# Major Achievements of Decade (2011-2020) at ICAR-CAZRI RRS, Jaisalmer


ICAR-Central Arid Zone Research Institute
(ISO 9001:2015)
Jodhpur 342 003 (India)

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**Published by:**

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Deputy Director General (Natural Resource Management)

# Foreword

The ICAR-Central Arid Zone Research Institute-Regional Research Station, Jaisalmer is located in the extremely hot arid region in the heart of the Great Indian Desert. This region falls under hot arid eco-system and is characterized by extreme temperatures, low and erratic rainfall with very high wind velocity and high evapotranspiration rate. The soil is light in texture having low organic carbon content, poor water retention capacity and poor biological activity. This region is affected by the process of land degradation, particularly soil erosion, ultimately leading to desertification.

Introduction of Indira Gandhi Nahar Pariyojna (IGNP), use of groundwater for irrigation and mechanization have changed the cropping pattern of hot arid agroecosystem. The increase in water availability has converted the grasslands into crop lands. Taking into account the problems of this region, the natural resources should be utilized in sustainable way for improving the crop as well as livestock productivity. The focus should be given for controlling desertification, improving soil quality and water productivity, development of area-specific farming systems, and improvement and management of rangelands for sustainable development. I am happy to note that this document entitled "Major Achievements of Decade (2011-2020) at ICAR-CAZRI, Regional Research Station, Jaisalmer" will provide good information and has come at a very appropriate time with sincere efforts by the authors. I congratulate the authors for the compilation of valuable information and hope that this document will be helpful for researchers and academicians for improvement of the livelihood of desert dwellers.

**(S.K. Chaudhari)**
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# Message

The ICAR-Central Arid Zone Research Institute, Regional Research Station, Jaisalmer, has played a crucial role in addressing the pressing challenges posed by the hyper-arid environment of the Great Indian Thar Desert. With its focus on research and development tailored to the extreme conditions of the region, the station has made significant contributions for advancement of sustainable agricultural practices. Over the past several decades, the station has pioneered work in improving rangelands, optimizing water productivity in arid crops, and enhancing the livelihoods of farmers through innovative agroforestry and silvi-pasture systems. The station's efforts have been instrumental in introducing new technologies, such as drought-resistant crop varieties, improved shelterbelt plantations, and advancements in soil moisture management, all of which are vital for sustainable development of the region. Major Achievements of Decade (2011-2020) at ICAR-CAZRI, Regional Research Station, Jaisalmer," reflects the station's steadfast commitment to advancing agricultural sustainability in the region. This document meticulously compiles research innovations, including silvi-pasture systems, soil erosion mitigation strategies, and capacity-building initiatives that directly benefit farmers and stakeholders. I extend my sincere congratulations to the authors for their diligent work, and I trust this document will serve as a valuable resource for researchers, policymakers, and all those dedicated for fostering sustainable development in the arid zone.

**(Rajbir Singh)**
Assistant Director General (AAF & CC)

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डॉ. ओम प्रकाश यादव
निदेशक
Dr. O.P. Yadav
Director

# Message

ICAR-Central Arid Zone Research Institute Regional Research Station, Jaisalmer is situated in hyper arid part of western Rajasthan and has major thrust on development of area-specific farming system; improvement and management of rangelands; and improving water productivity in commercial crops, cereals and pulses. Jaisalmer has very fragile agro-ecosystem, dominated by sand dunes and inter-dunal plains with extremes of temperatures (maximum 45ºC during summer and minimum goes below Zero ºC during winter), low and erratic rainfall (average 165 mm) with very high wind velocity (>30 km/h) and high evapo-transpiration rate (1600-2000 mm).

The station is undertaking research on rangeland management, improvement in fodder grasses mainly sewan grass (*Lasiurus sindicus*), evaluation of multipurpose trees and shrubs, quantification of soil erosion, water harvesting and diversification of crops in run-off farming. Many technologies suitable to agro- climatic conditions of hyper arid zone have been developed and disseminated for improving livelihoods of farmers in this region. The report consists of summary achievements in research, development and extension work taken up by the station during 2011-2020. I congratulate the Head and his dedicated team for a nice compilation of achievements and hope this may be very useful to the scientists and stakeholders working of the region.

**(O.P. Yadav)**
Director

# Contents

# Historical Background

Central Arid Zone Research Institute (CAZRI) was established at Jodhpur in October 1959 by the Government of India to address the problems of arid regions and it was handed over to the Indian Council of Agricultural Research (ICAR) in April 1966. The institute is carrying out systematic research on use and management of natural resources, sustainable farming systems, livestock production and management, and related rural livelihood issues for the last six decades to generate location-specific technologies that can provide impetus to the arid zone agriculture and control desertification.

In 1959, under the "Scheme for Control and Reclamation of Rajasthan Desert" 52 range management and soil conservation sites were selected for grassland improvement demonstrations. Of these 52 sites, 12 sites were in the Jaisalmer and Barmer districts upto 1969 under the administrative control of Sojat Unit, Range Management and Soil Conservation Section, Division of Plant Studies at CAZRI, Jodhpur. Later on as a matter of policy, eight sites were handed over to Rajasthan Government for further maintenance and development in 1969 and further two sites in 1986. However, experimental studies were continued at Chandan and Jaisalmer sites in Jaisalmer district. Later on, in the year 1987, it was given independent status of Regional Research Station of CAZRI, Jodhpur. Gradually, the center was strengthened by creating the necessary facilities like laboratory, library and research fields.

The research on rangeland management, improvement in fodder grasses mainly Sewan grass (*Lasiurus sindicus*), evaluation of multipurpose trees and shrubs, shelterbelt plantation, biodiversity conservation, medicinal plants, quantification of soil erosion, diversification of crops in runoff farming (*khadin*) etc. have been the major research areas of the station.

## Thrust Areas

- Development of area-specific farming systems
- Conservation, improvement and management of rangelands
- Improving water productivity in commercial crops, cereals and pulses

## Location

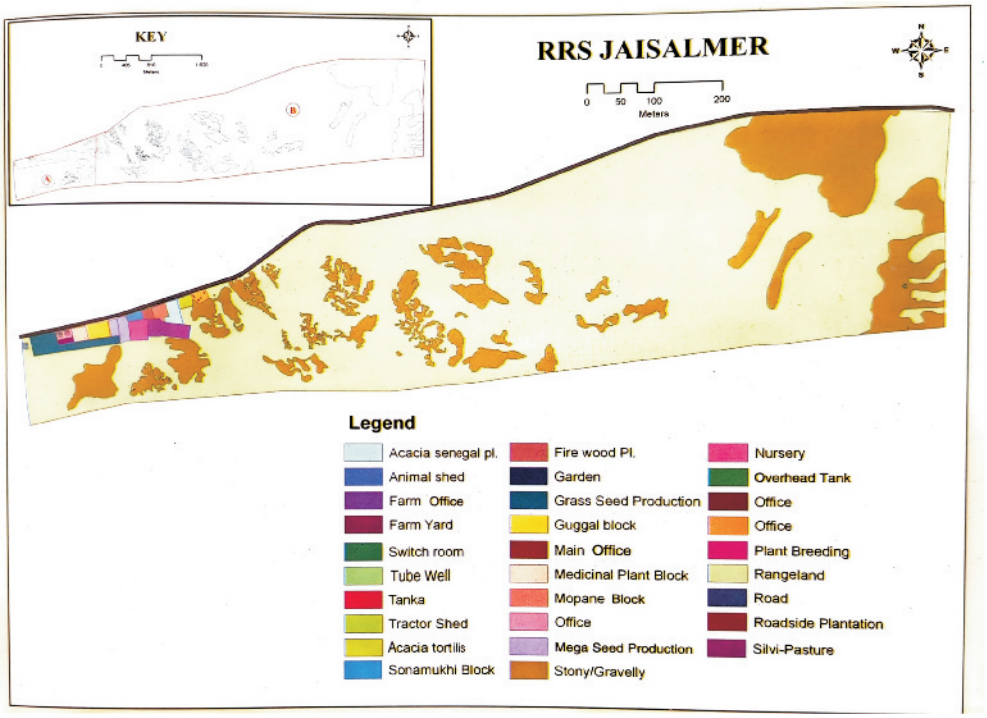
The CAZRI-Regional Research Station, Jaisalmer is situated on NH-15 about 5 km away from the Jaisalmer city. The station is located between 26°1' to 28°2' N latitude and 69°29'50" to 72°20'50" E longitude. Jaisalmer, the largest district (38,000 $km^2$) of Rajasthan state, is the extremely hot arid part. This region falls under hot arid eco-system and is characterized by low and erratic rainfall (average 165 mm) with very high wind velocity (>30 km $h^{-1}$) and high evapotranspiration rate (1600-2000 mm). May-June is the hottest period (maximum temperature goes beyond 45°C) and December-January is the coldest period (minimum temperature goes below 0°C). The soils of the region are light in texture having poor water retention capacity, low organic carbon content and poor biological activity. These soils are affected by the process of land degradation, particularly soil

erosion, ultimately leading to desertification, which is one of the serious impediments in crop production.

## Facilities

### Research Farm

The total area of the research farm under the station is 1032 ha at Jaisalmer and 95 ha at Chandan. There is one underground reservoir of 2 lakh liters capacity for roof-top water harvesting at Jaisalmer. Recently, tubewell, threshing floor and a model nursery have been established at the station. A tubewell was established at Chandan area for providing irrigations to the experimental crops with a facility of underground irrigation channel (1500 m length). Sheep pan is also available at Chandan for housing experimental animals. The station has two tractors equipped with farm implements like harrow, disc plough, cultivator, scrapper, auger etc.




### Laboratory

The laboratory is equipped with the instruments such as Kjeltech distillation and digestion unit, hot air oven, seed germinator, spectrophotometer, flame photometer, pH meter, conductivity meter, centrifuge, etc.

### Library

The station has one small library subscribing six national journals related to range management, agronomy, genetics and plant breeding, soil science, plant physiology etc. Library has about 1473 books on relevant subjects.

### Weather station

Two meteorological observatories are established at the station, one at Jaisalmer and another at Chandan farm to record weather parameters such as rainfall, soil and air temperatures, relative humidity, wind velocity, sunshine hours, etc. Recently, one automatic weather station is also established at Jaisalmer and agro-met station at Chandan farm by Space Research Application Centre (ISRO).

# Research Achievements

## Natural Resource Appraisal

### Measurement and modeling of infiltration characteristics of soils in hot arid region

Infiltration characteristics of 15 sites in Jaisalmer district were determined using double ring infiltrometer. Horton model and Green & Ampt model performed comparatively better than Philip model to fit the measured data on infiltration rate versus time. Across different land uses, measured infiltration rates were found 2.26, 17.4, 18.27, 20.7, 35.22, 44.44, 47.7 and 73.02 cm $h^{-1}$, respectively for runoff farming system, forestry plantation on rocky outcrops, rainfed agricultural land, rocky scrubs, rangelands, fallow land, forestry plantation on sandy soils and sand dunes (Fig. 1). Percent deviation of modeled steady-state infiltration rate from their measured values was 2, 8 and 38%, respectively for Green & Ampt, Horton and Philips model. Further, regression-based models were developed to estimate infiltration parameters of the standard models of infiltration using sand, silt, clay, organic carbon and gravel content of soil layers. From the present study it was observed that infiltration rate largely varies across the sites representing different soil types and land use conditions of hot arid region of India. The knowledge on infiltration generated in this study may help in sustainable water management in watersheds by modeling rainfall-runoff behavior. Since, it is time consuming and tedious to measure infiltration characteristics in field, the developed regression models may also be used to estimate infiltration characteristics in watersheds.

### Development of pedotransfer functions (PTFs) for estimation of soil water retention

Characterization of soil water retention, e.g., water content at field capacity (FC) and permanent wilting point (PWP) over a landscape plays a key role in efficient utilization of available scarce water resources in dryland agriculture. However, direct

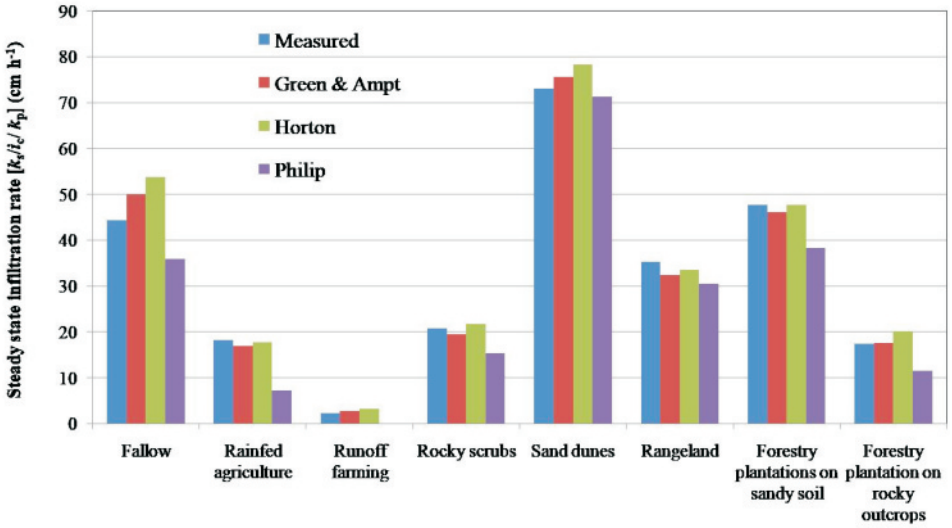



Fig. 1 Steady-state infiltration rate of soils from different land uses of Jaisalmer, Rajasthan

measurement thereof for multiple locations in the field is not always feasible. Therefore, pedotransfer functions (PTFs) were developed to estimate soil water retention at FC and PWP for dryland soils of western India. A soil database available for arid western India (N=370) was used to develop PTFs, which were tested using two independent datasets from arid regions of India (N=36) and an arid region of USA (N=1789). While testing these PTFs using independent data from India, root mean square error (RMSE) was found to be 2.65 and 1.08 for FC and PWP, respectively, whereas for most of the tested 'established' PTFs, the RMSE was >3.41 and >1.15, respectively. Performance of the developed PTFs from the independent dataset from USA was comparable with estimates derived from 'established' PTFs. For wide applicability of the developed PTFs, a user-friendly soil moisture calculator was developed. The PTF is available at CAZRI website at http://www.cazri.res.in/soil-moisture-calc.php (Fig. 2). The PTFs developed in this study may be quite useful to farmers for scheduling irrigation as per soil type.

## Loss of soil nutrients through wind erosion

Wind erosion is the most noticeable land degradation process in the hot arid region of India that covers about 16% of the geographical area of India. It results into loss of considerable amount of nutrient-rich particles from the region. Field investigations were carried out at RRS, Jaisalmer to quantify the nutrient loss through wind erosion. The aeolian mass fluxes ($M\ L^{-2}\ T^{-1}$) were collected from four different heights: 0.25, 0.50, 0.75 and 2 m above land surface. Analysis of eroded soil was performed using Foss Heraeus CHN-O-rapid elemental analyzer. The results revealed an average loss of 4 g C $kg^{-1}$ and 0.37 g N $kg^{-1}$ (Table 1). The study showed that the C and N content in eroded soils were highest during the month of July and the accumulated annual loss was approximated as 45.9 kg C $ha^{-1}$ and 4.3 kg N $ha^{-1}$. To mitigate such appreciable soil nutrient losses through wind erosion, suitable rangeland utilization practices, which can help to retain the soil health and support the crop/grassland productivity in arid ecosystem, need to be evolved on priority.

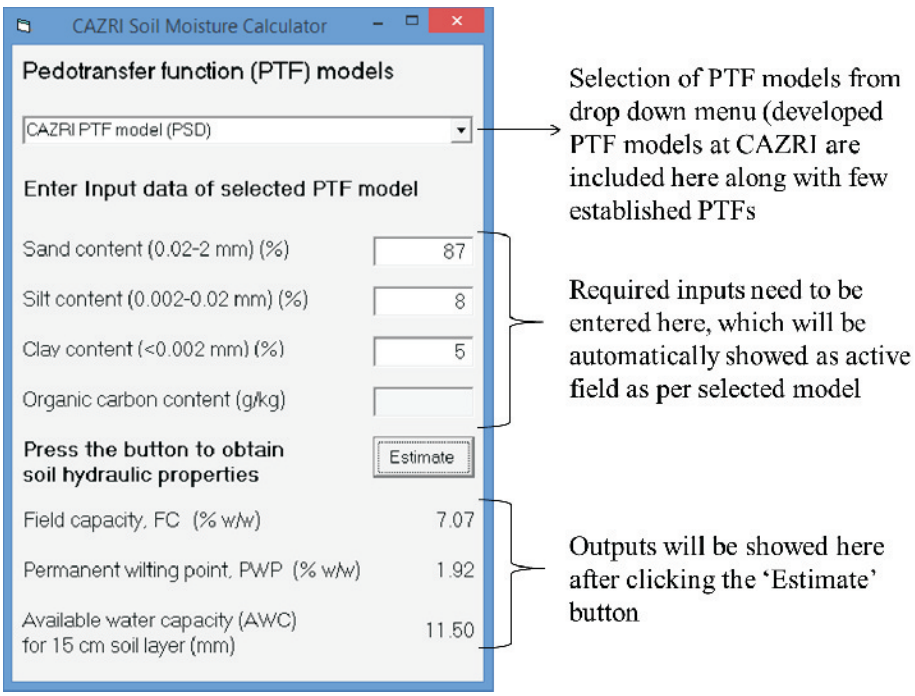



Fig. 2 CAZRI Soil moisture calculator

Table 1 Carbon (C) and Nitrogen (N) contents of eroded soils at different sampling heights during wind erosion events at Jaisalmer

| Sampling heights | §C (g kg$^{-1}$) | | §N (g kg$^{-1}$) | |
|---|---|---|---|---|
| | DSE | POWE | DSE | POWE |
| 0.25 m | 4.25±0.30 | 3.97±0.52 | 0.40±0.03 | 0.34±0.02 |
| 0.75 m | 4.51±0.33 | 3.50±0.20 | 0.42±0.04 | 0.34±0.02 |
| 1.25 m | 4.38±0.40 | 3.47±0.13 | 0.42±0.05 | 0.33±0.02 |
| 2.00 m | 4.40±0.53 | 3.44±0.41 | 0.40±0.04 | 0.34±0.03 |
| Top soil | 5.01±0.18 | | 0.44±0.03 | |

§Values of C and N contents are not significantly different between heights of observations ($p<0.05$, Tukey test), DSE: Dust Storm Event, POWE: Periodical Observation on Wind Erosion

## Hydrological behavior of runoff farming (*Khadin*) system at Bharamsar, Jaisalmer

*Khadin* is a unique runoff farming system of the Thar Desert in India. Jaisalmer district, lying at the centre of the desert, receives 100-200 mm rainfall annually. This runoff farming system involves collecting and storing runoff water from a high-elevation catchment area with shallow soil and underlying rocks in relatively low-elevation areas with deep soil. As the monsoon withdraws, the accumulated water starts receding due to seepage and evaporation. After the recession of accumulated water, *khadins* are cultivated to grow kharif or rabi season crops, depending on the depth of impounded water. In the *khadin* system, the bund at the lowest level is provided with a spillway and a sluice to regulate and drain out excess impounded water. To understand the physical process behind the accumulation of a significant amount of runoff water, even after a small rainfall event, the catchment area of a *khadin* was delineated. For this purpose SRTM elevation data (90 m × 90 m) was used, and the catchment was delineated using a watershed delineation module of Arc SWAT 1.7. It was found that the catchment area was ~20 times of the cultivated area under the *khadin* runoff farming system (Fig. 3).

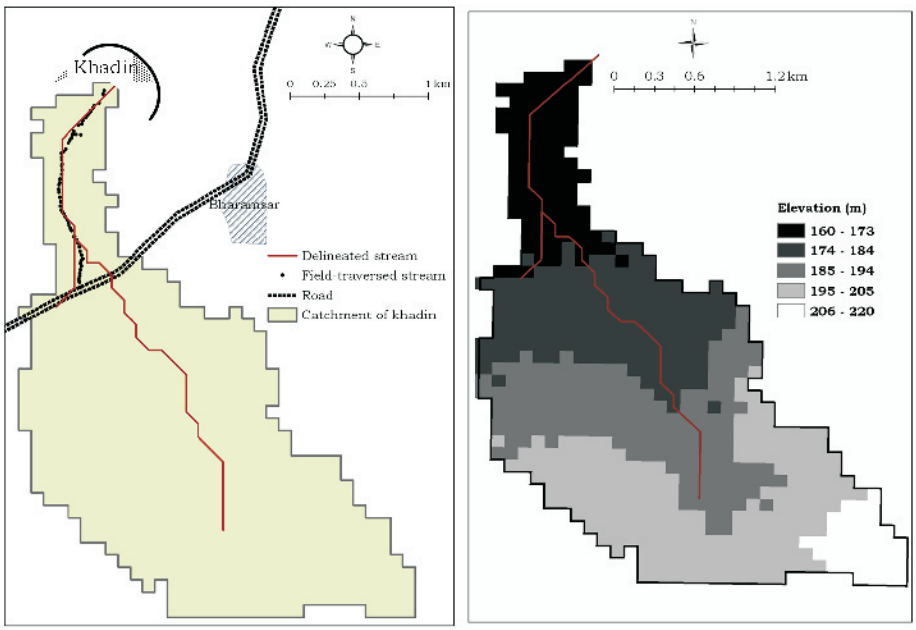



Fig. 3 Delineated catchment area and digital elevation model of a typical runoff farming system (*khadin*) at Bharamsar, Jaisalmer

The infiltration characteristics of soil at different portions of the *khadin* were also assessed. The steady-state infiltration rate at a cultivated area of the *khadin* was 0.39 mm $min^{-1}$ whereas it was 3.75 mm $min^{-1}$ at gravelly catchment areas (Fig. 4). This indicated that rainwater entered the soil surface of catchment area at a faster rate, then slowly moved through subsurface towards cultivated areas of the *khadin,* and thus contributing towards a sufficient soil moisture regime for crop growth. This suggested that future *khadin* development in drylands should focus on two major criteria, i) it should have a large catchment area of about 16-20 times of the *khadin* bed area with shallow sandy gravel cover so as to allow the entry of rainwater at a faster rate, and ii) gentle slope of catchment area for slow but steady sub-surface flow of water towards *khadin* bed area.

## Soils in Bharamsar *Khadin*

Six pedons, two each from upper, middle and lower reaches along two soil transects of a runoff farming system at the Bharamsar village, were taken up for morphometric study. Horizon soil samples were collected for physico-chemical analysis and macro and micronutrients characterization. Soil texture was found sandy loam in the upper and middle reaches, whereas in the lower reach, it was clay/sandy clay. Soil pH was generally alkaline and increase from upper to lower reaches. Soil salinity ($Ec_e$) was lower in the soils of lower reaches (0.28 to 0.97 dS $m^{-1}$) compared to middle (2.2-5.8 dS $m^{-1}$) and upper reaches. Soils were generally saline-sodic and sodic with an exchangeable sodium percentage (ESP) of more than 15 and electrical conductivity of more than 4 dS $m^{-1}$ in 70% of the total geographical area (TGA) of the surface soils. The gypsum requirement was calculated based on exchangeable sodium percentage (ESP) and cation exchange capacity (CEC) of the soils. For the reclamation of 60% of the sodium in the top 15 cm of the soil, 2,100 kg of gypsum per hectare is required. Soil organic carbon (SOC) increased from upper to lower reaches. High amount of ESP was observed throughout the depth of the soils of pedons studied from all reaches. The zinc (Zn) and iron (Fe) deficiencies were consistent with vertical distribution in soil pedons. Available potassium (K) was present in moderate amount (117-280 kg $ha^{-1}$) in 80% of the soils of the area. The use of zinc chelates and the application of Fe as a foliar spray are recommended to ameliorate Zn and Fe deficiencies.

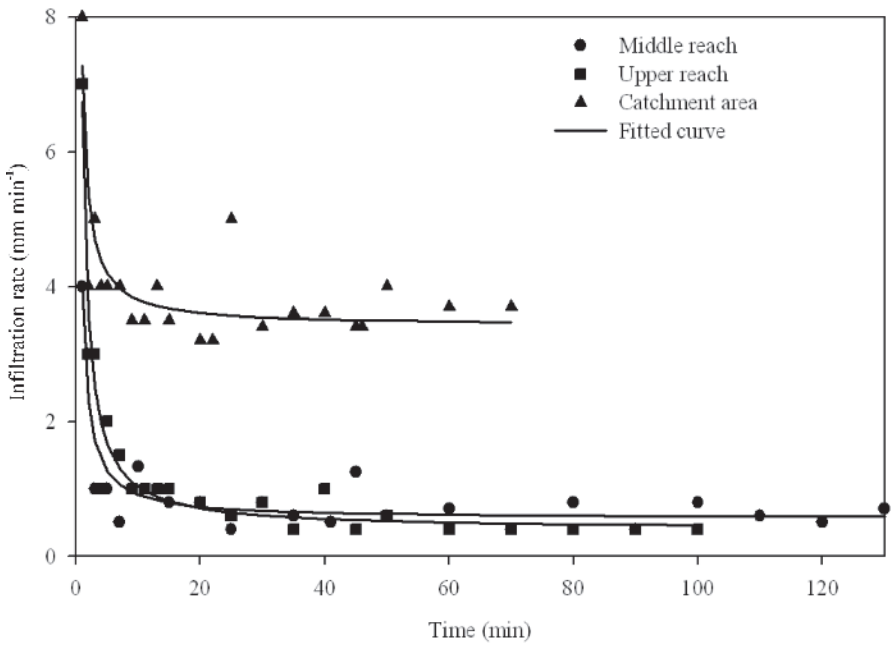



Fig. 4 Infiltration characteristics of soil at different locations of *khadin* (runoff farming) system at Bharamsar, Jaisalmer

## Assessment of annual and seasonal changes in vegetation coverage in Jaisalmer district through remote sensing

The western part of India, specifically the dry region, plays an important role in determining the Indian monsoon and even global climate patterns. Drastic change in land use pattern of the region has been observed during last few decades. Therefore, an effort was made to track the seasonal as well as annual changes of vegetation pattern in Jaisalmer district using MODIS normalized difference vegetation index (NDVI) products. Apart from this, ground data on vegetation were also collected under vegetation carbon pool assessment program of ISRO-IGBP. It was found that during the hot summer month of May, the area under NDVI class 0-0.1was reduced from 98% during 2003 to 95% during 2009 with a simultaneous increase in area under NDVI class 0.1-0.2 from 2 to 5%. During the month of September, area under NDVI class 0.2-0.3 increased from negligible during May to 34-39% during normal or surplus rainfall year but only to 3% during a deficit year. Vegetation biomass data were also collected from 10 forest sites and 4 outside forest sites of Jaisalmer district. To calculate the biomass in tree plantations, circumference at breast height (CBH) and the total height of each tree at each site were recorded (Table 2). From the ground data on vegetation biomass, it was found that *Prosopis juliflora* and *Acacia senegal* were the most abundant trees in Jaisalmer. The sites with NDVI value =0.2 were mostly found with existence of *P. juliflora* tree. Among shrubs, the most abundant species were *Calotropis procera* and *Ziziphus nummularia*. From this study, MODIS NDVI products may be used to quickly assess the vegetation changes in response to rainfall as well as due to anthroprogenic interventions in desert.

## Food-water-energy nexus in arid region

Drastic change in land use pattern in the Thar desert more specifically, a significant increase in irrigated area in Jaisalmer district has been observed. As a consequence, number of electrified wells and tubewells used for irrigation purpose has increased during last few decades. All these have led to over exploitation of groundwater for irrigation purpose. In this study, it was tried to analyze the spatial pattern of groundwater depletion in Jaisalmer district during last 15 years and its influence on energy and food security *vis a-vis* environmental pollution. Data on depth of groundwater table of 117 wells in Jaisalmer district both during pre- and post-monsoon seasons of 1995, 2004, 2008 and 2009 were used along with statistical data on irrigated area under wells and tubewells. The average depth of groundwater table was 42.64 m in 1995, which increased to 45.85 m in 2009. The annual rate of groundwater depletion was 0.20 m (Fig. 5). Overall, total annual energy consumption for irrigation in Jaisalmer was estimated at $277\times10^6$ MJ. Annual consumption of this energy for operating electric-operated submersible pumps indirectly leads

Table 2 Circumferences at breast height (CBH) and height of trees at Jaisalmer region

| Species | Circumference at breast height (cm) | | Height (m) | |
|---|---|---|---|---|
| | Range | Average | Range | Average |
| *Acacia nilotica* | - | 111.0 | - | 8.0 |
| *Acacia senegal* | 10.0-82.2 | 34.0 | 0.8-7.0 | 3.8 |
| *Capparis decidua* | 10.0-12.0 | 10.4 | 1.4-1.9 | 1.7 |
| *Prosopis juliflora* | 10.0-48.0 | 21.3 | 0.8-6.4 | 3.6 |
| *Prosopis cineraria* | 16.0-142.0 | 66.2 | 2.1-9.3 | 5.3 |
| *Salvadora oleoides* | 22.0-71.0 | 35.3 | 2.3-3.3 | 2.8 |
| *Tamarix* species | 22.0-39.0 | 31.0 | 2.9-4.9 | 4.1 |
| *Ziziphus nummularia* | 18.0-62.0 | 42.0 | 4.0-4.9 | 4.3 |

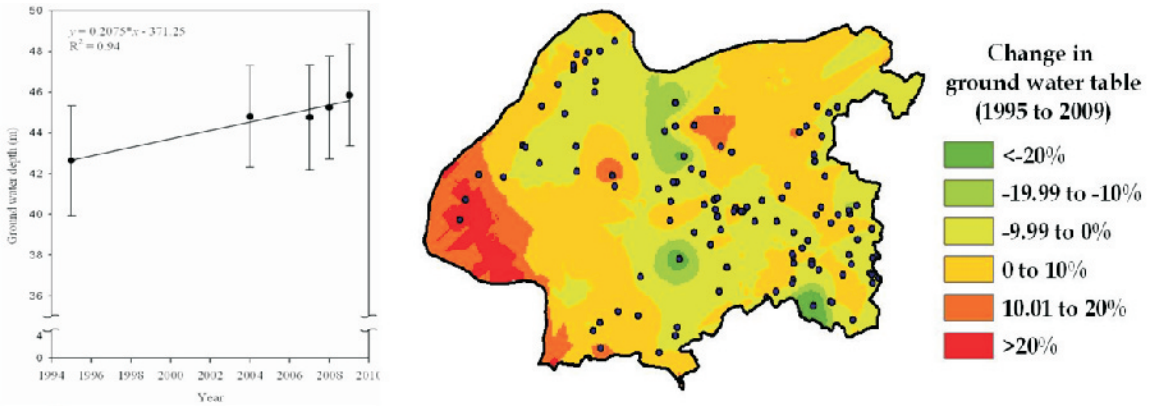



Fig. 5 Groundwater depletion pattern in Jaisalmer district, depletion trend during 1995-2009, Spatial trend of change in groundwater table during 1995-2009

to green house gas emission of 63.71 Gt $CO_2$ equivalents. It is imperative that irrigated agriculture in the Indian Thar desert is highly water and energy intensive, and both of these resources are becoming scarce. A sustainable approach for water and energy management in arid agriculture is, therefore, very essential.

## Monitoring of dust aerosol through remote sensing

Dust aerosol generated through wind erosion process was monitored through MODIS atmospheric products. Aerosol optical thickness (AOT) at 0.47 micrometer over Indian Thar Desert was mapped during severe dust storm events. It was found from AOT maps that dust aerosol was more active in western part of Jaisalmer and nearby areas (Fig. 6). A higher value of AOT represents the aerosol concentration content in the atmosphere, which is generally measured by the negative logarithm of the ratioof spectral irradiance at the top of the atmosphere and on the Earth's surface.

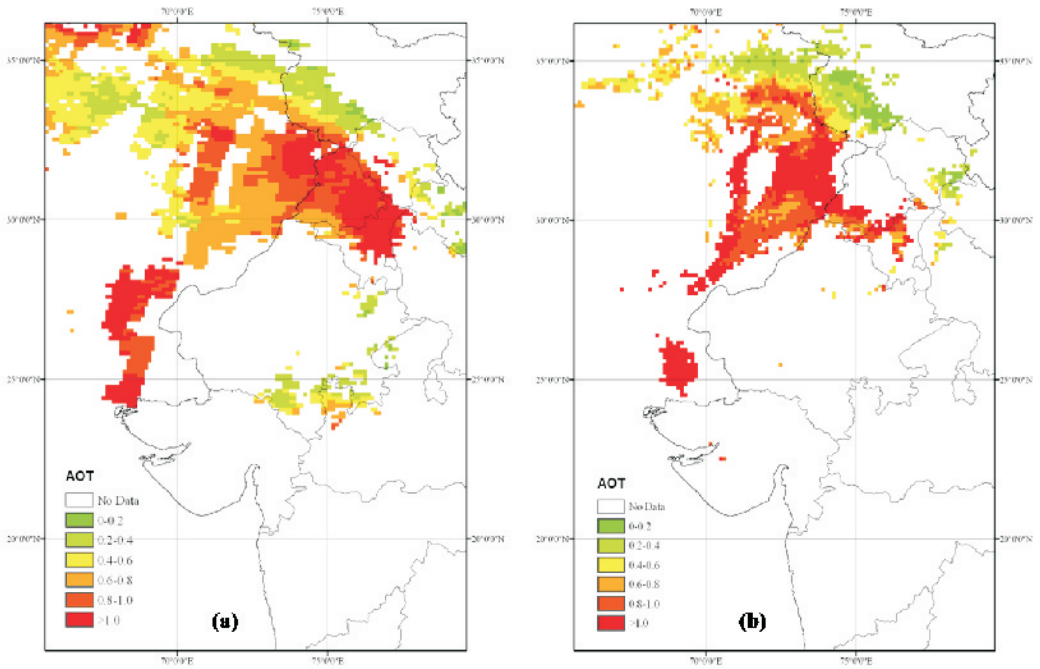



Fig. 6 Aerosol optical thickness near Jaisalmer and nearby areas during (a) July 8, 2009 and (b) July 9, 2009

# Biodiversity Conservation and Improvement of Annuals and Perennials

## Screening of date palm cultivars for their suitability in Jaisalmer

Date palm cultivars (Deglet Noor, Hayani, Shamran, Khadrawy, Barhee, Migraf, Medjool, Saidy, Khalash and Umsok) were screened and evaluated at Chandan, Jaisalmer to identify the suitable date palm cultivars and their production potential under extreme arid condition at Jaisalmer.

### Transplanting of off-shoots

September month was found more conducive for transplanting of date palm off shoots (90% survival) as compared to February-March (60% survival).

### Spathe emergence

Among 10 date palm cultivars spathe emergence ranged from February 28 to March 12. Spathe emergence was early in cv. Migraf and Umsok while it was late in cv. Khadrawy and Medjool. As far as spathe emergence to opening period is concerned, overall cv. Khadrawi took minimum time (8 days) while cv. Barhee took maximum time (19 days). The spathe opening remained for longer period in cv. Shamran (14 days).

### Yield attributes

Among the cultivars, Khadrawy, Umsok and Saidy produced maximum number of bunches per plant (9) followed by Khalash, Medjool and Shamran, while Migraf produced minimum (4) bunches only. The number of strands per bunch was maximum in cv. Khalash (36.3) and minimum in cv. Medjool (27). Maximum fruits per strand was in cv. Hayani followed by cv. Khalash while lowest 6.9 fruits per strand was recorded in Saidy (Fig. 7).

Umsok

Halawy

Migraf

Khalas

Fig. 7 Fruiting in datepalm cultivars at Chandan, Jaisalmer

### Physical characteristics of date palm fruits

Fruit length was maximum for the cv. Medjool (39.5 mm) and minimum for the cv. Khadrawy (25.1 mm). The thickness of pulp of date fruit was highest for the cv. Medjool (16.3 mm) whereas it was lowest for the cv. Hayani (7.4 mm). The weight of a single date palm fruit was recorded maximum for the cv. Medjool (16.1 g) whereas it was minimum for the cv. Hayani (3.8 g). At doka stage, largest fruit size was in cv. Saidy followed by cvs. Deglet Noor, Khalas and Umsok. The stone size was smallest in cv. Deglet Noor followed by cvs. Medjool, Shamran and Hayani while largest stone size was recorded in cv. Migraf and Saidy. Almost similar trend in fruit size was recorded at pind stage. Among cultivars, maximum fruit weight and pulp weight was recorded in cv. Deglet Noor followed by cv. Khalas. Pulp thickness was maximum in cv. Deglet Noor at both the stages. The pulp thickness of fruit (16.3 mm) and weight of a single fruit (16.1 g) was highest in cv Medjool.

### Acidity of the date palm fruits

At doka stage, maximum acidity was recorded for cv. Umsok (0.76%) followed by cv. Halawi (0.50%). The lowest value of acidity at doka stage was observed for cv. Migraf (0.14%), however, highest acidity at dang stage was observed in cv. Halawi (0.75%). For cultivars Migraf and Umsok, the acidity level at dang stage reduced from its level at doka stage.

### Physico-chemical properties

The physico-chemical composition of fruit pulp at pind stage revealed that the maximum total sugar content was in cv. Umsok (70.10%) followed by cv. Hayani (61.44%) and minimum in cv. Khadrawy (54.13%). The maximum amount of thiamine and riboflavin was also recorded in cv. Medjool (0.030 and 0.027%, respectively).

### Evaluation of Guggal (*Commiphora wightii*) germplasm

The morphological characterization of 12 year old plantation of Guggal (*Commiphora wightii)* from four provenances viz., Dantiwara, Mangaliawas, Kukma-Bhuj and Bhind-Morena showed significant variations in plant height, crown diameter, shoot diameter and mean collar diameter of primary branches. In all the provenances, crown was more pronounced in east-west direction than north-south direction except in Mangaliawas. Mangaliawas provenance showed more growth with respect to plant height, shoot diameter and mean girth of primary branches. Further, the preliminary results showed the highest canopy temperature in all provenances was at 13:00 hrs. However, Thaiyat provenance observed the highest canopy temperature followed by Akal and Kalidungar.

### Seed raised Guggal plants showed better growth than stem cuttings

Comparative growth performance after four years planting of Guggal plants showed the maximum plant height (average 198.6 cm) for seed raised plants compared to stem-cutting plants (145.2 cm). Similarly, maximum canopy spread was recorded in seed raised plants (276.0 cm) than cutting (162.0 cm). The number of branches was also recorded higher in the seed-raised plants (6.1) than the stem-cuttings plants (5.4). The ratio of main stem diameter to height, varied significantly among stock types. The value of sturdiness was observed 13.0% higher in seed-raised plants than the stem-cuttings. Therefore, this study proves superiority in the growth performance of seed-raised plants of Guggal as compared to stem-cuttings in the harsh situation of the Thar Desert (Fig. 8).

### Germplasm collection and evaluation of Kair (*Capparis decidua*)

Forty five collections of Kair (*Capparis decidua*) were collected from western Rajasthan covering diverse habitats viz., rocky, gravely, sand dunes, natural rangelands and cultivated fields. A wide range of variability was observed (Fig. 9) for fruit diameter (7.33-19.71 mm), fruit weight (0.77-8.24 g) and number of seeds per fruit (1-36). Among 45 collections, germination ranged from 41.6-93.4% with mean value of 72.4%, however, two collections (CZJK-3 and CZJK-5) did not show any germination. Under nursery condition, five months old seedlings showed varying magnitude of survival ranging from 44.2 to 76.8%. Seeds of all the 45 accessions were analyzed for biochemical parameters. Phenol content

Fig. 8 Seed-raised (left) and stem-cutting (right) Guggal plant after four years of planting

ranged from 33.47 to 79.0 (51.84±12.60) mg $g^{-1}$, flavonoid content ranged from 5.08 to 9.88 (7.25±1.33) mg $g^{-1}$ and anti-oxidant activity ranged from 7.03 to 16.59 (10.72±2.46) mg $g^{-1}$.

To explore the possibility of inducing seedling resistance in *C. decidua* for better survival, hollow plastic pipe approach was attempted in nursery as well as field conditions. Better seedling survival and high root-shoot ratio were observed in hollow plastic pipe (>90% and 0.84, respectively) as compared to poly bags (<50% and 0.63, respectively). After eight months of planting, 83% of plant survival with good vigour was recorded with hollow plastic pipe compared to traditional method (51%) of field planting. Since, the severe mortality is a major problem in the maintenance of kair seedlings under nursery, six months old seedlings raised through hollow plastic pipes can be directly planted in the field.

After two years of field planting, plant survival ranging from 16.7% (CAZJK-28) to 83.3% (CAZJK-8) was recorded among the different accessions. Accessions viz., CAZJK-4 (CAZRI Farm, Jaisalmer), CAZJK-6 (Lanella, Jaisalmer), CAZJK-7 (Mokal, Jaisalmer), CAZJK-8 (Mokal, Jaisalmer) and CAZJK-15 (Chaitral, Jaisalmer) showed more than 80% survival, while accessions CAZJK-14 (Chaitral, Jaisalmer), CAZJK-22 (Sanwta, Jaisalmer), CAZJK-28 (Chauk, Jaisalmer), CAZJK-32 (Chaud, Jaisalmer), CAZJK-34 (Amarpura, Jaisalmer), CAZJK-42 (Bothia, Barmer) and CAZJK-44 (Fatehgarh, Jaisalmer) showed poor survival (< 30 %) percentage. Sixteen plants representing 12 accessions viz., CAZJK-1-1, CAZJK-4-1, CAZJK-6-8, CAZJK-8-1, CAZJK-8-6, CAZJK-8-11, CAZJK-9-5, CAZJK-10-8, CAZJK-11-5, CAZJK-12-11, CAZJK-12-12, CAZJK-15-2, CAZJK-15-6, CAZJK-20-2, CAZJK-30-3 and CAZJK-38-6 were identified for earliness.

Fig.9 Kair: Diversity in flower color and fruit shape

## Genetic improvement for seed yield of Mateera (*Citrullus lanatus*)

In Mateera (*Citrullus lanatus*), 142 accessions [local collections from western Rajasthan (20), NBPGR Regional Station, Jodhpur (30), SKRAU, Mandore (21), USDA (71)] were evaluated for seed yields and related traits. Wide variability was observed for number of fruits per plant (2-27), number of seeds per fruit (156-1072), seed yield per fruit (18.5-66.5 g) and seed yield per plant (25-870 g) (Fig. 10). Three genotypes viz., SKNK-683, SKNK-112 and SKGPK-26 were identified as stable in performance over the period 2011-2013 through stability analysis. Further, the genotypes DRB-675, DRB-677, SKNK-665, SKNK-679, SKNK-903, SKGPK-22, SKGPK-24, SKGPK-31 and SPS-8 were also identified as better performer in a good rainfall year. Maximum protein content (50.9%) was recorded in entry CAZJK-13-1, while the minimum oil content (39.3%) in CAZJK-13-2. Evaluation of improved genotypes of watermelon over years/locations has resulted in development of variety "CAZRI Kalingada-1" (CAZJK-13-2). The variety provided 12.5-15.0 t $ha^{-1}$ of fruit yield and 350-450 kg $ha^{-1}$ seed yield under rainfed conditions with 28-30% oil content.

Fig. 10 Fruit and seed variability in Mateera germplasm

## Evaluation of *Grewia tenax* and *Indigofera oblongifolia*

Diverse germplasm of *Grewia tenax* (41) and *Indigofera oblongifolia* (10) were collected covering the range of habitats and also from varying rainfall gradients of Barmer, Jaisalmer, Jodhpur and Pali districts. Habitat occurrence of *G. tenax* was found in patches with dominant association of *Euphorbia caducifolia* across the surveyed districts. *I. obongifolia* was also noticed in irregular patchy distribution along the depression on the road sides. High browsing pressure on both the species was noticed in rangeland conditions, which limit the availability of mature seeds (Fig. 11). In *G. tenax*, average plant height and canopy area of individual plant on unprotected area was far lower (0.95 m and 1.75 $m^2$) than protected area (2.63 m and 13.89 $m^2$). Characterization of collected germplasm of *G. tenax* revealed considerable variations in seed characteristics and correlation among them. The range and mean values of important seed characters of *G. tenax* such as 100-seed weight, seed length and seed width were 2.02 to 7.00 g and 3.34 g, 3.92 to 7.10 mm and 5.36 mm and 3.02-5.59 mm and 4.25 mm respectively. Both the species showed poor germination in freshly collected seeds. Heat treatment at 50°C for 24 hr showed high germination percentage in *Grewia tenax.* Seeds of *I. oblongifolia* collected from Devikot (Jaisalmer) showed good germination and comparatively better survival in nursery as well as in field.

Fig. 11 *Grewia tenax* and *Indigofera oblongifolia* in rangelands

## Gondi (*Cordia gharaf*)

Twelve collections of *Cordia gharaf* representing diverse habitats of Jaisalmer district showed variation with respect to seed germination and seedling growth parameters under nursery condition. Higher germination (46%) was recorded in Badabag and minimum (17%) in Dangri collection. Among the collections, seedlings from the Badabagh collection were found superior. The shape and colour of ripe fruits were observed as round to ovoid and orange to reddish-brown, respectively. Fruit length ranged from 9.6-11.9 mm, while their diameter varied from 9.1-10.7 mm. The maximum juice recovery (37.4%) in ripe fruits was obtained from Amarsagar collection, while minimum for Badabag site (23.4%).

## Assessment of assimilation potential and partitioning of clusterbean

The assimilation potential and partitioning among 20 clusterbean genotypes showed significant genetic variability for yield attributing characters i.e., number of branches per plant, number of clusters per plant, number of pods per cluster and number of seeds per pod during two consecutive years (2015 and 2016). Number of branches ranged from 0.6 to 5.3 and 13 genotypes showed >4.0 branches per plant during 2015, whereas, it ranged from 0.8 to 6.0 during the year 2016 and 6 genotypes showed >4.0 branches per plant. Number of clusters per plant varied from 5.8 to 14.9 during 2015 with the mean of 10.9 and 2.3 to 8.8 with the mean of 4.8 during the year 2016. Nineteen genotypes showed >10.0 clusters per plant with maximum of 14.9 in GST-15-101 and 14.6 in GST-15-201 during the year 2015, whereas five genotypes showed >6 clusters per plant with the maximum of 8.8 in GST-15-204 during the year 2016. The number of seeds per pod also showed significant genetic variability and its value ranged from 5.3 to 7.3 in 2015 and from 6.0 to 8.3 in 2016. The genotypes GST-15-106 and GST-15-201 showed the maximum 7.3 seeds per pod followed by GST-15-204, GST-15-203 and GST-15-104 in the year 2015 and the genotypes GST-15-204 showed maximum (8.3) seeds per pod followed by GST-15-205 (8.2), GST-15-110, GST-15-111, GST-15-207 and GST-15-209 (8.0 in each) in the year 2016. Significant differences in total plant dry weight were observed for different genotypes. It varied from 14.7 to 28.7 and from 7.59 to 18.85 g plant$^{-1}$ in the years 2015 and 2016, respectively. Seven genotypes showed >24 and 14 g of plant dry weight during the years 2015 and 2016, respectively. High yield in GST-15-101, GST-15-104, GST-15-106, GST-15-109, GST-15-209, GST-15-202 and GST-15-203 genotypes during the year 2015 was because of their higher plant dry weight, more number of branches per plant with higher number of clusters and seeds. Whereas in 2016, high seed yield obtained in genotypes GST-15-205 (299.9 kg ha$^{-1}$) and GST-15-204 (984.9 kg ha$^{-1}$) may be due to higher plant dry weight of these genotypes as 16.0 and 18.9 g plant$^{-1}$, respectively, against control, RGC-936 (969.4 kg ha$^{-1}$ with 15.1 g plant$^{-1}$ dry weight).

# Integrated Arid Land Farming System Research

## Development of agro-techniques for sustainable rainfed production of arid legumes

Under coordinated trials, 75 moth bean and 33 clusterbean genotypes were evaluated during the years 2003 to 2012. Agronomic evaluation of promising genotypes of moth bean showed that variety CZM-3 produced significantly higher seed yield (305 kg $ha^{-1}$) followed by RMO-225 (138 kg $ha^{-1}$). The yield of moth bean was higher (359 kg $ha^{-1}$ seed and 957 kg $ha^{-1}$ straw yield) sown at closer spacing (30 cm) as compared to wider (45 cm) spacing which recorded 318 kg $ha^{-1}$ seed and 857 kg $ha^{-1}$ straw yield. Higher doses of fertilizer application (20 + 40 kg $ha^{-1}$ N + $P_2O_5$) produced significantly higher seed and straw yield (366 and 986 kg $ha^{-1}$, respectively) in comparison to lower doses (10 kg N + 20 kg $P_2O_5$) that gave 311 kg $ha^{-1}$ seed and 827 kg $ha^{-1}$ straw yield. Whereas, sowing of clusterbean at wider spacing (45 cm) produced higher yield (807 and 1679 kg $ha^{-1}$ seed and straw yield, respectively) than narrow spacing of 30 cm (663 and 1371 kg $ha^{-1}$ seed and straw yield, respectively). Thus 21.8 and 22.5% higher grain and straw yields were obtained with the sowing at 45 cm spacing. Skip-row planting also increased 23.7% seed yield (978 kg $ha^{-1}$) in clusterbean over normal planting (749 kg $ha^{-1}$). Basal application of 20 kg N $ha^{-1}$ coupled with two foliar spray of 1% urea at pre and post flowering stage also increased grain yield by 56.9%.

### Effect of live mulch of Colocynth (*Citrullus colocynthis*)

Introduction of colocynth (*Citrullus colocynthis*) as live mulch reduced the yield and yield attributes of pearl millet and moth bean considerably as compared to sole crops. Among the entire live mulch ratio, sole pearl millet recorded 49.5% higher grain yield over highly dense ratio of 1:1 crop and colocynth live mulch. In case of clusterbean, yield attributes in terms of pods $plant^{-1}$, pod weight $plant^{-1}$ and grain yield $plant^{-1}$ were recorded significantly higher with 4:1 crop: colocynth live mulch ratio among the different crop and colocynth ratios. Seed was 23.5% higher in 4:1 (crop: colocynth) as compared to sole crop. However, fodder yield was recorded significantly higher (32.8%) with 3:1 clusterbean: colocynth ratio (Fig. 12).

Significantly lower number of weeds and weed dry weight $m^{-2}$ were recorded with the introduction of colocynth in clusterbean but in pearl millet and moth bean lower weed density was recorded with sole pearl millet. Sole clusterbean showed higher weed density (38.3%) and weed dry weight (46.2%) whereas sole pearl millet and moth bean showed lower weed density (56.8% and 21.9%) and weed dry weight (58.8% and 22.4%), respectively compared to 1:1 crop: colocynth ratio.

Sole Colocynth

Pearl millet + Colocynth

Moth bean + Colocynth

Clusterbean + Colocynth

Fig.12 Colocynth live mulch in different crops

## Development of post-harvest technology for date palm

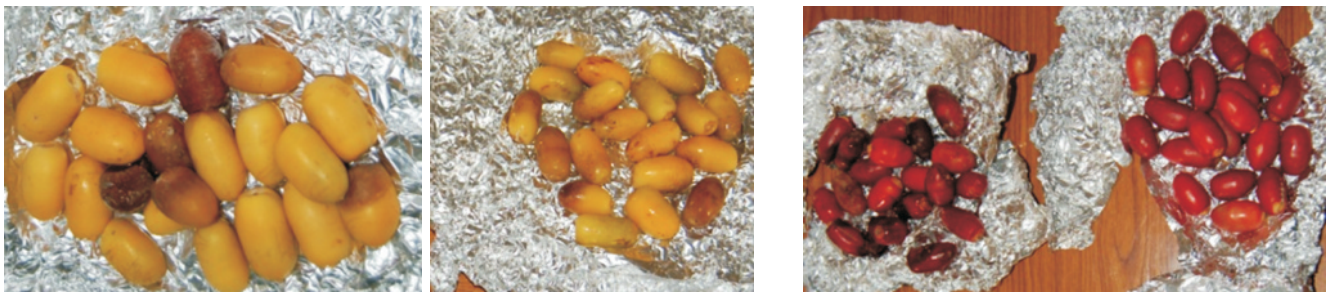
### Suitable packaging materials

Fruits of four cultivar of date palm viz., Barhee, Khadrawy, Khalas and Khunezi at doka stage were packed with four different materials such as corrugated fibre boxes, plastic punnets, perforated polyethylene bag (3% perforation) and metalized polyester film (aluminium employed). The fruits packed in different packaging materials were then stored under two storage conditions i.e. normal room/ambient temperature and cold storage under refrigerator (4°C). Experiment was repeated for two consecutive years of 2017-2018 and 2018-2019. The study revealed that metalized polyester film (aluminium foil) wrapping and storing at low temperature had minimum physiological loss in weight and less spoilage percentage in all the four cultivars at each interval of three days and extended even up to 15 days of storage i.e., Barhee (PLW-18.5%, Spoilage-39.1%), Khadrawy (PLW-15.7%, Spoilage-33.2%), Khala (PLW-12.8%, Spoilage-33.2%) and Khunezi (PLW-14.4%, Spoilage-31.9%) (Fig. 13).

### Post-harvest utilization of doka stage fruits

Fruits of four date palm cultivars viz. Barhee, Khadrawy, Khalas and Khunezi were solar dried with or without stone at doka stage for different periods (5, 7 and 9 days) to optimize treatment for minimum physiological loss in weight (PLW) and maximum recovery percentage

Barhee Khalas



Khadrawy Khunezi

Fig. 13 View of the cultivars of date palm packed with metalized polyester film after 9 days in comparison with control (ambient storage)

(RP). There was significant effect of the solar drying treatment on both the parameters of PLW (%) and RP (%) in the cultivar Barhee and Khadrawy but it was non-significant in the cultivar Khalas and Khunezi. Physiological loss in weight and recovery percentage in solar dried fruits ranged from 46.8 to 64.0% and from 34.4 to 53.8%, respectively (Table 3).

Table 3 Physiological loss in weight and per cent recovery of solar dried date cultivars

| Treatments | Barhee | | Khadrawy | | Khalash | | Khunezi | |
|---|---|---|---|---|---|---|---|---|
| | PLW (%) | RP (%) | PLW (%) | RP (%) | PLW (%) | RP (%) | PLW (%) | RP (%) |
| T1 | 56.6 | 43.4 | 53.1 | 49.6 | 61.1 | 38.0 | 59.2 | 40.8 |
| T2 | 58.4 | 41.6 | 50.7 | 46.6 | 61.2 | 53.3 | 63.1 | 36.9 |
| T3 | 60.2 | 39.8 | 48.2 | 52.2 | 57.1 | 40.2 | 59.2 | 40.8 |
| T4 | 64.1 | 35.9 | 49.7 | 49.4 | 60.0 | 35.4 | 61.3 | 38.7 |
| T5 | 60.0 | 40.0 | 46.8 | 53.8 | 59.0 | 37.4 | 59.4 | 40.6 |
| T6 | 64.0 | 36.0 | 53.7 | 48.1 | 62.2 | 34.4 | 56.9 | 43.1 |
| T7 | 56.1 | 43.9 | 52.4 | 48.2 | 55.5 | 41.2 | 55.2 | 44.8 |
| T8 | 62.2 | 37.8 | 62.0 | 37.4 | 55.8 | 38.3 | 62.1 | 37.9 |
| CD @5% | 03.9 | 03.9 | 05.0 | 05.0 | NS | NS | NS | NS |

PLW- Physiological loss in weight; RP- Recovery percentage; NS- Non significant

T1-Solar drying for 5 days with stone; T2- Solar drying for 5 days without stone; T3- Solar drying for 7 days with stone; T4- Solar drying for 7 days without stone; T5- Solar drying for 9 days with stone; T6- Solar drying for 9 days without stone; T7- Control; 9 days with stone in open and T8 - Control; 9 days without stone in open

Organoleptic tests for sensory evaluation for color, flavour, texture and taste revealed that among the cultivars the maximum score was obtained in all the four parameter in cultivar Khunezi (color-8, flavour-8, texture-8 and taste-8) compared to other cultivars especially when the whole fruits were dried for a period of 9 days. Khadrawy cultivar also fared well in sensory evaluation and also had high score (color-7, flavour-7, texture-7 and taste-7) when cut fruits were dried for a period of 5 days (Fig. 14 and 15).

## Characterization of soil seed bank of Sewan (*Lasiurus sindicus)* in arid rangeland

Study of soil seed banks of sewan (*Lasiurus sindicus*) grass revealed that seeds were found at all soil depths viz., 0-3, 3-6, 6-9 and 9-12 cm in July, October and December. Under controlled grazing, the soil seed bank status of all species was observed significantly higher in May (31.2%) and July (58.4%) with respect to total seeds. However, surface soil layer (0-3 cm) contained highest seed density, which decreased with depth. Significantly higher seed density (no. per $m^2$) of *L. sindicus* was observed in fully protected (54.7) followed by controlled (39.0) and open grazing (16.2) rangelands. Seed density of the species in seed bank showed seasonal dynamics (higher in October). Overall, seasonal vegetation coverage of fully protected, controlled grazing and open grazing dominated with *L. sindicus* was observed as 15.2, 14.6 and 8.2% respectively.

## Improvement of seed set and yield in Sewan (*Lasiurus sindicus*) grass

In sewan grass (*Lasiurus sindicus)*, lower seed yield due to poor seed set can be improved and high seed shattering rate can be reduced by application of plant hormones. The positive

Fig. 14 Solar dried Khunezi dates (cut and whole fruits after 5 days

Fig. 15 Solar dried Khadrawy dates (cut and whole fruits) after 5 days

relationship of canopy temperature with soil temperature and negative relationship with wind speed resulted in higher canopy temperature of sewan grass. Application of different harmones at pre-flowering and anthesis stage lowered the canopy temperature over the control by 1.3 to 4.5º C that resulted in higher percent green leaves and leaf area in sewan grass**.** The maximum sugar (31.3 mg $g^{-1}$ fresh wt.) and phenol content (7.97 mg $g^{-1}$ fresh wt.) in leaves were observed with cycocel (100 ppm) + pactobutrazol (200 ppm) over control (14.6 and 5.27 mg $g^{-1}$ fresh wt.). This combination of hormones [cycocel (100 ppm) + pactobutrazol (200 ppm)] was found more effective in comparison to other combinations in improving seed set and seed yield due to improved growth and better yield attributing characters and lowered canopy temperature.

## Evaluation of feeding and grazing practices for better adaptation to climate change

Preliminary results showed that only grazing on pastures would not express actual livestock productivity; it could be improved by supplementary grazing with balanced concentrates and adopting health management practices. Grazing study revealed decline in *Lasiurus sindicus* grass cover and dominance was much less in paddocks where sheep grazing with supplemental feed practiced than that being practiced without supplement feed. Irrespective of supplemental feed, 70-80% of *L. sindicus* cover was declined in paddock with double the carrying capacity during two years. The trend of dominance of *L. sindicus* indicated the more consumption of companion vegetation such as *Ochthochloa compressa, Cenchrus biflorus* by sheep. In contrast, sheep in optimum carrying capacity and given supplemental feed nearly maintained the plant cover of *Lasiurus sindicus* though cover decline was 60-70% in paddocks grazed by sheep and not given supplemental feed. Therefore, spatial heterogeneity imparted by seasonal vegetation in an overall matrix of perennial tall grasses and woody perennials needed to be managed optimally by grazing management of both seasonals and perennials.

## Energy-mass exchange in arid grassland system

The micro-meteorological and biophysical characterization of surface energy exchange and its drivers over an arid *Lasiurus sindicus* grassland ecosystem was studied at experimental area of Chandan, Jaisalmer. The energy balance components obtained from data logger in INSAT linked Automated Meteorological Station (AMS) of Indian Space Research Organization were analyzed to understand the variability of surface energy fluxes, their drivers and closure pattern. $R^2$ between radiation (Rn) and ground heat fluxes (G) was 0.55 ($p<0.001$). The mean G–Rn ratio was 0.31, which varied between 0.15 and 0.50 across the seasons. Inter-seasonal variability of G was minimum due to higher infiltration rate in sandy soil coupled with shorter wet period that could lead to low inter-seasonal variability of thermal conductivity. The highest sensible heat flux (SH~375 W $m^{-2}$) was found in summer season, being a function of air temperature, wind speed and vertical air temperature difference (VATD); Sensible heat (SH) fluxes was lesser under vegetation cover than in open field. Latent heat flux (LH) (88-115 $Wm^{-2}$) was higher during July to September than during summer due to rainfall and dense grass cover. Wet spells were found whenever the net available energy (NAE) was +ve; whereas, dry period occurred when NAE was negative.

Biomass productivity, water and light use efficiencies studies on *L. sindicus* indicated that this perennial grass species exhibited bimodal distribution in their diurnal photosynthetic rates with first peak (13 to 15 µmol $CO_2$ $m^{-2}$ $s^{-1}$) around 10:00 hrs and second but higher rate (18 to 20 µmol $CO_2$ $m^{-2}$ $s^{-1}$) around 16:00 hrs. The maximum radiation use efficiency (2.73 g $MJ^{-1}$) was between 10:00-11:00 and 16:00 to 17:00 hrs with dip (0.47 g $MJ^{-1}$) in the noon hours. The leaf to air vapour pressure difference was more due to more difference in leaf to air temperature from 23:00 hrs to early morning 5:00 hrs that might have reduced stomatal conductance. Night time leaf temperature was consistently lower than ambient temperature, which must have favored diffusion of gases including moisture into intercellular spaces. Land surface components within ARW regional atmospheric model was tested with AMS flux net data sets. The NOAH land surface model (LSM) produced better comparisons with observations over simple soil diffusion model. Large seasonal variations were found in the simulated fluxes and surface meteorological parameters at Chandan, largely controlled by vegetation and rainfall variations. The higher fluxes (~400-500 Watts $m^{-2}$) in summer and monsoon are also partly due to the advection of heat fluxes to the observation site which was identified from simulated wind field. Model biases were reduced with NOAH LSM for fluxes, temperature, wind and other variables.

## *Cordia gharaf* based silvipasture system

In *Cordia gharaf*, all the growth parameters viz., plant height, collar diameter, crown diameter, crown spread and secondary growth after two years of planting were better in sole plantation as compared to its silvipasture with sewan grass (*Lasiurus sindicus*) at Chandan, Jaisalmer. In silvipasture, the mean plant height ranged from 142.8 to 156.3 cm, the mean collar diameter from 29.4 to 35.2 mm and the mean crown area ranged from 0.82 to 0.98 $m^2$, whereas under sole plantation the mean plant height ranged from 187.3 to 204.6 cm, the mean collar diameter from 53.5 to 61.3 mm and the mean crown area from 2.86 to 3.73 $m^2$.

Fresh and dry grass yields of sewan was higher in sole grass (5.83 and 1.44 t $ha^{-1}$, respectively) as compared to the yield under *C. gharaf* based silvipasture treatments (4.54 and 1.12 t $ha^{-1}$, respeciively). Integration of *Cordia gharaf* with sewan grass resulted in 22% reduction in grass biomass yield of sewan.

After 30 months of planting, biomass and carbon stock of the system on unit area basis was slightly lower under silviculture system (3.00 and 1.35 t $ha^{-1}$, respectively) as compared to sole sewan grass system (3.61 and 1.62 t $ha^{-1}$, respectively). The reduction in carbon stock of the system (17%) was due to removal of grasses in the vicinity of trees. However, at this stage system biomass and its carbon stocks per unit area were significantly lower in sole tree plantation (0.67 and 0.31 t $ha^{-1}$, respectively), compared to sole sewan grass (3.61 and 1.62 t $ha^{-1}$, respectively) and *Cordia gharaf* + sewan-based silvipasture system (3.00 and 1.35 t $ha^{-1}$, respectively). Annual carbon sequestration potential of this 30 months old *C. gharaf* + sewan based silvipasture system (0.55 t $ha^{-1}$ $yr^{-1}$, respectively) was slightly lower than that of the sole sewan (0.67 t $ha^{-1}$ $yr^{-1}$); however, it was much lower in sole plantation of *C. gharaf* plantation (0.13 t $ha^{-1}$ $yr^{-1}$) (Fig. 16).

Fig. 16 *Cordia gharaf* sole plantation (left) and in silvipasture with sewan grass (right) after 30 months of planting

## Carbon stocks in different land use systems

Carbon stock in different land use systems of Jaisalmer district was estimated at 71 sites during 2017-18 and the maximum carbon accumulation was recorded in canal plantation ranging from 5.82 t $ha^{-1}$ in *Tecomella undulata* plantation to 31.50 t $ha^{-1}$ in plantation of *Eucalyptus* spp. with an average of 22.43 t $ha^{-1}$ above ground carbon. This exceptionally high biomass and carbon stock may be due to dense plantations (ranging from 200 to 400 trees $ha^{-1}$) along the both sides of IGNP main canal, continuous water supply and high degree of protection. Tree plantations outside the canal belt accounted above ground carbon stock ranging from 1.35 t $ha^{-1}$ (*A. nilotica* under rainfed conditions) to 6.34 t $ha^{-1}$ in *Prosopis cineraria* in irrigated fields. Tree plantations were followed by orans with an average above ground carbon of 2.47 t $ha^{-1}$ which ranged from 0.86 t $ha^{-1}$ in *Prosopis juliflora* to 5.36 t $ha^{-1}$ in *Ziziphus nummularia* dominated *Orans*.

Agroforestry systems accounted for an average above ground carbon of 2.28 t $ha^{-1}$ with a maximum of 4.62 t $ha^{-1}$ under *Prosopis cineraria* and *Acacia nilotica* dominated agroforestry under *khadin* farming system. Silvipasture systems accounted for an average above ground carbon of 2.51 t $ha^{-1}$ and it varied from 1.05 t $ha^{-1}$ under *Z. nummularia* to 3.37 t $ha^{-1}$ under *P. cineraria* dominated silvipasture. Horticultural systems accounted for an average above ground carbon of 1.94 t $ha^{-1}$, of which maximum of 4.37 t $ha^{-1}$ under horti-silvi system consisting of pomegranate with *Dalbergia sissoo*. Above ground carbon under rangeland condition varied from 0.46 to 1.51 t $ha^{-1}$, with an average of 0.82 t $ha^{-1}$. Under grassland condition, average aboveground carbon was found to be 0.49 t $ha^{-1}$, ranging from 0.23 to 0.76 t $ha^{-1}$.

# Integrated Pest Management

## Insect pest survey

Field surveys were conducted in Jaisalmer district to assess the diversity and abundance of different insects during rabi (chickpea, mustard and cumin) and kharif seasons (groundnut, mung bean and clusterbean). Fortnightly surveys for diversity and relative abundance of different insects of rabi crops in Jaisalmer district revealed presence of four insects on chickpea, major one being pod borer (*Helicoverpa armigera)*; nine insects on mustard including the major one *Liphaphis erysimi*, and four in cumin including cumin aphid. Shannon Winner Diversity (H') index in chickpea, mustard and cumin was 0.67, 0.58 and 0.04, respectively. Likewise, surveys in kharif crops revealed presence of 12 insects on groundnut the major ones being pod borer (*Helicoverpa armigera*), thrips (*Scritothrips dorsalis*), green weevil (*Myllocerus viridanus*), and ash weevil (*Myllocerus* sp); 9 insects on mung bean with the major ones including spotted pod borer (*Maruca testulalis*), pod borer (*Helicoverpa armigera*), whitefly (*Bemisia tabaci*), and thrips (*Megalurothrips usitatus*) and 5 insects on clusterbean such as jassid, whitefly, *Helicoverpa*, aphid and termite. Shannon Winner Diversity (H') index in groundnut, mung bean and clusterbean was 1.14, 1.35 and 0.82, respectively.

During the surveys, butterfly migration due to an outbreak of *Catopsilia pyranthe* on senna (*Cassia angustifolia*) was also noted. The migration was mainly in southwest direction in a steady line across Jaisalmer, Jodhpur, Pali, Sirohi and Ajmer districts. The highest density (1360 butterflies 10 $m^{-1}$ 5 $minute^{-1}$) accounting for 16,320 butterflies 10 $m^{-1}$ $hour^{-1}$ or 97,920.0 butterflies 10 $m^{-1}$ $day^{-1}$ were recorded in Keru, Jodhpur representing bell shaped curve of diurnal movement with a maximum activity between 12.00 noon and 1.00 PM.

# Socio-economic Investigations

## Rehabilitation of *Orans* (Sacred lands)

Under SUMAMAD Project, the preliminary study of some of the *Orans* in Jaisalmer district revealed that the diversity of trees and shrubs particularly species like *Ziziphus nummularia, Acacia senegal, Salvadora oleoides, Capparis decidua,* and *Prosopis cineraria* are being preserved (Fig. 17). However, ground vegetation, particularly perennial pasture grasses, decreased to a great extent due to increase in the livestock population and dwindling grazing lands, with sewan (*Lasiurus sindicus*) as the most affected grass. However, increasing grazing/ browsing pressure is one of the decisive factors related the degradation of sacred groves. For the management and sustainable utilization of *Orans,* the suggested rehabilitation measures include: developing a database; ensuring community participation through awareness campaigns; soil and water conservation measures; improvement in understory vegetation cover; reintroduction of locally rare, endangered and threatened plant species like Guggal (*Commiphora wightii*); rehabilitation of water storage structures; and grazing/browsing policy and provision of incentives.

Fig. 17 Orans in Jaisalmer district

# Outreach

## Trial on improved varieties at farmers' fields

Under SUMAMAD project, field trials on kharif and rabi crops using improved varieties and appropriate management practices were conducted in Bharamsar village, Jaisalmer district. During kharif 2011, nine field demonstrations on clusterbean were conducted on farmers' fields in Baramsar village for three clusterbean varieties e.g. RGC-936, HG-365 and RGC-1002 with application of 20 kg N + 40 kg $P_2O_5$ $ha^{-1}$ and two foliar sprays of Thiourea (0.05%) and Zinc Sulphate (0.5%) during vegetative and reproductive stages. The variety RGC-936 performed better than RGC-1002 and HG-365. In rabi season, adoption of improved varieties of cumin (GC 4), isabgol (GL-2), mustard (Bio-902) and wheat (PBW-502) along with RDF increased the grain yield by 37.1, 46.6, 22.9 and 34.7%, respectively compared to conventional practices. Overall the highest B :C ratio was recorded for mustard (2.15) and the lowest for wheat (1.46). However, most remunerative crop in terms of economic returns was cumin followed by wheat, isabgol and mustard. During rabi season of 2012, cumin var-GC-4 recorded 16% higher yield (435 kg $ha^{-1}$) as compared to existing cultivar (375 kg $ha^{-1}$). However, in isabgol, due to stormy rain during maturity stage, heavy shattering reduced the yield by 70-90%. From the study on weed dynamics of rabi crops, density of *Melilotus indica* was observed as the highest among all weeds.

Field demonstrations on planting the medicinal plants viz., Guggal, fruit trees (gonda, ber) and grass seed sowing technique for pasture development were demonstrated.

## Farmers' training on pasture development and management

One-day farmers' training on "Pasture development and management" was organized on September 12, 2011 for the farmers of Bharamsar village. The farm visit and lectures were conducted to acquaint the farmers with appropriate pasture development and seed collection techniques, particularly with regard to sewan (*Lasiurus sindicus*) grass. Discussions were also held with the farmers to enhance rangeland productivity through the use of water conservation techniques, improved forage diversity, nutrient management, and the management of weeds by introducing mix herd grazing.


## Nursery management

One-day farmers' training program on "Nursery management" was organized on March 16, 2012 at Bharamsar village and nearby areas. The nursery demonstration and lectures were conducted to acquaint the farmers with techniques of nursery raising of shrubs, trees and fruit plants. Emphasis was also given to pre-sowing treatment, seeding depth, watering and special care in different plant species.

## Training on rabi crops production-cum-field day

Training on rabi crops production-cum-field day was organized on February 22, 2012 at village Bharamsar. Field visits of the farmers were also conducted to demonstrate rabi crops viz., isabgol, cumin, mustard and wheat.

## Training and demonstration of gum induction technique

Demonstration for gum inducing technique in kumat (*Acacia senegal*) trees was organized on April 17, 2013 at village Bharamsar. A total of 25 farmers participated in the program. CAZRI Gum inducer was also distributed to the interested farmers.

## Rabi field day-cum *Kisan Goshthi*

Under SUMAMAD project, a rabi field day-cum-*Kisan Gosthi* was organized on March 9, 2013 at Bharamsar village. The farmers from the Bharamsar and nearby villages participated in the program.


## Training program on salinity and alkalinity problem in *khadins*

Under SUMAMAD project, one-day training on "Salinity and alkalinity problem in *khadin* and rodent control" at farmers' field was organized at Bharamsar village on June 27, 2013. The lectures and demonstrations were arranged for the farmers.

## Mateera field day

Mateera field day was organized on September 24, 2013 at village Jogasar, Barmer in collaboration with KVK, Danta, Barmer to acquaint the farmers with high seed yield genotypes of mateera.

## Animal health camp

Animal health camp was organized on July 24, 2013 under SUMAMAD project at village Bharamsar, Jaisalmer. In the camp, animals under different categories viz., cattle, goat, sheep and camel were treated for various diseases. Animals were de-wormed with broad spectrum anti-helmintic. More than half of the cattle were found deficient in body mineral content. About 1800 animals were examined and treated.

## Use of mineral mixture as animal feed supplement

Vitamin mineral mixture (Nutrimilk) was provided to 12 farmers for feeding to cattle, sheep and goats (4 farmers each) in Bharamsar village under SUMAMAD Project. The nutrimilk was mixed with feed for lactating cows at 50 g (25 g in morning and evening) and 5 g per day for goat and sheep. The results of initial six months indicated an increase in milk yield in cattle and improvement in the health of the animals.

## Farmers' trainings

About 10 farmers' training programs were organized on improved technologies of crops, fruits and natural resource conservation and management which were sponsored by various agencies including Schedule Caste Sub Plan (SCSP). Around 400-500 farmers took the advantage of these trainings. The main objective of these trainings was to make them aware for adoption of improved technologies of crop production and increase their income.

## Distribution of inputs to SC farmers under SCSP program

For upliftment of living standard of farmers of SC community, agricultural inputs such as improved varieties of crop seeds, fertilizers, multi-nutrient mixture, fruit plant seedlings were distributed to SC

farmers of Basanpeer, Narsingho ki dhani etc. under SCSP scheme during the year 2019-2020. Seeds of improved varieties of mung bean (IPM-2-3), bajra (HHB-272), moth bean (CAZRI moth-2), clusterbean (HG-2-20), cumin (GC-4) and mustard (NRCHB-101) were distributed under SCSP scheme. Besides, MNB (Multi Nutrient Block), MNM (Multi Nutrient Mixture) for livestock and fertilizers viz. DAP were also provided to the farmers. About 100 farmers benefitted from this program.

## Crop cafeteria

Promising cultivars of clusterbean, moth bean, mung bean and groundnut during kharif season and mustard, taramira, chickpea, cumin, isabgol and safflower in rabi season were demonstrated during 2018 in "crop cafeteria" with recommended package of practices. The major objective of the program was to showcase diversity and choice of cultivars available for different crops. About 500 stakeholders visited the crop cafeteria.

## Participation in farmer's fair/ exhibition

| Date | Venue |
|---|---|
| March 3, 2012 | Kisan Mela organized by Agriculture Department, Jaisalmer |
| February 9-11, 2013 | Exhibition at Bharat Nirman Jan Suchana Abhiyan, Pokaran, Jaisalmer |
| February 20, 2013 | Exhibition at District level Farmer' Fair at Jaisalmer |
| February 18, 2014 | District level Farmer' Fair organized by PD, ATMA, Jaisalmer |
| December 21, 2015 | Rojgar Mela - Koshal Rojgar evam Udyamita Shivir, District Employment Office, Gramin haat, Jaisalmer |
| August 30, 2016 | *Kisan Mela evam Krishi Pradarshani* organised by KVK, Jaisalmer (SKRAU, Bikaner) |
| September 13-15, 2018 | Farmer Fair-cum Farm Innovation Meet 2018, organized by CAZRI, Jodhpur |
| December 18, 2018 | Rabi *Sammelan* organized by KVK, Jaisalmer |

# Meetings and Events Organized

## National brainstorming workshop on rehabilitation of degraded rangelands

One-day national brainstorming workshop on 'Rehabilitation of degraded rangelands for sustainable livelihoods of Thar Desert' under UNESCO-funded SUMAMAD project was organized on September 5, 2012. The Chief Guest, Dr. T.S. Rathore, Director, AFRI, Jodhpur emphasized the importance of indigenous shrubs and trees along with grasses for improving productivity of rangelands through community participation. Delivering presidential address, Dr. M.M. Roy, Director, ICAR-CAZRI, Jodhpur elaborated on ways and means of rangeland improvement through improved technologies.

## National workshop on 'Managing resources for optimizing land productivity in the Thar Desert'

Under SUMAMAD Project, National workshop on 'Managing resources for optimizing of land productivity in Thar Desert' was organized at CAZRI, Jodhpur on July 19, 2013. The main themes on which participants deliberated were range management and agroforestry, arable arid farming, soil and water management, livestock management, energy management, socio economic issues and optimization of productivity with efficient natural resource conversion strategies.

## Mateera field day

A Mateera field day was organized on November 5, 2012 at the station to create awareness for seed purpose mateera as better livelihood option. More than 70 farmers of Jaisalmer district participated and visited the experimental site of mateera under rainfed conditions.

## Field day on threatened plants

A field day on threatened plants was organized on September 26, 2014 at the station under the DBT Project. About 85 participants including farmers, college students, officers from the state department of agriculture and forest; and representatives from NGOs participated in the program. There were lectures delivered by the scientists and discussion with the participants. It was followed by field visit to nursery and exhibition consisting the threatened plant species of the Thar Desert.


## Farmer's scientists interaction cum *Mateera* field day

Farmer's scientists interaction cum *Mateera* field day was organized on October 17, 2014 at the station, in collaboration with PD (ATMA) and Deputy Director (Extension), State Department of Agriculture, Jaisalmer. Scientists from CAZRI and officers from State Department of Agriculture and Animal Husbandry, Jaisalmer interacted with the farmers on various issues of crop production and

animal husbandry. Since, cultivation of seed purpose watermelon is an integral component of rainfed mix farming in the western Rajasthan, the main objective of the field day was to demonstrate the high seed yield genotypes of Mateera for increasing seed production and income generation of rainfed farmers. Selected mature fruits of Mateera from elite genotypes were also displayed to show the seed variability in fruits. About 80 farmers from nearby villages viz., Thaiyat, Basanpeer, Chandan, Bhairwa, Rupsi, Dabla, Jazia, Chhatrail participated in the program and showed their keen interest in growing seed purpose mateera.

## Sewan grass field day

Sewan grass field day was organized on September 29, 2015 under Mega Seed Project at Experimental Area, Chandan, Jaisalmer to create public awareness about its conservation and promotion. Chief Guest, Dr. Khyati Mathur, IFS, Deputy Conservator of Forest, Jaisalmer stressed upon

conservation of the precious arid sewan grasslands for sustainability of the grassland based animal husbandry system. Dr. J.P. Singh called upon the active people's participation for conservation and sustainable utilization of sewan grasslands. About 100 farmers from Chandan and nearby villages, representative of line departments of state government and NGO's actively participated.

## हिन्दी दिवस पर वैज्ञानिक गोष्ठी

स्थात्र पर 22 सितम्बर 2015 को 'हिन्दी भाषा का कृषि अनुसंधान क्षेत्र में उपयोग व महत्व' विषय पर गोष्ठी का आयोजन किया गया। मुख्य अतिथि श्री दीनदयाल ओझा, वरिष्ठ साहित्यकार, जैसलमेर ने कृषि की नवीनतम तकनीकी जानकारी को हिन्दी भाषा में कृषक समुदाय को उपलब्ध कराने का सुझाव दिया। डॉ. जे.पी. सिंह ने मरूस्थलीय वनस्पतियों के स्थानीय नामों की सार्थकता एवं उनकी उपयोगिता व जैव विविधता संरक्षण के विषय पर प्रकाश डाला।

हिन्दी चेतना मास के अवसर पर 29 सितम्बर 2016 को स्थात्र पर 'शुष्क दलहन की उत्पादकता वृद्धि में कृषकों एवं वैज्ञानिकों की सक्रिय भागीदारी' विषय पर एक वैज्ञानिक गोष्ठी आयोजित की गई। इस गोष्ठी में मुख्य अतिथि श्री राधेश्याम नारवाल, उपनिदेशक कृषि जैसलमेर थे। डॉ. जे.पी. सिंह ने शुष्क दलहन उत्पादन बढ़ाने में कृषकों एवं वैज्ञानिकों की सक्रिय भागीदारी की महता पर प्रकाश डाला।



## Visit of QRT

Institute QRT consisting, Dr. B. Venkateswarlu, Chairman, and members viz., Dr. G.R. Korwar, Dr. S.K. Gupta, Dr. K.S. Ramachandra and Dr. Bijay Singh visited the station along with Dr. O.P. Yadav, Director, ICAR-CAZRI and Dr. Praveen Kumar, Secretary QRT during November 13-14, 2016. The

team visited the research experiments at Jaisalmer and experimental area of Chandan. Dr. J.P. Singh, Head presented the past five years' salient achievements and future research thrusts of the station. The QRT Chairman and Members also interacted with the scientists of the station and gave their valuable suggestions.

## Consultation meeting on solar-wind hybrid potential in Rajasthan

A consultation meeting of solar-wind hybrid potential of Rajasthan was held at the station on November 14, 2016 under the Chairmanship of Dr. J.S. Samra, Chairman Institute RAC. Dr. O.P. Yadav, Director, welcomed Dr. J.S. Samra, Chairman RAC, Dr. B. Venkateswarlu, Chairman QRT, members of QRT, and resource persons from Rajasthan Renewable Energy Corporation Limited (RRECL), Jaipur. Potential of solar-wind hybrid was presented by Dr. Dilip Jain, Head, ICAR-CAZRI, Jodhpur. The present scenario of solar and wind energy utilization in world *vis-a-vis* India was discussed with special reference to hybrid potential on solar and wind at western Rajasthan. Resource personnel from RRECL, Suzlon Global Services Ltd. and Wind World Energy also shared their views. RAC Chairman, Dr. J.S. Samra emphasized to explore the possibilities and future potential of solar-wind hybrid power generation together with agriculture for best land utilization. He also emphasized for research works to study the impact of solar PV installation on soil erosion and shifting of sand dunes and combining agri-voltaic system with wind turbine. Team also visited the 1 MW solar power plant of Lanco Solar Energy Pvt. Ltd. at Lathi and wind turbine site of Suzlon Global Services Ltd. in Tejuva at Jaisalmer.

## Cleanliness drive

Swachhata Diwas was observed on October 2, 2019 under Swachhata Pakhwara from September 11-October 2, 2019 highlighting the theme *Ek Kadam Plastic Waste Mukt Bharat Ki Aur.* All the employees of the station actively participated with zeal and enthusiam in the cleaning activity. Plastic wrappers, glass bottles lying near premises outside of compound wall were collected and disposed off. All the *Prosopis juliflora* and *Calotropis procera* bushes outside and front of office compound wall were also cut and disposed off.

*Shramdaan* for general swachhata program was held on September 21, 2019. All staff including scientists, administrative, technical and supporting staff gathered and actively participated in collecting plastic trash and other waste material of the station campus on the occasion of national level program on "Open Defecation Free, Swachh Bharat Mission Grameen and Solid and Liquid waste management".

# Institute Development

- Construction of sheep pan, and tubewell at Experimental Area, Chandan
- Purchase and installation of power generator (25 KVA) during 2013-14
- Barbed wire fencing (1700 m length) carried out at experimental area, Chandan during 2014-15
- Civil works including repair, white washing, distempering and painting and maintenance of office building of main office at Jaisalmer and experimental area, Chandan completed
- Repair and renovation of office building and office premises and experimental area during 2018-19
- A tubewell was constructed at the station during the year 2019
- A threshing floor was constructed for threshing of farm produce at the station during the year 2020

# Linkages and Collaborations

- Agriculture Research Station, Mandore (AU, Jodhpur)
- AICRP on Pearl millet
- Department of Forest and Soil Conservation, Govt. of Rajasthan
- DRDA, Jaisalmer
- ICAR-Directorate of Medicinal and Aromatic Plants, Anand
- ICAR-IGFRI, Jhansi for AICRP on Forage Grasses and Legumes
- ICAR-NBPGR, New Delhi and its Regional Station, Jodhpur
- ICAR-NRC on Seed Spices, Ajmer
- KVK (SKRAU), Jaisalmer
- KVK (SKRAU), Pokaran
- KVK Gudamalani, Barmer
- Network Project on Arid Legumes
- SAC (ISRO), Ahmedabad
- State Department of Agriculture, Jaisalmer

# Capacity Building

## International Trainings

| Period | Name of training course and venue | Name of the participants |
|---|---|---|
| August 23-November 23, 2013 | NAIP sponsored training on "Marker Assisted Selection" at Michigan State University, East Lansing, Michigan, USA | H.R. Mahla |
| April 6-12, 2014 | Agro-ecological Monitoring at Jordan, organized by ICARDA REMU, Jordan and Oregon State University (OSU), USA | Venkatesan, K. |

## National Trainings

| Period | Name of training course and venue | Name of the participants |
|---|---|---|
| September15 - December 13, 2011 | 94th Foundation Course of Agricultural Research Service, ICAR-NAARM, Hyderabad | Venkatesan, K. |
| November 3-23, 2011 | Refresher Course on Agriculture Research Management for Newly Recruited Senior/Principal Scientists of Non-ICAR Institutes at ICAR-NAARM, Hyderabad | Dayanand |
| November 15-28, 2011 | National Training on Recent Trends of Geoinformatics in Land Resource Database Management for Sustainable Agriculture (NAIP), ICAR-NBSS& LUP, Nagpur | P. Raja |
| December 12-15, 2011 | International Training Program on Ecosystem Approach to Disaster Risk Reduction (Eco-DRR) at National Institute of Disaster Management (NIDM), New Delhi, India | N.K. Sinha |
| December 12-17, 2011 | Training Program on SAS software under "Strengthening of Statistical Computing for NARS" at MPUAT, Udaipur | P. Raja<br>Dayanand |
| January 23-April 24, 2012 | Professional Attachment Training with Short Problem titled "Morphological Characterization of *Aloe vera* Accessions from Rajasthan" at CAZRI, Jodhpur | Venkatesan, K. |
| April 9-20, 2012 | Management Development Program on Leadership Development (a pre-RMP prog.) ICAR-NAARM, Hyderabad | J.P. Singh |
| June 05-18, 2012 | Refresher Course on Agricultural Research Management for Newly Recruited Senior/Principal Scientists, ICAR-NAARM, Hyderabad | H.R. Mahla |
| October 15-19, 2012 | MDP Workshop on "Supply Chain Management in Agriculture" ICAR-NAARM, Hyderabad | H.R. Mahla |
| January 14-20, 2013 | Data Analysis using SAS Software, MPUAT, Udaipur | H.R. Mahla<br>Venkatesan, K. |
| March 24-28, 2014 | Drought Mitigation and Management. National Institute of Disaster Management, New Delhi at ICAR-CAZRI, Jodhpur | Venkatesan, K. |

| Period | Name of training course and venue | Name of the participants |
|---|---|---|
| December 8-17, 2014 | Climate Change Mitigation and Adaptation under Arid and Semi-arid Region at CAZRI, Jodhpur | Maharaj Singh |
| August 19-28, 2015 | Short course on "Crop Wild Relatives: Identification, Collecting and Utilization" at ICAR-NBPGR, New Delhi | Venkatesan, K |
| September15-25, 2015 | Integrated Farming System: An Approach Towards Livelihood Security and Natural Resource Conservation. ICAR Research Complex for NEH Region, Manipur Centre, Imphal | Julius Uchoi |
| August 03-23, 2016 | ICAR Summer School on "Livelihood and Climate Change Mitigation & Adaptation through Agroforestry" at ICAR-CAZRI, Jodhpur | Abhishek Kumar |
| July 2-September 29, 2018 | Foundation Course for Agricultural Research Service (FOCARS 108) at ICAR-NAARM, Hyderabad | Ankita Trivedi |
| November 20, 2018-February 19, 2019 | 3 months Professional Attachment Training for Probationers at ICAR-CSSRI, Karnal | Ankita Trivedi |
| November 20, 2018-February 19, 2019 | 3 months Professional Attachment Training for Probationers at ICAR-IARI, RRS, Karnal | Archana Sanyal |
| September 27-28, 2019 | Two days' Workshop cum Stakeholders Meeting organized by IWMI, New Delhi and KVK, Jaisalmer at KVK, Jaisalmer | M. Patidar<br>S.C. Meena<br>Ankita Trivedi |
| June 17, 2020 | One-day training program on e-office organized by ICAR-CAZRI, Jodhpur | M. Patidar<br>S.C. Meena<br>Archana Sanyal |
| July 13-October 13, 2020 | 3 months Professional Attachment Training for Probationers at ICAR-SBI, Coimbatore, Tamil Nadu | Saranya R. |
| August 18-September 02, 2020 | ABC of Scientific Writing organized by ICAR-NRRI, Cuttack in virtual mode | Anil Patidar |
| October 06-07, 2020 | National Workshop on Fundamental Concepts and Applications of Research Methodology organized by Bihar Agricultural University, Sabour, Bihar | Anil Patidar |
| October 14, 2020 | Nano-technological Interventions in Agriculture organized by Sri Karan Narendra Agriculture University, Jobner, Jaipur | Anil Patidar |
| November 09-17, 2020 | Analysis of Experimental Data using SAS organized by ICAR-NAARM, Hyderabad in virtual mode | Anil Patidar |

# Participation in Conference/Seminar/Symposia/ Workshop/Meetings

| Date | Name of seminar and venue | Name of participant |
|---|---|---|
| April 22-23, 2011 | National Seminar on "Contemporary Approaches to Crop Improvement" held at University of Agricultural Sciences, GKVK, Bangalore | H.R. Mahla |
| May 20-21, 2011 | Annual Arid Legumes Workshop held at SD Agricultural University, Sardarkrushinagar (Gujarat) | H.R. Mahla |
| May 31, 2011 | Meeting of the Sub-group on Feed and Fodder of the Working Group on Animal Husbandry and Dairying of the Planning Commission of India for the 12th Five Year Plan (2012-17) at CAZRI, Jodhpur | J.P. Singh |
| June 07, 2011 | Workshop on National Network Project on Guggal held at Directorate of Medicinal and Aromatic Plant Research, Anand | N.K. Sinha |
| June 09-10, 2011 | Workshop-cum-Review Meeting of Project "Energy and Mass Exchange in Vegetative Systems" at Forest Research Institute, Jabalpur | P. Raja |
| June 11-18, 2011 | Meeting-cum-Workshop on "Towards More Effective Role of Heads of Divisions and Regional Stations in ICAR Institutes" at ICAR-CIAE, Bhopal | J.P. Singh |
| August 01, 2011 | Review Meeting of Foreign Aided Projects under NRM Division, ICAR, New Delhi | J.P. Singh |
| August 08, 2011 | Workshop-cum-Review Meeting on Collective Natural Resource Conservation (LPPS) held at Gita Ashram, Jaisalmer, Rajasthan | N.K. Sinha |
| September 21-24, 2011 | 19th Group Meeting of AICRP on Medicinal & Aromatic Plants and Betelvine, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan | J.P. Singh |
| October 19-21, 2011 | National Symposium on "Recent Advances in Applied Geochemistry: Current Status and Future Trends", Indian Society of Applied Geochemist (ISAG) at AMD, Hyderabad | P. Raja |
| December 01, 2011 | XII Mid-Term Review Meeting of ICAR Committee-VI, CAZRI, Jodhpur | J.P. Singh |
| December 20-22, 2011 | National Symposium on Resource Utilization through Integrated Farming System and Biodiversity Conservation in Drylands. AZARI, CAZRI, RRS, Bhuj | J.P. Singh<br>H.R. Mahla<br>N.K. Sinha<br>Dayanand |
| January 02, 2012 | Review Meeting of Foreign Aided Projects under NRM Division, ICAR, New Delhi | J.P. Singh |
| February 18-19, 2012 | Brain Storming Workshop: Fodder for Sustainable Livestock Production and Environmental Security. ARS, SKRAU, Keshwana, Jalore | J.P. Singh |
| February 21-24, 2012 | International Open Science Congress on "Global Environmental Change-Challenges and Innovations" Deptt. of Geology, University of Madras, Chennai | P. Raja |
| March 12-13, 2012 | NAIP All India Workshop on Utilization of *Prosopis juliflora*: Challenges and Opportunities'. ICAR-CAZRI, Jodhpur | J.P. Singh |

| Date | Name of seminar and venue | Name of participant |
|---|---|---|
| March 25-28, 2012 | International Workshop cum Field Program on "Desert Dune Systems: Past Dynamics and Chronology" PRL (ISRO) GSI (GOI), Ministry of GSI (GOI), Ministry of Earth Sciences | P. Raja |
| May 02-03, 2012 | Annual Group Meet of National Network Research Project on Under-utilized Crops at MPKV, Rahuri | H.R. Mahla |
| July 09, 2012 | Review Meeting of Foreign Aided Projects at NRM Division, ICAR, New Delhi | J.P. Singh |
| September 05, 2012 | National Brainstorming Workshop on Rehabilitation of Degraded Rangelands for Sustainable Livelihood of the Thar Desert (under SUMAMAD project) CAZRI-RRS, Jaisalmer | J.P. Singh<br>H.R. Mahla<br>N.K. Sinha<br>K. Venkatesan |
| November 02-03, 2012 | National Symposium on Sustainable Production of Forages from Arable and Non-arable Land and its Utilization. RMSI, IGFRI, Jhansi | J.P. Singh |
| November 16-17, 2012 | XII Meeting of ICAR Regional Committee No. VI at CAZRI, Jodhpur | J.P. Singh |
| December 01-02, 2012 | National Symposium on "Managing Stresses in Drylands under Climate Change Scenario" at CAZRI, Jodhpur | J.P. Singh<br>H.R. Mahla |
| January 22, 2013 | Workshop on Biodiversity Program: CRP 1.1 Dryland Systems organized by Bioversity International Sub-regional Office for South Asia, New Delhi at CAZRI, Jodhpur | J.P. Singh |
| February 04, 2013 | Review Meeting of Foreign Aided Projects at NRM Division, ICAR, New Delhi | J.P. Singh |
| February 26 -27, 2013 | NAIP All India Workshop on *Prosopis juliflora*: Retrospect and Prospect. Bhuj (Kachchh), Gujarat | J.P. Singh |
| March 01-02, 2013 | National Workshop on Foresight and Future Pathways of Agricultural Research through Youth in India, NASC, New Delhi | H.R. Mahla |
| March 12, 2013 | Meeting of Heads of Division, PCs and Directors with DG, ICAR at New Delhi | J.P. Singh |
| March 14-15, 2013 | Workshop on Targeting Climate Resilient Agricultural Technologies in Arid Western Rajasthan (under NICRA Project), CAZRI, Jodhpur | J.P. Singh |
| March 19-21, 2013 | Workshop on "Museums and Intangible Natural Heritage with Focus on Desert" organized by National Museum of Natural History (Ministry of Environment & Forests, Govt. India, New Delhi) at Desert Cultural Centre, Jaisalmer | J.P. Singh |
| March 22, 2013 | Group Meeting of National Network Project on Guggal, DMAPR, Anand | N.K. Sinha |
| April 26-27, 2013 | Annual Group Meet of All India Coordinated Research Network on Under-utilized Crop at Agricultural Research Station, SKRAU, Mandore, Jodhpur | H.R. Mahla |
| July 19, 2013 | National Workshop on "Managing Resources for Optimizing Land Productivity in Thar Desert" under SUMAMAD-Project at CAZRI, Jodhpur | J.P. Singh<br>H.R. Mahla<br>N.K. Sinha |
| July 26, 2013 | Review Meeting of Foreign Aided Projects at NRM Division, ICAR, New Delhi | J.P. Singh |
| August 19, 2013 | Brain Storming Session on "Increasing Water Productivity in Indira Gandhi Command Area" at CAZRI-RRS, Bikaner | J.P. Singh |

| Date | Name of seminar and venue | Name of participant |
|---|---|---|
| December 18, 2013 | Mid-Term Review Meeting of ICAR Regional Committee No. VI at CAZRI, Jodhpur | J.P. Singh |
| January 06, 2014 | Interface Meeting on "Improving Health and Productivity of Tharparkar Cattle" at CAZRI, Jodhpur | J.P. Singh |
| January 10, 2014 | National Workshop on "Science, Technology, Innovation and Intellectual Property Rights: Envisaging the Interfaces" at CAZRI, Jodhpur | J.P. Singh |
| January 13, 2014 | Review Meeting of Foreign Aided Projects at NRM Division, ICAR, New Delhi | J.P. Singh |
| February 04, 2014 | Workshop on "Managing Arid Agriculture in Changing Climate. NICRA Project at CAZRI, Jodhpur | J.P. Singh<br>H.R. Mahla |
| February 05, 2014 | Regional Workshop on "Mainstreaming Agro biodiversity Conservation and Utilization in Agricultural Sector to Ensure Eco-system Services and Reduce Vulnerability" by Bioversity International, New Delhi at CAZRI, Jodhpur | J.P. Singh |
| February 23-24, 2014 | National Seminar on Breeding for Abiotic Stresses: Problems and Prospects. Indian Society of Genetics and Plant Breeding, Birsa Agricultural University, Ranchi | H.R. Mahla |
| March 21, 2014 | National Workshop on Cactus Pear at CAZRI, Jodhpur | J.P. Singh |
| May 12-13, 2014 | Annual Group Meet of All India Coordinated Research Network on Underutilized Crops held at NBPGR, Regional Station, Phagli, Shimla | H.R. Mahla |
| May 22, 2014 | 2nd Innovation Platform Meeting. CGIAR-Dryland Systems: Integrated Agricultural Production Systems for Improved Food Security and Livelihoods in Dry areas (South Asia), held at CAZRI, Jodhpur | J.P. Singh |
| May 29, 2014 | Terminal Workshop on Livestock Migration under ICAR-ICARDA Project "Coping Strategies for Livestock Smallholders in the Face of Climate Change and Soaring Feed Prices: Case Study of Livestock Mobility in the State of Rajasthan, India" held at CAZRI, Jodhpur | J.P. Singh<br>Venkatesan, K. |
| August 21, 2014 | Workshop on Crop Water Productivity in IGNP Areas under ICAR-ICARDA Project | J.P. Singh |
| September 12-13, 2014 | ICAR Regional Committee No. VI at AAU, Anand, Gujarat | J.P. Singh |
| October 07, 2014 | Workshop on "Potential for Sustainable Intensification under *Khadin* System" organized by ICRISAT, Hyderabad at Jaisalmer | J.P. Singh<br>Maharaj Singh<br>H.R. Mahla<br>Venkatesan, K. |
| October 16-18, 2014 | International Symposium on New Dimensions in Agrometeorology for Sustainable Agriculture, held at GBPUAT, Pantnagar | Maharaj Singh |
| June 08-09, 2015 | Annual Group Meet on Arid Legume, held at CAZRI, Jodhpur | Maharaj Singh |
| November 06, 2015 | Workshop on "Agricultural Development of Western Dry Region". CAZRI, Jodhpur | J.P. Singh |
| November 07, 2015 | Mid-Term Review Meeting of ICAR Regional Committee No. VI at CAZRI, Jodhpur | J.P. Singh |
| December 20-24, 2015 | 23rd International Grassland Congress, Rangeland Management Society of India, at New Delhi | J.P. Singh<br>Maharaj Singh |

| Date | Name of seminar and venue | Name of participant |
|---|---|---|
| February 26, 2016 | Climate Change: Mitigation and Adaptation in Hot Arid Region, Regional Research Station, Bikaner under NICRA Project | J.P. Singh<br>Abhishek Kumar |
| April 06-07, 2016 | Pre launch Meeting of GEF CEO Project "Mainstreaming Agrobiodiversity Conservation and Utilization in the Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability", organized by Bioversity International, NASC Complex, New Delhi | J.P. Singh |
| May 22-24, 2016 | Annual Group Meeting of All India Network Research Project on Arid Legumes held at UAS, Bengaluru | Maharaj Singh |
| June 18, 2016 | Meeting on "Research Priorities, Partnership and Policies for Increasing Productivity of Pearl millet in A1 Zone" jointly organized by ICAR-All India Coordinated Research Project on Pearl Millet, Jodhpur and ICAR-Central Arid Zone Research Institute, Jodhpur at CAZRI, Jodhpur | J.P. Singh |
| September 13-14, 2016 | ICAR Regional Committee No. VI Meeting. CAZRI, Jodhpur | J.P. Singh |
| September 19, 2016 | State Inception Workshop on Green Agriculture, organized by FAO and State Department of Agriculture at SIAM, Durgapura, Jaipur | J.P. Singh |
| November 06-09, 2016 | 1st International Agro Biodiversity Congress (IAC) 2016 organized by ISPGR and Bioversity International at New Delhi | J.P. Singh |
| January 16-18, 2017 | National Review Meeting on Cactus Pear. Sponsored by ICARDA and organized by ICAR-CAZRI, RegionalReserch Station, Kukma-Bhuj, Gujarat | J.P. Singh |
| January 21-23, 2017 | 5th National Seminar on "Climate Resilient Saline Agriculture: Sustaining Livelihood Security", SKRAU, Bikaner, organized by Indian Society of Soil Salinity and Water Quality, Karnal at SKRAU, Bikaner | J.P. Singh |
| March 03-04, 2017 | National Symposium on New Directions in Managing Forage Resources and Livestock Productivity in 21st Century: Challenges and Opportunities, RVSKVV, Gwalior, India | Anil Patidar |
| April 28-30, 2018 | Annual Group Meet on Kharif Pulses of All India Coordinated Research Project on MULLaRP and Arid Legumes at SDAU, S.K. Nagar, Dantiwada, Gujarat | Anil Patidar |
| December 26-27, 2018 | District Level Seminar organized by NRCSS Ajmer at Jaisalmer | S.C. Meena<br>Abhishek Kumar |
| January 10, 2019 | Seminar on Climate Change and Desertification: Renewable Energy Solutions for Enhancing Mitigation Potential in Rajasthan, organized by ENVIS Resource Partners- TERI, New Delhi and ICAR-CAZRI Jodhpur | S.C. Meena<br>Dileep Kumar<br>Abhishek Kumar |
| February 07-09, 2019 | International Salinity Conference (GJISC-2019), ICAR-CSSRI, Karnal | Ankita Trivedi |
| February 20-23, 2019 | XIV Agricultural Science Congress held at NASC Complex, Pusa, New Delhi | Julius Uchoi |
| September 27-28, 2019 | Workshop on "Scaling out Climate-smart Agriculture for Resilient Farming in India" organized by IWMI, New Delhi and KVK, Jaisalmer at KVK, Jaisalmer | M. Patidar<br>Dileep Kumar<br>S.C. Meena<br>Julius Uchoi<br>Ankita Trivedi |
| May 29, 2020 | International Webinar on Arsenic Mitigation: A Nexus Approach at Bihar Agricultural University, Sabour, Bihar | Archana Sanyal<br>Ankita Trivedi |

| Date | Name of seminar and venue | Name of participant |
|---|---|---|
| July 17-19, 2020 | National Conference on Agricultural Resource Management for Atmanirbhar Bharat at Central Agricultural University, Imphal, Manipur (online) | Archana Sanyal<br>Ankita Trivedi |
| October 29, 2020 | Online National Webinar on Management Options for Better Water Productivity in Oil Plam | M. Patidar |
| November 05, 2020 | Online Brain Storming on Integrated Farming System and Farmer Income, organized by Department of Agronomy, RCA, MPUAT Udaipur | M. Patidar |
| December 28-30 2020 | International Web Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2020) at Astha Foundation, Meerut, Uttar Pradesh | Dileep Kumar<br>Archana Sanyal |
| December 30, 2020 | Workshop on "Modern Intervention for Environmental Management" organized by ICAR-Indian Institute of Agricultural Biotechnology, Ranchi | Archana Sanyal<br>Saranya, R. |

# Participation in Meetings and Programs Organized by State Line Departments

| Date | Subject of meeting/program | Department/ stakeholder/agency | Place | Name of participants |
|---|---|---|---|---|
| May 12, 2011 | Training program on Krishak Mitra | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| July 13, 2011 | Scientific Advisory Committee Meeting | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| August 26, 2011 | Van Mahotsava Program | District Environment Society, Forest Department | Jaisalmer | J.P. Singh |
| September 16, 2011 | International Ozone Day | Forest Department | Jaisalmer | J.P. Singh |
| December 13, 2011 | Farmers Training Program & Farmers Scientists Interaction | Agriculture Department & ATMA | Bhopa, Jaisalmer | J.P. Singh H.R. Mahla |
| March 03, 2012 | District level Kisan Mela | Agriculture Department & ATMA | Pokaran, Jaisalmer | J.P. Singh |
| March 20, 2012 | Remote Sensing Awareness and Introduction Workshop | State Department of Science & Technology | Jaisalmer | J.P. Singh |
| October 10, 2012 | Scientific Advisory Committee Meeting | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| November 08, 2012 | Kisan Goshthi | Agriculture Department & ATMA | Fatehgarh, Jaisalmer | J.P. Singh |
| January 22, 2013 | Training Program for Women Tailors | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| February 20, 2013 | District level Kisan Mela | Agriculture Department & ATMA | Jaisalmer | J.P. Singh |
| March 07, 2013 | Two week Orientation Program of Newly Recruited Agricultural Supervisors | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| March 22, 2013 | Training Program on Village Level Water Management | Central Ground Water Board, Western Region, Jaipur | Jaisalmer | J.P. Singh |
| April 15, 2013 | Scientific Advisory Committee Meeting | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| July 09, 2013 | Farmers' Training on Improved Production Rechnology of Kharif Crops | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| August 13, 2013 | Scientific Advisory Committee Meeting | KVK, Danta | Barmer | J.P. Singh |
| September 16, 2013 | International Ozone Day | Forest Department | Jaisalmer | J.P. singh |

| Date | Subject of meeting/program | Department/ stakeholder/agency | Place | Name of participants |
|---|---|---|---|---|
| October 07, 2013 | Wildlife Week | Deputy Conservator of Forest, Wildlife | Jaisalmer | J.P. Singh |
| October 15, 2013 | One Day Farmers' Training under National Horticulture Mission | District Horticulture Society and ATMA | Village Bherwa (Sohan Singh ki Dhani) Jaisalmer | J.P. Singh |
| October 18, 2013 | One Day Farmers' Training under National Horticulture Mission | District Horticulture Society and DD Agriculture | Dabla, Jaisalmer | J.P. Singh |
| January 30, 2014 | Scientist-Farmers Interaction | Department of Agriculture at KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| February 18, 2014 | District Level Kisan Mela | Agriculture Department | Jaisalmer | J.P. Singh |
| September 16, 2014 | Meeting with regard to ATMA and other projects | Department of Agriculture, Jaisalmer | District Collector, Jaisalmer | J.P. Singh |
| November 05, 2014 | Farmer's Training Program on Rabi Crops | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| January 13, 2015 | Workshop on "Hamara Jal Hamara Jeevan" | Water Resource Department | Jaisalmer | J.P. Singh<br>H.R. Mahla |
| February 09, 2015 | One day INSIMP Training Program | Department of Agriculture | Jaisalmer | J.P. Singh |
| March 23, 2015 | Meeting with regard to National Mission on Agricultural Extension and Technology (NMAET) and National Mission for Sustainable Agriculture (NMSA) Project | Department of Agriculture | District Collectorate, Jaisalmer | J.P. Singh |
| March 25, 2015 | GO-NGO Coordination Workshop | CECODECON | DRDA, Jaisalmer | J.P. Singh |
| May 11, 2015 | Scientific Advisory Committee Meeting | KVK, Pokaran and Jaisalmer | Jaisalmer | J.P. Singh |
| June 05, 2015 | ICAR, DAC and Department of Agriculture, Govt. of Rajasthan Interface Meeting | Department of Agriculture | Jaipur | J.P. Singh |
| August 11, 2015 | Kisan Gosthi | Department of Agriculture | Tejwa, Jaisamer | J.P. Singh<br>Abhishek Kumar |
| October 16, 2015 | Farmers Scientists Interaction | KVK, Pokaran | Pokaran, Jaisalmer | J.P. Singh |
| December 13, 2015 | Workshop on Medicinal Plants | KVK, Danta | Barmer | J.P. Singh |
| December 16, 2015 | Soil Health Day | KVK, Jaisalmer | Jaisalmer | J.P. Singh |
| March 17, 2016 | Scientific Advisory Committee Meeting | KVK, Pokaran and Jaisalmer | Jaisalmer | J.P. Singh |

| Date | Subject of meeting/program | Department/ stakeholder/agency | Place | Name of participants |
|---|---|---|---|---|
| September 19, 2016 | State Inception Workshop on Green Agriculture | FAO and State Department of Agriculture | SIAM, Durgapura, Jaipur | J.P. Singh |
| September 22, 2016 | One-day Civil Society Workshop and Stakeholder Consultation with regard to Green Agriculture Project | KRAPAVIS Alwar and sponsored by FAO | KVK, Jaisalmer | J.P. Singh |
| January 21, 2020 | Scientific Advisory Committee Meeting | Krishi Vigyan Kendra, Pokaran | Pokaran | M. Patidar<br>Ankita Trivedi |
| January 22, 2020 | Scientific Advisory Committee Meeting | Krishi Vigyan Kendra, Jaisalmer | Jaisalmer | M. Patidar<br>S.C. Meena<br>Archana Sanyal |
| September 16, 2020 | Scientific Advisory Committee Meeting | Krishi Vigyan Kendra, Jaisalmer and Pokaran | Jaisalmer | M. Patidar<br>S.C. Meena<br>Archana Sanyal |

# Radio Talks

- 18 मार्च 2013. वन–चरागाह विकास एवं प्रबंधन, आकाशवाणी, जैसलमेर
- 6 सितम्बर 2013. गुग्गल का औषधीय एवं व्यापारिक महत्व, आकाशवाणी, जैसलमेर
- 18 सितम्बर 2014. क्षारीय भूमि का सुधार कैसे करें. आकाशवाणी, जैसलमेर
- 24 जून 2015. राष्ट्रीय कृषि विकास योजना. आकाशवाणी, जैसलमेर
- नवम्बर 27 2015. पश्चिमी राजस्थान के प्रमुख औषधीय पौधे एवं उनका महत्व. आकाशवाणी, जैसलमेर
- 5 जनवरी 2019. कृषि में पाला से बचाव के उपाय. आकाशवाणी, जैसलमेर
- 2 फरवरी 2019. रबी फसलों में फरवरी के प्रथम पखवाड़े के कृषि कार्य आकाशवाणी, जैसलमेर
- 19 मई 2019. मई माह के दूसरे पखवाड़े में कृषि क्रियाऐं. आकाशवाणी, जैसलमेर
- 4 जून 2019. जून के प्रथम पखवाड़े में कृषि कार्य, आकाशवाणी, जैसलमेर
- 3 अगस्त 2019. अगस्त माह के प्रथम पखवाड़े के कृषि कार्य, आकाशवाणी, जैसलमेर
- 2 नवम्बर 2019. रबी फसलों में नवम्बर माह के कृषि कार्य, आकाशवाणी, जैसलमेर
- 5 नवम्बर 2019. नवम्बर के प्रथम पखवाड़े में कृषि कार्य, आकाशवाणी, जैसलमेर
- 26 नवम्बर 2019. उद्यानिकी फसलों में पौध संरक्षण, आकाशवाणी, जैसलमेर
- 9 दिसंबर 2019. दिसम्बर माह के प्रथम पखवाड़े के कृषि कार्य, आकाशवाणी, जैसलमेर
- 25 दिसंबर 2019. दिसंबर माह के दूसरे पखवाड़े के कृषि कार्य, आकाशवाणी जैसलमेर
- 1 जनवरी 2020. कृषि में महिलाओं की भूमिका, आकाशवाणी, जैसलमेर
- 22 फरवरी 2020. कृषि वानिकी का सतत विकास में महत्व, आकाशवाणी, जैसलमेर
- 7 मार्च 2020. मार्च माह के कृषि कार्य, आकाशवाणी, जैसलमेर
- 19 अगस्त 2020. कृषि में गुणवत्ता युक्त बीज का महत्व, आकाशवाणी, जैसलमेर
- 4 सितम्बर 2020. सितम्बर माह के कृषि कार्य, आकाशवाणी, जैसलमेर

# Publications

## Research Papers


Birbal, Kumawat, R.N. and Mertia, R.S. 2016. Fruit physical characteristics of datepalm cultivation grown under Jaisalmer condition in western Rajasthan. *International Journal of Tropical Agriculture* 34(4): 951-954.

Chakraborty, D., Mazumdar, S.P., Garg, R.N., Banerjee, S., Santra, P., Singh, R. and Tomar, R.K. 2011. Pedotransfer functions for predicting points on the moisture retention curve of Indian soils. *Indian Journal of Agricultural Sciences* 81: 1030-1036.

Dayanand, Mahla, H.R., Rathore, V.S. and Singh, J.P. 2013. Effect of soil and foliar application of nitrogen on yield attributes and yield of clusterbean [*Cyamopsis tetregonoloba* (L.) Taub.] under extreme Thar Desert conditions. *Research on Crops* 14: 130-134.

Dev, R., Sureshkumar, M., Kumar, S., Venkatesan, K., Singh, T., Tetarwal, A.S., Patidar, A., Dayal, D. and Meghwal, P.R. 2020. Collection, characterization, conservation and utilization of *Cordia sinensis* Lam.: An underexploited multipurpose fruit species of hot arid regions. *Plant Genetic Resources: Characterization and Utilization* 18(6): 427-436.

Kumar, S., Singh, J.P., Venkatesan, K., Mathur, B.K. and Bhatt, R.K. 2017. Changes in seasonal vegetation and sustenance of tussocky arid rangeland under different grazing pressures. *Range Management & Agroforestry* 38: 35-42.

Kumawat, R.N., Mahajan, S.S. and Santra, P. 2013. Effect of panchgavya on soil chemical properties of groundnut (*Arachis hypogea*) and crop productivity in western Rajasthan. *Journal of Food Legumes* 26: 39-43.

Mahla, H.R. and Choudhary, B.R. 2013. Genetic diversity in seed purpose watermelon (*Citrullus lanatus*) genotypes under rainfed situations of Thar Desert. *Indian Journal of Agricultural Sciences* 83: 300-303.

Mahla, H.R. and Singh, J.P. 2013. Assessment of *in-situ* variability in Kair (*Capparis decidua*) germplasm for utilization in genetic improvement through *ex-situ* conservation. *Annals of Arid Zone* 52: 109-112.

Mahla, H.R., Kumar, D., Henry, A., Acharya, S. and Pahuja, S.K. 2011. Guar-Present status and future prospects in arid zone. *Journal of Arid Legumes* 8: 133-137.

Mahla, H.R., Rathore, V.S., Singh, D. and Singh, J.P. 2013. *Capparis decidua* (Forsk.) Edgew.: A underutilized multipurpose shrub of hot arid region-distribution, diversity and utilization. *Genetic Resources and Crop Evolution* 60: 385-394.

Mahla, H.R., Venkatesan, K. and Singh, J.P. 2017. Genetic variability and stability for seed yield related traits in seed purpose watermelon genotypes under rainfed situations for hot arid zone. *Annals of Arid Zone* 56: 103-106.

Mathur, B.K., Kumar, A., Tanwar, S.P.S., Barewa, M., Singh J.P. and Bhatt, R.K. 2019. Climate change adaptation: Coping strategies for minimizing constraints of extreme climatic conditions of Thar Desert on sheep production. *Annals of Arid Zone* 58: 107-116.

Mertia, R.S., Sinha, N.K., Santra, P. and Singh, D. 2012. Influence of seed size and sowing depth on emergence and growth performance of *Salvadora oleoides* in the Indian Thar Desert. *Indian Forester* 138: 646-651.

Prasad, R., Mertia, R.S., Gajja, B.L., Singh D. and Prajapat C.P. 2013. Morphological characteristics of tree shelterbelts and their impact on wind regimes, air temperature and soil quality. *Indian Journal of Agroforestry* 15: 74-81.

Raja, P., Bhattacharya, B.K., Singh, N., Sinha, N.K., Singh, J.P., Parihar, J.S. and Roy, M.M. 2013. Seasonal radiation and energy fluxes in a desert grassland ecosystem. *Journal of Applied Forest Ecology* 2: 45-52.

Raja, P., Bhattacharya, B.K., Singh, N., Sinha, N.K., Singh, J.P., Pandey, C.B., Parihar, J.S. and Roy, M.M. 2013. Surface energy balance and its closure in arid grassland ecosystems: A case study over Thar Desert. *Journal of Agrometerology* 15 (1): 94-99.

Santra, P., Kumawat, R.N., Mertia, R.S., Mahla, H.R. and Sinha, N.K. 2012. Soil organic carbon stock density and its spatial variation within a typical agricultural farm from hot arid ecosystem of India. *Current Science* 102: 1303-1309.

Santra, P., Mertia, R.S., Kumawat, R.N., Sinha, N.K. and Mahla, H.R. 2013. Loss of soil carbon and nitrogen through wind erosion in the Indian Thar desert. *Journal of Agricultural Physics* 13: 13-21.

Santra, P., Kumawat, R.N., Inakhiya, N.D., Bhati, T.K., Roy, M.M., Mishra, D. and Bhatt, R.K. 2014. Food-water-energy nexus in arid region: An analysis from Jaisalmer district of western Rajasthan. *Journal of Agricultural Physics* 14(2): 161-166.

Santra, P., Moharana, P.C., Kumar, M., Soni, M.L., Pandey, C.B., Chaudhari, S.K. and Sikka, A.K. 2017. Crop production and economic loss due to wind erosion in hot arid ecosystem of India. *Aeolian Research* 28: 71-82. doi: 10.1016/j.aeolia.2017.07.009.

Santra, P., Kumar, M., Kumawat, R.N., Painuli, D.K., Hati, K.M., Heuvelink, G. and Batjes, N. 2018. Pedotransfer functions to estimate soil water retention at field capacity and permanent wilting point in hot arid western India. *Journal of Earth System Science* 127: 35. doi:10.1007/s12040-018-0937-0

Singh, J.P., Kumar, S., Venkatesan, K. and Kulloli, R.N. 2016. Conservation status and utilization of *Caralluma edulis*: An important threatened medicinal plant species of the Thar Desert, India. *Genetic Resources and Crop Evolution* 63: 721-732. doi: 10.1007/s10722-016-0366-3

Singh, M., Sinha, N.K., Venkatesan, K. and Raja, P. 2014. Canopy temperature depression and its effect on seed set and seed yield of Sewan grass (*Lasiurus sindicus* Henr.). *Journal of Agro-meteorology* 16(1): 274-277.

Sinha, N.K., Mertia, R.S., Kandpal, B.K., Kumawat, R.N., Santra, P. and Singh, D. 2012. Morphological characterization of Guggal (*Commiphora wightii*) provenances from extremely arid parts of India. *Forests, Trees and Livelihoods* 21: 63-69.

Sinha, N.K., Kumar, S., Santra, P., Raja, P. and Mertia, D.S. 2014. Temporal growth performance of Indian myrrh (*Commiphora wightii*) raised by seedlings and cuttings from same genetic stocks in the extremely arid Thar desert of India. *The Ecoscan* 8: 241-244.

Sinha, N.K., Mertia, R.S., Santra, P. and Raja, P. 2014. Soil seed bank in rangelands of the Indian Thar desert under different grazing pressures. *The Ecoscan* 6: 323-328.

Trivedi, A. and Dutta, A. 2020. Soil health cards: Limitations and ways to fix the loopholes. *Current Science* 118 (9): 1137-1138.

Uchoi, J., Nikhumbhe, P.H., Kumar, A., Patidar, A. and Harish, G.D. 2020. Impact of inclined solar drier for dehydration quality in Khadrawy dates during doka maturity stage at northwestern arid India. *International Journal of Current Microbiology and Applied Sciences* 9(6): 119-125.

Uchoi, J., Singh, R.S., Bhargava, R., Krishna, H., Venkatesan, K., Kumar, A. and Patidar, A. 2018. Effect of harvesting of fruits at different stage of maturity on nutritional quality of Kinnow under hot arid zone of northwestern India. *Green Farming* 9(2): 379-382.

Venkatesan, K., Patidar, A., Singh, M., Kumar, M., Kumawat, R.N., Dev, R., Uchoi, J., Kumar, A., Mertia, D.S. and Singh, J.P. 2019. Distribution, associated vegetation, conservation and utilization of *Grewia tenax*: An important underutilized shrub species of the Thar Desert of India. *Plant Genetic Resources: Characterization and Utilization* 17(1): 73-80. doi:10.1017/S1479262118000370

## Bulletin

Mahla, H.R., Singh, J.P. and Roy, M.M. 2014. *Seed Purpose Watermelon in Arid Zone*. CAZRI, Jodhpur. 44 p.

## Training Manuals

Kumar D., Meena, S.C., Sanyal, A., Rangnathan, S. and Patidar, M. 2020. *Enhancing Productivity and Production of Kharif Crops through Improved Cultivation Practices in Arid Region of Rajasthan.* ICAR-CAZRI-RRS, Jaisalmer. 36 p.

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## Book Chapters

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# Awards and Recognitions

- Dr. J.P. Singh conferred with the Fellow of the Range Management Society of India (RMSI) Jhansi during 2011 for his contribution in Grassland Management and Biodiversity Conservation.
- CAZRI-RRS, Jaisalmer got first prize in District Farmer's Fair held on February 20, 2013 at Jaisalmer.
- Dr. Maharaj Singh, Sr. Scientist (Plant Physiology), was awarded "Rajeev Gandhi Gyan-Vigyan Moulik Pustak Lekhan Puraskar" by the Hon'ble President of India Shri Pranab Mukherjee on September 14, 2015 at Vigyan Bhawan, New Delhi.
- Dr. Dileep Kumar, Scientist, was awarded Young Scientist Award by Society for Scientific Development in Agriculture and Technology, Meerut, during International Conference held on December 02-04, 2017 at MPUAT, Udaipur
- Dr. S.C. Meena was appointed as one of the Editorial Board Members in SCIREA 'Journal of Agriculture'.
- Dr. M. Patidar was conferred with the Vasantrao Naik Award 2019 for research application in Agriculture.

# Distinguished Visitors

- Dr. P.S. Pathak, Member, QRT, ICAR-CAZRI, Jodhpur and Ex. Director, ICAR-IGFRI, Jhansi visited the Experimental Area, Chandan on September 23, 2011
- Dr. V.N. Sharda, Member, Agricultural Scientist Recruitment Board, ICAR, New Delhi on October 2-3, 2012

- Dr. S.P.S. Ahlawat (Chairman), Dr. D. Kumar, Head, Department of Parasitology, Pondicherry Veterinary College, Pondicherry (Member), Dr. D.K. Rao, Principal Scientist, Parasitology, NAARM, Hyderabad (Member), Miss K.I. Rollefsom, NGO, Lohit Pashupalak Sansthan, Pali (Member) and Dr. N.V. Patil, Director, NRC on Camel on October 04, 2012

- Dr. A.K. Singh, DDG (NRM) on October 06, 2012

- Dr. A.M. Shekh, VC, Dr. K.B. Kathiria, Director Research and Dr. P.P. Patel, Director Extension, Anand Agricultural University, Anand on November 15, 2012

- Dr. A.K. Sikka, DDG (NRM) on October 2, 2014

- Dr. N.K. Krishna Kumar, DDG (Hort.), ICAR, New Delhi on March 22, 2015, accompanied by Dr. S.K. Sharma, Director, ICAR-CIAH, Bikaner

- Dr. Joykrushna Jena, DDG (Fisheries Science), ICAR, New Delhi on September 11, 2016

- Shri N.K. Vasu, Director, AFRI, Jodhpur on December 20, 2016
- Dr. T. Mohapatra, Hon'ble DG, ICAR on September 29-30, 2018

- Dr. B. Bhattacharya, SRAC, Ahmedabad on April 25, 2011
- Shri P. Mansion, Joint Director (Agriculture), Jaipur on May 20, 2011
- Dr. H.P. Singh, DDG (Hort.), ICAR, New Delhi on August 15, 2011
- Dr. S.K. Sharma, Director, ICAR-CIAH, Bikaner on August 15, 2011
- Shri N.K. Sharma, Director, Desert Cultural Centre, Jaisalmer on September 14, 2011
- Dr. P.N. Kalla, Director (Ext.) SKRAU, Bikaner on January 16, 2012

- Prof. A.K. Dahma, VC, SKRAU, Bikaner on January 17, 2012
- Dr. K.D. Kokate, DDG (Extension), ICAR, New Delhi on January 17, 2012
- Dr. Gopal Lal, I/c Director, ICAR-NRC Seed Spices, Ajmer on March 04, 2012
- Dr. Balraj Singh, Director, ICAR-NRCSS, Ajmer on February 20, 2013
- Dr. Ashutosh Sarker, ICARDA, New Delhi on April 08-09, 2013
- Dr. T.S. Rathore, Director, AFRI, Jodhpur on December 19, 2013
- Dr. A.K. Srivastava, Director, NDRI, Karnal on January 05, 2014
- Dr. N.V. Patil, Director, ICAR-NRC Camel, Bikaner on January 05, 2014
- Dr. Madhumita Biswas, Director, MoEFCC, New Delhi on January 31, 2015
- Dr. S.K. Singh, Director, ICAR-NBSS & LUP, Nagpur on November 30, 2016
- Dr. S. Bhaskar, ADG, ICAR, New Delhi on December 14, 2018


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