भाकृअनुप
ICAR

राअस्ट्रैप्रसं
NIASM

Mission, Mandate & Projects of NIASM

ICAR-National Institute of Abiotic Stress Management
Baramati, Pune, Maharashtra
www.niam.res.in

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

भाकृअनुप ICAR

राअस्ट्रैप्रसं NIASM

Introduction

- ICAR-National Institute of Abiotic Stress Management (NIASM), established in 2009, to explore avenues for management of abiotic stresses affecting the progress and sustainability of national food production systems.
- It specifically addresses the stresses occurring from aberration in atmospheric, water and edaphic factors on crop, livestock, poultry and fisheries and their management.

Mandate

- Basic and strategic research to manage abiotic stresses in crops, livestock and fisheries.
- Repository of information on abiotic and biotic stresses, adaptation and mitigation strategies and policies.
- Building sustainable agriculture in multi-stressed agro-ecosystems.
- Serve as Center of Academic Excellence in managing multiple stresses in agriculture.

Mission

Managing abiotic stresses for sustainable agriculture.

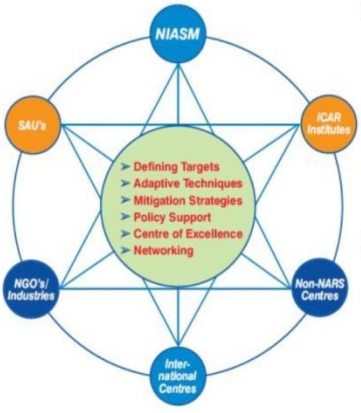
Schools

1. Atmospheric Stress Management
2. Soil Stress Management
3. Water Stress Management
4. Social Science and Policy Support

Objectives

- Assess the vulnerability of crops, horticulture, livestock, fisheries and microbes to abiotic stresses.
- Develop technologies and policies for adaptation and mitigation of atmospheric, water and soil stresses with frontier science.
- Develop repository of information on abiotic stress management for climate-smart agriculture.
- Establish Center of Academic Excellence for human resource development to manage multiple stresses in agriculture.

Strategy



- Six-point interlinked strategy is adopted to enhance effectiveness of research, extension and academic activities.
- It includes defining of target environments, adaptive techniques, mitigation strategies, policy support and synergies through networking.

2009: Original Site

2019: Rabi Season

2020: Kharif Season

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NIASM-A Decade of Service (2009-2019)

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

Introduction

- ICAR-NIASM has a mission to manage abiotic stresses for sustainable agriculture.
- It conducts basic and strategic research for developing sustainable technolgies for managing abiotic stresses.
- In one decade of its existance, NIASM has developed and disseminated the following technologies.

Technologies Developed

1. Transforming barren rocky basaltic terrain into cultivable land.


Ripping of rocky surface


Blasting


Application of spent wash


Spent mushroom substrate


Levelling


Growing of various crops

2. Orchard establishment for obviate drought and edaphic stresses in shallow basaltic soils of semi-arid region.


Pits after blasting


Establishment of mandarin


Mandarin orchard


Sapota orchard


Pomegranate orchard



Guava & sweet orange orchard

3. Dragon Fruit: Wonder crop for rocky barren lands and water scarce areas.


Trellies


Flowering


Drooping


Bagging

4. SORF: A multi-purpose machine for ratoon sugarcane.

5. Plant bio-regulators for enhancing productivity and quality of major crops in water-scarce regions.

6. Nano-structured material for stress alleviation in aquaculture.

7. Development of a microbial-derived polymeric product for drought mitigation.


Development and evaluation of biopolymer

8. Deficiency irrigation as a strategy for improving water productivity of horticulture crop grown in limited water in shallow basaltic terrain.

9. Mixed silage of sugarcane tops for sustaining milk production during scarcity periods in drought prone areas.

1. Research papers: 115
2. Technical bulletins: 40
3. Leaflet/Tech. Folder: 40
4. Trainings conducted: 20
5. Students guided: 20
6. Webinar/Conference: 10

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School of Atmospheric Stress Management

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

Introduction

- School of Atmospheric Stress Management (SASM) addresses the stresses due to atmospheric factors responsible for losses in crop, livestock and fisheries productivity, especially in arid and semiarid regions.
- Since the abiotic stresses are amplifying due to climate change and land degradation, the primary task for the School is to evolve strategies involving adaptation and mitigation techniques through advances in frontier science.
- The School is structured to enhance capacity of scientists and policy makers mainly by imparting knowledge and providing the state-of-art facilities for multidisciplinary and multi-commodity research.

Objectives

- Assessing vulnerability of crops, livestock and fisheries to atmospheric stressors.
- Unravelling the mechanisms and traits for atmospheric stress tolerance in crops and animals.
- Developing adaptation and mitigation strategies for atmospheric stress management.
- Developing decision support systems for optimizing input use and climate proofing.



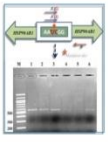
Major Projects

- Geo-spatial digital maps of multiple abiotic stresses, management options and future scenarios (NIASM Umbrella Project).
- Adaptation and mitigation of atmospheric stresses in crops, livestock, poultry and fishes for Sustainable productivity and profitability (NIASM Flagship Project).
- Characterizing sugarcane and citrus stress responses to abiotic and biotic stresses through hyperspectral remote sensing (DST).
- Study of immune response and HSP genes polymorphism in relation to heat stress in poultry.
- Spectral delineation of moisture and nutrient stresses in vineyards through hyperspectral spectroscopy.



Salient Achievements

- Quantified CO_2 and heat fluxes from crop ecosystems of shallow edaphically stressed soil environment using Eddy Covariance method.
- Developed methods for identification of SNP genotypes in Heat Shock Protein (HSP) genes of indigenous and cross bred dairy cattle.
- Identified temperature and hypoxia responsive genes in fish
- Identified bio-regulator as an option for recovery of hail damaged crops.
- Evaluation of mixed silage of sugarcane tops with Jowar fodder in lactating buffaloes revealed that mixed silage of sugarcane tops (upto 50%) with Jowar fodder can be used for sustaining production of lactating animals during scarcity periods.

Future Plan

- Strengthening of research facilities for stress management.
- Development of linkages and collaborations with other Institutions working on stress management.
- Study of stress indicators/markers for genetic improvement of livestock and poultry for stress adaptation.
- Characterization and possible predictions (advisories) of atmospheric stressors in crop plants, livestock and fishery.
- Development of methods/products/formulations for mitigation of thermal stress or stress due to climatic extremes.
- Creating facilities for training/demonstrations to farmers for mitigation of abiotic stressors mainly thermal and nutritional stressors.

Collaborations

- ICAR-CIFE, Mumbai
- ICAR- CSWRI, Awikanagar
- KNPCOVAS, Shirval

Facilities

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School of Water Stress Management

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

Introduction

- About 60% cultivated area in India is drought prone.
- Substantial area prone to flooding or waterlogging.
- Insights into crop response to water stress and technologies for crop per drop can play crucial role.
- Water stress (excess or limited) associated with climate change destabilizes yields in major crops.
- Crop loss due to water stress necessitate development of strategies for yield stability and resilience to stress
- Collection and utilization of diverse genetic resources of food and agriculture for basic research to unravel the mechanisms underlying tolerance to drought and water logging.

Major Projects

Flagship Project: Alternative Crops for Augmenting Farm Income in Abiotic Stress Regions

Umbrella Project: Genetic Garden and Gene Bank for Abiotic Stress Tolerant Plants, Animals and Fisheries for Food Security and Sustainability

In-house Projects:

- Genomics strategies for improvement of yield and seed composition traits under drought stress conditions in soybean
- Mitigating water stress effects in vegetable and orchard crops
- Evaluation of Soybean based cropping systems to deficit irrigation

Externally Funded Projects:

- Genomics strategies for improvement of yield and seed composition traits under drought stress conditions in soybean (NASF)
- Phenotyping of pulses for enhanced tolerance to drought and heat (NICRA)
- Conservation agriculture for enhancing resource-use efficiency, environmental quality and productivity of sugarcane cropping system (CRPCA)
- Abiotic stress detection from field to landscape scale in different crops using remote sensing tools (ISRO-SAC)
- Raising rice productivity through drought tolerant rice varieties and their matching management practices in Maharashtra (IRRI)
- Evaluation of efficacy of silixol (Privi Pvt. Ltd.)

Future Plan

- Extending phenomics facility to crop institutes associated with abioTic stress tolerance.
- Application of CRISPR-Cas, Gene silencing technologies to identify stress tolerance genes.
- Identification of novel bioformulations for alleviation of drought and waterlogging stress.
- Development of prebreeding lines of alternative crops.
- Root stock based solutions for vegetables to reduce water use
- Dissemination of technologies for alternative crops.
- Agronomic solution for alternative crops.

Objectives

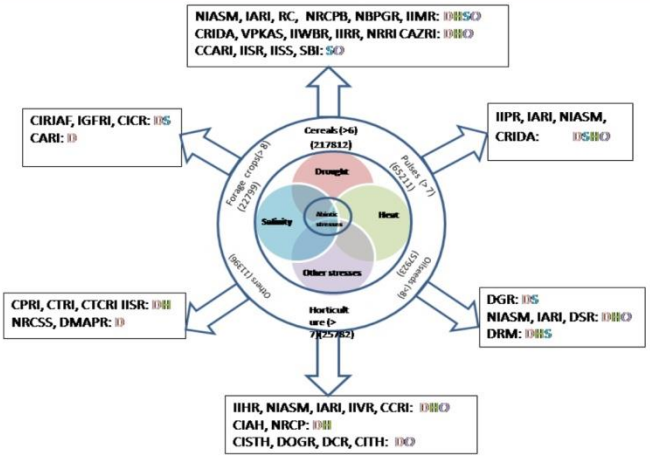
1. Unravelling the mechanisms and traits contributing to water stress tolerance in plants.
2. Optimizing novel genetic improvement approaches for enhancing resilience of crops to water stress.
3. Exploring alternative crops and cropping systems for alleviating water stress.
4. Developing precision agriculture for higher water productivity in crop, horticulture, livestock and aquaculture.

Salient Achievements

- Possibility of growing quinoa in murum rich soil has been demonstrated.
- Technology to evaluate bio-formulation for water stress alleviation optimized and promising bio-formulations for different crops identified.
- Phenomics protocols-optimized and promising lines identified.
- Gene silencing technology optimized for assessing relevance of genes for stress alleviation in soybean.
- About 25 genes identified for enhancing adaptation to water stress and yield stability in soybean.
- Promising wheat, soybean, mungbean, chickpea genotypes identified for water stress tolerance.
- Students and scientists from different universities and institutes were trained.



Collaborations



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School of Soil Stress Management

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

Introduction

- Indian soils are low in organic carbon, nitrogen and fertility.
- Intensive agriculture has resulted in land degradation and soil-related stresses.
- The situation is further worsened by global climate change.
- To mitigate the edaphic stress-impact on agriculture, new technology interventions promoting climate-smart agriculture is very essential.

Objectives

- Exploring mechanisms and traits of soil stress response in crop, livestock and fisheries.
- Developing adaptation and mitigation strategies for soil stress management.
- Mitigating the adverse impacts of nutrient imbalance and pollution in agriculture.
- Developing integrated farming systems for abiotic-stressed regions.

Major Projects

- Climate resilient integrated farming system for semi-arid regions (NIASM Umbrella Project).
- Amelioration of saline lands in arid and semi-arid regions with halophytes and associated microbiome (NIASM Flagship Project).
- Evaluation of halotolerant rhizobium and PGPB based biomolecules for mitigation of salt and drought stress (ICAR-AMAAS).
- Conservation agriculture for enhancing resource-use efficiency, environmental quality and productivity of sugarcane cropping system (ICAR-CRP-CA).
- Nutrient and gene interaction approaches through nutrigenomics in response to multiple stressors.
- Assessment and detoxification of heavy metals in aquatic water bodies using nutritional approaches.
- Wastewater treatment synergizing with integrated approach of constructed wetland and aquaponics.
- Establishment of model herbal garden for medicinal and aromatic plants (NMPB, New Delhi).

Salient Achievements

- Microbially derived polymeric product for gel formation, microbial colonization and metals binding.
- Microbial consortium has been formulated for crop growth enhancement.
- Nano-based feed has been developed for mitigation of abiotic stress in fish.
- Standardization of biomarker in open aquatic systems has been done for metal pollution.
- Vertical subsurface-flow wastewater treatment system has the potential to remove the different kinds of pollutant load by more than 95% along with additional profit of flower harvesting.
- A halotolerant *Rhizobium* strain and the biopolymer based inoculum was developed for mitigation of drought stress in fenugreek.

Future Plan

- To develop and promote microbe-based practices for climate smart agriculture.
- To measure the impact of soil nutrient-dynamics on crop performance under abiotic stress.
- To develop a climate-smart integrated farming system for semi-arid areas.
- To develop biosaline agriculture strategies for sustainable crop production in salinity affected areas.
- To optimize conservation agriculture and micro-irrigation practices for economic sugarcane production.

Collaborations

- ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan.
- ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh.
- ICAR-National Bureau of Agriculturally Important Microorganisms, Maunath Bhanjan, Uttar Pradesh.
- ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh.

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Geo-spatial Digital Maps of Abiotic Stresses, Their Impacts and Management

School of Atmospheric Stress Management
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

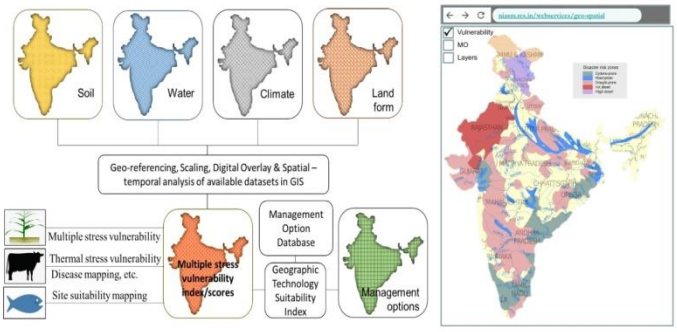
- Maps depicting the areas of the country prone to multiple abiotic stresses such as salinity, aridity, submergence, temperature and mineral stresses provide an overview of the present status and future projections on the impacts of stressors to agricultural production systems.
- Such GIS-based maps "Abiotic Stress Information System/ ASIS" can aid in decision making at national and regional scales for the abiotic stress related management goals.

Objectives

1. Creating repository of primary and secondary geo-spatial-temporal datasets and methodologies for representation of multiple abiotic stresses.
2. Creating repository of geo-spatial impacts and management options for addressing the stresses.
3. Projecting future scenarios through vulnerability assessment at district level.
4. Developing GIS framework (with web services architecture) for generating geo-spatial digital maps based on user-defined queries.

Methodology

1. Pooling geo-spatial-temporal datasets of single stressors from available sources to form a structured repository.
2. Scaling the datasets with appropriate scaling methods to the requirement of methodology/model.
3. Developing framework in GIS software for generating digital maps as per user-defined queries.
4. Depicting the management options on a geo-spatial-temporal scales in form of digital maps would need.
5. Depicting the future scenarios in form of digital maps through vulnerability assessment.



Progress of Work

1. Reviewed data sources of weather and soil related datasets.
2. Data pertaining to livestock census for last 25 years was collected.
3. Preprocessed data on major water reservoirs of India
4. Identified factors affecting farm pond based aquaculture and cage culture site selection.
5. Spatio-temporal variations of rainfall data of met sub divisions of India using parametric and non parametric methods.
6. Identified edaphic and atmospheric stress indicators for preparing vulnerability index.

Expected Outputs

1. A centralized repository of national geo-spatial-temporal datasets of abiotic stressors & associated parameters.
2. A centralized repository of management options for Abiotic stressors in agriculture, livestock and fisheries.
3. A collection of methodologies for combining multiple abiotic stresses for generating location specific management options.
4. A GIS framework (web based service) for generating district level geo-spatial digital maps based on user-defined queries (layers, spatial & temporal scale, management options, projections) for multiple abiotic stresses.
5. District level vulnerability maps to multiple abiotic stressors.

Potential Collaborators

- ICAR- NBSSLUP, Nagpur, Maharashtra
- ICAR- CRIDA, Hyderabad, Telangana
- ICAR- CSSRI, Karnal, Haryana
- ICAR- CAZRI, Jodhpur, Rajasthan
- ICAR-IISS, Bhopal, Madhya Pradesh
- ICAR-IIWM, Bhubaneswar, Odisha
- ICAR-CCARI, Goa
- ICAR- NIVEDI, Bengaluru, Karnataka

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Climate-smart Integrated Farming System for Semi-arid Regions

School of Soil Stress Management
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

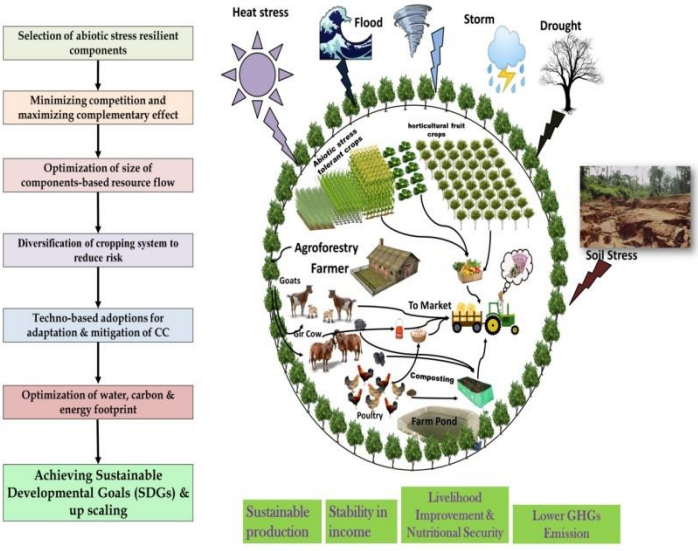
Introduction

- Climate change is one of the most serious problems of modern times.
- Climatic extremes are intensifying with higher frequency leading to decrease in productivity and sustainability.
- Carbon dioxide concentration reached 415 ppm, mean temperature increased by ~1°C, 6 warmest years recorded since, seasons shifting, rainfall variability and intensity increasing, glaciers retreating, sea level rising and new biotic and abiotic stresses emerging.
- To ensure livelihood and environmental securities, an integration of climate resilient technologies in integrated farming system (IFS) is required.

Objectives

1. To optimize the components of IFS for enhancing productivity, profitability and climate resilience.
2. To evaluate water, energy and carbon footprints of the climate-smart IFS (CIFS).
3. To assess the impact of CIFS model on soil health and crop quality.
4. To develop a decision support system for optimizing and upscaling the CIFS.

Methodology



Progress of Work

1. Farming system components suitable for climate resilience have been selected.
2. Optimization of size of different farming system components is in process.
3. Abiotic stress tolerant horticultural crops have been planted.
4. Agro-forestry components have been included by planting trees on boundaries.
5. Crop rotation and inter cropping of climate resilient crops being followed.
6. Farm pond & micro-irrigation systems laid out.
7. Construction of structure for multilayer/multitier farming system is in progress.
8. Drip irrigation system has been installed in orchards.

Expected Outputs

- Flow of resources in the CIFS will be optimized.
- Enhanced productivity and resource use efficiency in CIFS.
- Water, energy and carbon footprints of the CIFS will be developed.
- The CIFS model increase the soil health and crop quality.
- Developing decision support system for optimizing the size of farming system components and upscaling the CIFS.

Collaborations

- ICAR-Indian Institute of Integrated Farming Systems Research, Modipuram, Meerut, Uttar Pradesh

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Genetic Garden and Gene Bank for Abiotic Stress Tolerant Plants, Animals and Fisheries

School of Water Stress Management

ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- Threats to biodiversity due to population growth, climate change, pollution and various abiotic stresses have increased recently.
- Enhanced efforts are needed to conserve, maintain and utilise the genetic diversity for traits associated with tolerance to biotic and abiotic stresses for development and improvement of varieties of crops and breeds for animals and fisheries.
- Genetic garden aims to accomplish this task by collecting, conserving and maintaining diverse genetic resources and by facilitating basic research for better insights into the trait diversity and mechanisms underlying tolerance to abiotic stresses.

Objectives

1. To establish genetic garden and gene bank to collect, display, conserve abiotic stress tolerant plant, animal and fish genetic resources.
2. To utilize genetic resources of plants, animals and fishes for basic research to understand the mechanisms underlying tolerance to different abiotic stresses.
3. To create awareness on biodiversity conservation and strengthen capacity building for abiotic stress tolerance.

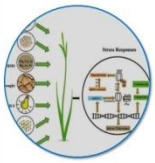
Methodology

Collection and exploration:

- Unexplored and diverse plant, animal and fisheries genetic resources.
- Abiotic tolerant varieties, genetic stocks, breeding lines, mutants, local cultivars, land races and wild relatives of crop plants.
- Indigenous and local breeds of livestock and vulnerable fish genetic resources.

Evaluation and characterization:

- For drought, high temperature, water logging and salinity.



Traits and gene identification and validation:

- QTLs/genes/alleles conferring tolerance to abiotic stress tolerance will be identified and also validated.
- Unravelling the mechanisms involved in complex of stress tolerance.

Publicity and capacity building:

- Facilitating agro-eco tourism, exposure visits, sharing genetic resources and organizing extension/HRD programmes.

Progress of Work

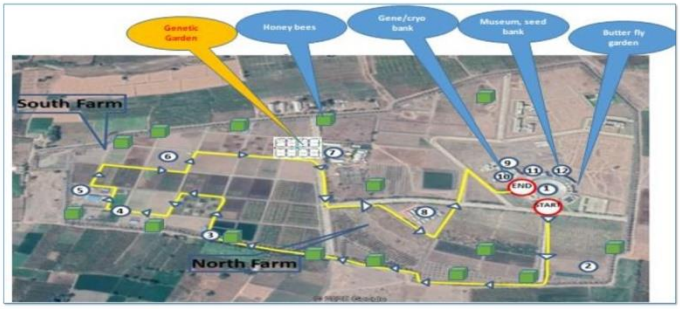
- Compiling information on genotypes tolerance to abiotic stresses.
- Abiotic stress tolerant germplasm of different crops collected:

Sl. No.	Crops	Germplasm/ genotypes	Abiotic stress tolerance	Source
1	Safflower	NARI-6, NARI-96 & GMU-2369	Drought	NARI, Phaltan
2	Sorghum	Madhura-2, Madhura-3 & Revati	Drought	
3	Stylo	Stylo hamata & Stylo sebrana	Drought	
4	Subabul	Wonder graze & Taramba	-	
5	Wheat	KRL 210, KRL 213, KRL 283, KRL 3-4, KRL 99, KRL 19, KRL 1-4 & Karchia 65	Salinity	ICAR-CSSRI, Karnal
		10 promising lines	Drought	ICAR-NIASM, Baramati
6	Chickpea	72 Genotypes	Evaluation under progress	IIPR, Kanpur & SWSM, ICAR-NIASM, Baramati
7	Lentil	32 Genotypes	Evaluation under progress	IIPR, Kanpur
8	Pigeon pea	4 Genotypes	Water logging	ICRISAT, Hyderabad
9	Soybean	JS-7105, JS-9752, EC-456556, TGX 814-78D, TGX 885-44E, TGX 854-60A	Drought	ICAR-IISR, Indore
		JS-9752, EC-95815	Water logging	
10	Quinoa	15 Genotypes	Evaluation under progress	MPKV, Rahuri and ICAR-IISS, RS, Bengaluru
11	Turmeric	16 Genotypes	Evaluation under progress	-
12	Fenugreek	17 Genotypes		NRCSS, Ajmeer

- Evaluation and characterization of collected germplasm for abiotic stress tolerance is in progress.

Expected Outputs

- Model and eco-friendly genetic garden for abiotic stress tolerance for enhanced awareness about biodiversity preservation.
- Seed bank, gene bank & repository of genes for investigations on abiotic stresses.
- Biodiversity preservation with diverse flora, butterflies and honey bees, fish, fowls and livestock.
- Insights into mechanisms underlying abiotic stress tolerance.



Collaborations

- **National collaborators:**
  - ICAR-National Bureau of Plant Genetic Resources, New Delhi
  - ICAR-National Bureau of Animal Genetic Resources, Karnal
  - ICAR- National Bureau of Fish Genetic Resources, Lucknow
  - ICAR- Central Soil Salinity Research Institute, Karnal
  - ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
  - ICAR-Central Arid Zone Research Institute, Jodhpur
  - ICAR- Research Complex for NEH Region, Barapani
  - ICAR- Research Complex for Eastern Region, Patna
  - Other ICAR institutes
  - State Agricultural universities
- **SHGs/ farmers organizations/NGOs:**
  - Kalsubai Parisar Biyanee Savardhan Samiti, Ahmednagar
- **International collaborators:**
  - CIMMYT, Mexico,
  - ICRISAT, Hyderabad,
  - IRRI, Philippines,
  - Bioversity International, Rome
  - World Vegetable Centre, Taiwan

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Environment-friendly, Economically Viable, State-of-the-art Model Farm for Abiotic Stressed Regions

School of Water Stress Management

ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- ICAR-NIASM has developed a farm of 56 ha with different soil and water conservation measures such as terracing, drip, compartmental bunding and planting of different horticulture crops with livestock and fishery units.
- The farm has shallow basaltic soil with low organic matter, low rainfall and high temperature during summer.
- The farm encounters multiple abiotic stresses such as atmospheric, edaphic and drought.
- There is a need to develop precision agricultural production system including management of soil health, insect pest, diseases and agro-waste with sensor-based application using non-conventional energy sources to reduce environmental footprints.

Objectives

1. To develop strategies to manage water deficits in farm with modern technologies to alleviate abiotic stresses of crops and livestock.
2. To assess soil quality under different stress conditions and develop technology for increased resilience of soils.
3. To design and develop artificial inteligence-based tools and energy conversion technologies for abiotic stress management in agriculture, livestock and fisheries sectors.
4. To develop improved package of practices for mitigating multiple stresses in horticulture and field crops for abiotic stress regions.
5. To develop and demonstrate of environment friendly management strategies for plant diseases and pests management under changing climate and abiotic stress conditions.
6. To develop strategies for agro-waste management and value addition.

Methodology

- **Soil and water conservation and management**
  1. Automated irrigation management, water, energy, C and N budgeting
  2. Evaluation of rain pipe irrigation system
  3. Demonstration of low head, low energy drip irrigation system
  4. Develop drainage network for farm, Runoff harvesting structures
  5. Utilization of solar and wind energy
  6. Generate soil map of farm
- **Crops: Dragon fruit, pomegranate, sapota, guava, tamarind, sandal wood, etc.**
  1. Improve package of practices, water and nutrient use efficiency under abiotic stressed conditions
  2. Evaluate the planting techniques for establishment of orchards under edaphic and drought stressed region
  3. Development of Ecofriendly management strategies for diseases and pest in dragon fruit
  4. Use of drones for crop imaging and spraying
- **Management of agro-waste, processing and value addition**
  1. Agro-waste techniques and recycling units for agro wastes for utilization of agro wastes from farm
  2. Post-harvest quality of dragon fruit, processing and value addition
- **Livestock and fisheries**
  1. Development of SPV based hydroponics for fodder production system
  2. Water quality assessment and management for irrigation water in fish ponds
- **Impact assessment**
  1. Assessment of carbon, water and energy foot prints
  2. Life cycle assessment and sustainability analysis

Progress of Work

- Automation of irrigation to every field plot in process
- Monitoring the diseases and pest in dragon fruit
- Integration of sandal wood plantation in tamarind orchard
- Study impact of planting techniques on root architecture in orchard crops grown in shallow basaltic soil
- Management of farm waste by vermicomposting and quality analysis.

Collaborations

- Indian Institute of Water Management, Bhubaneshwar
- Indian institute of Soil and Water Conservation, Dehradun
- NRC Pomegranate, Solapur; NRC Grape, Pune
- MPKV, Rahuri

Expected Outputs

1. Develop automated efficient water management technologies/strategies and soil and water conservation technologies/runoff harvesting with water accounting/water budgeting protocols in model farm.
2. Develop agro-waste utilization techniques and value addition of agro-waste products.
3. Standardize the horticulture practices for mitigating abiotic and biotic stress in fruit crops.
4. Alongwith genetic garden farm and other facilities, campus will be made as an eco-tourism, educational and biodiversity site.

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Adaptation and Mitigation of Atmospheric Stresses in Crops, Livestock, Poultry and Fisheries

School of Atmospheric Stress Management
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- Climate change has severe implications on productivity and profitability of crop, livestock, poultry and fisheries.
- It potentially can disturb the structure and functions of agro-ecosystems and sustainability of agriculture.
- Changing climate results in emergence of pest and diseases requiring additional preventive measures.
- Responses of crops, livestock and fish to various atmospheric stresses need to be assessed for developing adaptation and mitigation strategies.



Objectives

1. Unravelling relationship of atmospheric factors (temperature, humidity, rainfall and wind) with occurrence of pest in maize, fruit crops and diseases in goat.
2. Evaluating the responses of goat and fishes to environmental stressors.
3. Investigating relationship of abiotic and biotic stressors on prevalence of anaemia in goats.
4. Developing the adaptation and mitigation options for thermal stress in goat, poultry and cultured fish.



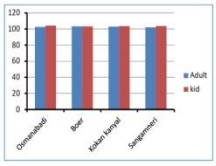

Methodology

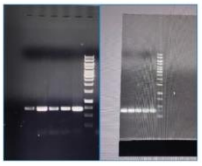
1. Assessment of comparative growth, production and thermo-tolerance of four breeds of goats in different seasons through physiological, haemato- biochemical and genetic parameters.
2. Exposing GIFT tilapia to different salinity levels and evaluation of growth and biochemical parameters for salinity tolerance.
3. Fruit fly population dynamics in dragon fruit in relation to weather parameters.
4. Comparative assessment of IPM strategies for management of fall armyworm in maize through field studies.
5. Collection and analysis of samples for studying abiotic and biotic interaction in anaemic goats.
6. Modelling thermal distress call classification through pattern matching; development and evaluation of thermal distress identification module for poultry.
7. Design, development and testing of automated chemical applicator for reducing evaporation from plastic lined farm ponds through modelling and mechatronic approach.
8. Develop standard operating protocol for culture of BSF and its evaluation as novel protein source for poultry and fishes.
9. Collection and analysis of meteorological datasets.

Progress of Work

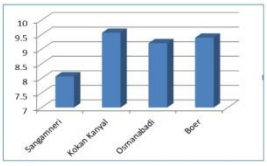
- Experiments on comparative growth and production performance of four breeds of goats, salinity tolerance of GIFT tilapia and IPM module for managing fall armyworm in maize are in progress.
- The COXI and Cytochrome b genes amplified using PCR to amplify 650 and 360 bp, respectively from the fin samples for the species and stock identification of *Hypselobarbus kolas* through DNA sequencing.
- Four species of Fruit flies were recorded i.e. *Bactrocera dorsalis, B. zonata, B. correcta* and *B. Cucurbitae* in dragon fruit orchard.
- Generated district wise monthly temperature and rainfall trend maps of Maharashtra.

Body temperature (^{0}C) in different breeds of goats





Haemoglobin (gm%) in different breeds of goats

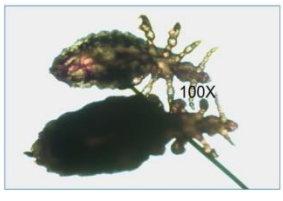


COXI and Cytochrome b genes amplified using PCR of *Hypselobarbus kolas* fish fin samples

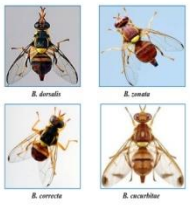
Expected Outputs

- Information on riverine fish, goat, poultry and crop responses to atmospheric/thermal stress.
- Relation of changing atmospheric factors and occurrence of various parasitic infestations in goats in the region and diseases of fish. An eco-friendly IPM module for the management of Fall Armyworm (FAW), Spodoptera frugiperda in maize
- Information on etiopathology of anaemia and relationship of abiotic and biotic factors in causation, pathogenesis and control of anaemia.
- Automated chemical applicator for reduction of evaporation losses from plastic lined farm ponds.
- A low cost thermal distress identification module for birds.

Biotic Stressors Recorded



Linognathus stenopsis -**Goat sucking lice**



Four species of fruit flies Dragon fruit

Collaborations

- ICAR-CIFE, Mumbai
- ICAR- CSWRI, Awikanagar
- KNPCOVAS, Shirval

Contact: Dr. NP Kurade, Head, SASM, Email: nitin.kurade@icar.gov.in

Alternative Crops for Augmenting Farm Income in Water Scarce Regions

School of Water Stress Management
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- Alternative crops are adapted to a range of agro-ecologies, are nutrient dense, climate resilient and offer better prospects in abiotic stress areas with low-input agriculture.
- Wider adoption of alternative crops can contribute to achieving the Sustainable Development Goals by involving small and marginal farmers in abiotic stress prone areas.
- Realizing the real benefits of these crops requires a systematic approach, multidisciplinary analysis, multi-stakeholder consultation and cross-sectoral coordination.

Objectives

1. To evaluate G x E interactions to optimise combinations of agro-ecology and alternative crops.
2. To facilitate genetic improvement of productivity and quality of alternative crops.
3. To optimise agronomy for alternative crops.
4. To explore value addition through post harvest technology.
5. To identify stress tolerance genes and microbial associations for improvement of drought tolerance in other crops.
6. To demonstrate the alternative crop in farmers field.

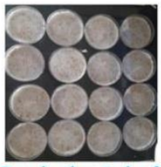
Methodology

- **Literature review, collection and exploration:** Extensive review on origin and agro-specific adaptation, market opportunities, nutritional values and uses of promising alternative crops. Getting access to alternative crops
- **Optimise agronomy**: Cropping season, water management, fertilizer management, harvesting, post harvest management.
- **Genetic improvement:** Prebreeding, genetic stock registration, introduction to AICRP trials.
- **Omics approach for identification of genes for different traits:** Stress tolerance, anti-nutritional, useful microbes, weed suppressant, anti-transpirants.
- **Insights and efforts for processing technology:** Removal of anti-nutritional factors, design of suitable processing machines, alternate use as animal feed and fish feed mix.
- **Outreach activities:** Farmers field demonstrations, trainings, webinars, workshops, collaboration with research organisations, KVKs and Universities.

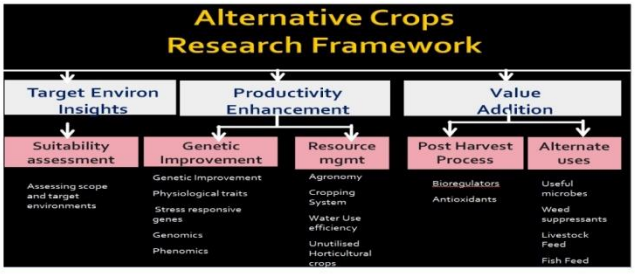
Progress of Work

- **Repository of information:** Bulletin on Mainstreaming Alternative crops for farmers income in abiotic stress regions.
- **New insights:** Evaluation of Chia as new crop for the region. Creation of genetic variability in Quinoa & Chia through gamma mutation. Establish the crop production technology of Quinoa.


National webinar on alternative crops


Germination study of irradiated quinoa seeds


Evaluation of chia as new crop

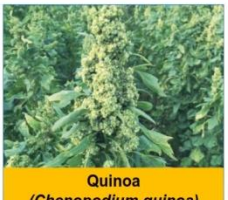


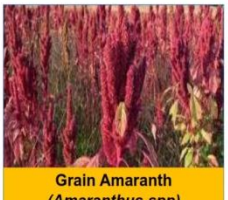
Expected Outputs

1. Repository of information on alternative crops
2. Genetically improved cultivar/genetic stock
3. Optimised packages of practices for making alternative crops profitable in water stress prone areas
4. Processing technology on reduction of anti-nutritional factors
5. Scientific insights into abiotic stress tolerance traits and mechanisms

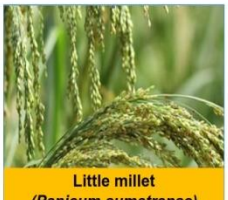
Collaborations

1. ICAR-National Bureau of Plant Genetic Resources, New Delhi
2. ICAR- Indian Institute of Millets Research, Hyderabad
3. CSIR-Central Food Technological Research Institute, Mysore
4. International Crops Research Institute for Semi Arid Tropics, Hyderabad,
5. Bioversity International, India, Rome & International Center for Tropical Agriculture, Colombia


Quinoa *(Chenopodium quinoa)*


Grain Amaranth *(Amaranthus spp)*


Buckwheat *(Fagopyrum esculentum)*


Little millet *(Panicum sumatrense)*


Chia *(Salvia hispanica)*

Contact: Dr. Jagadish Rane, Principal Scientist & Head, SWSM, E-mail: jagadish.rane@icar.gov.in

Halophytes and Associated Microbiomes for Amelioration of Saline Lands in Arid and Semi-arid Regions

School of Soil Stress Management

ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

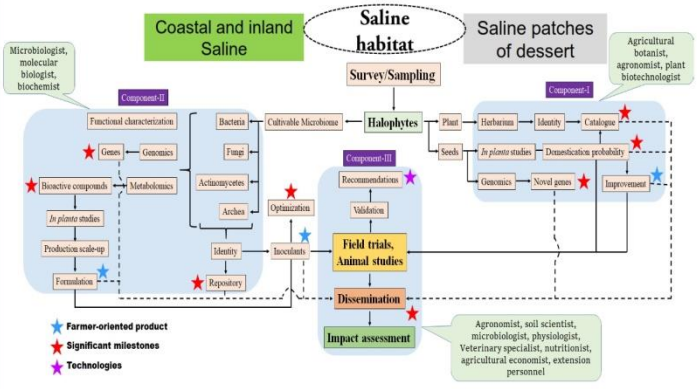
Introduction

- India has 6.7 million ha salt-affected soils i.e., about 5% of net cultivated area. More and more area is getting salinized due to primary and secondary salinization.
- Halophytic plants naturally growing in saline conditions can be a promising solution for agriculture in salinity affect areas.
- This project aims to utilize the potential of halophytic plants to deliver sustainable solutions for salinity-smart farming, and saline land restoration.

Objectives

- To identify halophytic plants from coastal, salt lake and desert saline regions and assess their salt removal potential from soil and water.
- To isolate halophytes-associated cultivable and uncultivable microbes and their derived bioactive compounds to developed Nano-formulations for induced systemic tolerance of salinity stress in wheat
- To identify the salt responsive genes from the halophytes using genomic and metabolomics approaches
- To study the suitability of halophytes as an alternative food and fodder crop for salinity affected arid and semiarid regions of the India
- To assess the socio-economic suitability of halophytes as an alternative food and fodder crop in salinity affected arid and semiarid regions of the India.

Methodology

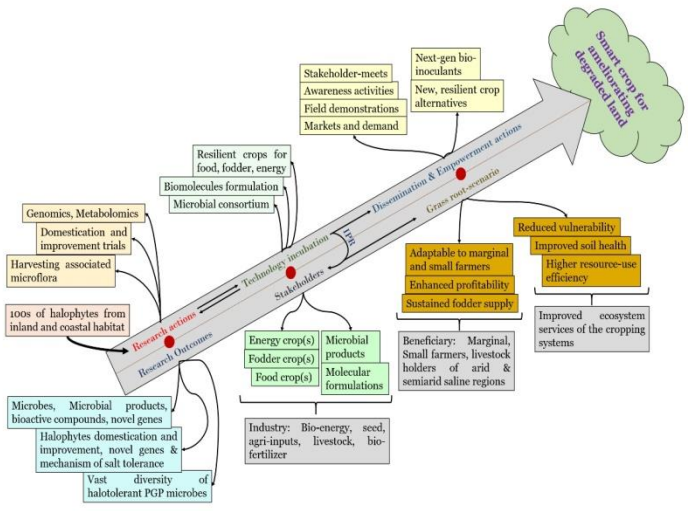


- A detailed survey of selected coastal regions (Diveagar, Raigad and Mumbai Coast), Inland saline lands (Thar/Rann of Kutch Deserts), and salt-lakes (Sambhar Lake/Chilka Lake/Lonar Lake) will be undertaken to identify agriculturally important halophytes.
- Microbiome studies will be undertaken to decipher the role of halophyte-associated microbes and their possible applications for enhancing salinity stress tolerance in crops.
- Halophytes will be evaluated for their salt accumulation potential for reclamation of the saline soils.
- Selected halophytes will be assessed for their potential as food and fodder.
- Genomic and metabolomic studies will be undertaken to decipher the molecular mechanism of salinity tolerance in selected halophytes.

Progress of Work

- A Preliminary survey of coastal saline habitats from Diveagar area of Raigad district (Konkan Region of Maharashtra) was conducted and samples (Mangroves water, Mangroves plants, Mangroves marshy soil, Sea water) were collected for microbiological studies. EC value of the mangroves marshy soil ranged between 10.37 to 23.4 dS m^{-1} whereas EC value of the water from Mangroves fields and coastal sea ranged between 74.7-123 dS m^{-1}.
- Cultured microbial isolates (endophytes, epiphytes and rhizospheric microbes) associated with xero-halophytic plant *Cullen Plicata* have been isolated are being explored for their PGPA traits.

Impact Pathway



Expected Outputs

- Cataloguing of the diversity of Halophytes in Indian coastal regions and the inland desert regions.
- Suitable halophytes for food and fodder for salinity affected regions.
- Elucidation of mechanism of salinity stress tolerance in halophytes, implicated genes, biomolecules, and related biochemical pathways.
- Useful microbes and microbial products for salt stress tolerance
- Halophytes-based nano-formulations for mitigation of abiotic stresses
- Recommendations related to Halophytic plant for ameliorating the degraded land.

Collaborators

- ICAR-Central Arid Zone Research Institute, Jodhpur-Rajasthan.
- National Centre for Microbial Resources, Pune.
- National Chemical Laboratory, Pune.
- ICAR-National Research Centre for Grapes, Pune.

Contact: Dr. Satish Kumar, School of Soil Stress Management, Email: satish.kumar10@icar.gov.in

Targeting Prospective Technologies for Managing Abiotic Stresses

School of Social Science and Policy Support
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

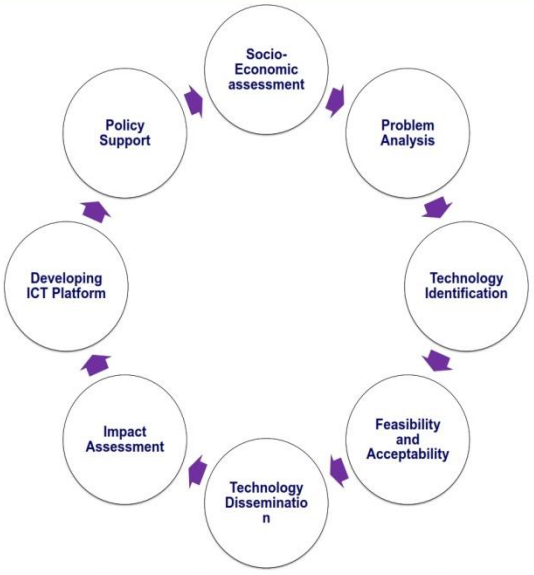
Introduction

- Rapidly changing, frequently occurring intensive abiotic stresses will be the major challenge for agriculture production, productivity and sustainability in coming years.
- Impacting the Food and livelihood security of billions of farmers mostly in rainfed and dryland region.
- The methodological approach with robust policy support for targeting potential technologies of abiotic stress resilience is needed.

Objectives

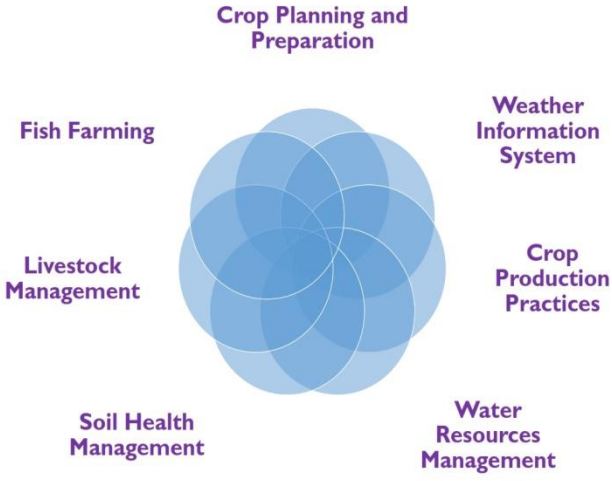
- Identifying biophysical and socio-economic constraints in major production systems in abiotic stressed regions.
- Developing a methodology for technology targeting to alleviate the constraints in selected regions.
- Identifying and demonstrating potential abiotic-stress mitigating technologies in target regions.
- Assessing the impacts of targeted technologies on productivity, income and climate resilience.

Methodology



- Assessing the problems, socio-economic situation through questionnaire and group discussion.
- Technology assessment through Feasibility, social acceptability and multidimensional impact study
- Developing ICT multimedia platform for dissemination and policy suggestion for upscaling.

Progress of Work



- Preparation of questionnaire for various respondents.
- Collection and compilation of various ITKs for Abiotic stresses of major production systems.
- Technical report on abiotic stress management in agriculture.

Expected Outputs

1. Information on Bio-physical and Socio-economic Constraints of major production systems.
2. Methodology for technology targeting to alleviate the constraints in abiotic stressed regions.
3. Demonstration and impact of potential technologies in agriculture, livestock and fisheries production systems
4. Development of ICT mass media platform for dissemination of technology information

Collaborations

1. International Water Management Institute, India-Office, New Delhi.
2. ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.
3. Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.
4. ICAR-Agricultural Technology Application Research Institute, Pune, Maharashtra.

Contact: Dr. DD Nangare, I/c Head & Principal Scientist, SSSPS Email: dd.nangare@icar.gov.in

Genomics strategies for improvement of yield and seed composition traits under drought stress conditions in soybean (NASF Project)

School of Water Stress Management

ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- Drought and waterlogging associated with climate change destabilize yields in soybean.
- Large number of plant genetic resources are available in soybean, but only a few are characterized for traits and genes associated with drought and waterlogging tolerance.
- Screening of soybean genotypes for the natural genetic variations for drought and waterlogging tolerance and yield related traits including root system architecture will help to identify best resources for genetic studies in soybean.
- Genomic tools and technologies to identify genes, genomic regions associated with drought and flood tolerance traits will be crucial for designing for better crop.
- Development of novel strategies particularly genomics for genetic gains to enhance climate resilience and yield stability under limited or excess soil moisture could be milestone for Indian agriculture and economy.

Methodology

- Genotyping by Sequencing (GBS) and/or SNP array/chip and Genome Wide Association Study (GWAS) for drought tolerance, seed composition and yield component traits under drought stress conditions.
- Phenotyping in phenomics for adaptive traits associated with drought tolerance, water stagnation stress condition, seed composition and yield component.
- Evaluation of soybean genotypes for traits like canopy coolness and greenness, photosynthetic efficiency (PS-II), and water status under well-watered and water stress (excess and limited) conditions.
- Bioinformatics analysis (KEGG pathways and GO Ontologies) of mapped genomic regions for identifying key genes.
- Expression profiling by RNA sequencing of selected soybean genotypes to identify key candidate genes under watered and moisture stress conditions, water logging conditions.
- Functional characterization of key candidate genes using RNAi-mediated gene silencing approach,.

Expected Output

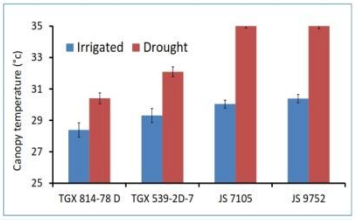
- Characterization of association mapping panel core set of soybean for genetic and genomic studies of drought stress tolerance, water stagnation stress tolerance, seed composition and seed yield related traits.
- Well characterized core set of soybean at molecular level using genotyping by sequencing approach
- Unique and genetically diverse germplasm sources for drought stress tolerance, seed composition and seed yield related traits to be utilized for soybean breeding programmes
- Information of genomic regions associated with drought tolerance, seed composition and seed yield component traits under drought stress conditions.
- Detailed knowledge of key pathways and master genes associated with drought stress tolerance.
- Deeper understanding of the genetic and molecular basis of soybean in response to abiotic stresses in an effort to maintain high yields, improved seed composition and improved crop resilience to changing climate.

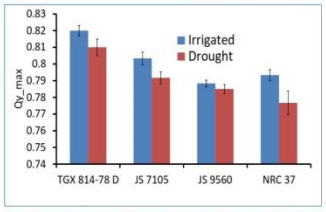
Objectives

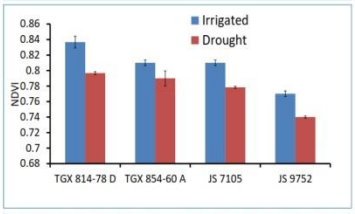
1. Genome wide association studies in soybean for drought adoptive traits, water stagnation stress condition and seed composition traits.
2. Identification of key genes and pathways associated with drought stress, water stagnation stress, seed composition and seed yield related attributes using gene expression profiling and bioinformatics analysis.
3. Functional characterization of candidate genes related to drought stress tolerance, water stagnation stress tolerance and seed composition traits through RNAi approach

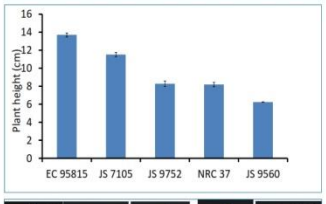
Progress of Work

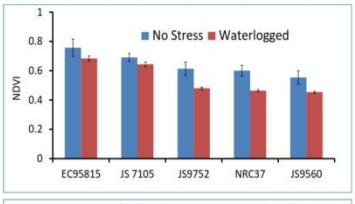
- Soybean genotypes along with check varieties were evaluated for adaptive traits associated with drought and water logging tolerance.
- Soybean genotype TGX 814-78D showed cooler and greener canopy, higher PS-II and RWC compared to JS-9752 and JS-7105 under drought and well-watered conditions.
- Soybean genotypes EC-95815 showed better plant height enhancement and canopy greenness and better adopted to waterlogged conditions.
- RNAi construct developed for silencing *Farnesyltransferase* gene

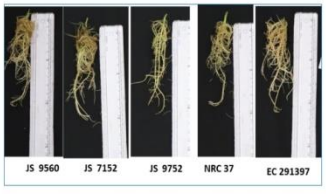


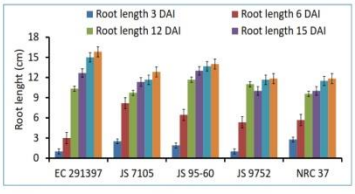












Collaborations

- **National Collaborator:**
  - ICAR-Indian Institute of Soybean Research, Indore
- **International collaborators:**
  - ICRISAT, Hyderabad

Contact: Dr. Ajay K Singh, Scientist, ICAR-NIASM, Baramati. E-mail: ajay.singh4@icar.gov.in

Standardization of Cultivation Practices of Dragon Fruit in Abiotic Stressed Areas

School of Soil Stress Management
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra

Introduction

- Dragon fruit is emerging as a remunerative and nutritionally potential fruit crop in India.
- Being a member of cactaceae family, the fruit has low water and fertilizer requirement and tolerant to several biotic and abiotic stresses.
- However, occurrence of sunburn and diseases such as anthracnose, soft rot, stem canker are observed in many orchards.
- An initiative is being taken up for management of these diseases and disorders in sustainable ways.

Objectives

- Impact of shading on sunburn in dragon fruit.
- Identification and management of anthracnose, stem canker, leaf and fruit spots and soft rot in dragon fruit.
- Demonstration and dissemination of improved dragon fruit cultivation practices under abiotic stressed regions.

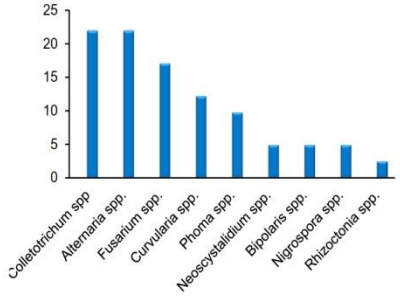
Methodology

- Sunburn management through natural and artificial approaches.
  - Natural shade through inter-row planting of drumstick, *Sesbania*, etc.
  - Artificial shade through coloured nets having 25 and 50% shade factor
- Monitoring, detection and integrated management of disease.

Dragon fruit plant affected by abiotic and biotic stress

Progress of Work

- Approaches for management of sunburn is being finalized.
- Dragon fruit plant harbours divers pathogenic fungi among which *Colletotrichum spp.*, *Fusarium spp.*, *Alternaria spp.* are noticed to be most dominant.
- *In-vitro* study of temperature assessment on mycelial growth and sporulation showed that, pathogens exhibited variation in their temperature requirement.



Frequency (%) of recovery of fungal spp. from infected leaves of dragon fruit

Divers pathogenic fungi in dragon fruit

Growth pattern of dragon fruit pathogens at 30 °C

Expected Outputs

- Management of sunburn in dragon fruit.
- Diagnosis of emerging pathogens in dragon fruit.
- Integrated disease management package.

Collaborations

- ICAR-Indian Institute of Horticulture Research, Bangalore, Karnataka

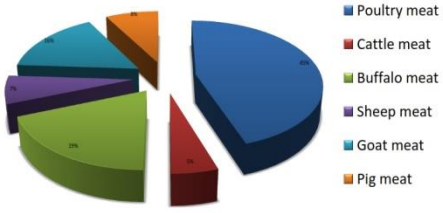
Contact: Dr. Vijaysinha Kakade, Scientist (Fruit Science), E mail: vijaysinha.kakade@icar.gov.in

Study of Immune Response and HSP Genes Polymorphism in Relation to Heat Stress in Poultry

S.S. Pawar, N.P. Kurade, A.V. Nirmale

Introduction

- Poultry is most efficient animal protein production system and a healthy alternative to red meat and other protein sources.
- Environmentally most efficient with smallest carbon foot print/unit product.
- India is 3rd largest producer of egg and 5th largest of poultry meat with estimated annual growth around 10%.
- 70% of poultry is under highly organized sector and total poultry industry is valued around ₹ 35,000 crores with exports worth ₹ 457 crores.
- Heat stress has emerged as major concern in poultry industry due to steadily rising average global surface temperature.



Species wise meat contribution in India
(Basic animal husbandry & fisheries statistics, 2014)

Environmental factors
sunlight, thermal irradiation, air temperature, humidity

Birds characteristics
breed, metabolism rate, bird movement, thermoregulatory mechanisms

Heat energy produced

Energy released to surrounding

Heat stress

- Increase in mortality
- Impaired growth performance
- Reduced body weight
- Lowered immunity and enhanced disease susceptibility
- Deterioration of meat quality *(lipid peroxidation & altered electrolyte balance)*
- Reduced egg production
- Loss of fertility

Rationale

- Optimum temperature for performance: 18-22°C for broilers and 19-22 °C for layers .
- Global average surface temperature expected to rise by 1.4 to 5.8 °C by 2100.
- Need for maintaining increasing trend of poultry production to meet demand by improved heat resilience and immunity of chickens.
- Important to understand genetic mechanisms that regulate immunity under heat stress.
- Inadequate understanding of immune response under heat stress in poultry.
- Need to study genetic relationship between immune response mediators and thermotolerance.

Poultry experimentation facility developed at ICAR-NIASM.

Objectives

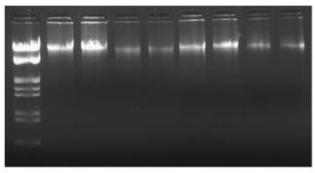
- To characterize HSP genes polymorphic regions.
- To evaluate cytokine expression profile of poultry birds under heat stress.
- To study association of HSP genes polymorphism with cytokine expression profile.
- To develop molecular marker based screening techniques for heat resilience in poultry.

Expected Outcome

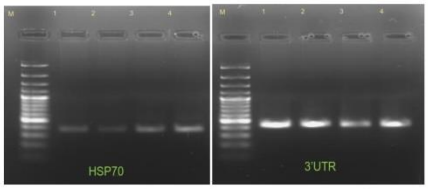
- Identification of genetic markers for breeding poultry aiming heat resilient poultry production with better immunity.

Work Done

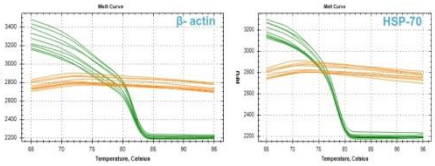
Genetic characterization and expression profiling of poultry HSP70 gene.

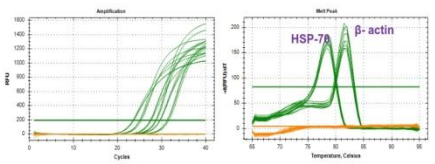


Genomic DNA isolated from chickens



Amplification of HSP70 promoter & 3' Untranslated regions



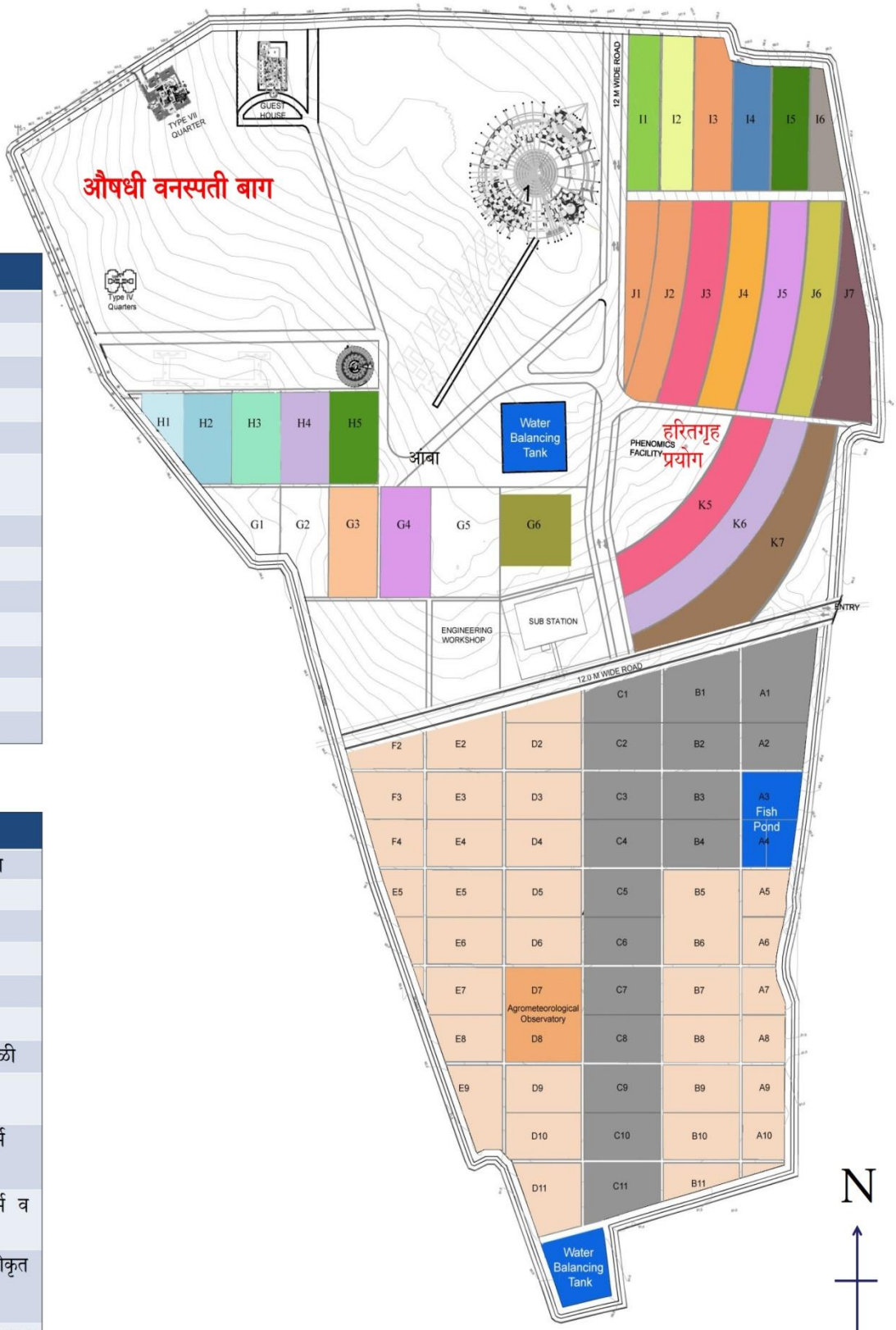


Expression analysis of HSP-70 gene in heat stressed birds.

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

भाकृअनुप ICAR

राअस्ट्रैप्रसं NIASM



उत्तर भाग

प्लॉट	पीक/प्रयोग
G3, J5	द्राक्ष बाग
H5, I4	ड्रॅगन फळ बाग
G2	आवळा बाग
H3	अंजीर बाग
G6	संतरा बाग
H1-H2	खजुर, शेवगा बाग
I1	करवंदा बाग
I2	लिंबू बाग
I3, J1-J2	मोसंबी बाग
J3, K5	डाळिंब बाग
J6	सीताफळ बाग
K6, H4	पेरु बाग
K7	चिकू बाग

दक्षिण भाग

प्लॉट	पीक/प्रयोग
A1,A2,B1	कृषि संरक्षण प्रयोग
B2	ज्वारी पीक
B3	ऊस पीक
B4	कांदा पीक प्रयोग
A3-A4	मत्स्य पालन तळे
A5-A6	मत्स्य प्रयोगशाळा
A7-A8	प्रायोगिक मत्स्य तळी
A10	बकरी विभाग
A9-A10, B9-B10, E9	पशुधन प्रयोग फार्म
B10	कोंबडी पालन फार्म व प्रयोग
B11, C10-C11, D10-D11, E10	जलवायु स्मार्ट एकीकृत कृषि प्रणाली
D7-D8	मौसम विज्ञान वेधशाला
E2-E6	आनुवंशिक उद्यान
F1-F3	चिंच फलबाग
F4-F5	गांडूळ खत प्रयोग

Farm Layout

Contact: Director, ICAR-NIASM, Email: director.niasm@icar.gov.in

QR_NIASM to Explore the Facilities and Activities of the Institute

ICAR-National Institute of Abiotic Stress Management
Baramati, Maharashtra

Introduction

- 'QR-NIASM' App, the first of its kind, acts as a personal guide for Android users for effective and easy access to information of the Institute.
- The user can scan the QR code on the nearby display board and get the desired information in audio format in Marathi, Hindi and English languages, as per the choice.
- Within this App, the user will get access to various Audio Books published by this institute, in trilingual format.

Methodology

Data collection and management:

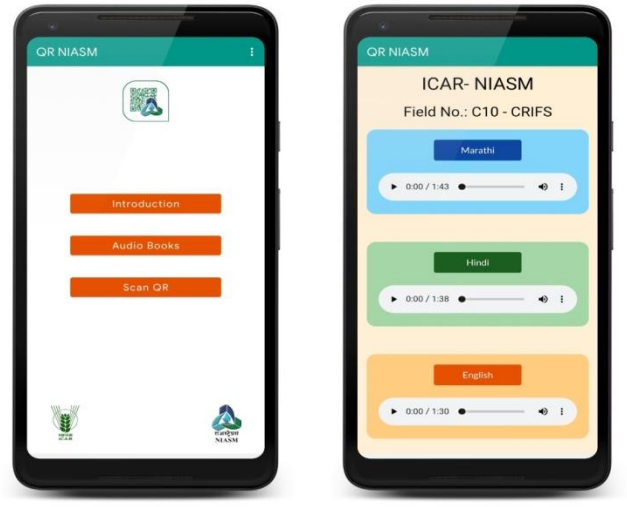
1. For creation of database, the technical information related to the infrastructures, research projects and other services is being collected, edited and recorded in MP3 format. All data is stored on institute's server.
2. An app for Android users has been developed by using Android Studio to access the database through QR codes. It supports all devices with Android API level > 21.
3. Generation of QR Codes was carried out using Python 3.8.

Procedure to download an App:

1. App can be downloaded through link- http://niam.res.in/QR_NIASM/
2. Or by searching NIASM on Google Play Store and install app first in list.

Sample QR codes & demonstration

Four sample QR codes to demonstrate its working through 'QR_NIASM'. Just scan the codes through App and get desired information. These QR codes linked to the information about Fishery Wet Lab-I (Field A-5), Conservation Agriculture Project (Field B-1), Climate Resilient Integrated Farming System (Field C-10) and Agro Meteorology Observatory (Field D-7).



An interface of the App QR_NIASM

Specialities of the App

- Dedicated scanner- the inbuilt scanner is restricted for reading NIASM QR codes only. Other codes will be disregarded providing cyber safety.
- After scanning QR code if connection to server is unavailable due to bandwidth issues, the code could be retrieved from scan history to get information as soon as the issue resolves. This feature will help during time limitations too.
- With this App there is easy access to the 'Audio Books' through the smart phone, so as to hear them during available spare time.

Sample QR Codes for demonstration through QR_NIASM

Developers:

Pravin B. Taware, Pravin H. More, Shon P. Taware and Bhaskar B. Gaikwad

Acknowledgement:

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