Rott. Cong.)

Impact in terms of area, production and income generation

The area and production of AHK-119 increased tremendously at large scale during 2007 to 2019. The area under the improved variety (AHK-119) was 2057 ha and production was 18.30 thousand tonnes in 2007 which estimated to increase >8 thousand ha and >60 thousand tonnes in the year of 2019, respectively in hot arid region of India. The estimated gross return from improved variety (AHK-119) of *kachri* alone was Rs. 28.19 crores in 2007 which increased to more than Rs. 85 crores in 2019.

Impacts in terms of employment generation and wages earning/income

Adoption and production of improved variety of *kachri* had highly positive impact on employment generation and wages earning/ income of the farmers /clients in the hot arid regions of the country (Table 83).

Table 83. Impact assessment of *kachri* cv. AHK-119 in hot arid regions

Years	Total area	No. of labour (man days/ ha/season)	Labour wage (Rs. /day)	Total employment (man days) gererated (lacs/year)	Concealed income labour wages (Rs. crore/year)
2007	2057	84	164	1.73	2.83
2008	1716	84	176	1.44	2.54
2009	1489	84	180	1.25	2.25
2010	4028	84	188	3.38	6.36
2011	2843	84	211	2.39	5.04
2012	3415	84	219	2.87	6.28
2013	2981	84	240	2.50	6.01
2014	4505	84	267	3.78	10.10
2015	3832	84	281	3.22	9.05
2016	3878	84	313	3.26	10.20
2017	6093	84	322	5.12	16.48
2018	6625	84	340	5.56	18.90
2019	6815	84	350	5.72	20.02
Total				42.22	116.06

Snapmelon (*Cucumis melo* var. *momordica*)

Impact in terms of area, production and income generation

The impact of adoption of improved variety (AHS-82) of snapmelon was carried out. The area under this variety (AHS-82) was 969 ha and production was 14.34 thousand tonnes in 2007 which estimated to increase >4 thousand ha and >60 thousand tonnes, respectively in the year of 2019. The gross return from this improved variety (AHS-82) alone was Rs. 11.76 crores in 2007 which increased to Rs. 50 crores in 2019.

Impact in terms of employment generation and wages earning/income

The data presented in Table 84 showed the adoption and production of improved variety of snapmelon had highly positive impact on employment generation and wages earning/ income of the farmers /clients in the hot arid regions of the country.

Table 84. Impact assessment of snapmelon cv. AHS-82 in hot arid regions

Year	Area	Labour engaged/ ha/season	Labour wage (Rs. /day)	Total employment (man days) gererated (lacs/year)	Concealed income labour wages (Rs. crore/year)
2007	969	71	164	0.69	1.13
2008	1202	71	176	0.85	1.50
2009	2245	71	180	1.59	2.87
2010	1993	71	188	1.42	2.66
2011	1315	71	211	0.93	1.97
2012	2489	71	219	1.77	3.87
2013	2231	71	240	1.58	3.80
2014	2252	71	267	1.60	4.27
2015	3278	71	281	2.33	6.54
2016	3470	71	313	2.46	7.71
2017	3562	71	322	2.53	8.14
2018	3815	71	340	2.71	9.21
2019	4120	71	350	2.92	10.22
Total				**23.38**	**63.89**

Information on adoption, area and production under improved variety of ber in hot arid region of Rajasthan

During the reported period of time, the information about the adoption, area and production under improved variety of ber in some districts of Rajasthan were also collected and were analyzed to draw the impact of the same in hot arid region of Rajasthan. The initial data/information are presented below (Table 85 to 86).

Table 85. Year wise area of improved ber varieties in hot arid regions

District	Year wise area (ha)			
	2005	2010	2015	2018
Bikaner	256	480	659	869
Jaisalmer	43	62	82	109
Pali	103	248	396	542
Jodhpur	251	352	520	669
Barmer	215	236	426	635
Total	868	1378	2083	2824

Table 86. Year wise total production of improved varieties of ber in hot arid regions

District	Year wise total production (tonnes)			
	2005	2010	2015	2018
Bikaner	2999.58	5624.21	7721.57	10182.2
Jaisalmer	503.835	726.46	960.802	1277.16
Pali	1206.86	2905.84	4639.97	6350.67
Jodhpur	2940.99	4124.41	6092.89	7838.73
Barmer	2519.18	2765.24	4991.48	7440.36
Total	10170.44	16146.16	24406.72	33089.09

4. EXTERNALLY FUNDED PROJECTS

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

Funding agency: ICAR, New Delhi

Field evaluation of tissue cultured plants for establishment, survival, growth, flowering, fruiting and yield attributes supplied by coordinating centres was done under field conditions. Tissue culture derived date palm elite cultivar Anand Local 1 (Red coloured) were procured at secondary hardening stage from Gujarat Agriculture University, Anand, Gujarat (India). Twenty five plants were transplanted in the field during July 2013 and 133 plants during September 2014 at ICAR-CIAH, Bikaner after successful secondary hardening of plants under hardening unit at ICAR-CIAH, Bikaner. These plants were evaluated for establishment, survival, growth, flowering, fruiting and yield attributes under hot arid ecosystem of Bikaner, Rajasthan. The success rate of establishment was 100 per cent with the first lot of planting and average height of plants reached up to 3.10 m. Number of leaves per plant were 31-36. Average canopy size (north-south x east-west) of the plants was recorded 3.68 x 3.66 m. No diseases were noticed in any of the plant. Good results were obtained with respect to vegetative growth and development of the plants. The success rate of establishment was 100 per cent and height of plants reached to almost triple to the initial height of the plants. Number of leaves per plant were also increased from 6-7 to 31-36 per plant at 6th year growth of the plants. Canopy size of the plants was also increased and reached up to 3.68 x 3.66 m.

Emergence of spathe and hand pollination

Spathes were emerged in 35 plants having 2-11 spathes/plant. Hand pollination was done using Ghanami male pollen in these plants. Pollination was done manually from first week of March to first week of April, 2019.

Flowering, fruiting and yield attributes

The good results were obtained in case of flowering, fruiting and yield related parameters of Anand Local 1 plants. Profuse flowering was commenced in 35 plants during first week of March to first week of April, 2019. Heavy fruiting was recorded in these plants. Fruit was attractive shiny red coloured but medium in size. Fruits were matured and ready for harvest in the last week of June 2019. Fruits were red in colour during ripening period. The fruit yield was recorded 11-14.5 kg per plant (Fig. 76).

Fig. 76. Heavy fruiting in date palm cultivar 'Anand Local 1'

2. DUS Centre on date palm

Funding agency: PPV& FRA, New Delhi

Under DUS centre on date palm, data on morphological and fruit characters in reference varieties were recorded as per DUS guidelines. The spathe emergence/flowering/fruiting were recorded in 30 varieties out of 42 varieties during 2019. Early emergence of spathe/opening in female palms in comparison to male was also observed. Early flowering/fruiting and maturity were noted in cv. Nagal, Tayer and Surya. Variation in fruit weight, size, shape, and stone weight were observed. Fruit yield varied from 2.0 to 50 kg/plant at *doka* stage. Medjool, Sabiah, Dayari and Siwi cultivars were harvested late at the end of July and beginning of August. The reference varieties were maintained at the centre. One farmer from Rajasthan has submitted application to PPV&FRA for testing of date palm varieties.

3. DUS Centre on ber

Funding agency: PPV& FRA, New Delhi

During reporting period reference varietal block of Indian jujube (ber) were maintained and data were recorded as per DUS-guideline to conform the distinctness, uniformity and stability of the described characteristics. One exploration programme for characterizing farmers' varieties onsite data collection (146 entries) were conducted in Chhattisgarh state as per schedule received from PPV&FR authority, New Delhi (4-10th March, 2019).

Twenty five reference and 85 example varieties of ber were maintained in field gene bank and simultaneously eight claim varieties on site data collection from Kesharwani, Lakhuri, Raipur is in progress for validation as per descriptor. This year, we are going to tally morphometric, flowering, fruiting and fruit quality stable traits in field conditions.

4. DUS Centre on bael

Funding agency: PPV& FRA, New Delhi

Reference varieties *viz.,* Goma Yashi, Thar Divya, NB-5, NB-7, NB-9, NB-16, NB-17, Pant Aparna, Pant Sujata, Pant Shivani, Pant Urvashi, CISH-B-1 and CISH-B-2 are being maintained at the station to characterize the farmers varieties. Farmers varieties of Chhatishgarh, West Bengal and Bihar are being studied for DUS characters.

5. DUS Centre on aonla

Funding agency: PPV& FRA, New Delhi

Reference varieties *viz*., NA-7, NA-6, Banarasi, Chakaiya, Francis, Anand-1, Anand-2, NA-4 and NA-5 are being maintained at the station to characterize the farmer's varieties.

6. DUS Centre on jamun

Morphological descriptors and DUS test guidelines for jamun have been developed and submitted to the authority. Varieties are being maintained at the station.

7. DUS Centre on tamarind and chironji

Morphological descriptors and DUS test guidelines for tamarind and chironji have been developed and submitted to the authority. Varieties are being maintained at the station.

8. DUS Centre on watermelon and muskmelon

Funding agency: PPV& FRA, New Delhi

Conducted DUS testing of five candidate varieties (VCK) of watermelon and one variety of muskmelon. Maintained the reference varieties of watermelon and muskmelon for further use in DUS testing.

9. Enhancing food and water security in arid region through improved understanding of quantity, quality and management of blue, green and grey water

Funding agency: Department of Science and Technology, New Delhi

The ICAR-CIAH, Bikaner centre is involved in "Integration of surface and ground water to achieve per drop more horticultural crop". The disease free tissue cultured plants of Bhagwa cultivar were procured from Jain Irrigation System Limited, Jalgaon. The planting was done on 10th August 2019. The plant survival was 85% and plant growth was also satisfactory. The plants were irrigated with canal water (0.32 dSm^{-1}) for the better establishment.

5. TRANSFER OF TECHNOLOGY

Mega Events Organized

Kisan Sammelan

Institute has organized Kisan Sammelan programme on 30th August, 2019 at ICAR, CIAH, Bikaner in which 350 farmers were participated. Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare and Sh. Arjun Ram Meghwal, State Minister of Parliamentary Affairs, Heavy Industry and Public Industry addressed to the farmers and imphasized on use of horticultural technologies developed by ICAR-CIAH, Bikaner in a scientific way for better yield and quality production. They also appreciated the institute for development of *khejri* variety 'Thar Shobha' and *kachri* variety 'AHK-119' for benefit of farmers of arid region. In the programme, technologies on arid horticultural crops were demonstrated and interaction programme was held with farmers. The publications of the institute *viz*. technical folders/ bulletins were released and distributed to the farmers.

Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare and Sh. Arjun Ram Meghwal, State Minister of Parliamentary Affairs, Heavy Industries and Public Enterprises addressed to the farmers and visited exhibition stalls during kisan sammelan

Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare visited research farm and interacted with scientists of the Institute

North Zone Hindi Workshop

Institute has organized North Zone Hindi Workshop during 30-31st August, 2019 at ICAR-CIAH, Bikaner. The workshop was inaugurated and addressed by Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare and Sh. Arjun Ram Meghwal, State Minister of Parliamentary Affairs, Heavy Industry and Public Industry. All the technical officers/Hindi Officers working in Rajbhasha activities in North Zone ICAR Institutes (45) and ICAR HQ were participated in the workshop. The objective of workshop was to improve efficiency of the ICAR employees in implementation of Rajbhasha.

Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare and Sh. Arjun Ram Meghwal, State Minister of Parliamentary Affairs, Heavy Industries and Public Enterprises addressed the participants of the Hindi Workshop

National Conference

A national conference on "Arid Horituclture: A way forward for sustainable production and nutritional security" was jointly organized by University of Agricultural Sciences, Raichur (Karnataka) and ICAR-Central Institute for Arid Horticulture, Bikaner 28-30th November, 2019 at UAS, Raichur where more than 250 scientists/ teachers/students/farmers and personnels from growers associations were participated. The AICRP on Arid Zone Fruits workers were also participated in this conference. The key note on arid fruits was presented by Project Coordinator, AICRP on Arid Zone Fruits and some lead papers were also presented by the scientists of ICAR-CIAH, Bikaner. The conference was inaugurated by Dr. Bhimanagouda S. Patil, Vegetable and Fruit Improvement Center, Depattment of Horticultural Sciences, Texas, A&M University, College Station, TX 77843, USA and presided over by Dr. K. N. Kattimani, Vice Chancellor, UAS, Raichur. On this occation several senior officials of ICAR/SAUs and State Department were present.

National conference organized at UAS, Raichur

AICRP-AZF Workshop

The institute has organized Annual Group Meet of Research Workers of All India Coordinated Research Project on Arid Zone Fruits in collaboration with Vasantrao Naik Marathwada Krishi Vidyapeeth at Parbhani, Maharastra from 23rd to 25th February, 2019. In this workshop 18 different centres of SAUs and ICAR Institute were participated and presented their annual progress report.

AICRP-AZF Research Workers Meet organized at VNMKV, Parbhani

Horticulture Technology Workshop

A workshop on various technologies developed for horticultural crops of the arid region was organized by ICAR-CIAH, Bikaner on 5th November, 2019. About 150, Farmers, farm women, scientists, KVK staffs, state department personnel were participated. A document in hindi is under preparation.

Workshop on technologies developed for arid horticultural crops

Training imparted on hi-tech propagation techniques during International Training Programme

Capacity Building Programmes

International Training Programme

Institute has organized International Training programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid eco-system from 9-18th August, 2019 at ICAR-CIAH, Bikaner. In this training programme, five participants from different internatonal organizations *viz*. National Institute of Agricultural Research, Meknes, Morocco; National Horticultural Research Institute, Ibadan, Nigeria; Agricultural Research Council of Nigeria, Abuja, Nigeria; Minisrty of Agriculture, Zambia and CSIR, Ghana were participated. In the programme various lectures were delivered on different aspects of hi-tech propagation and production of arid fruit and vegetable and field visits were conducted by the different experts.

Agriculture Skill Council of India Sponsored Training Programmes

- Twenty one days training programme on "Quality Seed Producers" organized at institute from 11th February to 03rd March, 2019.
- Twenty one days training programme on "Organic Grower" organized at institute from 05-25th March, 2019.

Model Training

- A Model Training Programme was organized on "Integrated Pests Management in Arid Horticultural Crops" for extension personnel/ field workers from 02-09th September, 2019, sponsored by Ministry of Agriculture and Farmers Welfare, Govt. of India.


Training programmes organized at ICAR-CIAH, Bikaner


A Model Training organized on IPM in Arid Horticultural Crops

National Training Progammes

- Three days farmers training on "Integrated production technology for pomegranate under dry lands" organized from 26-28th August, 2019. The training was sponsored by Project Director (ATMA), Bhuj- Kutch (Gujarat).
- Five days farmers training was organized on "Integrated Pest Management on fruits and vegetables" sponsored by Deputy Director (Hort.) (ATMA), Jhunjhunu, Rajasthan from 16-20th September, 2019.
- Organized four month training for B. Tech (Ag. Eng.) students of Anand Agricultural University, Anand on "Recent advances in production and post harvest technology of semi-arid horticultural crops" at ICAR-CIAH Regional Station, Vejalpur from 1st February to 31st May, 2019.
- Organized summer training programme on "Innovative interventions in sustainable horticultural production and post harvest technology under changing climate scenario" for B. Tech. (Ag. Eng.) Students of College of Godhra by ICAR-CIAH Regional Station, Vejalpur from 1-30th June, 2019.

Besides, different training programmes for students and farmers were conducted at ICAR-CIAH, Regional Station at Vejalpur during 2019 on various aspects of semi-arid fruits and vegetable crops. The details of activities are given below (Table 87).

Table 87. Students and farmers visit at ICAR-CIAH, Regional Station, Vejalpur during 2019

Date	Sponsors	Total no. of participants
17.05.2019	Deputy Director Horticulture, Rajkot region, Gujarat	12
01.07.2019	Deepak Foundation, Halol,Gujarat	22
06.07.2019	Sh. N.M. Sadguru Foundation, Chosala, Dahod	36
12.07.2019	Sh. N.M. Sadguru Foundation, Chosala, Dahod	38
16.07.2019	Sh. N.M. Sadguru Foundation, Chosala, Dahod	25
26.08.2019	B.Sc. (Hons) Agril. Students AAU Anand. Gujarat	37
27.08.2019	Department of Horticulture, B.Sc. Students BACA, AAU, Anand, Gujarat	38
28.08.2019	Department of Horticulture, B.Sc. Students BACA, AAU, Anand, Gujarat	34

Date	Sponsors	Total no. of participants
31.08.2019	Sri. N.M. Sadguru Foundation, Chosala, Dahod	30
04.09.2019	ATMA Project, Alirajpur, Madhya Pradesh	30
04.11.2019	Deputy Director of Training, FTC, Thasara, Gujarat	35
07.11.2019	Sh. N. M. Sadguru Foundation, Chosala, Dahod	35
18.12.2019	ATMA Project, Ujjain, Madhya Pradesh	36
01.07.2019	Deepak Foundation, Halol, Gujarat	22
15.07.2019	ATMA Project, Limkherda, Distt. Dahod, Gujarat	30
16.07.2019	ATMA Project, Devgarh Baria, Distt. Dahod, Gujarat	30
17.07.2019	ATMA Project, Dahod, Distt. Dahod, Gujarat	30
18.07.2019	ATMA Project, Dhanpur, Distt. Dahod, Gujarat	30
19.07.2019	ATMA Project, Garbada, Distt. Dahod, Gujarat	30
22.07.2019	ATMA Project, Sanjali, Distt. Dahod, Gujarat	30
23.07.2019	ATMA Project, Fatepura, Distt. Dahod, Gujarat	30
24.07.2019	ATMA Project, Zalod, Distt. Dahod, Gujarat	30
25.07.2019	ATMA Project, Singhvad, Distt. Dahod, Gujarat	30
29.07.2019	ATMA Project, Galteshwar, Distt. Kheda, Gujarat	30
30.07.2019	ATMA Project, Thasra, Distt. Kheda, Gujarat	30
31.07.2019	ATMA Project, Mahudha, Distt. Kheda, Gujarat	30
01.08.2019	ATMA Project, Matar, Distt. Kheda, Gujarat	65
02.08.2019	ATMA Project, Nadiyad, Distt. Kheda, Gujarat	35
03.08.2019	ATMA Project, Vaso, Distt. Kheda, Gujarat	57
05.08.2019	ATMA Project, Kheda, Distt. Kheda, Gujarat	50
06.08.2019	ATMA Project, Kathlal, Distt. Kheda, Gujarat	55
07.08.2019	ATMA Project, Kapadvanj, Distt. Kheda, Gujarat	55
27.09.2019	Parul University, Waghodiya, B.Sc. Bio-Technology, Vadodara	115
22.12.2019	ATMA Project, Dahod, Distt. Dahod, Gujarat	30
23.12.2019	ATMA Project,Garbada , Distt. Dahod, Gujarat	30
26.12.2019	ATMA Project, Fatepura, Distt. Dahod, Gujarat	30
27.12.2019	ATMA Project, Sanjali, Distt. Dahod, Gujarat	30
28.12.2019	ATMA Project, Devgarh Baria, Distt. Dahod, Gujarat	30
29.12.2019	ATMA Project, Dhanpur, Distt. Dahod, Gujarat	30
30.12.2019	ATMA Project, Limkherda, Distt. Dahod, Gujarat	30
31.12.2019	ATMA Project, Zalod, Distt. Dahod, Gujarat	30
31.12.2019	ATMA Project, Singhvad, Distt. Dahod, Gujarat	30

Scheduled Caste Sub Plan Programme (SCSP)

The Institute organized 11 training programmes for empowerment of scheduled caste farmers on "Improved arid horticultural crop production and value addition technologies". More than 300 farmers and 250 SC farm women were benefitted through the training programmes. The inputs like fertilizers, seeds of improved varieties of vegetable, spices, kitchen gardening packets, milk collection canes, power spraying machines, technical folders, *etc*. were distributed among

the above trainee farmers and farm women. They were visited to the experimental blocks, technological museum and nursery complex of the institute to create awareness and impart knowledge on modern production, propagation and post harvest management technologies of arid horticultural crops.

Activities organized under SCSP

- Farmers training programme on technology for arid fruit production was conducted at Benisar village district Bikaner on 25th March, 2019.
- Farmers training programme was organised on fertilizer and manures on fruit crops at Husansar village district Bikaner on 26th March, 2019.
- Farmers training programme on micro-irrigation and water management in arid fruit crops was organised at Chani village district Bikaner on 27th March, 2019.
- Farmers training programme on horticulture nursery production and management was organised at Gersar village district Bikaner on 28th March, 2019.
- Farmers training programme was organised on introduction to new varieties of fruit crops at Lakhasar village district Bikaner on 29th March, 2019.
- Training of SC farmers from Kolasar village was organized on 06th August 2019 at institute and fertilizers (Urea, DAP, MOP) were distributed to 12 SC farmers.
- Training of SC farmers from Ambasar, Sujasar of Bikaner district was organized on 10th August 2019 at institute and fertilizers (Urea, DAP, MOP) were distributed to 39 farmers under SCSP Scheme.
- Training of SC farmers from Pemasar, Udasar of Bikaner district was organized on 19th August 2019 at institute and fertilizers (Urea, MOP) were distributed to 49 farmers of SC under SCSP Scheme.
- Knap sac sprayer were distributed to SC farmers (sarpanch) under SCSP Scheme.
- Training of SC farmers from Ambasar, Sujasar of Bikaner district was organized on 6th November 2019 at Institute and milk cane, seeds of cumin, coriander and fenugreek were distributed to 39 SC farmers.
- Training of SC farmers from Salasar, Naiyo ki Dhani of Bikaner district was organized on 26th December, 2019 at institute and seed bin drum, kitchen gardening kit and seeds of methi, palak, turai and bottle guard were distributed to 39 SC farmers.




Training programme and distribution of inputs under SCSP Scheme

Demonstrations Conducted

Field/research demonstration on arid vegetables

- To promote arid vegetable technology, demonstrations have been conducted at farmer's field of Jamsar, Ambasar and Sujasar, Khara villages in Bikaner district of Rajasthan. Technological demonstration were conducted on improved varieties of snap melon (AHS-82), cluster bean (Thar Bhadavi), bottle guard (Thar Samridhi), Indian bean and palak at farmers' field.
- Farmers were benefited by adopting improved varieties of vegetable crops. Yield of improved varieties of snap melon (AHS-82), cluster bean (Thar Bhadavi), bottle guard (Thar Samridhi), Indian bean and palak was better as compared to their local cultivar. Farmers also collected the seed of vegetable crops for seed production.
- Under ToT programmes, visits were made at KVK Lunkarnsar, Sardarsahar and Chandgothi (Churu) on 14th and 15th October to develop arid horticulture technology, orchard establishment and seed production skill development, growing of seasonal vegetable varieties and their seed production so that local farmers can be benefited with research output.

Front Line Demonstration

Different front line demonstrations were organized on improved varieties of arid fruits and vegetables crops developed by the institute (Table 88). In addition to above FLDs, 48 method demonstration on the production technologies of arid horticulture were also performed by the institute at farmers' field.

Farmers Field Demonstration

Table 88. Front Line Demonstration (FLDs) organized at farmers field

S. No.	Crop and variety	Farmers name and address	Date
1	*kachri* (AHK-119)	Sh. Banti VPO-Sarahkunjiya, Bikaner	22nd May 2019
2	Ridge gourd (Thar Karni) & snapmelon (AHS-82)	Sh. Om S/o Kana Ram Mali Village-Khinchiya (4KHM), Bikaner	23rd May 2019
3	*Khejri* (Thar Shobha) and lasora (Thar Bold)	Sh. Rawat Ram S/o Hadmana Ram Kumawat, 4 JMD (VMD), Khara, Bikaner	24th September, 2019

S. No.	Crop and variety	Farmers name and address	Date
4	Ber (Gola, Thai apple and Thar Sevika) and lasora (Thar Bold)	Kuldeep Sharma S/o Smt. Chandra Devi, Bachchhasar and Rawat Ram S/o Sh. Hadmana Ram Kumawat, 4 JMD (VMD), Khara, Bikaner	25th September, 2019
5	*Kachri* (AHK-119) and ridge gourd (Thar Karni)	Panna Lal S/o Mula Ram Meghwal, Village- Khinchiya (4KHM), Bikaner	02nd August, 2019
6	*Kachri* (AHK-119) and ridge gourd (Thar Karni)	Dhanna Ram S/o Gorakha Ram Meghwal, Village-Jalasar, Bikaner	02nd August 2019
7	*Kachri* (AHK-119) and cluster bean (Thar Bhadavi)	Rewant Ram Kumawat, village-JMD, Khara, Bikaner	31st July, 2019

Popularization of potato in non traditional area of arid region

During 2018, demonstrations were conducted on farmer's field at different locations of Bikaner districts revealed that maximum tuber yield was obtained from Kufri Chipsona followed by Kufri Badshah and Kufri Khayti, while minimum yield was observed in farmers practices and seed was purchased from local market which was used for sowing in the treatments of farmers practices.

Participatory research programme and evaluation of different potato varieties and their agronomic efficiency in north-western Rajasthan at farmer's field were conducted at different location of Bikaner district. Tuber yield varied significantly from variety to variety and maximum mean tuber yield was obtained from Kufri Frysona (337 q/ha) followed by Kufri Chipsona-4 (304 q/ha) and Kufri Garima (280 q/ha), while minimum yield was observed in Kufri Pukhraj (190 q/ha) and Kufri Jyoti (203 q/ha). Kufri Khyati and Kufri Surya produced 236 and 257 q/ha potato yield, respectively.

During 2019 FLDs/method demonstration/ result demonstration were conducted among the farmers of old as well as newly adopted villages under MGMG scheme and others villages at different locations of Bikaner district. ICAR-CIAH received potato seed from CPRS-Gwalior (MP) cultivar Kufri Sinduri for collaborative project with ICAR-CPRI, Shimla. Farmers were selected by a committee constituted by CA through survey/discussion/personal contact/telephonic discussion etc. and the seed was distributed accordingly for FLD's/method demonstration/ result demonstration for timely planting. List of farmers are given below (Table 89).

Table 89. Farmers field demonstration for potato cv. Kufri Sinduri for the year 2019

S. No.	Name of Farmer's	Address
1	Anthu Ram Suthar	12 SSM Pugal, Bikaner
2	Prem Chand	12 SSM Pugal, Bikaner
3	Govind Godara	496, Sarahkunjia, Bikaner
4	Manohari Lal w/o Ram Pratap	Chak 489 RDL
5	Sabir Ali S/o Mahammad Ali	Jhajhu, Kolayat, Bikaner
6	Mohammad Javed S/o Manjoor Ali	Raisar, Bikaner
7	Bhanwar Dhatarwal S/o Shri Krishan Lal	Chak 489, Bikaner
8	Subhash S/o Shri Krishan Lal	Chak 489, Bikaner
9	Chandu Nath S/o Arjun Nath	Chak 489, Bikaner
10	Banti S/o Shri Prem Singh	Chak 493, Bikaner
11	Amra Ram S/o Parta Ram Nayak	Chak 493, Bikaner
12	Babul al S/o Shri Ramu nath Singh	Chak 483 RDL, Bikaner

S. No.	Name of Farmer's	Address
13	Panna Lal S/o Mula Ram Meghwal	Khinchiya, Bikaner
14	Jetha Ram Ji Meghwal	Ambasar, Bikaner
15	Prabhu Singh S/o Hari Singh Rajpoot	Ambasar, Bikaner
16	Ramdev Ji Meghwal	Kolasar, Bikaner
17	Hari Ram S/o Moda Ram	Sujasar, Bikaner
18	Jaydayal S/o Shri Askaran Ji Maharaj	Meghasar, Bikaner
19	Sunil Kumar S/0 Shri Dungar Ram Ji Upadhyay	Meghasar, Bikaner
20	Devi Singh Bad Gurjar	9 JMD Jamsar, Bikaner
21	Omprakash Vishnoi S/o Sh. Birbal Ram	496, Sarahkunjia, Bikaner
22	Bhanwar lal Meghwal S/o Shri Moda Ram Meghwal	Ambasar, Bikaner
23	Bhagirath Ram S/o Mangtoo nath	483 RD Husangsar, Bikaner

Demonstrations at KVKs

To promote arid vegetable technology, visits were made at KVK's of Lunkaransar (Bikaner), Nagaur, Sardarsahar and Chandgothi (Churu) and demonstrations on vegetable crops were conducted *viz.*, *Kachri* (AHK-119), snap melon (AHS-82), cluster bean (Thar Bhadavi), bottle guard (Thar Samridhi), Indian bean, palak, kundru (ivy gourd), *etc*. (29 demonstrations). During visit at KVK's farm, interaction were made with In-charge and SMS to develop arid horticulture technology orchards, crop specific museums, growing of seasonal vegetable varieties and their seed production so that local farmers can be benefited with newer-research output of CIAH. Also adviced to promote/conduct trainings on budding, grafting, *in-situ* orchard establishment and seed production skill development, interactions for poster display on arid horticulture technologies at museum of KVK. Frequently visited *kachri* AHK-119 seed production field at KVK Lunkarnsar and monitored harvested fruit & demonstrated seed extraction procedure.

Kachri AHK-119 at KVK Lunkaransar, Rajasthan

Arid vegetables at KVK, Panchmahal, Gujarat

Visit to demonstration site at KVK Lunkaransar, Sardarsahar and Chandgothi

Exhibitions

- Participated and arranged technological exhibition of the institute during the foundation day celebration of ARC of CSWRI, Bikaner on 04th April, 2019.
- A technological exhibition of the institute was displayed on the occasion of celebration of foundation day of the institute on 28th September, 2019.
- Displayed an exhibition of the institute in "Kisan Sammelan" organized by state Goverment of Rajasthan at Jaipur on 17th December, 2019.

Exhibited institute technologies during kisan mela and fairs

Scientists-farmers interaction programmes

- **Scientists-farmers interaction meet:** A scientists-farmers interaction meet was organized at the institute on 30th August, 2019. The meet was inuagurated by Sh. Kailash Chaudhary, Hon'ble State Agriculture Minister, Govt. of India in which more than 400 farmers, students, scientists, SMS, experts and officials from state departments were participated.
- **Institute Foundation Day:** The foundation day of the institute was celebrated on 28th September 2019 in which more than 300 farmers, students, scientists, field workers and dignitaries were participated. During this programme, organization of an exhibition, visit of farmers, students and other dignitaries, *etc*. were held.
- **Agriculture Education Day:** The Agriculture Education Day was celebrated at the institute on 03rd December 2019 in which more than 100 students (KV-II, Bikaner), scientists, teachers, and other people were participated. On this occasion, a science quiz programme was organized for the participating students.
- **Interaction with NHB officials:** A meeting was conducted with Sh. Sansar Ahmed, Deputy Director (Hort), Rajasthan to explain the Schemes of NHB on 8th April, 2019 at the institute and visit to farmers' fields of Sh. Govind Godara Sarahrupayat was also organised.
- **Farmers' School conducted:** A "Farmers' School" on improved variety of *kachri* (AHK-119) was conducted in collaboration with ATMA, Bikaner during the *kharif* season at the field of Ravindra Kumar Bisnoi S/o Dilip Kumar, Sarahkunjiya (493 RDL), Bikaner.
- **Jal Sakti Abhiyan**: At institute, Jal Sakti Abhiyan was organized during 02-09th September, 2019. Under this programme various activities like farmers meeting, trainings, discussion with farmers was conducted in different villages of the Bikaner to create awareness to save and conserve water resources for future on 5th Sept., and 7th Sept., 2019.
- **World Soil Health Day**: The World Soil Health Day was celebrated at Meghsar Village of Bikaner on 5th December, 2019 in which more than 100 farmers, scientists and other people were participated. On this occasion a farmers' training was organized on "Maintaining the soil health and fertility status".
- **Parthenium Awareness Week**: The Institute organized "Parthenium Awareness Week" from 6-22nd August 2019 to make campus parthenium free.

Mera Gaon Mera Gaurav (MGMG) Programmes

Several extension programmes and activities were organized under Mera Gaon Mera Gaurav Scheme in adopted villages of the institute like farmers' visits, meeting/*Sangosthi,* discussions, training, FLDs, method demonstrations, mobile advisory, creating linkages, creating knowledge and awareness, distribution of seeds and planting materials, technical literature, etc. among the farmers/clients of the five adopted villages of the Institute during 2019.

Celebration of International Yoga Diwas and Workshop

Employees of the institute (ICAR-CIAH, Bikaner) participated and celebrated International Yoga Divas at SKRAU, Bikaner on 21st June 2019. On this occasion, a workshop on "India and yoga knowledge to the world" was also organized by the institute in which various scientists, CIAH staff and common men/women students, farmers participated. Dr. (Col.) A.K. Gahlot, Former V.C., RAJUVAS, Bikaner as Chief Guest and Sh. Vinod Joshi as Guest of Honour participated in the programme.

Organized International Yoga Divas at ICAR-CIAH, Bikaner

Swachchh Bharat Abhiyan

As per directions of Goverment of India and ICAR, New Delhi, the cleaning work under *Swachchhta Abhiyan* was organized time to time within and outside of the Institute. The awareness and knowledge about *Swachchhta Abhiyan* was also created among the students, farmers and masses during the reported period.

Activities organized during *Swachchh Bharat Abhiyan*

Other important extension activities

- Twenty six on campus Research-Extension-Farmers-Interface-Meetings were held with visiting farmers/stakeholders at the Institute during 2019.
- Sixteen off campus Research-Extension-Farmers-Interface-Meetings were held while

visiting to farmers' fields/villages during the reported period of time.

- Nineteen diagnostic visit or advisory visits were made to farmer's fields to provide technical help/suggestions for better crop production/farming system.
- More than 200 technological advisory works (on line/telephonic/off line discussions/ guidance/Qns.–Ans.) with farmers were performed.
- More than 1000 technical literature were distributed among the farmers/clients during different extension programmes and activities within/outside of the Institute during the year.

Lead/Oral Presentations in Seminar/ Symposium/ Conferences

Dr. P. L. Saroj

- Lead Speaker to present a paper on "Potato in nontraditional areas of India" during 3rd Global Potato Conference: 2020 on 29th January" organized by ICAR-CPRI, Shimla at Ahmedabad from 28-31 January, 2020.
- Key Note on "Arid Horticulture: An option for doubling farmers income in arid and semi-arid regions" during "Global Conference on Science and Technology" organized at National Research Centre on Seed Spices at Ajmer during 1-3rd December, 2019 by Hi-tech Horticulture Society, Meerut (UP).
- Lead paper on "Technology options for doubling farmers income through arid horticulture" during Horticulture Summit 2020: Mitigating Climate Changes for Doubling Farmers Income through Diversification" organized at Mahatama Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot (MP) from 14-16 February, 2020.
- Lead paper on "Farmers friendly technologies for enhancing nutritional and income security through arid horticulture" during Progressive Horticulture Conclave 2020 on Futuristic Technologies in horticulture from 8-10th December, 2019 at ICAR-IISR, Lucknow, organized by ISHRD, Uttarakhand and ICAR-CISH, Lucknow.

Dr. B. D. Sharma

- Lead lecture on "Advances in nutrient and water management with special reference to arid fruits" in National Conference on arid fruits at UAS, Raichur on 28-30th November, 2019.

Dr. S. R. Meena

- Oral presentation on "Rural wisdom based value addition in arid fruits and vegetables for livelihood security: A case study in western Rajasthan" in National Seminar on Holistic Approach for Enhancing Agricultural Growth in Changing Rural Scenario" at SKRAU, Bikaner on 14-19th November, 2019

Mr. Ramesh Kumar

- Key note presentation on "Tapping the potential of arid fruit genetic resources for nutritional security" in National conference on arid fruits: A way forward for sustainable production and nutritional security organized from 28-30th November, 2019 at UAS, Raichur, Karnataka.
- Oral presentation on "Quality of pomegranate fruits as influenced by flower regulation under hot arid climate" in National conference on arid fruits: A way forward for sustainable production and nutritional security organized from 28-30th November, 2019 at UAS, Raichur, Karnataka.

Dr. Kamlesh Kumar

- Oral lecture on "Standardization of *in-vitro* protocol for mass multiplication of date palm cultivars Halawy and Khalas" in International conference on innovative horticulture and value chain management-Shaping future horticulture held at GBPUAT, Pantnagar (UK) during 28-31st May, 2019.

Dr. Ajay Kumar Verma

- Oral presentation on "Standardization of date of sowing and covering material under low tunnels for early harvest of cucurbits" in 3rd GMST at NRc on Seed Spices during 1-3rd December, 2019.

Lectures Delivered

Dr. P. L. Saroj

- Delivered a lecture on "Overview of Arid and

semi-arid Horticulture in India" on 9th August, 2019 during training on "Hi-tech Propagation and Production of Fruits and Vegetables in Arid and semi-arid Ecosystem" from 09-18th August, 2019, sponsored by Ministry of External Affairs, Govt. of India under Indo-African Forum Summit-III.

- Delivered a lecture on "Fruit based cropping systems in India" on 12th August, 2019 during training on "Hi-tech Propagation and Production of Fruits and Vegetables in Arid and semi-arid Ecosystem" from 09-18th August, 2019, sponsored by Ministry of External Affairs, Govt. of India under Indo-African Forum Summit-III.
- Delivered a lecture on "Arid Ecotourism" on 16th August, 2019 during training on "Hi-tech Propagation and Production of Fruits and Vegetables in Arid and Semi-arid Ecosystem" from 09-18th August, 2019, sponsored by Ministry of External Affairs, Govt. of India under Indo-African Forum Summit-III.
- Delivered a lecture on "Scenario of arid horticulture in India" on 02nd September, 2019 during Model Training on Plant Protection of Arid and Semi-arid Crops from 02-08th September, 2019 sponsored by Ministry of Agriculture and Farmers Welfare, Govt. of India.
- Delivered a lecture on "Improvement of arid zone fruits through AICRP on AZF" during "Brainstorming Session on Improvement of Arid Zone Fruits" on 18th January 2020 at SKN Agriculture University, Jobner (Rajasthan).
- Delivered a lecture on "Advances in improvement of arid fruits" in Winter School on "Non-conventional approaches for genetic improvement of perennial horticultural crops" organized by Division of Fruits and Horticulture Technology, ICAR-IARI, New Delhi on 27th January, 2020.

Dr. B. D. Sharma

- Delivered lecture on "Characteristics of arid and semi-arid soil and fertigation in important fruit crops" in ICAR sponsored winter school on hi-tech approaches for production and value addition of horticultural crops in arid and semi-arid regions at DHRD, SKRAU, Bikaner on 07th November, 2019.
- Delivered lecture in International Training Programme on "Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro ecosystem" held at ICAR-CIAH, Bikaner during 9-18th August, 2019.
- Delivered lecture on "Role of organic farming in pest management of arid fruit crops in MTC on IPM in arid fruits and vegetables" during 2-9th September, 2019.
- Delivered lecture on "Description of utility of soil test fertilizer recommendation (STFR) meter" at KVK, Bikaner on 17th July, 2019.
- Delivered a lecture "Automatic fertigation in fruit crops" in ICAR sponsored winter school on Digital fert-irrigation at SKRAU, Bikaner.

Dr. Sanjay Singh

- Delivered lecture on "Dry land Horticulture" to the students of AAU, Anand during Rural Horticulture Work Experience Training on 26th August, 2019.
- Delivered lecture on "Dry land Horticulture" to students of Parul University Vadodara during Rural Horticulture Work Experience Training on 17th September, 2019.
- Delivered lecture on "Dry land Horticulture" in Rural Horticulture Work Experience Training to the students of AAU, Chhotaudepur on 7th November, 2019.
- Delivered lecture on "Status and achievement of the CHES, Godhra" during training programme of students of B. Tech. (Agril. Eng.), AAU, Anand on 01st June, 2019.
- Delivered lecture on "Innovative interventions to reduce post harvest losses of semi-arid horticultural crops" during training programme of students of B. Tech. (Agril. Eng.), Engineering College, Godhra, AAU, Anand on 14th and 19th June, 2019.
- Delivered lecture on "Prospects and potential of jamun and khirni in semi-arid and arid conditions of western India" in training programme of students of B. Tech. (Agril. Eng.), Engineering College Godhra, AAU, Anand on 22nd June, 2019.

Dr. R. S. Singh

- Delivered lecture on "Date palm varieties and uses" in training programme for students under NAHEP held at IABM, SKRAU, Bikaner on 18th July, 2019.
- Delivered lecture on "Potential of exotic fruit crops in hot arid region" in international training on Hi-tech propagation and production of fruits and vegetables in arid and Semi-arid eco-system organized at ICAR-CIAH, Bikaner on 16th August, 2019.
- Delivered lecture on "Good agricultural practices in arid fruits" in Model Training programme held at ICAR-CIAH, Bikaner on 06th September, 2019.
- Lecture on "Scope of exotic fruit production in arid region" in winter school on Hi-tech approaches for production and value addition of horticultural crops in arid and semi-arid regions, SKRAU, Bikaner on 07th November, 2019.

Dr. D. K. Samadia

- Delivered lecture on "Genetic diversity and improvement of vegetable crops in hot arid region" in International training programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem organized at ICAR-CIAH, Bikaner on 13th August, 2019.
- Delivered lecture on "*Khejri* based crop production systems for hot arid region" in International training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem organized at ICAR-CIAH, Bikaner on 16th August, 2019.
- Delivered lecture on "Suitable vegetable crop-genotypes and production technology for safe pest management" in Modal training course on Integrated pest management in arid fruits and vegetables crops organized at ICAR-CIAH, Bikaner on 03rd September, 2019.
- Delivered lecture on "Arid vegetable crop germplasm and production technology" in Training programme on Advances and opportunities in entrepreneurship in seed sector organized at COA, SKRAU, Bikaner on 17th October, 2019.
- Delivered lecture on "Arid vegetables-genetic improvement and crop production technology" in winter school on Hi-tech approaches for production and value addition in horticulture crops of arid and semi-arid region organized at DHRD, SKRAU, Bikaner on 18th November, 2019.
- Delivered lecture on "Selected vegetable crops, genotypes and integrated production technology" in Farmers training programme of ATMA, organized by ICAR-CIAH, Bikaner on 17th September, 2019.
- Delivered lecture on "Good management practices for fruit crop production in drylands" in Farmer's training programme of ATMA, Bhuj- Improved production technologies for pomegranate under drylands organized by ICAR-CIAH, Bikaner on 27th August, 2019.

Dr. M. K. Jatav

- Delivered lecture on "Potato Cultivation in Hot Arid Region of North-Western Rajasthan: Possibilities and Constraints" in the International training on Hi-tech propagation and production of fruits and vegetables in arid and Semi-arid agro-ecosystems organized at ICAR- CIAH, Bikaner, Rajasthan, India on 09-18th August, 2019.
- Delivered lecture on "Judicious Nutrient Management in Vegetable Crops for Higher Productivity and Net Return" in the International training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystems organized at ICAR- CIAH, Bikaner, Rajasthan, India on 09-18th August, 2019.
- Delivered lecture on "Introduction and Performance of Tuber Crops in the Arid Region" in the International training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystems organized at ICAR- CIAH, Bikaner, Rajasthan, India on 09-18th August, 2019.
- Delivered lecture on "Fertilizer management in vegetable seed production" in ASCI training programme on quality seed producer organized at ICAR-CIAH, Bikaner on 19th February, 2019

- Delivered lecture on "Importance of organic manures in quality seed proction" in ASCI training programme on quality seed producer organized at ICAR-CIAH Bikaner on 26th February, 2019.
- Delivered lecture on "Fertilizer management in vegetable seed production" in ASCI training programme on quality seed producer organized at ICAR-CIAH Bikaner on 06th March, 2019.
- Delivered lecture on practical on "Soil testing and its importance in vegetable seed production" in the training programme on organic grower at ICAR-CIAH Bikaner on 06th March, 2019,

Dr. D. K. Sarolia

- Delivered lecture on "Genetic diversity & improvement in fruit crops in arid region" during international training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-eco-systems during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Vegetative propagation of fruit crops & their nursery management" during international training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-eco-systems during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Pest free planting material through nursery management" on 18th September, 2019 in farmers training on IPM in arid horticultural crops held at ICAR-CIAH, Bikaner during 16-20th September, 2019.
- Delivered lecture on "Advance techniques for quality planting material raising in horticultural crops under hot arid ecosystem" on 8th November, 2019 and "Hi-tech approaches for production and value addition of mango in Rajasthan context" on 12th November, 2019 at held at SKRAU, Bikaner.
- Delivered lecture on "Fruit production in urban landscape" at IABM, SKRAU, Bikaner on 14th September, 2019.

Dr. S. K. Maheshwari

- Delivered lecture on "Integrated disease management in arid cucurbitaceous crops" in MTC organized by ICAR-CIAH, Bikaner during 02-09th September, 2019.
- Delivered lecture on "Preparation of bio-formulation of *Trichoderma* spp. against plant diseases" in MTC organized by ICAR-CIAH, Bikaner during 02-09th September, 2019.
- Delivered two lectures on "Tricodarma prajation se jev sutrikaran banana ki vidhi" in 05 days on-campus farmers training programme during 16-20th September, 2019 at ICAR-CIAH, Bikaner.

Dr. A. K. Singh

- Delivered twenty five lectures on various aspects of arid horticulture *viz.*, propagation, cultivation, nursery management, post harvest products and medicinal significance of aonla, bael and noni to the ATMA farmers.

Dr. D. S. Mishra

- Delivered nineteen lectures on various aspects *viz.*, propagation, cultivation, orchard management of guava, pomegranate and acid lime to the ATMA farmers.

Dr. Vikas Yadav

- Delivered eleven lectures on various aspects *viz.*, propagation, cultivation, nursery management, post harvest products and medicinal significance of wood apple and custard apple to the ATMA farmers.

Dr. Lalu Prasad Yadav

- Delivered twelve lectures on various aspects of semi-arid horticulture to tribal farmers sponsored by ATMA, Gujarat.

Dr. Gangadhara K

- Delivered fourteen lectures on various aspects *viz.*, production technology, pest and disease management, cultivation, etc. of vegetable cowpea, chilli, Dolichos bean and yardlong bean to the ATMA farmers.

Dr. B. R. Choudhary

- Delivered lecture on "Production technology of cucurbit vegetables" in International

Training programme organized at ICAR-CIAH, Bikaner from 09-18th August, 2019.

- Delivered lecture on "Advance production technology of cucurbits for safe pest management" in MTC sponsored by Ministry of External Affairs, GOI, New Delhi and organized at ICAR-CIAH, Bikaner from 02-09th September, 2019.
- Delivered lecture on "Tunnel technology of cucurbits for safe pests management" on 18th September, 2019 in MTC on Integrated pests management in arid horticultural crops organized at ICAR-CIAH, Bikaner during 16-20th September, 2019.
- Delivered lecture on "Low tunnel technology for early summer vegetable production" on 20th October, 2019 in Short Course organized by ICAR-CAZRI, Jodhpur during 15-24th October, 2019.
- Delivered lecture on "Tunnel cultivation for cucurbits in arid ecosystem" on 14th November, 2019 in Winter School organized by SKRAU, Bikaner during 7-27th November, 2019.

Dr. S. M. Haldhar

- Delivered lecture on "IPM in arid horticulture crops" in International Training programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystems during 09-18th August, 2019.
- Delivered lecture on "Taxonomy of insect-pests of arid horticultural crops" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Integrated pest management of cucurbitaceous vegetable crops" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Integrated pest management in aonla crop" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Role of host plant resistance (HPR) study in arid horticultural crops" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Principles of integrated pest management (IPM)" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops 02-09th September, 2019 at CIAH, Bikaner.

Dr. Ramkesh Meena

- Delivered lecture on "Acquaintance of different value added products of arid fruit crops" in winter school training held at SKRAU, Bikaner during 7-20th November, 2019.
- Delivered lecture on "Training, pruning and crop production aspects of pomegranate" in Training programme on integrated production technology for pomegranate under dry lands held on 26th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Vegetative propagation of date palm" in International training on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-eco-systems during 9-18th August, 2019 at ICAR-CIAH, Bikaner.

Dr. M. K. Berwal

- Delivered lecture on "Nutraceutical Values of Flora of Arid Zone" in International Training Programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Horticultural Crops: Potential source of Functional food and nutraceuticals" in winter school training on Hi-tech approaches for production and value addition of horticultural crops in arid and semi-arid regions held at SKRAU, Bikaner during 07-27th November, 2019.
- Delivered lecture on "Role of bio-active compounds in pest management of arid horticultural crops" in MTC on Integrated

Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at CIAH, Bikaner.

Dr. Ramesh Kumar

- Delivered lecture on "Hi-tech approaches for production and value addition of pomegranate" in Winter school on Hi-tech approaches for production and value addition of horticultural crops in arid and semi-arid regions organized at DHRD, SKRAU, Bikaner during 7 -27th November, 2019.
- Delivered lecture on "Good management practices in pomegranate against pests" in MTC on Integrated pest management in arid horticultural crops organized from 16-20th September, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture in training programme on "Growing ornamental in container in arid region" at IABM, SKRAU, Bikaner on 13th September, 2019.

Dr. Chet Ram

- Delivered lecture on "DNA fingerprinting for cultivar identification" in International Training Programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Molecular breeding for biotic stress management in arid horticultural crops" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Bacteria: As biological control agents in agriculture" in the training programme Mass Production of Bio Agents for entrepreneurship Development during 25-31st December, 2019 at COA, SKRAU, Bikaner.

Dr. Anita Meena

- Delivered lecture on "Integrated nutrient management for quality seed production" in 21 days training programme on Quality Seed Producer during 11th February, 2019 to 03rd March, 2019, at ICAR-Central Institute for Arid Horticulture, Bikaner.
- Delivered lecture on "Importance of micronutrient and treatment for deficiency symptoms in plants" in training programme on Quality Seed Producer during 11th February, 2019 to 03rd March, 2019, at ICAR-Central Institute for Arid Horticulture, Bikaner.
- Delivered lecture on "Importance of *Tricoderma* and its application process" in training programme on Vermicompost Producer on 26th March, 2019 at ARS, SKRAU, Bikaner.

Dr. Ajay Kumar Verma

- Delivered lecture on "Maintenance of arid vegetable genetic resources" in International Training programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Management of pest in protected cultivation of vegetable for quality production" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at ICAR-CIAH, Bikaner.

Dr. Kamlesh Kumar

- Delivered lecture on "Suitable genotypes of underutilized crops for pest management" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at CIAH, Bikaner.
- Delivered lecture on "Greenhouse for propagation and management" in International Training Programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem during 9-18th August, 2019 at ICAR-CIAH, Bikaner.

Dr. Vijay Rakesh Reddy S

- Delivered lecture on "Post-harvest management and handling of horticultural produce" in International Training Programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem during 9-18th August, 2019 at ICAR-CIAH, Bikaner.

- Delivered lecture on "Processing and value addition of arid fruits and vegetables" in winter school on Hi-tech approaches for production and value addition of horticulture crops in arid and semi-arid regions organized by SKRAU, Bikaner from 07-27th November, 2019.
- Delivered lecture on "Value chain management of arid fruits and vegetables" in winter school on Digital Nutrigation for Resource Conservation in Arid Agro Ecosystem organized by SKRAU, Bikaner from 06-26th December, 2019.
- Delivered lecture on "Value addition in Pomegranate" in Training programme on Integrated production technology for pomegranate under dry lands sponsored by ATMA, Gujarat during 26-28th August, 2019.

Dr. Ramyashree Devi G. S.

- Delivered lecture on "Spawn preparation and mushroom cultivation" in training programme on Quality Seed Grower held from 11th February to 3rd March, 2019 at ICAR-CIAH, Bikaner.
- Delivered lecture on "Identification of major diseases in arid horticultural crops" in MTC on Integrated Pests Management in Arid Fruit and Vegetable Crops during 02-09th September, 2019 at ICAR-CIAH, Bikaner.

Activities of KVK, Panchmahal

On farm trials (OFTs)

During 2019, eight on farm trials were conducted on farmers field involving 82 farm families. The major on farm trials conducted where on nutrient management in acid lime cv. Kagji lime, evaluation of varieties of bottle gourd during summer, management of pink boll worm in Bt cotton, termite management in wheat, intergrated nutrient management in castor, pro-biotic supplementation on growth of growing goats, nutritional management of cattle calves with pro-biotics and sim-biotic etc.

Front line demonstrations (FLDs)

During reporting period total 21 front line demonstrations (FLD) were laid out in 148 ha area at 492 farmer's field (Table 90). The range of increase in production in various demonstrations 21.33 -157.69 per cent were recorded. The range of cost benefit ratio of various demonstrations was recorded 2.20 -3.94.

Effect of RDF and bio fertilizers on yield of acid lime cv. Kagzi Lime

Performance of bottle gourd varieties under semi-arid condition

Table 90. Front line demonstrations organized by KVK, Panchmahal

Particular of the FLDs	Season	Name of crops (Variety)	Critical input	Area (ha./ Unit)	No. of farmers	Yield (qt/ha.)		Increase in yield (%)	B:C ratio
						Demo	Local		
Use of HYV with INM	Summer	Groundnut (TG-37A)	Seed	08	45	19.50	15.34	26.60	3.40
Use of HYV with INM	Summer	Green Gram (GAM-5)	Seed	30	75	10.40	8.10	28.40	2.50
Use of HYV with INM	Summer	Sesamum (GT-5)	Seed	10	14	5.4	4.1	34.10	2.4
Use of HYV with INM	Rabi	Maize (GAM-3)	Seed	10	25	30.62	21.95	39.50	2.20
Use of HYV with INM	Kharif	Pigeonpea (AGT-2)	Seed	30	75	Crop has been harvested and final results are awaited			
Use of HYV with INM	Kharif	Castor (GCH-7)	Seed	10	25	Crop has been harvested and final results are awaited			
Use of HYV with INM	Rabi	Maize (GAM-3)	seed	10	25	Crop is on vegetative growth stage and final results are awaited			
Use of HYV with INM	Rabi	Gram (GG-3)	seed	10	25	Crop is on flowering stage and final results are awaited			
Use of HYV with improved practices	Kharif	Chilli (NSC 623B)	Seedling	04	10	Crop is on flowering and fruiting stage and final data are waited			
Use of HYV with improved practices	Kharif	Brinjal (NSC 627B)	Seedling	04	10	Crop is of flowering and fruiting stage and final data are waited			
Use of HYV with improved practices	Kharif	Tomato (Arka Rakshak)	Seedling	02	5	Crop is on flowering and fruiting stage and final data are waited.			
Use of HYV with improved practices	Rabi	Fennel (GF-1)	Seed	4	10	Crop is on growth stage and final data are waited			
Use of HYV with improved practices	Kharif	Mango (Kesar and Rajapuri)	Grafted plants	2	10	Planting distance (8X6m), average plant height upto February (1.38m)			
Management of pod borer in pigeon pea.	Kharif	Pigeon pea	Emamectin benzoate Pheromone traps	02	10	Crop is on podding stage and final results are awaited			

Particular of the FLDs	Season	Name of crops (Variety)	Critical input	Area (ha./ Unit)	No. of farmers	Yield (qt/ha.)		Increase in yield (%)	B:C ratio
						Demo	Local		
Management of fall armyworm in maize crop	Kharif	Maize	Neem oil	02	10	32.50	24.10	34.85	2.33
Management of diseases in maize crop	Rabi	Maize	*Trichoderma viridae*	02	10	Crop is on vegetative growth stage and final results are awaited			
Management of wilt and root rot in chickpea	Rabi	Chickpea	*Trichoderma viridae*	02	10	Crop is on flowering stage and final results are awaited			
Green fodder Production	Rabi	Sorghum (CoFS-29)	Seed	08	20	489	306	59.80	3.23
Mineral mixture	-	Buffalo (ASMM)	Mineral mixture	-	30	7.11	5.86	21.33	3.01
Backyard poultry production	-	Poultry (Anand Triple Cross)	Chicks	-	28	Egg production up to 40 wks- 67 (No.)	Egg production up to 40 wks- 26 (No.)	157.69	3.94
Backyard poultry production	-	Poultry (Ankleshwer)	Chicks	-	20	Data related to body weight are being recoded and final results are awaited			




FLDs programmes conducted by KVK, Panchmahal

Training Programmes Organized

KVK Panchmahal organized 35 training programmes on different aspects of agriculture and animal husbandry and 786 farmers were benefited (Table 91).

Table 91.Training programmes organized by KVK, Panchmahal during 2019

Title of training	Duration (Days)	Venue/place	Beneficiaries (Nos).
Weed management in kharif crops	03	KVK	20
Green manureing	03	KVK	20
Soil and water conservation	01	Ratanpur Reliya	31
Role of micro nutrient in crops production	03	KVK	18
Bio-fertilizer application pulses	01	Nayasda	28
Integrated water management	01	Vata	23
Seed production technology in gram	03	KVK	20
Maintenance of farm machinery and implements	01	Chachpur	29
Mango grower	25	KVK	20
Cultivation of summer bottle gourd	01	Bukhi	21
Cultivation of tomato	01	KVK	20
Vegetable nursery management	01	KVK	22
Layout and planting of orchard	03	KVK	20
Cultivation of fennel	01	KVK	15
Cultivation of citrus	01	Lilesara	23
Cultivation of marigold	01	Arad	18
Cultivation of chilli	01	Wata	21
Nursery management of horticultural crops	07	KVK	25
Pest management in pigeonpea	01	KVK	21
IPM in cotton	01	Dantol	22
Microbial pesticides for insect, pest & disease management	03	KVK	20
Plant protection measures in brinjal	01	Vejalpur	20
Pest and disease management in paddy	01	KVK	21
Training on beekeeping	03	Mirpura	19
Pest management in wheat	01	Bediya	18
IPM in maize	01	KVK	22
Plant protection measures in chickpea	01	Bediya	25
Health management of dairy management	01	Doom	28
Improved production technologies for goats rearing	03	KVK	20
Clean milk production	01	Bediya	30
Silage and hay making	01	KVK	19
Green fodder production round the year	02	KVK	28
Broiler production and management	03	KVK	37
Backyard poultry production	01	KVK	23
Nutrition for growing goats	01	Kharsalia	19

Training Programmes conducted by KVK, Panchmahal

Other Programme Organized

- Organized national animal disease (Pashu mela) control and national artificial insemination programme on 11th September, 2019 at KVK, Panchmahal.
- Live telecast of inaugural address of Pradhan Mantri – Kisan Maandhan Yojna on 12th September, 2019 arranged at KVK, Panchmahal.
- The programme on distribution of agro forestry and fruit plant was organized on 17th September, 2019. In this programme 100 famers were participated and 600 plants of bael, custard apple, karonda and guava were distributed.
- Awareness programme organized for farmers on proper use of fertilizer on 22nd, October, 2019 at KVK Panchmahal.
- Swachchta Abhiyan programmes were organized by KVK, Panchmahal at KVK and different villages.

Distribution of plants

Swachchta Abhiyan

Exhibition Organized

Date	Venue	No. of participants	Organizing agency
11th September, 2019	KVK, Panchmahal	300	KVK, Panchmahal
15th October, 2019	Vill.-Sanjivav, Tal.- Kalol	1260	KVK, Panchmahal & PMM
22nd October, 2019	KVK, Panchmahal	150	KVK, Panchmahal

Field day, Awareness and Extension Programmes

Title of programme	Date	Place	No. of beneficiaries
Field day on groundnut production	18th April, 2019	Raniya ni Muvadi	35
Field day on backyard poultry production	22nd April, 2019	Chalwad	33
Field day on broiler production	6th May, 2019	Kharsaliya	23
Animal health awareness camps			
Animal health awareness camps	17th May, 2019	Richiya	46

Title of programme	Date	Place	No. of beneficiaries
Animal health awareness camps	13th June, 2019	Bhadroli	32
Animal health awareness camps	20th November, 2019	Kharsalia	27
Other extension activities/farmers' programmes			
World Yoga day	21st June, 2019	KVK	36
Hindi divas	14th September, 2019	KVK	26
Swachchta Abhiyan	16th September – 2nd October,2019	KVK, Bediya and Jeetpura	176
World soil health day	5th December, 2019	KVK	45
Kisan divas	23rd December, 2019	KVK	20
Advisory services	Advisory services were imported to farmers in 207 cases related to their problems pertaining to agriculture matters which benefited 676 farmers.		
Telephone helpline	Total 398 cases of helpline were dealt with, this included matters concerned with agriculture and allied sectors.		
Diagnostic visit	Diagnostic visits (107) were carried out at farmer's field to solve his/her problem related to agriculture and animal husbandry.		
Method demonstration	Method demonstrations (39) were carried out at farmer's field/ KVK to solve his/her problem related to agriculture and allied sectors.		
Lectures delivered	Total 205 lectures were delivered as resource person in various meetings/training/gosthi/field day/kisan mela/ day celebration/ farmers meeting/ campaign etc.		

Radio talk / Hello Kisan Programme

- Dr. A. K. Rai, delivered a radio talk on cultivation of castor, 3rd October, 2019.
- Dr. Raj Kumar, delivered a radio talk on nutrient management on fruit crops, 3rd October, 2019.
- Dr. Kanak Lata, delivered a tv talk on Akshya Urja on 1st July 2019.

Awards

- ICAR-KVK, Panchmahal awarded "A" grade from ICAR, New Delhi for work and activities carried out during last five year.
- Dr. B.S. Khadda, SMS (Animal Husbandry) awarded for "Best Ph.D. Thesis award" from Society for Scientific Development in Agriculture and Technology (SSDAT) during international conference on GRISAAS-2019 held at NAARM, Rajendranagar, Hyderabad on 20-22nd October, 2019.
- Dr. B.S. Khadda, SMS (Animal Husbandry) received "Best poster award" on the topic "Efficacy of *Pashu chocolate* (UMMB) on milk production and reproductive performance of lactating buffalo" during international conference on GRISAAS-2019 held at NAARM, Rajendranagar, Hyderabad on 20-22nd October, 2019.
- Dr. Raj Kumar, SMS (Hort.) received "Best oral award" on the topic of "Protocols for *in-vitro* shoot tip grafting in Kinnow mandarin (*Citrus deliciosa* in National Seminar on Technological Advancement in Horticulture for 21 century" held at College of Horticulture and Forestry, Jhalrapatan-Jhalawar, (Rajasthan) on 18-19th February, 2019.

Organized one month training for Bachelor in Rural Studies (BRS) course

- ICAR-KVK, Panchmahal organized one month training course for the students of Bachelor in Rural Studies (BRS) from 27th November to 26th December, 2019 in which 20 students of BRS final years were participated from Mangal Bharti BRS College, Vadodara and Shri Narmada Gram Vidhyapith, Mangrol.

Seminar/ symposium/ conference attended

- Dr. B.S. Khadda, SMS (Animal Husbandry) attended international conference on global research initiatives for sustainable agriculture & allied science (GRISAAS-2019) held at NAARM, Rajendranagar, Hyderabad on 20-22nd October, 2019.
- Dr. Raj Kumar, SMS (Hort.) attended national seminar on technological advancement in horticulture for 21 century" held on 18-19th February, 2019 at College of Horticulture and Forestry, Jhalrapatan-Jhalawar, (Rajasthan).

Training programme attended

- Dr. B.S. Khadda, SMS (Animal Husbandry) attended ICAR Sponsored Master training program for developing entrepreneurship held at KVK–Narayangoan, Pune, organized by Director, ATARI, Pune from 27 to 30th January, 2019.
- Dr. B.S. Khadda, SMS (Animal Husbandry) attended Model training programme in IPM in arid fruit and vegetable crops held at ICAR-CIAH, Bikaner during 02-09th September, 2019.

6. TRAINING AND CAPACITY BUILDING

Training and Capacity Building of ICAR employees

The following staff member of the institute underwent in different training programmes

Scientists			
Name of scientists	**Topics**	**Orgnaization**	**Duration**
Dr. D. K. Sarolia	CAFT-training on national problems and constraints in fruit crops	MPKV, Rahuri (Maharashtra)	14th Nov., to 4th Dec., 2019
Sh. R. C. Balai	Digital nutrigation for resource conservation in arid agro-eco-system	SKRAU, Bikaner, Rajasthan	06-26th Dec., 2019
Dr. S. M. Haldhar	Workshop on ICAR research data repository for knowledge management	ICAR-IASRI, New Delhi	10-11th Dec., 2019
Dr. Ajay Kumar Verma	Short course on protected cultivation for enhancing resource use efficiency and productivity of horticultural crops	ICAR-CAZRI, Jodhpur, Rajasthan	15-24th Oct., 2019
Dr. V. R. Reddy S	Intellectual property rights (IPR) awareness workshop and training programme	M.N. College & Research Institute, Bikaner, Rajasthan	28th March 2019
Ms. Ramyashree Devi G S	Professional attachment training	ICAR-NRCG, Pune	14th Nov., to 14th Feb., 2019
	CAFT training on crop diseases & their management through manipulation of soil health	GBPUAT, Pantnagar, Uttarakhand	03-23rd Nov., 2019
Technical			
Mr. C. L. Meena	Farm management	ICAR-IIFSR, Modipuram, Meerut	17-23rd Sept., 2019
Mr. B. C. Meena	Automobile maintenance, road safety and behavioral skill	ICAR-CIAE, Bhopal	24-30th Sept., 2019.
SSS Staff			
Mr. D. B. Yadav	Skill development of supporting staff	ICAR-CIAH, Bikaner	24-27th June, 2019
Mr. Mohan Lal	Skill development of supporting staff	ICAR-CIAH, Bikaner	24-27th June, 2019
Mr. Manoj Vyas	Skill development of supporting staff	ICAR-CIAH, Bikaner	24-27th June, 2019
Mr. Shiv Lal	Skill development of supporting staff	ICAR-CIAH, Bikaner	24-27th June, 2019

Training programme and distribution of certificate to the supporting staff

Seminar/Symposium/Conferences Attended by ICAR-CIAH Employees

Prof. (Dr.) P. L. Saroj

- Participated in "Seed spices farmers fair and conference" as Guest of Honour at NRC on Seed Spices, Tabiji, Ajmer on 8th February, 2019.
- Participated in "13th ICDD conference" as partner institute at CAZRI, Jodhpur and submitted invited article during 11-14th February, 2019.
- Participated in brainstorming session on "Technologies innovation and strategies for farmer's prosperity in Rajasthan" at ICAR, New Delhi on 13th July, 2019.
- Participated in valedictory function of "ICAR zonal tournament" as Guest of Honour on 18th November, 2019 at ICAR-CSWRI, Avikanagar.
- Participated in "National conference on arid fruits: A way forward for sustainable production and nutritional security" at UAS, Raichur, Karnataka as co-institute during 28-30th November, 2019.
- Participated in "3rd Global Meet on Science and Technology" at ICAR-NRCSS, Ajmer during 01-03rd December, 2019.
- Participated in "Progressive Horticulture Conclave-2019" at ICAR-IISR, Lucknow on 08-10th December, 2019.
- Attended the brainstorming session on "Technological innovations and strategies for farmers' prosperity" in Rajasthan held on 13th July, 2019 at NASC, New Delhi.

Dr. B. D. Sharma

- Attended the brainstorming session on "Technological innovations and strategies for farmers' prosperity" in Rajasthan held on 13th July, 2019 at NASC, New Delhi.
- Attended "Rajbhasha karyashala of officials of north zone ICAR's institutes" held at ICAR-CIAH, Bikaner during 30-31st August, 2019.
- Attended "National conference on arid fruits: A way forward for sustainable production and nutritional security" held at UAS, Raichur (Karnataka) during 28-30th November, 2019.
- Participated in one day workshop on "Technologies developed for horticultural crops of the arid region" held at ICAR- CIAH, Bikaner on 15th November, 2019.

Dr. Sanjay Singh

- Participated in "International conference on innovative horticulture and value chain management: Shaping future horticulture" during 28-30th May, 2019 at GB Pant University of Agricultural and Technology, Pantnagar.

Dr. R. S. Singh

- Attended brainstorming session on "Technological innovations and strategies for farmers' prosperity in Rajasthan" on 13th July, 2019 at NASC Complex, New Delhi.
- Participated in one day workshop on "Technologies developed for horticultural crops of the arid region" held at ICAR- CIAH, Bikaner on 15th November, 2019.
- Attended "National seminar on holistic approach for enhancing agricultural growth in changing rural scenario" held at SKRAU, Bikaner during 14-16th Novemebr, 2019.

Dr. D. K. Samadia

- Attended brainstorming session on "Technological innovations and strategies for farmers' prosperity in Rajasthan" on 13th July, 2019 at NASC Complex, New Delhi.

Dr. D. S. Mishra

- Participated in the Progressive Horticulture Conclave (PHC)-2019 on "Futuristic technologies of horticulture" jointly organized by ISHRD, Uttarakhand and CISH, Lucknow at ICAR-IISR, Lucknow, Uttar Pradesh during 8-10th December, 2019.

Dr. B. R. Choudhary

- Attended "International conference cum 3rd Global Meet on science and technology for ensuring food and nutritional security" held at ICAR-NRCSS, Ajmer from 1-3rd December, 2019.

Dr. R. C. Balai

- Participated in one day workshop on "Technologies developed for horticultural

crops of the arid region" held at ICAR- CIAH, Bikaner on 15th November, 2019.

Dr. S. M. Haldhar

- Attended "XIXth International Plant Protection Congress" at ICRISAT, Hyderabad during 10-14th November, 2019.
- Attended "1st Vegetable Science Congress" on emerging challenges in vegetable research & education at AU, Jodhpur, Rajasthan during 01-03rd February, 2019.

Dr. M.K. Berwal

- Attended "International conference on innovative horticulture and value chain in management" held at GBPUA&T, Pantanagar during 28-31st May, 2019.

Mr. Ramesh Kumar

- Attended "National conference on arid fruits: A way forward for sustainable production and nutritional security" organized by UAS, Raichur, ICAR-CIAH, Bikaner and ICAR-NRC on Pomegranate at UAS, Raichur, Karnataka from 28-30th November, 2019.

Dr. Anita Meena

- Attended "International conference on global research initiatives for sustainable agriculture allied sciences" during 20-22nd October, 2019, at ICAR-NAARM, Hyderabad.
- Attended "National conference on innovation in agriculture for socio-economic empowerment of farmers" organized by SKRAU, Bikaner, Rajasthan during 12-13th March, 2019.

Dr. Vikas Yadav

- Attended "International seminar on modern agriculture approaches in 21st century" held at Lucknow (UP) during 22-23rd November, 2019.

Dr. Ajay Kumar Verma

- Attended "International conference cum 3rd Global Meet on science and technology for ensuring food and nutritional security (GMST-2019)" held at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan during 01-03rd December, 2019.

Dr. Kamlesh Kumar

- Attended "International conference on Innovative horticulture and value chain management-shaping future horticulture" organized by CHAI Society at GBPUAT, Pantnagar (UK) during 28-31st May, 2019.

Dr. Vijay Rakesh Reddy S

- Attended "International conference on innovations in horticulture and value chain management" organized by CHAI Society at GBPAUT, Pant Nagar, Uttarakhand from 28-31st May, 2019.
- Attended one day "Brain storming session on Horti-Millets: Researchable issues & Way Forward" organized by ICAR-IIMR, Hyderabad on 13th September 2019.

Meeting Attended

Prof. (Dr.) P. L. Saroj

- Participated in the 58th Foundation Day Function of CSWRI, Avikanagar as Special Guest on 04th January, 2019.
- Participated in the 15th Hooker Award Judging Committee as Member at IARI, New Delhi on 21st January, 2019.
- Participated in the Director's Conference at ICAR, New Delhi during 31st January to 01st February, 2019.
- Participated in the meeting of VI Regional Committee at AAU, Anand during 4-5th February, 2019.
- Participated in the meeting with Chairman, QRT for submitting final report of QRT to the D.G., ICAR on 05th March, 2019.
- Participated in the two days National Advisory Meeting by NHB, Gurugram during 23-24th April, 2019.
- Participated in the one day meeting to inclusion in the list of resource institutes organized by SFAC, New Delhi on 10th May, 2019.
- Participated in the meeting related to AICRP on Vegetable Testing with Director (Research) at RARI, Durgapura on 21st May, 2019.
- Participated in the Annual Review Meeting

and Exhibition on date palm diversity at SDAU, S.K. Nagar on 21st June, 2019.

- Participated in the Foundation Day and Award Ceremony programme at ICAR, New Delhi on 16th July, 2019.
- Participated and Chaired Institute Reseach Committee Meeting at CHES, Vejalpur, Godhra during 8-9th July, 2019.
- Attended meeting with Sh. Kailash Choudhary, Hon'ble Agril. State Minister, Govt. of India on 12th August, 2019 at ICAR-CAZRI, Jodhpur.
- Participated in the meeting of State Seed Sub Committee at Pant Krishi Bhavan, Jaipur on 23rd August, 2019.
- Participated in the meeting as Chairman of Interview Committee at KVK Panchmahal, Vejalpur on 25th September, 2019.
- Participated in the meeting as Nominee of Hon'ble President in the recruitment of Teaching staff at BHU, Varanasi during 04-05th October, 2019.
- Participated and Chaired Institute Management Committee meeting on 29th June, 2019 at ICAR-CIAH, Bikaner.
- Participated Rajbhasha Meeting of Northern Region at CIAH, Bikaner during 30-31st August, 2019.

Dr. B.D. Sharma

- Attended the Institute Management Committee Meeting of ICAR-Central Institute for Arid Horticulture, Bikaner held on 29th June, 2019.
- Attended the Institute Management Committee Meeting of ICAR-Central Arid Zone Research Institute, Jodhpur held on 21st August, 2019.
- Attended the Interface Meeting with farmers on 'Shusk chhetron mein *rabi* fasal prabandhan evam samanvit krishi pranali' held at 14-15th October 2019 at ICAR-CAZRI, RRS, Bikaner.
- Attended Interaction Meeting of scientists with National Horticulture Board and farmers held at ICAR-CIAH, Bikaner on 8th April, 2019.
- Attended Mid-term Review Meeting of DST (water) project held at DST, New Delhi on 13th November, 2019.
- Attended meeting on 'Technologies development for horticultural crops' held on 15th November, 2019 at ICAR-CIAH, Bikaner.
- Attended Meeting for finalization of the AICRP Review Committee recommendation held on 30th October, 2019 held at NASC, New Delhi.

Dr. R. S. Singh

- Attended Interaction Meeting of scientists with National Horticulture Board and farmers held at ICAR-CIAH, Bikaner on 08th April, 2019.
- Attended 15th Review Meeting of DUS test centers for *kharif* crops-2019 held at NASC complex, New Delhi from 25-26th April, 2019.
- Attended Review Meeting of date palm Project at SDAU, S.K. Nagar, Gujarat on 20th June, 2019 and acted as rapporteur in a Technical session.
- Attended farmer's Interaction Meet & date palm exhibition at DRS, Mundra on 21st June, 2019.
- Attended IMC Meeting of the Institute as Invitee member for presentation of scientific achievements of the Institute on 29th June, 2019 at ICAR-CIAH, Bikaner

Dr. D. K. Samadia

- Attended Scientific-Interaction Meeting on protected cultivation, organized by Deputy Director (Horticulture), National Horticulture Board, Jaipur at ICAR-CIAH, Bikaner on 08th April, 2019.
- Attended meeting of QRT visit team of KVK, Panchmahal (Godhra) on 26th November, 2019.

Dr. S. K. Maheshwari

- Attended Interaction Meeting between Deputy Director (Horticulture), National Horticulture Board, Jaipur and Scientists of this Institute on 08th April, 2019.
- Attended Project Monitoring and Evaluation Committee (PMEC) meeting as Invitee Member regarding approval of status report

for the initiation of the projects held on 08th May, 2019.

Dr. P. P. Singh

- Attended Interaction Meeting between Deputy Director (Horticulture), National Horticulture Board, Jaipur and Scientists of this Institute on 08th April, 2019.

Dr. B. R. Choudhary

- Attended 33rd meeting of the State Seed Sub Committee for Agricultural and Horticultural Crops held at Pant Krishi Bhawan, Jaipur on 23rd August, 2019.
- Attended Review Meeting of QRT of AICRP (Vegetable crops) centres held at ICAR-IARI, New Delhi from 20-21st November, 2019.

Dr. Ramesh Kumar

- Attended AICRP on Arid Zone Fruits review meeting chaired by DG, ICAR, New Delhi at NASC, New Delhi on 30th October, 2019.

Dr. Kamlesh Kumar

- Attended Annual Review Meeting of date palm network project at SK Nagar and date palm diversity exhibition meeting at Mundra during 21-22nd May, 2019.

7. EMPOWERMENT OF WOMEN AND PERSON WITH DISABILITIES (DIVYANGIAN)

Training programmes on women empowerment

Trainings programmes on women empowerment and women farmers gosthy were organized time to time under different occasion like SC-SP programmes. The training programmes on "Women empowerment through processing and value addition of arid horticultural crops" were organized from 26-28th March, 2019 under Scheduled caste –sub plan. A total of 250 SC farm women were benefitted through the different training programmes. The inputs like seeds of improved varieties of vegetable, spices, kitchen gardening packets, milk collection canes, etc., were distributed to trainee farm women. The visit of experimental blocks, technological museum and nursery complex of the institute was also conducted to create awareness and impart knowledge on modern production, propagation and post harvest management technologies of arid horticultural crops.




Training organized and input distribution under SC-SP programme to women farmers at ICAR-CIAH, Bikaner

Specific training modules formulated and conducted for women

- Entrepreneurial empowerment of women through processing of arid horticultural crops
- Women empowerment through nursery management of arid horticulrural crops
- Post harvest management and value addition of arid fruits and vegetables

Accessiblity to the person with disabilities (divyangian)

The Institute has constructed ramp and washrooms in all office buildings/guest house for person with disabilities (divyangian). The scientists also interacted with them and conducted their visit to museum, experimental fields etc.

8. AWARDS AND RECOGNITIONS

Institute Awards

The Institute has received "First Best Exhibition Award" for the best exhibition stall during Kisan Mela organized by Directorate of Extension Education (SKRAU), at KVK, Lunkarnsar on 07th March, 2019. This Award was presented by the Chief Guest of the programme, Sh. Arjun Ram Meghwal, Hon'ble Union Minister of State for Water Resources, River Development & Ganga Rejuvenation and Parliamentary Affairs, GOI. Besides, the institute has awarded "Third Best Exhibition Award" for the technological exhibition of the Institute in "Beejiya Masala Kisan Mela evam Sangosthi" at ICAR-National Research Centre on Seed Spices, Ajmer on 08th Febraury, 2019.

Institute received first best exhibition prize at KVK, Lunkaransar and third best exhibition prize at ICAR-NRCSS, Ajmer

Individual Awards

- Prof. (Dr.) P. L. Saroj received Life Time Achievement Award from Hi-tech Horticulture Society during 3rd Global Meet on Science and Technology at ICAR-NRCSS, Ajmer on 1st Dec., 2019.
- Dr. S. M. Haldhar received the Young Scientist Award from Agriculture Today Group at New Delhi by Sh. N. S. Tomar Union Minister of Agriculture and Farmers Welfare, Govt. of India on 11th July, 2019.
- Dr. S. M. Haldhar received the Young Scientist Award from Dr. B. Vasantharaj David Foundation at Chennai dated 17th July, 2019.
- Dr. Anita Meena recieved Young Scientist Award by society for scientific development in agriculture and technology during international conference on Global Research Initiatives for sustainable agriculture allied sciences during 20-22th October, 2019 at ICAR-NAARM, Hyderabad.
- Dr. Ajay Kumar Verma received Bharat Gaurav Puraskar from Best Citizen Publishing House, New Delhi.
- Dr. R. S. Singh recieved best oral presentation Award in ISEE-National Seminar held at SKRAU, Bikaner during 14-16th November, 2019.
- Dr. M. K. Jatav recieved best oral presentation award for paper "Performance in non traditional area of north-western Rajasthan of India" in Progressive Horticulture Conclave during 8-10th December, 2019 at Lucknow organized by ISHRD in collaboration with ICAR-CISH, Lucknow (UP).
- Dr. D. S. Mishra received best oral presentation award for the paper "Hybridization and evaluation of F1 hybrids in guava under semi-arid ecosystem" of central Gujarat in Progressive Horticulture Conclave-2019 on held at ICAR-IISR, Lucknow during 8-10th December, 2019.
- Dr. D. S. Mishra received best poster paper award-2019 for the paper "Seed germination

of fruit crops: a review" published in HortFlora Research Spectrum, 1(3):199-201.

- Dr. Ramkesh Meena received best oral paper presentation award for paper "Diversified uses of date palm fruits for nutrition and livelihood security in arid region" in National seminar held at SKRAU, Bikaner during 14-16th November, 2019.
- Dr. Vikas Yadav received best oral presentation by presenting "Thar Gaurav: A new wood apple variety for dry land" in International seminar on modern agriculture approaches in 21st century, 22-23rd November, 2019 at Lucknow (UP).

Miscellaneous Award

- Ms. Ramyashree Devi G S received first prize in shotput at ICAR inter institutions sports (West Zone) held at ICAR-CSWRI, Avikanagar, Rajasthan during 14-18th November, 2019.
- Ms. Ramyashree Devi G S received second prize in discus throw at ICAR inter institutions sports (West Zone) held at ICAR-CSWRI, Avikanagar, Rajasthan during 14-18th November, 2019.

Recognitions

Prof. (Dr.) P. L. Saroj

- Acted as Visitors' Nominee (His Excellency President of India) of Banaras Hindu University, Varanasi from 2018 onwards.
- Acted as Chairman, Awards/Fellowship Committee, Indian Society for Horticulture Research and Development, Uttrakhand.
- Acted as Special Guest in the 58th Foundation Day Function of CSWRI, Avikanagar on 04th January, 2019.
- Acted as Chairman, Sukumar Basu Memorial Award Committee, IARI, New Delhi on 30th Dec., 2019.
- Acted as Member of 15th Hooker Award Judging Committee at IARI, New Delhi on 21st January, 2019.
- Acted as Guest of Honour in the Seed Spices Farmers Fare and Conference at NRC on Seed Spices, Tabiji, Ajmer on 08th February, 2019.
- Acted as Chairman of Interview Committee Meeting at KVK Panchmahal, Vejalpur on 25th September, 2019.
- Acted as Chief Guest in the Valedictory Function of ICAR Zonal Tournament on 18th November, 2019 at ICAR-CWSRI, Avikanagar.
- Acted as President, Indian Society for Arid Horticulture, Bikaner, Rajasthan from 2016 onwards.
- Acted as Editor, Indian Horticulure, Published by ICAR-DKMA, New Delhi from 2014 onwards.
- Acted as Member, Board of Studies, IABM, SKRAU, Bikaner from 2018 onwards.

Dr. B.D. Sharma

- Acted as Co-chairman in the Farmers-Scientists Interaction Session in National Conference on Arid Fruits at UAS, Raichur on 28-30th November 2019.
- Acted as Course Coordinator of International Training Programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem held during 9-18th August, 2019 at ICAR-CIAH, Bikaner.

Dr. R. S. Singh

- Worked as Nodal Officer, DUS test centre on date palm, PPV&FRA during the year.

Dr. Sanjay Singh

- Acted as Convener of Technical Session in the International Conference on Innovative Horticulture and value chain management: Shaping future horticulture during 28-30th May, 2019 at GB Pant University of Agricultural and Technology, Pantnagar.
- Acted as Expert for evaluation of poster papers in International Conference on Innovative Horticulture and value chain management: Shaping future horticulture during 28-30th May, 2019 at GB Pant University of Agricultural and Technology, Pantnagar.
- Acted as Expert member for the selection of Assistant Professor and Professor during 20-21st July, 2019.

- Acted as Member in the Assessment Committee for the promotion of scientist to Senior scale at DMAPR, Boriavi, Anand on 5th December, 2019.

Dr. S. R. Meena

- Acted as member of SAC meeting of KVK (SKRAU), Chandgothi, Churu on 06th December, 2019 and interacted about arid horticultural technologies with the farmers.

Dr. M. K. Jatav

- Acted as Course Co-Coordinator in International training programme on Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem held during 9-18th August, 2019 at ICAR-CIAH, Bikaner.
- Worked as judge/evaluator in 27th KVS National Children Science Congress-2019 and evaluated projects presented by the students from different Kendriya Vidyalaya of Rajasthan at KV-1, Bikaner during 23-24th September, 2018.

Dr. D. S. Mishra

- Acted as Editor of the Hort Flora Research Spectrum published by Biosciences & Agriculture Advancement Society, Meerut.
- Acted as Associate Editor for Indian Journal of Arid Horticulture published by Indian Society for Arid Horticulture, Bikaner.

Dr. S. M. Haldhar

- Acted as Editor of Indian Journal of Arid Horticulture published by Indian Society for Arid Horticulture, Bikaner.
- Acted as Editor of International Journal of Agriculture Sciences (https://bioinfopublication.org).

Dr. Chet Ram

- Recognized as judge for 27th KVS National Science Congress (NCSC)-2019 on 23-24th September, 2019 at KV-1, Bikaner-334 001, Rajasthan.

Dr. Ramesh Kumar

- Acted as academic editor for International Journal of Agriculture Sciences published by Bioinfo Publication, Pune, Maharashtra.
- Acted as associate editor for Indian Journal of Arid Horticulture published by Indian Society of Arid Horticulture, Bikaner.
- Acted as co-chairman in the poster evaluation session on "Farmers interaction and market linkage" during National conference on arid fruits-A way forward for sustainable production and nutritional security organized by UAS, Raichur and ICAR-CIAH, Bikaner from 28-30th November, 2019 at UAS, Raichur, Karnataka.

Dr. Ajay Kumar Verma

- Adjudged outstanding participant in ICAR sponsored short course on "Protected cultivation for enhancing resource use efficiency and productivity of horticultural crops" held at ICAR-CAZRI, Jodhpur from 15-24th October, 2019.

Dr. Vijay Rakesh Reddy

- Acted as an editor for Post Harvest Technology Section for the Journal of Agriculture and Ecology.

9. PUBLICATIONS

Research Papers

- Berwal, M. K., Chugh, L. K., Goyal, P. and Kumar, R. 2019. Exploiting the pearl millet genetic diversity for identification of iron and zinc dense seed parental lines. *International Journal of Genetics*, 11(5): 583-586.
- Choudhary, B. R., Sharma, B. D. and Maheshwari, S. K. 2019. Influence of different organic sources of plant nutrients on growth, yield and quality of muskmelon (*Cucumis melo* L.). *International Journal of Current Microbiology and Applied Sciences,* 8(6): 3015-3021.
- Choudhary, B. R., Singh, D. and Saroj, P. L. 2019. Development and characterization of intraspecific hybrids derived from *Cucumis melo* L. *Bangladesh Journal of Botany,* 48(2): 359-366.
- Dev, R., Singh, S. K., Dayal, V., Kumar K. and Singh, T. 2019. Standardization of *in vitro* hardening strategies for tissue cultured wine grape (*Vitis vinifera* L.) genotypes. *International Journal of Current Microbiology and Applied Sciences,* 8(2): 2108-2117.
- Gangadhara, K., Raj Kumar, Selvakumar, R., Appa Rao, V. V. and Yadav, L. P. 2019. Evaluation of cucumber hybrids/lines for yield and quality under polyhouse. *International Journal of Current Microbiology and Applied Sciences*, 8(06): 1652-1661.
- Gangadhara, K., Yadav, L. P., Raj Kumar, Appa Rao, V. V. and Selvakumar, R. 2019. Genetic analysis for growth and yield parameters in common bean (*Phaseolus vulgaris* L.). *International Journal of Current Microbiology and Applied Sciences,* 8(06): 1550-1555.
- Haldhar, S. M. and Behere, G. T. 2019. *Digama hearseyana* (Lepidoptera: Noctuidae), a new threat to karonda (*Carissa carandus*) in Rajasthan. *Indian Journal of Entomology*, 81(3): 618-622.
- Haldhar, S. M., Bhargava, R., Hare Krishna, Berwal, M. K., and Saroj, P. L. 2018. Bottom-up effects of different host plant resistance cultivars of ber (*Ziziphus mauritiana)* fruit fly *(Carpomyia vesuviana) interactions. Crop Protection, 106: 117-124.*
- Jalwania, R., Kaushik, R. A., Sarolia, D. K., Intodia, S. K. and Balai, C. M. 2019. Response of nutrient management on yield attributes and yield of sweet potato (*Ipomoea batatas* L.). *Green Farming,* 10(5): 576-579.
- Khan Rashid and Sarolia, D. K. 2019. Stability analysis in bitter gourd (*Momordica charantia L.*). *Agriculture Research Journal,* 56 (3): 392-400.
- Koramutla, M. K., Chet Ram, Bhatt, D., Annamalai, M. and Bhattacharya, R. 2019. Genome-wide identification and expression analysis of sucrose synthase genes in allotetraploid *Brassica juncea*. *Gene,* 707:126–135.
- Krishna, H., Singh, D., Singh, R. S., Meena, R. K. and Kumar, L. 2019. Phyllotaxic diversity as a means of assessing variations in mulberry (*Morus* spp.) *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 5(1): 38-43.
- Kumar, A., Pratap, B., Gautam, D. K., Yadav, V., Gangadhara, K., Beer, K., Singh, A. K. and Singh, V.K. 2019. Variability, heritability and genetic advance studies in French marigold (*Tagetes patula L.*). *Journal of Pharmacognosy and Phytochemistry,* 8(5): 1046-1048.
- Kumar, K., Gora, J. S. and Singh, C. P. 2019. Bioefficacy of paclobutrazol on growth, flowering, fruiting and yield attributes of mango cv. Dashehari under Pantnagar agro-climatic condition. *Journal of Agriculture and Ecology,* 7: 27-37.
- Kumar, K., Srivastav, M., Singh, S. K., Vinod and Chet Ram. 2019. Microsatellite markers analysis for evaluation of genetic variation in mango genotypes. *International Journal of Chemical Studies*, 7(3): 4546-4551.
- Kumar, R. and Saroj, S. 2019. Dehydration of

karonda (*Carissa carandus* L.) fruits for culinary utilization, *Indian Journal of Arid Horticulture*, 1(1): 33-38.

- Kumawat, K. L., Sarolia, D. K., Kaushik, R. A., Ramniwas and Devra, N. S. 2019. Effect of irrigation and fertigation scheduling on input use efficiency, yield and quality of guava cv. Lalit under intensive orcharding system. *Journal of Soil and Water Conservation,* 18(2): 136-143.
- Meena, H. R., Somasundaram, J., Kaushik, R. A., Sarolia, D. K., Singh, R. K., Kala, S. and Meena, G. L. 2019. Integrated nutrient management affects fruit yield of sapota (*Achras zapota* L.) and nutrient availability in a vertisol. *Communications in Soil Science and Plant Analysis*, 50(22): 1-16.
- Mishra, D. S., Singh, S., Singh, A. K., Yadav, V. and Saroj, P. L. 2019. Evaluation of guava (*Psidium guajava* L.) germplasm under semi-arid environment of central Gujarat. *Indian Journal of Arid Horticulture*, 1(1): 53-55.
- Mog, B. Janani, P., Nayak, M. G., Adiga, J. D. and Meena, R. K. 2019. Manipulation of vegetative growth and improvement of yield potential of cashew (*Anacardium occidentale* L.) by paclobutrazol. *Scientia Horticulturae,* 257:108748.
- Nihad, K., Berwal, M. K., Hebbar, K. B., Bhat, R., Haris, A. A. and Ramesh, S. V. 2019. Photochemical and biochemical responses of heliconia (*Heliconia stricta* 'Iris') to different light intensities in a humid coastal environment. *Horticulture, Environment and Biotechnology*, 60:799–808.
- Sajeev, M.V. and Saroj, P. L. 2018. Socio-economic determinants and adoption of pest managements practices in cashew farming: A study in Dakshina Kannada, Karnataka. *Journal of Plantation Crops, 46(1): 66-73.*
- Sajeev, M.V. and Saroj, P.L., Meera Manjusha, A.V. 2018. Impact of production technologies on area and productivity of cashew in north Kerala. *Journal of Extension Education, 54(2): 100-107.*
- Sarolia, D. K., Singh, V., Kaushik, R. A., Shukla, A. K., Meena, R. K., Meena, V. S. and Pandey, G. 2019. Winter season crop regulation in Sardar guava**,** *Indian Journal of Horticulture,* 76(3): 535-538.
- Sarolia, D. K., Singh, V., Kaushik, R. A., Shukla, A. K., Pandey, G. and Lakhawat, S. S. 2019. Response of guava cv. Sardar under different planting systems. *Indian Horticulture Journal,* 9(1/2): 1-4.
- Singh, A. K., Singh, S., Saroj, P. L., Appa Rao, V. V. and Singh, R. S. 2019. Studies on stooling in bael (*Aegle marmelos* Correa). *Indian Journal of Arid Horticulture,* 1(1):60-62.
- Singh, A., Panwar, N. R., Meghwal, P. R., Khapte P. S. and Berwal, M. K. 2019. Bioactive compositions in guava (*Psidium guajava*) at different stages of maturation in arid conditions. *Indian Journal of Agricultural Sciences*, 89(11): 1797-1801.
- Singh, D., Sivalingam, P. N., Kumar, K., Saroj, P. L., Patil, G. B., Subhash, and Subhash, N. 2019. Integrated management of graphiola leaf spot (*Graphiola phoenicis*) in tissue cultured date palm saplings during plant hardening stage. *Indian Journal of Arid Horticulture,* 1(1): 14-17.
- Singh, R. S., Meena, R. K., Bhargava, R. and Sharma, B. D. 2019. Effect of stored pollen on fruit set, yield and quality of date palm cv. Halawy under hot arid conditions. *Indian Journal of Arid Horticulture,* 1(1): 82-83.
- Singh, S., Singh, A. K., Mishra, D. S. and Appa Rao, V. V. 2019. Genetic diversity in phalsa (*Grewia subinaequalis* D.C.) under semi-arid ecosystem of western India. *Indian Journal of Arid Horticulture*, 1(1): 56-59.
- Singh, S., Singh, A. K., Saroj, P. L., Appa Rao, V. V. and Mishra, D. S. 2019. Genetic divergence in jamun under semi-arid ecosystem of western India. *Indian Journal of Horticulture*, 76(2): 206-211.
- Verma, A. K., Choudhary, B. R., Samadia, D. K. and Singh, D. 2019. Standardization of sowing date and covering material under low tunnels for early harvest of longmelon. *Vegetable Science, 46(1&2): 28-33. (*http://krishi.icar.gov.in/jspui/handle/ 123456789/33526)

- Verma, A. K., Mehta, A. K., Sharma, D., Singh, R. P. and Singh, P. 2019. Genetic variability, heritability and genetic advance studies for yield components in F_2 generation of Cowpea (*Vigna unguiculata* L. Walp). *International Journal of Chemical Studies*, 7(6): 3084-3088. (http://krishi.icar.gov.in/jspui/handle/123456789/29677).

Scientific Reviews

- Chet Ram, Berwal, M. K. and Saroj, S. 2019. Genomic and biotechnological interventions for enhanced utilization of date palm (*Phoenix dactylifera* L.) germplasm. *Indian Journal of Arid Horticulture,* 1(1):1-7.
- Chet Ram, Berwal, M. K., Gora, J. S., Kumar, R., Haldhar, S. M., Gurjar, K. and Singh, D. 2019. Genomic and biotechnological interventions for crop improvement in cucurbitaceous crops: A review. *Journal of Agriculture and Ecology*, 7: 1-15.
- Haldhar, S. M., Chet Ram and Singh, D. 2019. Biotic stress (insect) of aonla (*Emblica officinalis*) in arid region of India: A review. *Journal of Agriculture and Ecology*, 7: 16-26.
- Krishna, H., Saroj, P. L., Maheshwari, S. K., Singh, R. S., Meena, R. K., Chandra, R. and Parashar, A. 2019. Underutilized fruits of arid and semi-arid regions for nutritional and livelihood security. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 5(2):01-14.
- Kumar, R., Berwal, M. K. and Saroj, P. L. 2019. Morphological, physiological, biochemical and molecular facet of drought stress in horticultural crops. *International Journal of Bio-resource and Stress Management*, 10(5): 545-560.
- Kumar, R., Saroj, P. L. and Sharma, B. D. 2019. Flower regulation in pomegranate for higher yield, improved quality and enhanced management- A review. *Fruits,* 74(4): 150-166.
- Samadia, D. K. and Haldhar, S. M. 2019. Scope and strategies for genetic improvement in vegetable crop-plants under high temperature and abiotic stressed climate of Rajasthan: A gap analysis. *Journal of Agriculture and Ecology*, 8: 1-18.
- Saroj, P. L. and Kumar, R. 2019. Recent advances in pomegranate production in India-A review. *Annals of Horticulture, 12(1):1-10.*
- Singh, A. K. Singh, S., Saroj, P. L., Krishna, H., Singh, R. S. and Singh, R. K. 2019. Research status of bael in India: A review. *Indian Journal of Agricultural Sciences,* 84(10): 1563-71.
- Singh, A. K., Singh, S., Saroj, P. L., Mishra, D. S., Singh, P. P. and Singh, R. K. 2019. Aonla (*Emblica officinalis*) in India: A review of its improvement, production and diversified uses. *Indian Journal of Agricultural Sciences*, 89(11): 1773–81,
- Singh, S., Singh, A. K., Saroj, P. L. and Mishra, D. S. 2019. Research status for technological development of jamun (*Syzygium cuminii*) in India: A review. *Indian Journal of Agricultural Sciences*, 89(12): 1991-1998.

Popular Articles

- Reddy, S. V. R., Hiremath, V. and Lakshmipathy, M. 2019. Valley of flowers - a paradise on earth for nature lovers. *Indian Horticulture*, 64(4): 84-92.
- Reddy, S. V. R., Kumar, R. and Saroj, P. L. 2019. Indigenous ornamental flora for arid landscapes. *Indian Horticulture,* 64(4): 105-112.
- Samadia, D. K., Haldhar, S. M., Verma, A. K. and Saroj, P. L. 2019. Brinjal- Thar Rachit for cultivation under hot arid agro-climate. *Indian Horticulture*, 63(5): 53-58. (http://krishi.icar.gov.in/jspui/handle/123456789/29676).
- Singh, S. Singh, A. K., Mishra, D. S. and Saroj, P. L. 2019. Scientific cultivation of jamun in semi-arid region. *Phal phul*, 40(6): pp. 44-47.
- Yadav, L. P. 2019. Ivy gourd. *Indian Horticulture*. 64 (3).
- Yadav, L. P., Gangadhara K., Koley, T. K., Verma, A. K., Singh, S. and Saroj, P. L. 2019. Microgreens: A new generation nutria-rich organic functional food. *Kerla Karshakan*, 7(4): 34-42.
- सरोज, पी. एल., एवं पारीक, प्रेम प्रकाश 2019. संस्थान की प्रमुख राजभाषा गतिविधियां, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर (13): 1–3.

- सरोज, पी. एल., एवं वर्मा, अजय कुमार 2019. केंद्रीय शुष्क बागवानी संस्थान– एक सफल यात्रा, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर (13): 14–25.
- हिवाले, एस. एस., यादव विकास, सिंह, ऐ.के, अप्पाराव, वीवी., सिंह संजय और सरोज, पी. एल. 2019. थार गौरवः कैंथ की नयी उच्च उत्पादन प्रजाति, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर (13): 36–38.
- सिंह, आर. एस. और मीना, आर. के. 2019. खजूर उत्पादन में परागण का महत्व, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर, (13): 26–28
- यादव, एल. पी., के. गंगाधरा, सिंह, संजय एवं सरोज, पी.एल. 2019. अर्ध–शुष्क क्षेत्रों में कुंदरू की खेती, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर, (13): 48–51.
- मीना, ए. 2019. किसानों की कृषि आय में स्मार्टफोन का योगदान. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केशुबास, बीकानेर.
- सिंह, ए. के., सिंह, एस., सरोज, पी. एल., मिश्रा, डी. एस. और सिंह, पी. पी. 2019. आंवले की बागवानी से करे कमाई, *फल–फूल,* 40(4):34–38.
- सिंह, ए. के., सिंह, एस., सरोज, पी. एल., सिंह, आर. एस. और सिंह, पी. पी. 2019. बेल की नई किस्मः थार नीलकण्ड, *फल–फूल,* 40(5):8–10.
- यादव, एल. पी., गंगाधरा, के. और सिंह, एस. 2019. आदिवासी किसानों की स्वास्थय एवंम पौषण का *आधार, राजस्थान प्रताप खेती,* अगस्त (1).
- झाड़े, आर. के., वर्मा, ए. के., अम्बुलकर, पी. एल., श्रीवास्तव, डी. सी., सावरकर, एस. डी. एवं पन्नासे, एस. 2019. कृषि का वर्तमान स्वरुप, नैसर्गिक खेती की आवश्यकता एवं जैविक खाद बनाने की देशी विधियां. *मरू बागवानी,* राजभाषा पत्रिका, भाकृ अनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 13:90–92.
- समादिया, डी. के. एवं पारीक, पी. पी. 2019. फूट ककड़ी फसल एवं बीज उत्पाद तकनीकी. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 13:52–57.
- वर्मा, ए. के. एव समादिया, डी. के. 2019. चवलाफली (लोबिया) की उत्पादन प्रौद्योगिकी. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 13:58–60.
- चौधरी, बी. आर., हलधर, एस. एम. एवं माहेश्वरी, एस. के. 2019. तर–ककड़ी उत्पादन की प्रौद्योगिकी. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 13:45–47.
- बिश्नोई, सी., गोरा, जी. एस., कुमार, आर., एवं बलाई, आर. सी. 2019. निम्बू वर्गीय फलों की व्यावसायिक खेती. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 39–41.
- बिश्नोई, सी., गोरा, जी. एस., कुमार, आर., एवं बलाई, आर. सी. 2019. बारानी क्षेत्रों में वैज्ञानिक विधि से सफल बाग लगायें. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 77–79.
- माहेश्वरी, एस. के., देवी राम्याश्री, चौधरी, बी. आर, सिंह, पी. पी. एवं सरोज, पी. एल. 2019. शुष्क एवं अर्ध–शुष्क क्षेत्र में बैंगन की प्रमुख बीमारियाँ एवं उनका एकीकृत प्रबंधन, *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, 13:61–64.
- मीना, आर. के. एवं सरोलिया, डी. के. 2019. राजस्थान के शुष्क पारिस्थितिकी क्षेत्र में अनार उत्पादन की विधि. *मरू बागवानी,* राजभाषा पत्रिका, भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, 29–32.
- मीना, आर. के., सरोलिया, डी. के., रेड्डी, एस. वी. आर. एवं सरोज, पी. एल. 2019. पशिचमी राजस्थान की शुष्क फल फसलो में फटन के कारण एवं निवारण, *मरू बागवानी* राजभाषा पत्रिका, भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, 42–44.
- शर्मा, आर., कृष्णा, एच., शर्मा, एस. एवं रेड्डी एस. वी. आर. 2019. जुलाई से अगस्त में संवारें बागों को, *फल–फूल,* 40(4):52–56.
- शर्मा, आर., कृष्णा, एच., शर्मा, एस. एवं रेड्डी एस. वी. आर. 2019. सितम्बर से अक्टूबर में बागों में प्रमुख कार्यकलाप, *फल–फूल,* 40(5): 48–52 (http://krishi-icar-gov-in/ jspui/handle/123456789/18030)
- शर्मा, आर., कृष्णा, एच., शर्मा, एस. एवं रेड्डी, एस. वी. आर. 2019. नवंबर से दिसंबर में बागों के प्रमुख कार्यकलाप, *फल–फूल,* 40(6):48–51.
- सिंह, आर. एस. एवं मीना, आर के. 2019. खजूर

उत्पादन में पराग कण का महत्व *मरू बागवानी*, राजभाषा पत्रिका, भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, 26–28.

- हलधर, एस .एम. 2019. कीट मुक्त रबी फसलें रखने की एक पहल. *खाद पत्रिका*, अक्टूबर, 2019, 40–47.

Books, Bulletin and Technical Manual

- Jatav, M. K., Saroj P. L., and Sharma, B. D. (eds.) 2019. Dryland Horticulture. New India Publishing Agency, New Delhi, pp- 1-642.
- Singh, A. K., Pandey, D., Singh, S., Singh, R. S., Misra, A. K. and Singh, R. K. 2019. The Bael in India. Published by DKMA, ICAR, New Delhi, pp.1-130, ISBN: 978-81-7164-186-4.
- Singh, S., Saroj, P. L., Mishra, D. S. and Singh, A. K. 2019. Under utilized fruit crops: Crop improvement and agro-techniques. Kaav, Publication, Delhi, pp. 1-306.
- Singh, V. P., Singh, P. N., Singh, C. P. and Mishra, D. S. 2019. Phal Vrikshon Ki Jeernoddhar Takneek. ATIC, Directorate of Extension, GBPUAT, Pantnagar, pp. 1-35.
- Yadav, V. Singh, P. N. and Yadav, P. 2019. Micro-nutrients management in low-chill peach. Published by Lap Lambert, Mauritius, ISBN: 978-3-330-06650-2.

Book Chapters

- Choudhary, B. R. 2019. Watermelon. In: Handbook of Horticulture Volume I. Chadha K. L. (ed.). ICAR Publication, pp. 636-640. ISBN: 978-81-7164-187-1. (http://krishi.icar.gov.in/jspui/handle/123456789/30937).
- Choudhary, B. R. and Singh, D. 2019. Cucurbits. In: Origin and Biological Diversity of Horticultural Crops. Peter, K. V. (ed.). Brillion Publishing, New Delhi. pp. 265-277. ISBN: 978-93-89350-00-5. (http://krishi.icar.gov.in/jspui/handle/123456789/30935).
- Haldhar, S. M. 2019. IPM strategies in arid horticultural crops for getting higher income. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 449-478. ISBN: 9789387973558.
- Kumar, R. Saroj, P. L., Sharma, B. D. and Meena, R. K. 2019. Flower regulation in Pomegranate (*Punica granatum* L.) under hot arid climate. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 277-288. ISBN: 9789387973558.
- Meena, R. K., Sarolia, D. K., Reddy, S. V. R., Kumar, R., Chet Ram and Meena, A. 2019. Diagnosis and management of physiological disorders in arid fruit crops. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 327-338. ISBN: 9789387973558.
- Meena, S. R., Saroj, P. L., Jatav, M. K, Meena, R. K. and Balai, R. 2019. Socio-economic importance of cucurbitaceous vegetables in hot arid zones of India. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 617-630. ISBN: 9789387973558.
- Mishra, D. S. and Nimbolkar, P.K. 2019. Plant growth regulators in litchi. In: Plant growth regulators in tropical and sub-tropical fruits. Part I. Gosh, S.N. *et al.* (eds.). Jaya Publication. House, New Delhi.
- Mishra, D. S., Goswamy, A. K., Kumar, R., Singh, S., Singh, A. K. and Singh, P. P. 2019. Guava (*Psidium guajava*) origin and biological diversity of horticultural crops. Peter, K. V. (ed.). Brillion Publishing, New Delhi –110 005. ISBN: 978-93-89350-00-5.
- Mishra, D. S., Singh, S. and Singh, A. K. 2019. Plant growth regulators in phalsa. In: Plant growth regulators in tropical and sub-tropical fruits. Part I. Gosh, S. N. *et al.* (eds.). Jaya Publication. House, New Delhi, pp. 520-526.
- Samadia, D. K. 2019. Doubling horticultural productivity under *khejri* based cropping models in arid environment. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 511-531.
- Samadia, D. K. 2019. Improving yield and income of arid vegetables. In: Dry Land

Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 365-388.

- Saroj, P. L. 2019. Cashew. In: Handbook of Horticulture Vol. II Chadha, K. L. (eds). Published by ICAR-DKMA, New Delhi, pp 781-785.
- Saroj, P. L. and Berwal, M. K. 2019. Concept and strategies for doubling farmers income: Focus on Horticulture, Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 351-364.
- Saroj, P. L. and Jatav, M. K. 2019. Approaches for improving productivity and profitability in arid horticulture. In Dryland Horticulture, Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 1-28.
- Sarolia, D. K., Meena, R. K., Kumar, R., Singh, D. P. and Gora J. S. 2019. Mass multiplication of quality planting material in horticulture crops. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 131-140. ISBN: 9789387973558.
- Sharma, R. R. and Reddy, S. V. R. 2019. Ber. In: Handbook of Horticulture. Volume-I. Chada, K. L., Verma, S. A., Dutt, S., and Pradhan, S. (eds.). DKMA, ICAR, New Delhi-110012, pp. 271-273.
- Sharma, R. R. and Reddy, S. V. R. 2019. Loquat. In: Handbook of Horticulture. Volume-I. Chada, K. L., Verma, S. A., Dutt, S., and Pradhan, S. (eds.). DKMA, ICAR, New Delhi-110012, pp. 348-350.
- Singh, D., Kumar, K. and Verma, A. K. 2019. Tissue culture of fruit crops for quality planting materials. In: Horticulture in arid and semi-arid regions, Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, India, pp. 315-337.
- Singh, R. S. and Meena, R. 2019. Date palm cultivation in arid eco-system. In: Dry Land Horticulture. Jatav, M. K., Saroj, P. L. and Sharma, B. D. (eds.). New India Publishing Agency, New Delhi, pp. 255-276. ISBN: 9789387973558.

Compendium

- Choudhary, B. R., Haldhar, S. M. and Saroj, P. L. 2019. Seed production of arid vegetables (Hindi). Technical manual published by Director, ICAR-CIAH, Bikaner, pp. 1-143. (http://krishi. icar.gov.in/ jspui/ handle/123456789/17945).
- Haldhar, S. M. and Maheshwari, S. K. 2019. Integrated pests management of arid fruit and vegetable crops. Published by ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, pp. 1-272.
- Saroj, P. L., Dhurendra Singh, Samadia, D. K., Jatav, M. K., Sarolia, D. K., Choudhary, B. R. and Kumar R. 2019. Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystems. Published by ICAR-CIAH, Bikaner, pp. 1-370.
- हलधर, एस. एम., वर्मा ए. के., मीना एस. आर. एवं समादिया डी. के. 2019. शुष्क बागवानी फसलों में समेकित नाशीजीव प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान, पुस्तक पेज न. 1–144.
- शर्मा, बी. डी., सरोज, पी. एल, चौधरी, बालू राम, बलाई, रूप चन्द 2019. शुष्क क्षेत्रीय फल एवं सब्जियों की जैविक खेती, भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान, पुस्तक पेज न. 1–145.

Compendium Chapters

- Berwal, M. K., Chet Ram, Kumar, R. and Gora, J. S. 2019. Arid horticultural flora: Potential source of functional food and nutaceuticals. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al.* (eds.). ICAR-CIAH, Bikaner, Rajasthan. pp. 52-59.
- Chet Ram, Berwal, M. K., Gora, J. S., Kumar, R. and Kumar, K. 2019. Biotechnology: Changing scenario of agriculture. In: Organic cultivation of fruits and vegetables in arid regions, Sharma, B. D., Saroj, P. L., Choudhary, B. R. and Balai, R. C. (eds.). ICAR-CIAH, Bikaner, Rajasthan, pp. 96-92.
- Chet Ram, Berwal, M. K., Kumar, R., Gora, J. S. and Singh, D. 2019. DNA finger printing for

cultivar identification. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P.L. *et al*. (eds.). ICAR-CIAH, Bikaner, Rajasthan, pp. 60-64.

- Choudhary, B. R. 2019. Low tunnel technology for early summer vegetable production. In: Compendium of short course published by ICAR-CAZRI, Jodhpur, Rajasthan, pp. 43-51.
- Choudhary, B. R. and Haldhar, S. M. 2019. Low tunnel technology: Safe pest management in cucurbits (Hindi). Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 33-40.
- Choudhary, B. R. and Verma, A. K. 2019. Production technology of cucurbit vegetables. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp. 179-196. (http://krishi.icar.gov.in/jspui/handle/123456789/30936).
- Choudhary, B.R. and Singh, P.P. 2019. Advance production technology of cucurbits in arid region. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, Rajasthan, pp. 109-119.
- Gora, J. S., Kumar, R., Chet Ram, Berwal, M. K. and Haldhar, S. M. 2019. Role of rootstocks in quality productions of fruit crops. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp. 144-150.
- Haldhar, S. M., Berwal, M. K., Gora, J. S. and Kumar, R. 2019. Integrated pest management in arid horticultural crops. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp. 305-325.
- Haldhar, S. M., Choudhary, B. R. and Verma, A. K. 2019. Integrated pest management of cucurbitaceous vegetable crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-Central Institute for Arid Horticulture, Bikaner, pp. 99-108.
- Haldhar, S. M., Kumar, R. and Saroj, P. L. 2019. Integrated pest management in aonla crop. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-Central Institute for Arid Horticulture, Bikaner, pp. 73-81.
- Haldhar, S. M., Maheshwari, S. K., Ramyashree, D. G. S. and Saroj, P. L. 2019. Taxonomy of insect-pests of arid horticultural crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 11-27.
- Haldhar, S. M., Naqvi, A. R. and Saroj, P. L. 2019. Integrated insect-pest management of date palm crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-Central Institute for Arid Horticulture, Bikaner, pp. 57-64.
- Haldhar, S.M., Sarolia, D.K., Reddy, V.R. and Berwal, M.K. 2019. Role of host plant resistance (HPR) in pests management of arid horticultural crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.), ICAR-CIAH, Bikaner, pp. 150-157.
- Jatav, M. K., Balai, R. C., Meena, A. and Sharma, B. D. 2019. Role of macro and micro nutrient in pest management of arid Horticultural crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner.
- Jatav, M. K., Balai, R. C., Meena, S. R. and Meena, A. 2019. Judicious nutrient management in vegetable crops for higher productivity and net return. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L *et al.* (eds.) published by ICAR-CIAH, Bikaner. pp. 276-293.

- Jatav, M. K., Saroj, P. L., Balai, R. C. and Ramyashree, D. G. S. 2019. Introduction and performance of tuber crops in the arid region. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L. *et al.* (eds.) published by ICAR-CIAH, Bikaner. pp. 245-253.
- Jatav, M. K., Saroj, P. L., Balai, R. C., Dua, V. K., Chakarborti, S. K. and Ramyashree, D. G. S. 2019. Potato cultivation hot arid region of north-western Rajasthan: Possibilities and constraints. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L. *et al.* (eds.) published by ICAR-CIAH, Bikaner. pp. 233-244.
- Kumar, K. 2019. Artificial seed production technique. In: Quality Seed Producer. Published by ICAR-CIAH, Bikaner. pp. 95-98. (http:// krishi.icar.gov.in/ jspui/ handle/ 123456789/17916).
- Kumar, K. and Chet Ram 2019. Organic cultivation of lasoda in arid regions. In: Organic cultivation of fruits and vegetables in arid regions. Sharma, B. D., Saroj, P. L., Choudhary, B. R. and Balai, R. C. (*eds.*), pp. 47-50. (http:// krishi.icar.gov.in/ jspui/ handle/123456789/17926).
- Kumar, K. and Haldhar, S. M. 2019. Suitable genotypes of underutilized fruit crops for pest management. In: Integrated pests management of arid fruits and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 168-182.
- Kumar, K. and Singh, D. 2019. Organic cultivation of vegetable cactus pear. In: Organic cultivation of fruits and vegetables in arid regions. Sharma, B. D., Saroj, P. L., Choudhary, B. R. and Balai, R. C. (eds.), pp. 73-77 (http:// krishi.icar.gov.in/ jspui/ handle/123456789/17927).
- Kumar, R., Gora, J. S., Reddy, S. V. R. and Berwal, M. K. 2019. Hi-tech approaches for production and value addition of pomegranate. In: Hi-Tech Approaches for production and value addition of horticultural crops in arid and semi-arid regions organized by DHRD, SKRAU, Bikaner.
- Kumar, R., Haldhar, S. M. and Gora, J. S. 2019. Good management practices in pomegranate against pests. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 50-55.
- Kumar, R., Saroj, P. L., Sharma, B. D. and Singh, R. S. 2019. Tapping the potential of arid fruit genetic resources for nutritional security. In: National conference on arid fruits-A way forward for sustainable production and nutritional security organized at UAS, Raichur, Karnataka, pp.37-44.
- Maheshwari, S. K., Ramyashree, D. G. S., Haldhar, S. M. and Saroj, P. L. 2019. Integrated disease management in arid cucurbitaceous crops. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 92-98.
- Maheshwari, S. K., Ramyashree, D. G. S., Haldhar, S. M. and Saroj, P. L. 2019. Preparation of bio-formulation of *Trichoderma* species against plant diseases. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, Rajasthan, pp. 246-249.
- Meena, S. R., Balai, R. C., Jatav, M. K. and Meena, A. 2019. Rural wisdom based technologies in horticulture development of India. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L. *et al.* (eds.) published by ICAR-CIAH, Bikaner. pp. 356-370.
- Reddy, S. V. R. 2019. Value chain management of arid fruits and vegetables. In: Winter school on digital nutrigation for resource conservation in arid agro ecosystem organized by SKRAU, Bikaner, Rajasthan from 06-26 December, 2019.
- Reddy, S. V. R., Meena, R. K., and Singh, R. S. 2019. Processing and value addition of arid fruits and vegetables. In: Winter school on Hi-tech approaches for production and value addition of horticulture crops in arid and semi-arid regions organized by SKRAU,

Bikaner from 07-27 November, 2019.

- Samadia, D. K. 2019. Arid vegetables - Genetic improvement and crop production technology. In: Winter school on Hi-tech approaches for production and value addition in horticulture crops of arid and semi-arid region organized by SKRAU, Bikaner, Rajasthan from 07-27 November, 2019.
- Samadia, D. K. and Haldhar, S. M. 2019. *Khejri* based crop production systems for hot arid region. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid agro-ecosystem. Saroj, P. L. *et al*. (eds.). Publisheed by ICAR-CIAH, Bikaner. pp. 169-178.
- Samadia, D. K. and Verma, A. K. 2019. Genetic diversity and improvement of vegetable crops in hot arid region. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp. 28-39.
- Samadia, D. K. and Verma, A. K. 2019. Suitable vegetable crop - Genotypes and production technology for safe pest management. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 43-50.
- Saroj, P. L. and Kumar, R. 2019. Arid and semi-arid horticulture in India. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp.1-13.
- Saroj, P. L., Sharma, B. D. and Kumar, R. 2019. Sustainable fruit production for nutritional security in arid and semi-arid regions of India. In: National conference on arid fruits- A way forward for sustainable production and nutritional security organized at UAS, Raichur, Karnataka, pp.10-23.
- Sarolia, D. K, Haldhar, S. M. and Pareek, P. K. 2019. Production technology and insect-pest management of ber crop. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 36-42.
- Sarolia, D. K., Krishna, H., Kumar, K., Kumar, L. and Saroj, P. L. 2019. Variability of ber (*Ziziphus* sp.) and its prospects for crop improvement in western Rajasthan. In: Compendium of Entrepreneurship and innovation in agriculture for socio - Economic empowerment of farmer. Pareek N. K., Mathur A. and Rathore M. L. (eds.), SKRAU, Bikaner: 113-119 (ISBN: 978-81-868824-4-8).
- Sarolia, D. K., Saroj, P. L., Reddy, S. V. R. and Meena, R. K. 2019. Vegetative propagation of fruit crops and their nursery management. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp. 65-74.
- Sarolia, D. K., Saroj, P. L., Singh, R. S., Meena, R. K. and Kumar, L. 2019. Genetic diversity and improvement in fruit crops in arid region. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al*. (eds.). Published by ICAR-CIAH, Bikaner, pp.14-27.
- Sarolia, D.K., Meena, R.K. and Kumar, L. 2019. Insect-pest free planting material through nursery management. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, pp. 132-136.
- Sharma, B. D. 2019. Advances in nutrient and water management with special reference to arid fruits In: National conference on arid fruits-A way forward for sustainable production and nutritional security organized at UAS, Raichur, Karnataka, pp.45-56.
- Sharma, B. D. and Jatav, M. K. 2019. Micro irrigation and fertigation in fruit crops. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L. *et al*. (eds.) published by ICAR-CIAH, Bikaner, pp. 294-304.

- Sharma, B. D. Meena, A. and Jatav, M. K. 2019. Nutrient management in orchard crops. In: Hi-tech production of fruits and vegetables in arid and semi-arid agro-ecosystems. Saroj, P. L. *et al.* (eds.) published by ICAR-CIAH, Bikaner, pp. 262-275.
- Singh, D. and Kumar, K. 2019. Hardening of tissue culture plants and field plantation. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al.* (eds.). Published by ICAR-CIAH, Bikaner, Rajasthan from 09-18 August, 2019, pp. 75-88.
- Singh, P. P., Verma A. K. and Singh, P. 2019. Production technology of Solanaceous Vegetable crops. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al.* (eds.). Published by ICAR-CIAH, Bikaner, pp. 197-210.
- Singh, R. S. 2019. Prospect and scope of exotic fruits cultivation in arid region. In: Winter school on Hi-tech approaches for production and value addition of horticultural crops in arid and semi-arid regions organized by SKRAU, Bikaner during 7-27 Novemnber, 2019.
- Verma, A. K. and Haldhar, S. M. 2019. Management of pest in protected cultivation of vegetable for quality production. In: Integrated pest management of arid fruit and vegetable crops. Haldhar, S. M. and Maheshwari, S. K. (eds.). Published by ICAR-CIAH, Bikaner, Rajasthan, pp. 120-131. (http://krishi.icar.gov.in/jspui/handle/123456789/29682).
- Verma, A. K., Singh, P. P. and Singh, D. 2019. Protected cultivation of vegetable crops: Principles, structures and agro-techniques. In: Hi-tech propagation and production of fruits and vegetables in arid and semi-arid ecosystems. Saroj, P. L. *et al.* (eds.). Published by ICAR-CIAH, Bikaner, pp. 218-232. (http://krishi.icar.gov.in/jspui/handle/123456789/29688).
- बलाई, आर. सी., चौधरी, बी. आर. जाटव, एम. के. एवं मीना, एस. आर. 2019. शुष्क क्षेत्रों में टिकाऊ विकास हेतु जैविक खेती बनाम परंपरागत खेती. शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एव ंबलाई, आर. सी. भा.कृ.अनु.प.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 57–61
- बलाई, आर. सी., जाटव, एम. के. एवं मीणा, ए. 2019. मृदा स्वास्थ्य कार्ड की जैविक खेती में उपयोगिता. शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एवं बलाई, आर. सी. भा.कृ.अनु.प.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 103–107.
- बलाई, आर. सी., जाटव, एम. के., मीना, एस. आर. एवं मीणा, ए. 2019. शुष्क एवं अर्ध–शुष्क क्षेत्रों में जैव–उर्वरकों की उपयोगिता. शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एवं बलाई, आर. सी. भा. कृ.अनु.प.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 70–72.
- बलाई, रूप चंद, जाटव, मुकेश कुमार, मीना, एस आरएवं मीना अनीता 2019. शुष्क क्षेत्रों में सूक्ष्म पौषक तत्वों द्वारा समेकित कीट प्रबंधन, कृषक प्रशिक्षण पुस्तिका: शुष्क बागवानी फसलों में समेकित नाशीजीव प्रबंधन, हलधर, श्रवण एम, वर्मा, अजय कुमार, मीना एस आर एवं समादिया डी के, भा. कृ.अनु.प.–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर। पेज 104–109.
- मीणा, ए., जाटव, एम. के., मीना, आर., कुमार, जे., गोरा, जे. एस., मीना, एम. एवं मीना, एन. 2019. जैविक खेती व पर्यावरण की सफाई के लिए एक संभावित बायोरेमेडिएटर: ट्राइकोडर्मा का महत्त्वव उपयोग शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एवं बलाई, आर. सी. भा.कृ.अनु.प.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 43–46.
- मीना, एस. आर., जाटव, एम. के. एवं बलाई, आर. सी. 2019. शुष्क क्षेत्रों में जैविक बागवानी उत्पादों की संभावनाएं एवं लाभ. शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एवं बलाई, आर. सी. भा. कृ.अनु.प.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 62–69.

- मीना, शिव राम, बलाई,रूप चंद, जाटव, एम के एवं मीना, रामकेश 2019. परम्परागत तकनीकों से शुष्क बागवानी की फसलों में लगने वाले कीट एवं व्याधि नियंत्रण, कृषक प्रशिक्षण पुस्तिकाः शुष्क बागवानी फसलों में समेकित नाशीजीव प्रबंधन, हलधर, श्रवण एम, वर्मा, अजय कुमार, मीना, एस आर एवं समादिया, डी. के. भा.कृ.अनु.प.–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज 118–125.
- मीना, शिव राम एवं सरोज, पी एल 2019. मरू प्रदेश के भेड़पालन व्यवसाय में शुष्क बागवानी का महत्व। प्रशिक्षण पुस्तिकाः आहार तकनीकी कौशल प्रशिक्षण–लाभप्रद भेड़पालन एवं स्वर्णिम भविष्य, सेनी निर्मला, नरूला, एच के चोपड़ा, आशीष, प्रकाश, चन्द्र एवं कुमार अशोक, भा.कृ.अनु.प.–के.भे. एवं ऊअनुस., मरु क्षेत्रीय परिसर, बीकानेर, पेज 54–60.
- शर्मा, बी. डी., बलाई, आर. सी. एवं जाटव, एम. के. 2019. शुष्क क्षेत्रों में किन्नो में पोषक तत्व प्रबंन्ध कैसे करें. शुष्क क्षेत्रों में फल एवं सब्जियों की जैविक खेती. शर्मा, बी. डी., सरोज, पी. एल. चौधरी, बी. आर. एवं बलाई, आर. सी. भा.कृ.अनुप.–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान). पेज न. 33–36.
- कुमार, आर., गोरा, जे. एस., बेरवाल, एम. के. एवं चेत राम. 2019. अनार की उत्पादन तकनीकी एवं समेकित कीट प्रबंधन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 41–48.
- कुमार, के. 2019. कीट प्रबंधन हेतु अवप्रयोगी फल फसलों के लिए उपयुक्त जीनोटाइप. शुष्क बागवानी फसलों में समेकित नाशीजीव प्रबंधन पर 16–20 सितंबर 2019 के दौरान प्रशिक्षण की सार संक्षिप्त पुस्तिका, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान) द्वारा प्रकाशित.
- माहेश्वरी, एस. के., देवी, राम्याश्री, चौधरी, बी. आर. एवं हलधर, एस. एम. 2019. शुष्क कद्दु वर्गीय सब्जियों में समेकित रोग प्रबंधन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 22–24.
- माहेश्वरी, एस. के., देवी, राम्याश्री, वर्मा, ए. के. एवं मीणा, आर. के. 2019. ट्राइकोडर्मा प्रजातियों से जैव–सूत्रीकरण (बायो–फोर्मूलेसन) बनाने की विधि. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेजन.110–112.
- मीना, आर. के., सरोलिया, डी. के., रेड्डी, एस. वी. आर. एवं पारीक, पी. के. 2019. शुष्क क्षेत्रिये बागवानी फसलों मे समेकित कीट प्रबंधन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृ अनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 141–144.
- हलधर, एस. एम., चौधरी, बी. आर. एवं माहेश्वरी, एस. के. 2019. शुष्क क्षेत्र में सब्जियों के मुख्य कीटों का समेकित कीट प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर द्वारा प्रकाशीत पुस्तक शुष्क क्षेत्रीय सब्जियों का बीजोत्पादन. चौधरी, बी. आर., हलधर, एस. एम. एवं सरोज, पी. एल. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 113–116.
- हलधर, एस. एम. एवं वर्मा, ए. के. 2019. कैसे करे सब्जियों में प्रमुख कीटों की पहचान. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर द्वारा प्रकाशीत पुस्तक शुष्क क्षेत्रीय सब्जियों का बीजोत्पादन. चौधरी, बी. आर., हलधर, एस. एम. एवं सरोज, पी. एल. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 107–112.
- हलधर, एस. एम. एवं सरोलिया, डी. के. 2019. बेर में लगने वाले मुख्य कीटों का समेकित कीट प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 7–11.
- हलधर, एस. एम., वर्मा, ए. के., कुमार, आर. एवं

समादिया डी. के. 2019. गैर–कीटनाशकों द्वारा शुष्क बागवानी मे कीट प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृ अनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 90–95.

- हलधर, एस. एम., माहेश्वरी, एस. के. एवं मीना, ए. 2019. खजूर में लगने वाले मुख्य कीटों का समेकित कीट प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 19–21.
- हलधर, एस. एम., वर्मा, ए. के., चौधरी, बी. आर. एवं समादिया, डी. के. 2019. कददू वर्गीय सब्जियों में समेकित कीट प्रबन्धन. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 25–32.
- समादिया, डी. के. एवं वर्मा, के. 2019. शुष्क क्षेत्र की चयनित सब्जी फसलें, प्रजातियाँ ,वं समेकित उत्पादन तकनीकियाँ. भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, द्वारा प्रकाशीत पुस्तक शुष्क बागवानी फसलों में समेकित नाशी जीव प्रबन्धन. हलधर, एस. एम., वर्मा, ए. के., मीना, एस. आर. एवं समादिया, डी. के. (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, पेज न. 65–76.
- समादिया, डी. के. 2019. खेजड़ी आधारित जैविक फसल उत्पादन प्रणालियाँ. शुष्क क्षेत्रीय फल एवं सब्जियों की जैविक खेती. शर्मा बी. डी. *एट आल.* (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान, पेज 6–11.
- समादिया, डी. के. 2019. शुष्क क्षेत्र में सब्जी बीज उत्पादन का सैद्धान्तिक ज्ञान. शुष्क क्षेत्रीय फल एवं सब्जियों की जैविक खेती. शर्मा बी. डी. *एट आल.* (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान, पेज नं 23–28.
- समादिया, डी. के. 2019. शुष्क क्षेत्र में जैविक सब्जी फसल उत्पादन तकनीकी. शुष्क क्षेत्रीय फल एवं सब्जियों की जैविक खेती. शर्मा बी. डी. *एट आल.* (संपादक). भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान, पेज नं 12–19.
- वर्मा, ए. के., समादिया, डी. के. एवं हलधर, एस. एम. 2019. दलहनी सब्जियों में कीट प्रबंधन हेतु उन्नत उत्पादन प्रौद्योगिकी. शुष्क बागवानी में समेकित नाशीजीव प्रबंधन. हलधर, एस. एम., वर्मा, ए. के., मीना एस.आर. एवं समादिया, डी. के. (संपादक). भा. कृ.अनु.प.–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान. पेज नं. 77–82. (http://krishi-icar-gov-in/jspui/handle/123456789/29674).
- वर्मा, ए. के. एवं हलधर, एस. एम. 2019. गुणवत्ता उत्पादन के लिये सब्जियों की संरक्षित खेती में कीट प्रबंधन. शुष्क बागवानी में समेकित नाशीजीव प्रबंधन. हलधर, एस. एम., वर्मा, ए. के., मीना एस. आर. एवं समादिया, डी. के. (संपादक). भा.कृ.अनु.प.–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान. पेज नं. 126&133- (http://krishi-icar-gov-in/jspui/handle/123456789/29681).

Folders

- चौधरी, बी. आर., हलधर, एस. एम. और माहेश्वरी, एस. के. 2019. तर–ककड़ी की उत्पादन प्रौधोगिकी, प्रकाशक भाकृअनुप–केशुबास, बीकानेर. (http://krishi.icar.gov.in/jspui/handle/123456789/30938).
- कुमार, के. एवं हलधर, एस. एम. 2019. शुष्क क्षेत्र में फालसा की खेती. तकनीकी पत्रक, भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर (राजस्थान).
- मीना, अनिता, जाटव, मुकेश कुमार, शर्मा, बी. डी 2019. खेती के लिए मृदा परीक्षण एक आवश्यक कदम, भाकृअनुप–केशुबास, बीकानेर (राजस्थान).
- मीना, एस. आर., वर्मा, ए. के., एवं समादिया, डी. के. 2019. सब्जी हेतु ग्वार फली उत्पादन प्रौद्योगिकी. तकनीकी पत्रक. भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान. (http://krishi-icar-gov-in/jspui/handle/123456789/33524)
- वर्मा, ए. के., मीना एस. आर. एवं समादिया, डी.के. 2019. लौकी उत्पादन की उन्नत तकनीक. तकनीकी पत्रक. भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान. (http://krishi-icar-gov-in/jspui/handle/123456789/33528)

- वर्मा, ए. के., मीना एस. आर. एवं समादिया, डी. के. 2019. शुष्क क्षेत्रों में टिंडा उत्पादन प्रौद्योगिकी. तकनीकी पत्रक. भाकृअनुप–केंद्रीय शुष्क बागवानी संस्थान, बीकानेर, राजस्थान (http://krishi-icar-gov-in/jspui/handle/123456789/33525)

TV and Radio Talks

- Dr. Snajay Singh delivered a TV talk on "Management of aonla, bael and ber" at DD Kisan, New Delhi telecasted on 16th September, 2019.
- Dr. Sanjay Singh delivered a radio talk on "Management of mango at Godhra" All India Radio, Godhra broadcasted on 2nd September, 2019.
- Dr. A. K. Singh, delivered TV talk on "Bael, jamun aur karonda ka prabandhan" at Doordarshan telecasted under Hello Kisan on DD Kisan Channel on 24th November, 2019.
- Dr. D. S. Mishra delivered a radio talk on "Jamfal ni kheti" at All India Radio, Godhra on 20th September, 2019.
- Dr. Vikas Yadav delivered a radio talk on "Management of custard, wood apple and fig cultivation in India" in Hello Kisan on DD Kisan Channel on 3rd January, 2020, New Delhi.
- Dr. L. P. Yadav delivered phone based TV programme on "Tamatar ki dekhbhal" on Hello Kisan on DD Kisan Channel, New Delhi on 07th June, 2019.
- Dr. Gangadhara K. delivered a radio talk on "Scientific cultivation of vegetable cowpea" in Hindi at All India Radio, Godhra on September, 2019.

10. RESEARCH PROJECTS

Code	Title of project	Name of PI & Co-PI
	Institute Based **I. New Research Project Proposals**	
1.	Standardization of production technology of jamun and custard apple under semi-arid conditions of western India.	Dr. Sanjay Singh Dr. D. S. Mishra Dr. V. V. Appa Rao
2.	Tuber crops in the arid region (Potato and sweet potato).	Dr. M. K. Jatav Ms. Ramyashree Devi Mr. R. C. Balai
3.	Response of date palm cultivar to pollen sources, pollen quality, quantity and suitability under hot arid ecosystem.	Dr. Ramkesh Meena Dr. Chet Ram
4.	Conservation, utilization and maintenance of underexploited fruit crops (lasora, *ker*, karonda and phalsa).	Dr. Kamlesh Kumar Dr. Chet Ram Dr. D. K. Samadia Dr. S. M. Haldhar
5.	Development of a bio-fertilizer cum bio-pesticide formulation of native *Rhizobium* sp. for vegetable cultivation.	Ms. Ramyashree Devi Dr. Anita Meena
	II. On-going Research Project	
CIAH: 1	Introduction, collection, characterization, conservation and evaluation of germplasm of arid and semi-arid fruit and vegetable crops:	
(a)	Ber (*Ziziphus* spp.)	Dr. D. K. Sarolia Dr. Kamlesh Kumar Dr. S.M. Haldhar
(b)	Pomegranate (*Punica granatum* L.)	Sh. Ramesh Kumar Dr. D. S. Mishra Dr. Ramkesh Meena Dr. S. M. Haldhar
c)	Date palm (*Phoenix dactylifera* L.)	Dr. R. S. Singh Dr. B. D. Sharma Dr. Ramkesh Meena
(d)	Aonla (*Emblica officinalis* Gaertn)	Dr. A. K. Singh Dr. D. S. Mishra Dr. Mukesh K. Berwal
(e)	Bael (*Aegle marmelos* Correa.)	Dr. A. K. Singh Dr. Ramkesh Meena Mr. Roop Chand Balai
(f)	Wood apple (*Feronia limonia*) and custard apple (*Annona squomosa)*	Dr. Vikas Yadav Dr. A. K. Singh
(g)	Jamun and manila tamarind.	Dr. Sanjay Singh Dr. A. K. Singh Dr. V. V. Appa Rao Dr. D. S. Mishra
(i)	Introduction, collection, characterization, conservation and evaluation of guava and acid lime under rainfed semi-arid conditions of western India.	Dr. D. S. Mishra Dr. Vikas Yadav

Code	Title of project	Name of PI & Co-PI
(j)	Maintenance and use of arid vegetable genetic resources for crop improvement.	Dr. D. K. Samadia Dr. S. M. Haldhar Dr. Ajay Kr. Verma
(k)	Cucurbitaceous crops: Muskmelon, watermelon, sponge gourd and longmelon.	Dr. B. R. Choudhary Dr. S. K. Maheshwari Dr. S. M. Haldhar
(l)	Introduction, collection, characterization, conservation and evaluation of vegetable crops (dolichosbean, clusterbean and cowpea) under rainfed semi-arid conditions of western India	Dr. Gangadhara, K. Dr. V. V. Appa Rao Dr. L. P. Yadav
(m)	Introduction, collection, characterization, conservation and evaluation of germplasm of drumstick, spine gourd, ivy gourd, tomato, pumpkin and bottle gourd.	Dr. L. P. Yadav Dr. V. V. Appa Rao Dr. Gangadhara, K.
CIAH: 2	Improvement of arid and semi-arid fruit and vegetable crops including biotechnological interventions:	
(b)	Breeding for abiotic stress tolerance in solanaceous crops.	Dr. P. P. Singh Dr. Ajay Kr. Verma
(d)	Biochemical and biotechnological interventions:	
(i)	Standardization and commercialization of micro-propagation techniques of horticultural crops under arid agro eco-system: Date palm	Dr. Dhurendra Singh Dr. Kamlesh Kumar Dr. Chet Ram
(iii)	Biochemical mechanism of abiotic stress tolerance in arid horticultural crops.	Dr. Mukesh K. Berwal Dr. S. M. Haldhar Dr. Chet Ram
iv)	Development, exploitation and validation of genomic resources for enhanced utilization of arid horticultural crops.	Dr. Chet Ram Dr. M. K. Berwal Dr. Ajay K. Verma Dr. Kamlesh Kumar
CIAH: 3	Standardization of arid and semi-arid fruits and vegetables production technology:	
(a)	Evaluation of fruit based diversified cropping models for arid region.	Dr. M. K. Jatav Dr. Ajay Kr. Verma Dr. Anita Meena Sh. Roop Chand Balai
(c)	Intensification of research on tissue cultured date palm in hot arid region.	Dr. B. D. Sharma Dr. R. S. Singh Dr. Ramkesh Meena
(d)	Standardization of production technology of bael under rainfed semi-arid conditions of western India.	Dr. A. K. Singh Dr. Sanjay Singh Dr. V. V. Appa Rao
(e)	Studies on compatibility and adaptability of citrus rootstock under hot arid environment of Rajasthan.	Sh. Ramesh Kumar Dr. B. D. Sharma
(f)	Studies on flowering regulation, cracking management and root stock adaptability in pomegranate under hot arid environment of Rajasthan.	Mr. Ramesh Kumar Dr. M. K. Jatav Dr. Ramkesh Meena Ms. Ramyashree Devi
(h)	Intensification of production technology in guava, jamun and mulberry under hot arid conditions.	Dr. D. K. Sarolia Dr. Dhurendra Singh Dr. Vijay R. Reddy Dr. Anita Meena

Code	Title of project	Name of PI & Co-PI
(i)	Nutrient management in chironji, custard apple, jamun and tamarind.	Dr. V. V. Appa Rao Dr. Sanjay Singh Dr. A. K. Singh
(j)	Production system management in ber under hot arid ecosystem.	Prof. (Dr.) P. L. Saroj Dr. D. K. Sarolia Dr. B. D. Sharma Dr. S. M. Haldhar
(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. D. K. Samadia Dr. Anita Meena Sh. Roop Chand Balai
(l)	Protected cultivation of vegetables under hot arid conditions.	Dr. Ajay Kr. Verma Dr. Dhurendra Singh Dr. D. K. Samadia Dr. B. R. Choudhary
(m)	Management practices for saline soil and water for crop production in arid region.	Dr. Anita Meena Dr. P. P. Singh Sh. Roop Chand Balai
(o)	Exploitation of arid fruits and vegetables for value addition and commercialization.	Dr. Vijay R. Reddy Dr. R. S. Singh Dr. S. R. Meena Dr. Ramkesh Meena Dr. Mukesh K. Berwal
(p)	Development of functional foods and nutraceutical value added products from arid horticultural crops.	Dr. Vijay R. Reddy Dr. Mukesh K. Berwal Sh. Ramesh Kumar
(q)	Technological interventions for arid horticulture development and its impact assessment.	Dr. S. R. Meena Dr. R. S. Singh Dr. D. K. Samadia Dr. D. K. Sarolia Sh. Roop Chand Balai
CIAH: 4	Plant health management studies in arid and semi-arid fruit and vegetable crops:	
(b)	Management of different diseases of arid horticultural crops through botanicals and inorganic salts under hot arid conditions of Rajasthan.	Dr. S. K. Maheshwari Dr. B. R. Choudhary Dr. Mukesh K. Berwal Dr. S. M. Haldhar
III. Concluded Projects		
CIAH-1 (h)	Indigenous and exotic underutilized fruit crops (Lasora, *ker*, karonda and phalsa).	Dr. Kamlesh Kumar Dr. Dhurendra Singh Dr. S. M. Haldhar
CIAH-3 (b)	Standardization of integrated nutrient management in arid horticultural crops.	Dr. B. D. Sharma Dr. S. K. Maheshwari Dr. Anita Meena
CIAH-3 (n)	Value addition in semi-arid fruit crops.	Dr. Vikas Yadav Dr. Sanjay Singh Dr. V.V. Appa Rao Dr. D. S. Mishra

Code	Title of project	Name of PI & Co-PI
	Externally funded projects	
I.	DST Sponsored	
EF 9	Enhancing food and water security in arid region through improved understanding of quantity, quality and management of blue, green and grey water.	Dr. B. D. Sharma Sh. Ramesh Kumar
II.	PPV&FRA Sponsored	
EF 1	DUS centre (watermelon and muskmelon).	Dr. B. R. Choudhary
EF 2	DUS centre for ber (*Ziziphus* sp.).	Dr. D. K. Sarolia
EF 3	DUS centre for date palm horticultural crop.	Dr. R. S. Singh Dr. Ramkesh Meena
EF 4	DUS nodal centre for bael.	Dr. A. K. Singh Dr. Sanjay Singh
EF 5	DUS co-nodal centre for aonla.	Dr. A. K. Singh
EF 6	DUS co-nodal centre for jamun.	Dr. Sanjay Singh
EF 7	DUS nodal centre for chironji and tamarind.	Dr. Sanjay Singh Dr. A.K. Singh
	Flagship programme	
1	Production and demonstration of tissue culture raised plants under three locations and collection and maintenance of elite germplasm of date palm.	Director, Nodal Officer Dr. Dhurendra Singh Dr. R. K. Kaul Dr. Ghanshyam Patil Dr. C. Muralidharana
	Collaborative Project	
1	Introduction of potato in non-traditional area of Rajashan	ICAR-CPRI and ICAR-CIAH
2	Performance of onion varieties of germplasm under arid region.	ICAR-DOGR, Pune and ICAR-CIAH
3	Developing road map for branding of Rose products	ICAR HQ, New Delhi; ICAR-DFR, Pune; ICAR-CIAE, Bhopal; ICAR-IISR, Calicut; ICAR-IARI, New Delhi; NAU, Navsari; MPUAT, Udiapur; KVK, Chitorgarh and ICAR-CIAH, Bikaner

11. RAC, IMC AND IRC

Research Advisory Committee

In pursuance of Rule 71(A) of the Rules and Bye-laws of the ICAR Society, the DG, ICAR, New Delhi has consitutted the following Research Advisory Committee to review the progress of the on going research programme and suggest the future modalities of the future programme.

Chairman

Dr. T. A. More
Former-Vice Chancellor
MPKV, Rahuri-413722, MS

Members

Dr. P. S. Naik
Former Director
ICAR-IIVR, Varanasi (U.P.)

Dr. Ashwani Kumar
Ex-Director, ICAR-IIWM
Chandrasekharpur, Bhubneswar-751023

Dr. M. Anandaraj
Ex-Director, ICAR-IISR, Calicut-673012

Dr. D. S. Khurdia
Former Head, Division of Post Harvest Technology
ICAR-IARI, Pusa, New Delhi-110 012

Director

ICAR-CIAH, Bikaner

Asstt. Director General (Hort.-I)

ICAR, KAB-II
New Delhi

Member Secretary

Dr. Dhurendra Singh
Head, Division of Crop Improvement
ICAR-CIAH, Bikaner

Institute Management Committee

The Institute Management Committee Chaired by Director of the Institute to discuss the agenda from different units of the Institute regarding finance, administration, research and other miscellaneous issues and submit the recommendations to the Council for necessary approval during the report period a meeting was held on 29.06.2019 in which agendas received from units and regional stations were discussed.

S. No.	Name of members
1	Prof. (Dr.) P. L. Saroj, Director, ICAR-CIAH, Bikaner, Chairman
2	ADG (H-II), ICAR, KAB-II, Pusa, New Delhi
3	Director (Horticulture) Government of Rajasthan, Jaipur (Rajasthan)
4	Director of Horticulture Gujarat State, Krsihi Bhavan, Sector No.10-A, Gandhinagar (Gujarat)
5	Director of Research, SKRAU, Bikaner
6	Finance & Accounts Officer, Central Arid Zone Research Institute, Jodhpur
7	Dr. A.K. Singh, Pr. Scientist, CHES, Vejalpur, Godhra
8	Dr. D. Singh, Head, Division of Crop Improvement, CIAH, Bikaner
9	Dr. R.A. Sharma, Pr. Scientist, CAZRI, Jodhpur
10	Dr. T.K. Behera, Pr. Scientist, Vegetable Science, IARI, New Delhi
11	Administrative Officer & Member Secretary

IMC Meeting held on 29.06.2019.

Institute Research Committee

The Committee chaired by Director of the Institute to discuss the progress of the ongoing research programmes and to finalize the new proposals. During the repoted period, the meeting was held at ICAR-CIAH Regional Station, Vejalpur of the Institute on 8-9th July 2019.

Chairman

Prof. (Dr.) P. L. Saroj
Director
ICAR-CIAH, Bikaner

Members

All Scientists of the Institute

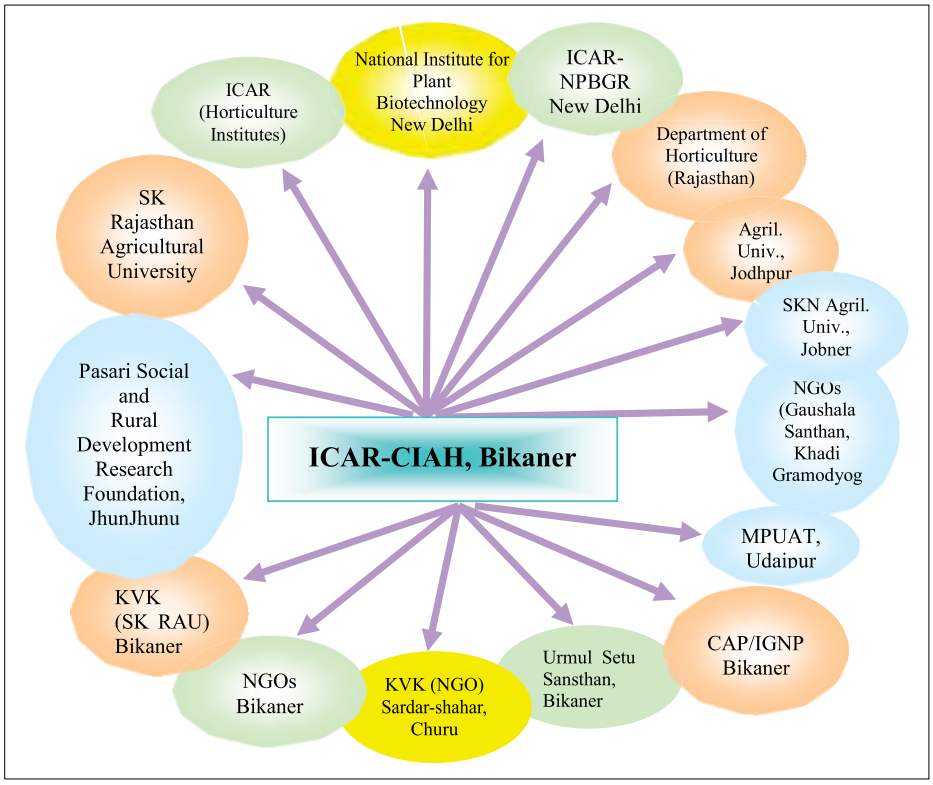
Member Secretary

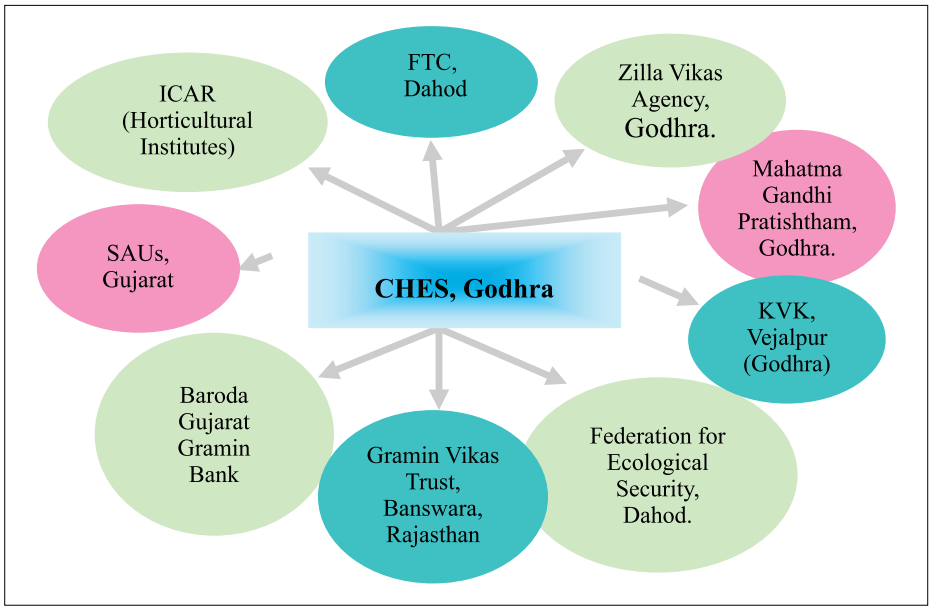
Dr. S. K. Maheshwari
Principal Scientist (Plant Pathology)

IRC meeting held during 2019

12. LINKAGES AND COLLABORATIONS

The Institute has made linkages with the other ICAR Institutes, SAUs and other developmental agencies to exchange the research information, inter-institutional projects and exchange of seed and planting materials and guiding and teaching of the PG students. The Institute has made MoUs with S. K. RAU, Bikaner and Agriculture University, Jodhpur. The Institute also initiated collaborative projects with other ICAR Institutes i.e. ICAR-CPRI, Shimla, ICAR-DOGR, Pune and ICAR-CAZRI, Jodhpur.





13. RAJBHASHA

उत्तरी क्षेत्र में स्थित परिषद के संस्थानों में कार्यरत राजभाषा अधिकारियों के लिए दो दिवसीय हिन्दी कार्यशाला

बीकानेर स्थित केन्द्रीय शुष्क बागवानी संस्थाान में दिनांक 30 और 31 अगस्त, 2019 को उत्तरी क्षेत्र में स्थित परिषद के संस्थानों में कार्यरत राजभाषा अधिकारियों के लिए दो दिवसीय हिन्दी कार्यशाला का आयोजन किया गया। इस कार्यशाला का मुख्य उद्देश्य परिषद के संस्थानों में कार्यरत उप निदेशक (राजभाषा)/सहायक निदेशक (राजभाषा)/मुख्य तकनीकी अधिकारी/सहायक मुख्य तकनीकी अधिकारी/वरिष्ठ तकनीकी अधिकारी तथा हिन्दी का कार्य देख रहे अन्य अधिकारियों को राजभाषा कार्यान्वयन को कारगर ढ़ंग से लागू करने में जागरूक तथा सक्षम बनाना था। कार्यशाला का उद्घाटन माननीय श्री अर्जुन राम मेघवाल, केन्द्रीय संसदीय कार्य एवं भारी उद्योग राज्य मंत्री तथा माननीय श्री कैलाश चौधरी, केन्द्रीय कृषि एवं किसान कल्याण राज्य मंत्री ने किया। इस अवसर पर प्रो. आर. पी. सिंह, माननीय कुलपति, स्वामी केशवानंद राजस्थान कृषि विश्वविद्यालय, बीकानेर, डॉ. टी. जानकीराम, सहायक महानिदेशक (बागवानी विज्ञान), भाकृअनुप, नई दिल्ली सम्माननीय अतिथि थे। इस अवसर पर संस्थान के निदेशक प्रो. (डॉ.) पी. एल. सरोज के अलावा मुख्य वक्ता के रूप में श्री मधु आचार्य 'आशावादी', वरिष्ठ साहित्यकार एवं कार्यकारी सम्पादक, दैनिक भास्कर, बीकानेर और निदेशक (राजभाषा) भाकृअनुप, नई दिल्ली श्रीमति सीमा चोपड़ा भी मंचासीन थे। इनके अतिरिक्त इस कार्यशाला में भाकृअनुप के राजस्थान स्थित अनुसंधान संस्थानों/केन्द्रों के निदेशक के रूप में डॉ. ओ. पी. यादव, निदेशक, काजरी, जोधपुर, डॉ. गोपाल लाल, निदेशक, राष्ट्रीय बीजीय मसाला केन्द्र, तबीजी, अजमेर, डॉ. ए. साहू, निदेशक, केन्द्रीय भेड़ व ऊन अनुसंधान संस्थान, अविकानगर, डॉ. आर. के. सावल, निदेशक, राष्ट्रीय उष्ट्र अनुसंधान संस्थान, बीकानेर और डॉ. बी. एन. त्रिपाठी, निदेशक, राष्ट्रीय अश्व अनुसंधान संस्थान, हिसार उपस्थित थे। अन्य गणमान्य अतिथियों में डॉ. विश्वनाथ मेघवाल, पूर्व विधायक, खाजूवाला सहित बीकानेर के प्रतिष्ठित साहित्यकार एवं नागरिकगण उपस्थित थे।

संस्थान के निदेशक प्रोफेसर (डॉ.) पी.एल. सरोज ने अपने स्वागत उद्बोधन में अतिथियों का स्वागत करते हुए इस दो दिवसीय हिन्दी कार्यशाला की रूप रेखा के बारे में बताया एवं कहा कि हिन्दी को राष्ट्र भाषा का दर्जा दिया जाना चाहिए। निदेशक (राजभाषा) श्रीमती सीमा चोपड़ा ने क क्षेत्र के सभी संस्थानों से पधारे अतिथितियों का आभार व्यक्त किया। इस अवसर पर मंचासीन अतिथियों ने केन्द्रीय शुष्क बागवानी संस्थान द्वारा प्रकाशित वार्षिक हिन्दी गृह पत्रिका 'मरु बागवाणी' का भी विमोचन किया। कार्यशाला में परिषद के उत्तर भारत के 'क' क्षेत्र में स्थित कुल 45 संस्थानों के लगभग 48 प्रतिभागियों ने भाग लिया। इस कार्यशाला का संचालन राजभाषा अधिकारी श्री प्रेम प्रकाश पारीक ने किया।

मंचासीन सम्माननीय अतिथिगण

प्रो. (डॉ.) पी.एल. सरोज द्वारा स्वागत संबोधन

संस्थान की राजभाषा पत्रिका ''मरु बागवाणी'' का विमोचन करते हुए अतिथिगण

हिन्दी कार्यशाला का समापन समारोह

हिंदी कार्यशाला के दौरान व्याख्यान देते अतिथि

राजभाषा कार्यन्वयन समिति की बैठक एवं त्रैमासिक हिन्दी कार्यशाला

राजभाषा कार्यन्वयन समिति की तिमाही बैठकों का आयोजन क्रमशः दिनांक 16 मार्च. 2019, 28 जून, 2019, 06 सितम्बर, 2019 एवं 24 दिसम्बर, 2019 को किया गया था। इन सभी बैठकों में संस्थान की राजभाषा गतिविधियों की समीक्षा की गयी एवं हिन्दी की प्रगति को संस्थान के दैनिक कार्यों में सुनिश्चित किया गया। इन बैठकों का कार्यवत्त तैयार कर उसी अनुसार कार्रवाई की गयी।

संस्थान में कार्यरत अधिकारियों/कर्मचारियों को हिन्दी में कार्य करने की प्रेरणा के लिए राजभाषा विभाग के निर्देशानुसार चार त्रैमासिक कार्यशालाओं का आयोजन किया गया। वर्ष 2019 की पहली कार्यशाला का आयोजन दिनांक 25 मार्च, 2019 को किया गया जिसमें 'जैविक खेती और उसकी उपयोगिता' विषय पर किया गया। इसमें राजकीय बालिका महाविद्यालय, गुरूग्राम (हरियाणा) की व्याख्याता विस्तार शिक्षा डॉ. सोनाली सक्सेना में व्याख्यान दिया। वर्ष की दूसरी कार्यशाला दिनांक 21 जून, 2019 को आयोजित की गयी जिसमें 'योग एवं स्वास्थ्य' विषय पर योग शिक्षक श्री विनोद जोशी ने व्याख्यान दिया। इसी क्रम में तीसरी कार्यशाला का आयोजन 26 सितम्बर, 2019 को किया गया जिसमें 'स्वच्छता मिशन' पर संस्थान के प्रशासनिक अधिकारी श्री रामदीन ने अपना व्याख्यान दिया। वर्ष 2019 की अंतिम कार्यशाला का आयोजन दिनांक 30 दिसम्बर, 2019 को किया गया जिसमें 'राजभाषा नीति और उसका अनुप्रयोग' विषय पर श्री प्रदीप कुमार, वरिष्ठ प्रबंधक (राजभाषा), भारतीय स्टेट बैंक, बीकानेर ने अपना व्याख्यान दिया।

हिंदी पखवाड़ा का आयोजन

संस्थान में दिनांक 14 से 28 सितम्बर 2019 के दौरान ''हिंदी पखवाड़ा'' मनाया गया। इस दौरान जान–माने वरिष्ठ साहित्यकार गृह मंत्रालय की हिंदी समिति के पूर्व सदस्य, रेलवे बोर्ड के हिंदी सलाहकार सदस्य, लेखक और चिंतक डॉ. नंद किशोर आचार्य मुख्य अतिथि के रूप में आमंत्रित किये गये। उन्होंने कहा कि हिंदी कार्यक्रम की हिंदी भाषी राज्यों में कोई विशेष सार्थकता नहीं है। हिंदी का कई स्थानों पर विरोध होता आया है। परन्तु हिंदी भाषा का अन्य भारतीय भाषाओं से वैमनस्य नहीं है। यह अन्य सभी भाषाओं को साथ लेकर चलने वाली भाषा है। अपनी भाषा से प्रेम करने की सीख देते हुए आचार्य ने कहा कि भाषा वही आगे बढ़ती है जिसे उसके बोलने वाले अपने माता–पिता की तरह से सम्मान देते हैं। अन्यथा एक शोध के अनुसार वर्ष 1950 से लेकर 2010 तक भारत की 220 बोलियां लुप्त हो गयी वैसे ही एक न एक दिन यह भाषा भी लुप्त हो जाएगी। अंग्रेजी शिक्षा के फैलते जाल के प्रति चिंता जताते हुए उन्होंने कहा कि यह इस देश की संस्कृति और भाषा के लिए मीठा जहर है।

संस्थान के निदेशक प्रो. (डॉ.) पी. एल. सरोज ने इस अवसर पर बोलते हुए कहा कि हिंदी को बढ़ाने में समाचार पत्रों की विशेष भूमिका रही है। हिंदी सिनेमा की चर्चा करते हुए कहा कि महाराष्ट्र में मराठी भाषा के मध्य, अधिकतर उर्दु भाषा वालों ने हिंदी को आगे बढ़ाया है। हिंदी को व्यापारियों ने भी संपर्क भाषा के रूप में विकसित किया है। कृषि अनुसंधान को हिंदी के द्वारा व्यापक बनाने पर बल देते हुए प्रो. सरोज ने कहा कि इस संस्थान ने हिंदी भाषा में प्रकाशित विभिन्न पुस्तिकाओं, पत्रकों, आदि के माध्यम से अनुसंधान कार्य को किसानों तक पंहुचाया है।

हिंदी पखवाड़ा उद्घाटन कार्यक्रम में बोलते हुए डॉ. नंदकिशोर आचार्य और मंचासीन संस्थान के निदेशक प्रो. (डॉ.) पी. एल.सरोज एवं पखवाड़ा कार्यक्रम के संयोजक डॉ धुरेन्द्र सिंह

हिंदी पखवाड़ा समापन कार्यक्रम में मंचासीन अतिथि और पारितोषिक ग्रहण करते हुए स्टाफ के बच्चे

पखवाड़े का समारोह पूर्वक समापन किया गया। इस दौरान मुख्यप अतिथि के रूप में बोलते हुए बीकानेर के जान–माने वरिष्ठ साहित्यकार और राजस्थानी भाषाविद् श्री राजेन्द्र जोशी ने कहा कि भाषाएं कभी मरती नहीं है। भाषा संस्कृति का भाग होती हैं और भाषा से जुड़ाव होता है। मनुष्य का ज्ञान एक भाषा से कभी भी बढ़ नहीं सकता है। एक से अधिक भाषा का ज्ञान हमें विवेकशील बनाता है। भाषाओं के पीछे राजनीति की बात करते हुए उन्हों ने कहा कि देश में साक्षरता दर का प्रतिशत बढ़ने के साथ ही राजनीति से प्रेरित आंदोलनों में कमी आयी है। इस अवसर पर कार्यक्रम की अध्यक्षता करते हुए संस्थान के निदेशक प्रो. (डॉ) पी. एल. सरोज ने कहा कि हिंदी भाषा के कार्यक्रमों को उत्सव के रूप में मनाना चाहिए।

कार्यक्रम में सम्मानीय अतिथि के रूप में राष्ट्रीय उष्ट्र अनुसंधान केन्द्र के निदेशक डॉ. आर. के. सावल केन्द्रीय भेड़ व ऊन अनुसंधान संस्थान, मरु क्षेत्रीय परिसर, बीकानेर के अध्यक्ष डॉ. एच. के. नरूला, और राष्ट्रीय अश्व अनुसंधान केन्द्र, अश्व उत्पादन परिसर, बीकानेर के अध्यक्ष डॉ. एस. सी. मेहता, उपस्थित थे।

पखवाड़े के दौरान हिंदी सामान्यन ज्ञान, यूनिकोड हिंदी टंकण, सम सामयिक विषयक हिंदी लेख, हिंदी कविता, हिंदी शब्द लेखन और बच्चों की स्वंच्छल भारत पर पोस्टिर प्रतियोगिता सहित वर्ष भर हिंदी में सर्वाधिक कार्य करने वाले कार्मिकों को भी पुरस्कृनत किया गया। सात प्रकार की प्रतियोगिताएं की गई जिनमें संस्थान के कार्मिकों के अलावा उनके परिवार जन व बच्चों ने भी भाग लिया।

हिंदी पखवाड़ा कार्यक्रम में स्वच्छता मिशन पर चित्रकारी करते हुए स्टाफ के बच्चे

संस्थान द्वारा प्रकाशित हिंदी के प्रकाशन

भाकृअनुप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर ने इस वर्ष के दौरान विभिन्न फल–सब्जी फसलों के 17 पत्रकों (फोल्डर) का प्रकाशन हिंदी में किया है। इन पत्रकों को किसान मेलों/किसान प्रशिक्षणों के दौरान किसानों को दिया जाता है। इनके अतिरिक्त संस्थान ने अपने वार्षिक प्रतिवेदन को पूर्ण रूप से द्विभाषी प्रकाशित किया है। संस्थान का छःमाही समाचार पत्र द्विभाषी प्रकाशित किया जाता है।

संस्थान द्वारा प्रकाशित पत्रकों का विवरण इस प्रकार है:-

1. संस्थान एक परिचय 2. शुष्क क्षेत्र में बेर उत्पादन प्रौद्योगिकी 3. ग्वारपाठा उत्पादन की उन्नत तकनीक एवं उपयोग 4. शुष्क क्षेत्र में अनार उत्पादन प्रौद्योगिकी 5. आंवला उत्पादन की उन्नत तकनीक 6. बेलपत्र की उन्नत खेती 7. शुष्क क्षेत्र में फालसा की खेती 8. फूटककड़ी (काकड़िया) उत्पादन की उन्नत तकनीक 9. सब्जी हेतु ग्वारफली उत्पादन प्रौद्योगिकी 10. काचरी उत्पादन की उन्नत तकनीक 11. खेजड़ी की उन्नत बागवानी 12. लौकी उत्पादन की उन्नत तकनीक 13. मतीरा उत्पादन की उन्नत तकनीक 14. शुष्क क्षेत्रों में टिण्डा उत्पादन प्रौद्योगिकी 15. धारीधार तोरई की वैज्ञानिक खेती 16. खेती के लिए मृदा परीक्षण 17. तर–ककड़ी उत्पादन की तकनीक

वर्ष 2019 के दौरान संस्थान द्वारा प्रकाशित पत्रक (फोल्डर)

गोधरा गुजरात केन्द्र में वर्ष के दौरान राजभाषा कार्यान्वयन के लिए आयोजित कार्यक्रम

राजभाषा कार्यन्वयन समिति

राजभाषा कार्यन्वयन समिति की तिमाही बैठकों का आयोजन क्रमशरू दिनांक 24.06.2019, 23.09.2019 और 28.12.2019 को आयोजित किया गया। जिसमें केन्द्र की राजभाषा की प्रगति की समीक्षा की गई एवं कार्यान्वयन में आ रही कठिनाईयों को दूर करने के लिए विचार विमर्श करके हिन्दी की प्रगति को सुनिश्चित करने के लिए कदम उठाये।

हिन्दी कार्यशाला

केन्द्र में कार्यरत अधिकारियों को हिन्दी में कार्य करने की प्रेरणा के लिए राजभाषा विभाग के निर्देशानुसार दिनांक 25.09.2019 को राजभाषा हिंदी के प्रचार–प्रसार में नियम अधिनियम की भूमिका कार्यक्रम की शुरूआत में श्री मकवाणा ने बताया की हिंदी के प्रचार, प्रसार में नियम अधिनियम का अत्यंत महत्व है। देश की एकता और अखंडता में राजभाषा हिन्दी का योगदान विषय पर आयोजित इस कार्यशाला में कार्यक्रम की शुरूआत में श्री मकवाणा ने बताया की देश की एकता के लिए अंतर की एकता परमावश्यक है और वह राजनीति से नही, भारत की रत्नगर्भा भाषाओं के उपयोग द्वारा स्थापित हो सकती है। प्रधान महोदय ने संतोष व्यक्त करते हुए बताया कि आज की कार्यशाला में हिन्दी के विकास एवं प्रचार हेतु किये गये प्रयास को देखकर मुझे बहुत हर्ष होता है, तथा ऐसे प्रयास जारी रहने चाहिये।

हिन्दी सप्ताह का आयोजन

केन्द्रीय बागवानी परीक्षण केन्द्र , वेजलपुर (गोधरा) में दिनांक 16.09.2019 से 21.09.2019 तक हिन्दी सप्ताह मनाने का आयोजन किया गया था। हिन्दी सप्ताह दौरान यह निर्णय लिया गया कि सभी कर्मचारी एवं अधिकरीयों अपना महत्म कार्य हिंदी में ही करने का प्रयास करे।

हिन्दी दिवस

दिनांक 23.09.2019 को हिन्दी कार्यांवयन में वक्ता अथवा व्याख्याता की प्रभावी भूमिका के गुर विषय पर आयोजित हिन्दी दिवस पर कार्यक्रम की शुरूआत में श्री मकवाणा ने बताया कि निम्न लिखित बिंदु पर ज्यादा ध्यान देना अति आवश्यक है (1) व्याख्यान देने की शैली,

(2) विषय वस्तु का समुचित ज्ञान, (3) स्पष्टता, (4) अंतिम पड़ाव, (5) समय सिमा का ध्यान, (6) आंगिक अभिव्यक्ति, (7) व्याख्यान का प्रारंभ, मध्य और चरम। डा. ए. के. सिंह, वैज्ञानिक ने बताया कि प्रस्तुतिकरण सिर्फ मौखिक अभिव्यक्ति से नही करना बल्कि आंगिक अभिनय करके अपनी प्रस्तुति को और अधिक प्रभावी बना सकता है।

किसान प्रशिक्षण

केन्द्र द्वारा समय–समय पर किसान प्रशिक्षण आयोजित किए जाते है। इन किसान प्रशिक्षणों में केवल हिन्दी भाषा का ही प्रयोग किया जाता है। केन्द्रीय बागवानी परीक्षण केन्द्र वेजलपुर पर आत्मा के सहयोग से दाहोद जिले, गुजरात के पीपलोद और वन्दार गांव से किसानो और महिला किसानो को ग्रामिण विकास के लिए अर्ध–शुष्क बागवानी प्रशिक्षण कार्यक्रम का आयोजन किया गया।

राजभाषा पुरस्कार

संस्थान को वर्ष 2019 के दौरान नगर राजभाषा कार्यान्वयन समिति, बीकानेर ने हिंदी में वर्ष 2018–19 के दौरान किए गये सर्वक्षेष्ठ कार्य के लिए प्रशस्ति पत्र प्रदान कर सम्मानित किया। नगर राजभाषा कार्यान्वयन समिति की बैठक के दौरान मण्डल रेल प्रबन्धक, बीकानेर श्री संजय कुमार श्रीवास्तव से संस्थान के निदेशक प्रो. (डॉ.) पी. एल. सरोज ने यह प्रशस्ति पत्र प्राप्त किया।


भारत सरकार

नगर राजभाषा कार्यान्वयन समिति, बीकानेर

प्रशस्ति-पत्र

वर्ष 2018-19 के दौरान नगर में राजभाषा के उत्कृष्ट प्रयोग के लिए केंद्रीय शुष्क बागवानी संस्थान, बीकानेर को प्रशस्ति-पत्र प्रदान किया जाता है।

दिनांक -29-07-2019

(संजय कुमार श्रीवास्तव)
अध्यक्ष, नराकास एवं
मंडल रेल प्रबंधक

नगर राजभाषा कार्यान्वयन समिति की बैठक के दौरान मण्डल रेल प्रबन्धन, बीकानेर से प्राप्त प्रशस्ति पत्र

हिंदी पखवाड़ा के दौरान दिये गये पुरस्कार

सामान्य ज्ञान प्रश्नोत्तरी प्रतियोगिता

	वैज्ञानिक समूह	तकनीकी समूह	प्रशासनिक समूह	एसएसएस एवं वाईपी समूह
प्रथम	डॉ. कमलेश कुमार	श्री संजय पाटिल	श्री रावत सिंह	श्रीमती किरण कुमारी
द्वितीय	डॉ. विजय राकेश रेड्डी	–	श्री राकेश कुमार स्वामी	श्री राधेश्याम
तृतीय	डॉ. चेतराम	–	–	श्री मुकेश कुमार

हिंदी शब्द लेखन प्रतियोगिता

	वैज्ञानिक समूह	तकनीकी समूह	प्रशासनिक समूह	एसएसएस एवं वाईपी समूह
प्रथम	डॉ. अजय कुमार वर्मा	श्री छुट्टन लाल मीणा	श्री कुलदीप पान्डे	सुश्री कल्याणी खत्री
द्वितीय	डॉ. सुशील कुमार महेश्वरी	–	श्री राजेश दैया	श्री लोकेश कुमार
तृतीय	–	–	श्रीमती पूजा जोशी	श्री मामराज पचार

यूनिकोड हिन्दी टंकण प्रतियोगिता

	वैज्ञानिक समूह
प्रथम	श्री रूप चंद बलाई
द्वितीय	डॉ. मुकेश कुमार बेरवाल
तृतीय	डॉ. अजय कुमार वर्मा

सम सामयिक विषय पर लेख प्रतियोगिता

वैज्ञानिक समूह	
प्रथम	डॉ. दीपक कुमार सुरोलिया, वरिष्ठ वैज्ञानिक
द्वितीय	डॉ. पी. पी. सिंह, प्रधान वैज्ञानिक

हिंदी में कविता लेखन प्रतियोगिता

वैज्ञानिक समूह	
प्रथम	डॉ. कमलेश कुमार, वैज्ञानिक
द्वितीय	डॉ. दीपक कुमार सुरोलिया, वरिष्ठ वैज्ञानिक
तृतीय	डॉ. रामकेश मीना, वैज्ञानिक

बच्चों की चित्रकला पोस्टर प्रतियोगिता

	एलकेजी से पांचवी तक	कक्षा पांच एवं आगे के बच्चे	सांत्वना पुरस्कार
प्रथम	कु. भाविका पुत्री डॉ. चेतराम	कु. मोनिका	1 कु. निहारिका 2 कु. मायरा 3 चिं. यशवर्धन 4 चिं. विवान
द्वितीय	कु. भाविका पुत्री डॉ. रमेश कुमार	चिं. अंशुमान	
तृतीय	कु. द्वयिांशी अलोर	कु. अवन्तिका	

14. DISTINGUISHED VISITORS

Name	Designation	Date of visit
Visit at ICAR-CIAH, Bikaner		
Dr. B. D. Kalla	Cabinet Minister, Govt. of Rajasthan, Jaipur	27.01.2019
Dr. (Col.) A. K. Gahlot	Former V.C., RAJUVAS, Bikaner	27.01.2019
Dr. S. P. Purohit	Former Dean, SKRAU, Bikaner	27.01.2019
Dr. Gopal Lal	Director, ICAR-NRC on Seed Spices, Ajmer	27.01.2019 30.08.2019 28.09.2019
Dr. W. S. Dhillon	ADG (Hort. Sci.-II), ICAR, New Delhi	29.06.2019
Ms. Sushila Sivar	Jila Pramukh, Bikaner	06.08.2019
Dr. A. K. Mishra	Chairman, ASRB, New Delhi	09.08.2019
Dr. T. Janakiram	ADG (Hort. Sci.-I), ICAR, New Delhi	30.08.2019
Sh. Arjun Ram Meghwal	State Minister of Parliamentary Affairs, Heavy Industries and Public Enterprises	30.08.2019
Sh. Kailash Choudhary	State Minister of Agriculture and Farmers Welfare	30.08.2019
Dr. Vishwanath Meghwal	Former, MLA, Khajuwala, Bikaner	30.08.2019
Smt. Seema Chopra	Director, Rajbhasha, ICAR, New Delhi	30.08.2019
Prof. R. P. Singh	Vice Chancellor, SKRAU, Bikaner	30.08.2019 28.09.2019
Sh. Madhu Acharya 'Aashawadi'	Acting Editor of Dainik Bhaskar and senior writer	30.08.2019
Dr. O. P. Yadav	Director, ICAR-CAZRI, Jodhpur	30.08.2019
Sh. Vishnu Sharma	Vice Chancellor, RAJUVAS, Bikaner	30.08.2019 28.09.2019
Dr. H. P. Yvas	Ex-Vice Chancellor, Technical University, Bikaner	31.08.2019 28.09.2019
Prof. R. P. Singh,	Vice Chancellor. SKRAU, Bikaner	28.09.2019
Dr. S. K. Sharma	Director, DEE, SKRAU, Bikaner	02.09.2019
Prof. V. P. Sharma	Chairman, Commission for Agricultural Costs and Prices, Delhi	29.09.2019
Prof. Jeet Singh Sandhu	Vice-Chancellor, SKNAU, Jobner	16.11.2019
Dr. K. K. Kochar	Ex-Director, Law Department, MGS University, Bikaner	26.11.2019
Dr. Umesh Srivastava	Former ADG, ICAR, New Delhi	18.12.2019
Visit at CHES, Vejalpur, Godhra		
Sh. Udit Agarval	IAS, Collector Panchmahal, Gujarat	25.04.2019
Prof. Manashi. R.	Parul University, Vadodara	17.09.2019
Dr. Sudhir Raizada	Emeritus Scientist, N.B.F.G.R. Lucknow, U.P.	26.11.2019
Dr. K. S. Khokhar	Ex-Vice Chancellor, C.C.S.H.A.U., Hisar, Haryana	26.11.2019
Dr. Lakhan Singh	Director ATARI, Pune, Maharastra	26.11.2019
Dr. M. C. Jain	Dean, COA, Kota Rajasthan	28.12.2019

Sh. Kailash Choudhary, State Minister of Agriculture and Farmers Welfare, Govt. of India visited ICAR-CIAH nursery

Prof. B. D. Kalla, Cabinet Minister Govt. of Rajasthan visited ICAR-CIAH, Bikaner

Sh. Arjun Ram Meghwal, State Minister of Parliamentary Affairs, Heavy Industries and public enterprises visited ICAR-CIAH, Bikaner

Dr. H. P. Vyas, Ex-Vice Chancellor, Technical University, Bikaner visited ICAR-CIAH, Bikaner

Prof. J. S. Sandhu, VC, SKNAU, Jobner visited ICAR-CIAH, Bikaner

Dr. W. S. Dhillon, ADG (HS-I), ICAR, New Delhi visited ICAR-CIAH, Bikaner

Dr. A. K. Mishra, Chairman, ASRB, Visited ICAR-CIAH, Bikaner

Sh. V. P. Sharma, Chairman, Commission for Agricultural Cost and Prices, Govt. of India visited ICAR-CIAH, Bikaner

Dr. Umesh Srivastava, Former ADG, ICAR, New Delhi interacting with scientists

Dr. K. K. Kochar, Ex-Director, Law Department, MGS University, Bikaner visited ICAR-CIAH, Bikaner

15. PERSONNEL

Staff Position as on 31.12.2019

ICAR-CIAH, Bikaner (including Regional Station, Vejalpur)

S. No.	Category	Sanctioned posts	Posts filled	Posts vacant
1.	RMP (Director)	01	01	Nil
2.	Scientists	44	28	16
3.	Technical	42	34	08
4.	Administrative	23	15	08
5.	SSS	19	19	Nil
	Total	129	97	32

Krishi Vigyan Kendra

S. No.	Category	Sanctioned posts	Posts filled	Posts vacant
1.	Programme Coordinator	01	01	00
2.	Administrative	02	02	00
3.	Technical	11	10	01
4.	Supporting	02	01	01
	Total	16	14	02

ICAR-CIAH, Bikaner – Headquarter

S. No.	Name	Designation/Discipline
	I. RESEARCH MANAGEMENT POSITION	
1.	Prof. (Dr.) P. L. Saroj	Director
	II. SCIENTIFIC	
1.	Dr. Dhurendra Singh	Head, Division of Crop Improvement
2.	Dr. B. D. Sharma	Acting Head, Division of Crop Production
3.	Dr. R. S. Singh	Principal Scientist (Horticulture)
4.	Dr. D. K. Samadia	Principal Scientist (Horticulture)
5.	Dr. S. K. Maheshwari	Principal Scientist (Plant Pathology)
6.	Dr. S. R. Meena	Principal Scientist (Agriculture Extension)
7.	Dr. M. K. Jatav	Principal Scientist (Soil Science)
8.	Dr. P. P. Singh	Principal Scientist (Vegetable Science)
9.	Dr. B. R. Choudhary	Senior Scientist (Horticulture-Vegetable Science)
10.	Dr. Deepak Kumar Sarolia	Senior Scientist (Horticulture-Fruit Science)
11.	Dr. Ramkesh Meena	Senior Scientist (Horticulture-Fruit Science)
12.	Sh. Roop Chand Balai	Scientist (Soil Science)
13.	Sh. Ramesh Kumar	Scientist (Horticulture-Floriculture)

S. No.	Name	Designation/Discipline
14.	Dr. Mukesh Kumar Berwal	Scientist (Biochemistry)
15.	Dr. S. M. Haldhar	Scientist (Agriculture Biochemistry)
16.	Dr. Chet Ram	Scientist (Agriculture Biotechnology)
17.	Dr. Anita Meena	Scientist (Soil Science)
18.	Sh. Jagan Singh Gora	Scientist (on study leave)
19.	Dr. Vijay Rakesh Reddy	Scientist (Horticulture-Fruit Science)
20.	Dr. Kamlesh Kumar	Scientist (Horticulture-Fruit Science)
21.	Sh. Ajay Kumar Verma	Scientist (Horticulture-Vegetable Science)
22.	Ms. Ramyashree Devi G.S.	Scientist (Plant Pathology)
	III. ADMINISTRATIVE	
1.	Shri H. L. Meena	Admministrative Officer (upto 29.06.2019)
2.	Shri Ramesh	Administrative Officer (from 08.08.2019)
3.	Shri Kuldeep Pandey	Assistant Administrative Officer
4.	--(Vacant)	Asstt. Finance & Account Officer
	IV. TECHNICAL	
1.	Dr. U. V. Singh	Asstt. Chief Technical Officer (Field)
2.	Shri P. P. Pareek	Asstt. Chief Technical Officer (Official Language)
3.	Shri A. V. Dhobi	Sr. Technical Officer (Overseer)
4.	Shri Sanjay Patil	Sr. Technical Officer (Artist & Photography)
5.	Shri C. L. Meena	Sr. Technical Officer (Field)
6.	Shri M. K. Jain	Technical Officer (Computer)
7.	Shri B. R. Khatri	Technical Officer (Computer)
8.	Shri P. R. Singh	Technical Officer (Field)

B. ICAR-CIAH Regional Station, Vejalpur

S. No.	Name	Designation/Discipline
	I. SCIENTIFIC	
1.	Dr. Sanjay Singh	Head
2.	Dr. A. K. Singh	Principal Scientist (Hoticulture-Fruit Science)
3.	Dr. V. V. Appa Rao	Principal Scientist (Soil Science)
4.	Dr. Daya Shankar Mishra	Senior Scientist (Horticulture-Fruit Science)
5.	Dr. Vikas Yadav	Scientist (Horticulture-Fruit Science)
6.	Dr. Lalu Prasad Yadav	Scientist (Horticulture-Vegetable Science)
7.	Dr. Gangadhara, K. Scientist	Scientist (Horticulture-Vegetable Science)
	II. ADMINISTRATIVE	
1.	Dr. D. S. Mishra	I/c Assistant Administrative Officer
2.	Sh. Nihal Singh	I/c Asstt. Finance & Account Officer

S. No.	Name	Designation/Discipline
	III. TECHNICAL	
1.	Sh. Nihal Singh	Chief Technical Officer (Field)
2.	Sh. G. U. Trivedi	Astt. Chief Technical Officer (Library)
3.	Sh. M. N. Makwana	Astt. Chief Technical Officer (Official Language)
4.	Sh. G. R. Baira	Sr. Technical Officer (Field)
5.	Sh. R. B. Baria	Technical Officer (Field)
6.	Sh. K. K. Vankar	Technical Officer (Field)
7.	Sh. R. D. Rathva	Technical Officer (Lab)
8.	Sh. D. C. Joshi	Technical Officer (Field)
9.	Sh. K. V. Parmar	Technical Officer (Lab.)
10	Sh. C. S. Chamar	Technical Officer (Field)
11.	Sh. B. M. Patelia	Technical Officer (Field)
12.	Sh. D. P. Patel	Technical Officer (Field)
13.	Sh. A. J. Solanki	Technical Officer (Field)
14.	Sh. B. F. Patelia	Technical Officer (Field)
15.	Sh. K. M. Parmar	Technical Officer (Field)

ICAR-CIAH KVK, Panchmahal

S. No.	Name	Designation/Discipline
	I. SR. SCI. & HEAD	
1	Dr. (Mrs). Kanak Lata	Sr. Scientist & Head
	II. TECHNICAL	
1	Sh. J. K.Jadav	Astt. Chief Tech. Officer (Extension) on study leave
2	Sh. Balbir Singh	Astt. Chief Tech. Officer (Animal Husbandry)
3	Dr. Ajay Kr. Rai	Astt. Chief Tech. Officer (Soil Science)
4	Dr. Raj Kumar	Astt. Chief Tech. Officer (Horticulture)
5	Dr. Shakti Khajuria	Astt. Chief Tech. Officer (Plant Pathology)

Promotion

Scientists

S. No.	Name& Designation of the Scientist(s)	Placement/Promotion on the post of Senior Scientist/Scientist with Pay Band + RGP/Pay Scale	Date of Placement Promotion
2.	Sh. Roopchand Balai, Scientist (Soil Science)	Next Higher Grade (Rs.37400-67000 + RGP 9000) (Designation – Scientist)	13.09.2015
3.	Dr. Balu Ram Choudhary, Sr. Scientist (Horticulture – Vegetable Science)	Recommended to the next higher grade / Rs37400-67000 + RGP of Rs.9000/- (Revised level-13 A)	27.06.2017
4.	Dr. Ramkesh Meena, Scientist, (Horticulture-Fruit Science)	Recommended to the next higher grade / Rs15600-39100 + RGP of Rs.8000/- (Revised level-12) to be designated as Sr. Scientist	06.06.2017

Technical

S. No.	Name and Present Grade/ Designation	Promoted to Grade/Scale	Date of merit Promotion	Present Place of Posting
1.	Sh. D. P. Patel Sr. Technical Assistant (Field)	Technical Officer (Field) PB-2 Rs.9300-34800 with Grade pay of Rs.4600 (pre-revised)	01.01.2015	CHES, Vejalpur, Godhra
2.	Sh. B. M. Patelia Sr. Technical Assistant (Field)	Technical Officer (Field) PB-2 Rs.9300-34800 with Grade pay of Rs.4600 (pre-revised)	03.02.2015	ICAR-CIAH, Bikaner
3.	Sh. A. J. Solanki Sr. Technical Assistant (Field)	Technical Officer (Field) PB-2 Rs.9300-34800 with Grade pay of Rs.4600 (pre-revised)	01.07.2015	CHES, Vejalpur, Godhra
4.	Sh. B. F. Patelia Sr. Technical Assistant (Field)	Technical Officer (Field) Pay Level-7	16.12.2017	CHES, Vejalpur, Godhra
5.	Sh. B. R. Baria Technical Assistant (Lab.)	Sr. Technical Assistant (Lab.) PB-2 Rs.9300-34800 with Grade Pay of Rs.4200 (pre-revised)	05.02.2012	ICAR-CIAH, Bikaner
6.	Sh. B. V. Rathva Technical Assistant (Lab.)	Sr. Technical Assistant (Lab.) PB-2 Rs.9300-34800 with Grade Pay of Rs.4200 (pre-revised)	10.11.2014	CHES, Vejalpur, Godhra
7.	Sh. R. V. Rathva Technical Assistant (Lab.)	Sr. Technical Assistant (Lab.) Pay Level-6	17.07.2017	CHES, Vejalpur, Godhra
8.	Shri M. N. Makwana, Senior Tenchical Officer (OL)	Assistant Chief Technical Officer Pay level-11	29.06.2016	CHES, Vejalpur, Godhra

Modified Assured Career Progression Scheme

S. No.	Name of Official with designation	Existing pay Level in Pay Matrix	Date of grant of 2nd Financial Up-gradation and Level in Pay Matrix
1.	Shri Rawat Singh, LDC	Level-2 (Pre-revised PB-1 Rs 5200-20200+GP 1900	18.06.2016 Level-3
2.	Shri Gulla Ram, LDC	Level-2 (Pre-revised PB-1 Rs 5200-20200+GP 1900	12.09.2016 Level-3
3.	Shri Shiv Lal, SSS	Level-2 (Pre-revised PB-1 Rs 5200-20200+GP 1900	02.07.2016 Level-3
4.	Shri Mohan Lal, SSS	Level-2 (Pre-revised PB-1 Rs 5200-20200+GP 1900	10.02.2017 Level-3
5.	Shri Manoj Kumar Vyas, SSS	Level-2 (Pre-revised PB-1 Rs 5200-20200+GP 1900	10.11.2017 Level-3

Probation Clearance & Confirmation

Scientists

S. No.	Name and Designation	Date of confirmation
1.	Dr. Deepak Kumar Sarolia, Sr. Scientist (Fruit Science)	07.10.2017
2.	Dr. D. S. Mishra, Sr. Scientist (Fruit Science)	02.03.2018
3.	Dr. Vikas Yadav, Scientist (Fruit Science)	01.01.2017
4.	Dr. Vijay Rakesh Reddy S, Scientist (Fruit Science)	01.07.2017

S. No.	Name and Designation	Date of confirmation
5.	Dr. Kamlesh Kumar, Scientist (Fruit Science)	01.01.2018
6.	Dr. Lalu Prasad Yadav, Scientist (Vegetable Science)	01.01.2017
7.	Dr. Gangadhara K, Scientist (Vegetable Science)	01.07.2017
8.	Dr. Ajay Kumar Verma, Scientist (Vegetable Science)	01.01.2018

Administration

S. No.	Name and Designation	Post/Grade	Date of appointment	Date of clearance of Probation
1.	Sh. H. S. Patel, Assistant	Assistant Level – 6 (Pre-revised Pay Band-2/Rs.9300-34800 with Grade Pay of Rs.4200/-)	23.01.2016	22.01.2018

Joining on Transfer/Promotion/ Retirement

1 Sh. H.L. Meena, Administrative Officer joined on 4th February, 2019 on transfer from ICAR-VPKAS, Almora.

2 Sh. Ramdeen, Administrative Officer relieved from Institute on 08th February, 2019 on transfer to ICAR-DMAPR, Anand.

3 Sh. Swaroop Chand Rathore, L.D.C. relieved from Institute on 23rd May, 2019 for a period of one year deputation to join the post of UDC through promotion/deputation basis in Level-4 of Pay Matrix at ICAR-CSWRI - Arid Region Campus, Bikaner.

4 Dr. Rakesh Bhargava, Principal Scientist (Plant Physiology) retired on superannuation from the Council's services in the afternoon of 31st May, 2019.

5 Sh. H. L. Meena, Administrative Officer relieved from Institute on 29th June, .2019 on promotion to the post of Senior Administrative Officer at ICAR-CIPHET, Anand.

6 Sh. Ramesh, Asstt. Admn. Officer, ICAR-CITH, Srinagar joined to the post of Administrative Officer at the Institute on promotion on 8th August, 2019.

7 Sh. A. V. Dhobi, STO (Overseer) joined at Institute headquarters ICAR-CIAH, Bikaner on 2nd September, 2019 on transfer from regional station CHES, Vejalpur, Godhra.

8 Sh. B. M. Patelia, TO (Field) relieved in the afternoon of 5th October, 2019 from Institute headquarters ICAR-CIAH, Bikaner on transfer to regional station CHES, Vejalpur, Godhra.

9 Dr. P. P. Singh, Principal Scientist (Vegetable Science) relieved from the Institute in the afternoon of 9th December, 2019 on transfer to IIFSR, Meerut.

16. BUDGET

Consolidate Expenditure 2019-20							
Progressive Exp Upto Dec, 2019		**CIAH**		**CHES**		**Consolidate**	
S.No.	Head	BE 2019-20	EXP	BE 2019-20	EXP	BE 2019-20	EXP
Grants for creation of Capital Asset (CAPITAL)							
1	Works	0	0	0	0	0	0
	A. Land	0	0	0	0	0	0
	B. Building	0	0	0	0	0	0
	i. Office Building	9115000	4000000	0	0	9115000	4000000
	ii Residential Building	0	0	0	0	0	0
	iii Minor works	0	0	0	0	0	0
2	Equipments	300000	14000	100000	0	400000	14000
3	Information Technology	100000	0	0	0	100000	0
4	Library Books and journals	150000	14600	50000	0	200000	14600
5	Vehicles & Vessels	0	0	0	0	0	0
6	Livestock	0	0	0	0	0	0
7	Furniture & Fixtures	185000	61982	0	0	185000	61982
8	Others	0	0	0	0	0	0
Total- Capital (Grants for creation of Capital Assets)		9850000	4090582	150000	0	10000000	4090582
Grants for creation of Salaries (Revenue)		0	0	0	0	0	0
1	Establishment Expenses	0	0	0	0	0	0
	Salaries	0	0	0	0	0	0
	i. Establishment Charges	66015000	63734134	50000000	39078014	116015000	102812148
	ii. Wages	0	0	25000000	15372583	25000000	15372583
	iii. Overtime Allowance	0	0	0	0	0	0
Total- Establishment Expenses(GIA- Salaries)		66015000	63734134	75000000	54450597	141015000	118184731
Grant in Aid- General(REVENUE)		0	0	0	0	0	0
1	Pension & Other Retirement Benefits	7000000	7948916	1700000	1040831	8700000	8989747
2	Travelling Alowances						
	A. Domestic TA/ Transfer TA	1600000	1072326	200000	191272	1800000	1263598
	B. Foreign TA	200000	0	0	0	200000	0
	Total- Traveling Allowance	1800000	1072326	200000	191272	2000000	1263598
3	Research & Operational Expenses	0	0	0	0	0	0
	A. Research Expenses	6395928	4385400	500000	468665	6895928	4854065
	B. Operation Exp.	6504072	6504072	1000000	887023	7504072	7391095
	Total Research & Operational Expenses	12900000	10889472	1500000	1355688	14400000	12245160
4	Administrative Expenses	0	0	0	0	0	0

Consolidate Expenditure 2019-20							
Progressive Exp Upto Dec, 2019		CIAH		CHES		Consolidate	
	A. Infrastructure	7453516	7453516	1000000	864996	8453516	8318512
	B. Communication	575028	506423	500000	568605	1075028	1075028
	C. Repairs & Maintenance	0	0	0	0	0	0
	i.Equipments, Vehicles & Others	800000	389595	300000	105040	1100000	494635
	ii. Office Building	1592132	465808	200000	103040	1792132	568848
	iii. Residential Building	409324	409324	100000	0	509324	409324
	iv) Minor Works	600000	600000	200000	0	800000	600000
	D. other (Excluding TA)	2745028	2715387	200000	229641	2945028	2945028
	Total Administrative Expenses	12800000	12540053	2500000	1871322	15300000	14411375
5	Miscellaneous Expenses	0	0	0	0	0	0
	A. HRD	124972	101840	100000	24000	224972	125840
	B. Other Items (Fellowship, Scholarship etc.)	0	0	0	0	0	0
	C. Publicity & Exibitions	1200000	1192757	100000	0	1300000	1192757
	D. Guest House -Maintenance	100000	69212	200000	106953	300000	176165
	E. Other Miscellaneous	600000	598896.78	300000	299501	900000	898397.78
	Total- Miscellaneous Expenses	3400000	1962705.8	700000	430454	4100000	2393159.78
Total Grant In Aid- General		30900000	26464557	4900000	3848736	35800000	30313292.78
Total Revenue (GIA-Salaries + GIA- Gen + GIA-Pension)		103915000	98147607	81600000	59340164	185515000	157487770.8
Grand Total (Capital + Revenue)		113765000	102238189	81750000	59340164	195515000	161578352.8
	SCSP						
	Total Grant In Aid-General	1500000	331627	500000		2000000	331627
	Total- Capital (Grants for creation of Capital Assets)	400000		100000		500000	0
		1900000	331627	600000	0	2500000	331627

Revenue Receipt 2019-20 upto 31.12.19					
Head	CIAH	CHES	KVK-RFS	Seed Project	Amount
i) Sale of Farm Produce	404340	2146370	18729	83370	2652809
ii) Sale of Condemned item	98000				98000
iii) Electric Charges	123188	399			123587
iv) Water Charges	6118				6118
v) Sale of Tender Form	104000				104000
vi) Interest on P Loan	14900				14900
vii) License Fee	66090	40975			107065
viii) Other -Misc Receipt	205376			28	205404
ix) Guest House	102800				102800
x) Interest earned on short term deposits	1780735			114750	1895485
xi) Recoveries of Loans and Advances	93100	45000			138100
Total Other Receipts	2998647	2232744	18729	198148	5448268

17. SEED AND PLANTING MATERIAL PRODUCTION

Seed Production, ICAR-CIAH, Bikaner

I. Institute level			
S. No.	**Name of crop**	**Quantity produced (kg)**	**Quantity sold (kg)**
1.	Longmelon (Thar Sheetal)	2.00	1.20
2.	*Kachri* (AHK-119)	2.00	2.00
3.	Watermelon (AHW/BR-40)	3.10	1.150
4.	Ridge gourd (Thar Karni)	72.00	33.10
II. Under Seed Project			
1.	*Kachri* (AHK-119)	100.00	96.550
2.	Snapmelon (AHS-82)	12.50	10.950
3.	Cluster bean (Thar Bhadavi)	57.00	47.500
4.	Sponge gourd (Thar Tapish)	27.50	6.300
5.	Palak (Thar Hariparna)	38.00	26.750
6.	Brinjal (Thar Rachit)	0.650	0.625
	Total	314.750	226.125

Planting Material Production, ICAR-CIAH, Bikaner

S. No.	Name of the crop	Quantity produced (Nos.)	Quantity sold (Nos.)
I. Institute level			
1.	*Khejri* (Budded)	770	492
2.	Citrus-Mosambi	1000	86
3.	Citrus-Kinnow	500	34
4.	Date palm	100	-
II. RFS			
1	Lime/ lemon	2100	361
2	Lasoda	2000	1436
3	Pomegranate	3600	3156
4	Karonda	2200	730
5	Phalsa	2600	1805
6	*Khejri* (Budded)	0	105
7	*Ber* (Budded)	600	505
8	*Bael* (Budded)	90	76
9	Kinnow/Mosambi	0	216
10	Mulberry rooted cuttings	350	255
11	Moringa	250	148
12	Ber *Rotundifolia*	550	508
13	Bael deshi	2500	130
14	Rough lemon	3000	400

S. No.	Name of the crop	Quantity produced (Nos.)	Quantity sold (Nos.)
	I. Institute level		
15	Aloe sucker	278	278
16	Bassela	50	10
17	Fig	50	20
18	Rootstocks & others	1123	181
19	Total	23761	10932

Seed Production, ICAR-CIAH Regional Station, Vejalpur

I. Institute level			
S. No.	Name of crop	Quantity produced (kg)	Quantity sold (kg)
1.	Drumstick Thar Harsha	20 kg	15 kg
2.	Tomato Thar Annant	500 g	--
3.	Bottle gourd	2 kg	--
4.	Pumpking Thar Kavi	2 kg	1.5 kg
	Total	24.5 kg	16.5 kg

Planting Material Production, ICAR-CIAH Regional Station, Vejalpur

S. No.	Name of plants	Quantity produced (Nos.)	Quantity sold (Nos.)
	I. Institute level		
1	Mango Plants grafted	1965	1867
2	Ber Budded	07	07
3	Pomegranate Air layer	700	636
4	Kagzi Lime Air layer	700	684
5	Lime seedling	05	05
6	Guava Budded	1000	984
7	Guava seedling	30	20
8	Rayan Budded	535	497
9	Tamarind Budded	170	165
10	Jamun Budded	1065	1016
11	Bael Budded	650	631
12	Sweet Orange Budded	07	07
13	Custard Apple Budded	800	773
14	Wood Apple	04	04
15	Phalsa seedling	10	10
16	Karonda Seedling	70	65
17	Muhava Seedling	35	33
18	Chironji Seedlings	165	158

S. No.	Name of plants	Quantity produced (Nos.)	Quantity sold (Nos.)
		II. RFS	
1.	Mango Plants grafted	6086	6017
2.	Jamun Budded	3345	3299
3.	Custard Apple Budded	18	15
4.	Custard Apple seedling	18	14
5.	Bael Budded	1015	1005
6.	Guava Seedlings	02	02
7.	Kagzi Lime Air layer	110	103
8.	Aonla Plants	05	05
9.	Tamarind	427	400
10.	Bael Plants	545	520
11.	Karonda Seedlings	945	900
	Total	20434	19842

18. METEOROLOGICAL DATA

Meteorological Data: Bikaner (Rajasthan)-2019

Month	Temperature (°C)		R.H. (%)		Total rainfall (mm)	Rainy days	Wind speed (km/h)	Evaporation (mm/day)	BSSH
	Max.	Min.	RH_1	RH_2					
January	22.1	5.9	85.3	36.8	2.7	0.0	3.5	2.8	6.6
February	23.5	7.8	82.9	38.3	0.0	0.0	4.9	3.8	7.4
March	30.5	13.1	69.8	34.1	1.8	0.0	5.2	5.6	6.9
April	39.6	22.6	87.6	76.6	31	3.0	6.1	9.9	3.2
May	41.4	25.4	72.2	53.5	9	2.0	7.4	12.2	10.6
June	43.4	29.4	85.9	66.8	12.8	1.0	8.8	12.1	9.8
July	39.8	28.7	77.4	55.2	40.6	2.0	11.5	9.0	6.0
August	36.3	26.7	84.2	63.9	128.2	6.0	6.3	8.4	7.3
September	38.0	26.0	87.4	60.9	16.2	1.0	4.89	10.1	8.5
October	34.6	18.6	71.6	39.5	28.8	2.0	3.4	10.0	8.8
November	27.1	12.8	84.2	48.6	27.2	4.0	3.5	7.8	6.0
December	20.9	5.0	86.8	45.1	6.8	2.0	3.1	6.2	7.0

Meteorological Data: Vejalpur (Gujarat)-2019

Month	Temperature (°C)		RH (%)	Rainfall (mm)	Rainy days
	Maximum	Minimum			
January	29.52	9.58	68.10	--	--
February	31.25	11.76	67.5	--	--
March	36.21	18.53	71.4	--	--
April	41	27	--	--	41
May	43	29	--	--	43
June	44	26	98.48	12	44
July	38	27	182.85	16	38
August	32	25	204.76	20	32
September	34	24	275.40	26	34
October	36	20	218.48	21	36
November	32	19	220.03	22	32
December	28	13	005.0	01	28

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

स्वच्छ भारत
एक कदम स्वच्छता की ओर