August
2020

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ICAR

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NIASM

Project Coordinator

.... a monthly update

ICAR-National Institute of Abiotic Stress Management
Baramati, Pune, Maharashtra 413115

Project Coordinator

.... a monthly update

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From Director's Desk .....

Greetings from ICAR-NIASM.

The current issue on project coordinator highlights the progress made under all the ICAR-NIASM projects during August, 2020 and targets for September, 2020. Along with the common project related activities two national webinars were arranged focusing on research themes of one flagship and one umbrella project. The objective was to identify the methodologies, research gaps, build awareness, and explore the scope of multi-institutional collaboration for knowledge integration and project development under respective research areas. The webinars also provided an opportunity to scientists from public and private research institutes, post-graduate students, agricultural consultants and progressive farmers to listen to concerned experts. The Project Coordinator also includes sections on 'Insights from global research' and 'A leaf from history' on historical developments solely for reader's interest.

I sincerely hope that this issue will help the scientists and the farm personnel of NIASM and other research Institutes to improve the coordination among scientists, technical, administrative and farm staff for implementing the planned activities. I thank Dr. Aliza Pradhan and team for their dedication and sincerity in bringing out this publication and wish that the issue would be received well by readers across all domains.

(Himanshu Pathak)

Contents

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During the last month, the project mainly focused on designing and layout, literature search, communications for institutional collaborations, methodology exploration, organizing webinar, data collection and analyses regarding effect of abiotic stress factors on crops, animals, fish and poultry, installation of automation systems, analysis of weather parameters, crop intercultural operations, evaluation of germplasm traits to certain abiotic stresses, soil analyses, field visits, quantitative analysis of bacterial strains, preparation/ submission/publication of agro-advisory, technical bulletin, popular articles and research papers, etc. followed by their plan of action for the upcoming month.

Agriculture not only gives riches to a nation, but the only riches she can call her own.

-Samuel Johnson

UP 1. Abiotic Stress Information System (ASIS):

Geo-spatial digital maps of multiple abiotic stresses, management options and future scenarios

PI: Bhaskar B Gaikwad; **Co-PI(s):** Amresh Choudhary, Ram N Singh, Dhananjay D Nangare, Nitin P Kurade, Sachinkumar S Pawar and Mukeshkumar P Bhendarkar, Madhukar L Gubbala, Sunil V Potekar, Pravin H More

Webinar e-broucher

Outputs

- Review of literature on methodology for utilizing open data sources for stress mapping.
- Organized National Webinar on "Abiotic stress in Agriculture: Geospatial characterization and management" on August 27, 2020.

Targets for next month

- Exploring collaboration avenues with IWMI, CCAFS and ICAR-NIVEDI.
- Exploring services for geo-spatial framework.

UP 2. Germplasm conservation and management (GCM):

Genetic garden and gene bank for abiotic stress tolerant plants, animals and fisheries for food security and sustainability

PI: Boraiah K M; **Co-PI(s):** Ajay K Singh, Basavaraj, P S, Mahesh Kumar, Satish Kumar, Rajkumar, N Karthikeyan, Paritosh Kumar, Sanjeev K Kochewad, Mukesh kumar P Bhendarkar, Jagadish Rane, Pravin B Taware, Aniket More, Rushikesh Gophane, Lalitkumar Aher

Sowing of soybean germplasm lines

Outputs

- Sowing of soybean germplasm lines (327), mungbean (15), Bajra (2), groundnut (1) and sorghum (1) genotypes.
- Inter-institutional communications to ICAR-CAZRI, Jodhpur; ICAR-CIAH, Bikaner; ICAR-CSSRI, Karnal, ICAR- RC for NEH Region for collaboration and seeking seed materials.

Targets for next month

- Genetic characterization of soybean, turmeric and mungbean along with carrying out of according management practices.
- Planning for sowing of rabi crops *viz*., quinoa, chia, chickpea, wheat.
- Preparation of planting material of different species of dragon fruit.

UP 3. Model Green Farm (MGF):

Environment-friendly, economically viable, state-of-the-art model farm for abiotic stressed regions

PI: Dhananjay D Nangare; **Co-PI(s):** Goraksha C Wackchaure, Bhaskar B Gaikwad, Vanita Salunkhe, Rajkumar, Paritosh Kumar, Aliza Pradhan, Amresh Chaudhary, Mukesh kumar P Bhendarkar, Pravin B Taware, Rushikesh Gophane, Noshin Shaikh, Santosh Pawar, Avinash V Nirmale, Himanshu Pathak

Profuse flowering in dragon fruit orchard

Outputs

- Collected the dragon fruit yield, average fruit weight and post-harvest quality parameters *viz*., sphericity, shape index, TSS and percentage of seed and peel ratio.
- Monitoring the progress of LIS work and installation of automation system.
- Collected of farm waste to the composting unit NIASM.
- Online market survey for purchase of various solar products to be installed in model farm.
- Collection of stem girth data of medicinal plants.

Targets for next month

- Review of research on water requirement of different crops to be grown in abiotic stressed region under surface and drip irrigation.
- Monitoring of diseases in dragon fruit and simultaneous isolation & purification of pathogenic fungi associated with dragon fruit.
- Data collection on yield of dragon fruit and pomegranate followed by post harvest analysis.
- Monitoring compost and vermicompost pits.
- Monitoring progress of automation system installation in field.

UP 4. Climate-smart IFS (CIFS):

Climate resilient integrated farming system in semi-arid region

PI: Sanjiv A Kochewad; **Co-PI(s):** Kamlesh K Meena, Goraksha C Wackchaure, Vanita Salunkhe, Rajkumar, Mukeshkumar P Bhendarkar, Aliza Pradhan, Amresh Chaudhary, N Subash, Laxman R Meena, Pravin B Taware, Patwaru Chahande

Basal dose of fertilizer application

Outputs

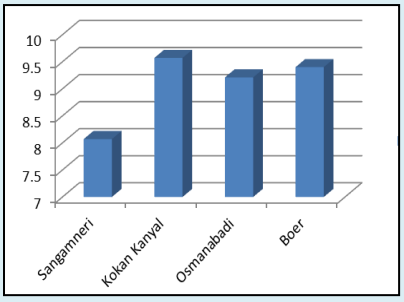
- Sowing and intercultural operations in respective cropping systems.
- Communications for inter-institutional collaboration.

Targets next month

- Lining of geo-membrane HDPE sheet in fish pond.
- Planting of horticulture and agro-forestry plants.
- Design & construction for multilayer farming.
- Analysis of collected soil samples.

FP 1. Atmospheric Stress Management:
Adaptation and mitigation of atmospheric stress in crops, livestock, poultry and fishes for sustainable productivity and profitability

PI: Nitin P Kurade; **Co-PI(s):** Manoj P Brahmane, Sachinkumar S Pawar, Sanjiv A Kochewad, Bhaskar B Gaikwad, Rajkumar, Mukeshkumar P Bhendarkar, Ram N Singh, Dhananjay D Nangre, Avinash V Nirmale, Sunil V Potekar



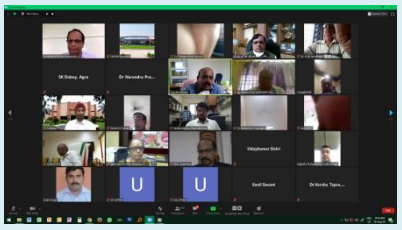
Haemoglobin (gm%) in different breeds of goats during Aug 2020

Outputs
- Haemoglobin estimation in the Sangamneri goats revealed lower values than other breeds. Prevalence of sucking lice was more in these goats as compared to other breeds.
- The cold adapted fish Hypselobarbus kolus were collected form the backwaters of Dimbhe reservoir. The fish tissues were sampled and DNA extracted using standard protocol for amplifying the species-specific cytochrome oxidase subunit I gene.
- The Cytochrome b gene and COXI gene was amplified using PCR to amplify 650 bp from the fin samples for the species identification through DNA sequencing.
- 10 parapheromone (Methyl eugenol) traps were erected for monitoring of fruit flies (FF) in the dragon fruit orchard.
- District wise rainfall gridded data and temperature data were collected for Maharashtra.

Targets for next month:
- Evaluation of endoparasitic prevalence in different breeds of goat.
- Collection and analysis of Meteorological data of MH.
- District wise temperature trend maps of MH to identify heat stresses areas.
- Stocking management, acclimatization, conditioning of fish seed and post-stocking management of ponds.
- Development of Live fish feed culture unit.

FP 2. New Crops:
Exploiting Underutilised Crops (ex. quinoa) for Augmenting Income in Water Scarce Regions

PI: Jagadish Rane ;**Co-PI(s):** Ajay K Singh, Dhananjay D Nangre, Goraksha C Wackchaure, Mahesh Kumar, Satish Kumar, Karthikeyan N, Boraiah K M, Sanjiv A Kochewad, Aliza Pradhan, Amresh Chaudhary, Ram N Singh, Basavraj P



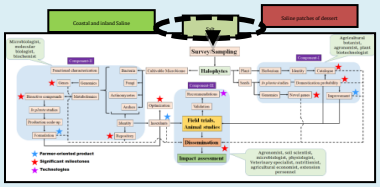
National webinar on "Augmenting underutilized crops for farmers income in abiotic stress regions"

Outputs
- Conducted National webinar on "Augmenting underutilized crops for farmers income in abiotic stress regions" on 10th August, 2020.
- The webinar highlighted scope for enhancing farm income, however, it was felt that the farmers need to be supported with planting material, crop production technology, value addition aspects and market demand to get maximum profit.
- Around 275 participants including scientist, students, agricultural consultants and progressive farmers attended the webinar.

Targets for next month
- Preparation of review article on research progress on underutilized crops in India.

FP 3. Bio-saline agriculture:
Exploitation of halophytic plant and associated microbiome for amelioration of saline agricultural land of arid & semiarid regions

PI: Kamlesh K Meena; **Co- PI(s):** Satish Kumar, Ajay K Singh, Vanita Salunkhe, Sanjiv A Kochewad, Mahesh Kumar, Paritosh Kumar, Neeraj Kumar, Aliza Pradhan, Amresh Chaudhary, Himanshu Pathak



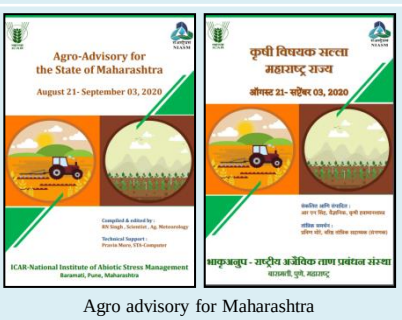
Conceptual Framework of Biosaline Agriculture

Outputs
- The project has been proposed, formulated, revised as per suggestions of the experts and submitted.

Targets for next month
- Literature search and preparation of status review article on the halophytes and associated microbiome for ameliorating the saline soil of semi-arid region of the country.

FP 4. Technology targeting and policy:
Targeting prospective technologies for abiotic stress resilience in rainfed and dryland regions

PI: Manoj P Brahmane; **Co-PI(s)**: Dhananjay D Nangare, Sachinkumar S Pawar, Sanjiv A Kochewad, Bhaskar B Gaikwad, Boraiha K M, Kartikeyan N, Rajkumar, Mukeshkumar P Bhendarkar, Himanshu Pathak



Agro advisory for Maharashtra

Outputs
- Two fortnightly agro advisories published on the Institute's website for stakeholders (English and Marathi versions).
- Extension article entitled "मत्स्य शेतीतील अजैविक स्ट्रेस - कारणे आणि व्यवस्थापन" submitted. Farm ponds of Maharashtra, technical report under preparation and partly completed.
- ITKs in Insect Pest Management compiled.

Targets for next month
- Completion of the technical report on Farm ponds of Maharashtra.
- Compilation of ITK's for abiotic stress resilience in agriculture, livestock and fisheries.

A) School of Atmospheric Stress Management (SASM)

1. Study of immune response and HSP genes polymorphism in relation to heat stress in poultry

PI: Sachinkumar S. Pawar; **Co-PI:** N P Kurade

Outputs
- Recording of environmental parameters for heat stress in poultry.

Targets next month
- Preparation of poultry shed for starting new batch of experimental birds.
- Procurement of experimental poultry birds.
- Recording of environmental parameters for heat stress for August.

B) School of Drought Stress Management (SDSM)

1. Mitigating water stress effects in vegetable and orchard crops

PI: Goraksha C Wackchaure; **Co -PI(s):** Dhananjay D Nangare, Satish Kumar, Aliza Pradhan, K M Boraiah, Karthikeyan N, Jagadish Rane

Visit of ICAR-NIASM Scientist to progressive farmer's field, Malegaon BK, Baramati

Outputs
- In order to understand the constraints in dragon fruit cultivation, around 125 dragon fruit growers were contacted along with visits to some dragon fruit orchards of the progressive farmers in Malegaon BK, Baramati.
- Constraints in dragon fruit cultivation were mostly related to availability of planting material, water and nutrient management, flowering and fruiting, insect and pest management during fruiting, marketing and post-harvest management.

Targets for next month
- To conduct a one day webinar on "Farmers constraints in Dragon Fruit Cultivation" for the farmers, entrepreneurs, scientists and students.

2. Exploring cropping system approaches for enhanced water productivity and income: Evaluating performance of soybean based cropping systems in response to deficit irrigation

PI: Aliza Pradhan; **Co-PI(s):** Jagadish Rane, Amresh Chaudhary, Karthikeyan N

Weeding in soybean cropping system

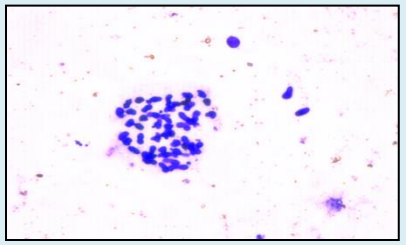
Outputs
- Gap filling, first hoeing and weeding completed.
- Collection of plant samples for measuring crop growth rate, nodule weight, nodule count, shoot: root.

Targets next month
- Measurement of canopy greenness, canopy temperature, leaf area.
- Collection of soil samples for soil moisture measurement.

C) School of Edaphic Stress Management (SESM)

1. Assessment and detoxification of heavy metals in aquatic water bodies using nutritional approaches

PI: Neeraj Kumar; **Co-PI:** Paritosh Kumar



Abnormal chromosome with exposure to chromium, low pH and high temperature

Outputs
- A chronic experiment was conducted on chromium toxicity in Anabas testudineus.
- A. testudineus were exposed with chromium alone and concurrently with low pH and high temperature for 67 days.
- After exposure of above stressors, the genotoxicity in the form of karyotyping was determined.
- The control group (no stressors) has normal chromosome but all the stressors group (Chromium alone groups and concurrent with low pH and high tempeaerture) with 1/10th and 1/20th of LC50 were found abnormal chromosome.

- The control group (no stressors) has normal chromosome but all the stressors group (Chromium alone groups and concurrent with low pH and high tempeaerture) with 1/10th and 1/20th of LC50 were found abnormal chromosome.
- Apart from karyotyping the biochemical biomarkers have also been studied.

Targets for next month
- A similar experiment (Cr+pH+T) in other fish Pangasianodon hypophthalmus has been conducted.
- The experiment has been completed and need analyses of biomarker, histopathology and other related parametrs.

2. Nutrient and gene interaction approaches through nutri-genomics in response to multiple stressors

PI: Neeraj Kumar ; **Co-PI(s):** Kamlesh K Meena, Ajay Kumar Singh, Satish Kumar

Feed Ingredients	Control	Cu-NPs diet
Soybean Meal	35.5	35.5
Fish Meal	20	20
Groundnut Meal	10	10
Wheat Flour	23.47	23.6695
Sunflower Oil	6	5.8
CMC	2	2
Vitamin Mineral Mixture	2	2
Lecithin	1	1
Vit C	0.03	0.03
Cu-NPs	0	0.0005

Outputs

- Cu-NPs has been synthesized using green approach (Fish gill).
- The experiment has been arranged for screening of Cu and Cu-NPs diet for alleviation of multiple stressors.

Target for next month

- Diet formulation based on Cu and Cu-NPs.

3. Dynamics of soil organic matter and primary nutrients in sugarcane-based cropping systems of abiotic stressed regions of Deccan plateau

PI: Amresh Chaudhary; **Co-PI(s):** Aliza Pradhan, Ram N Singh

Outputs

- Post harvesting Depth-wise soil sampling has been completed
- Nutrient analysis of soil samples are carried out.

Targets for next month

- Soil aggregation study in different tillage systems.
- Analysis of soil microbial enzymatic activities.

Sugarcane cropping system

EAP 1. Genomics strategies for improvement of yield and seed composition traits under drought stress conditions in soybean (Funded by: ICAR-NASF)

PI: Ajay Kumar Singh; **Co-PI(s):** Mahesh Kumar, Jagadish Rane

Soybean under No stress

Soybean under Drought Stress

Soybean field experiment

Outputs

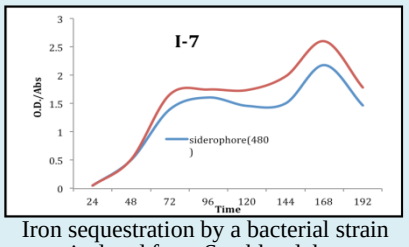
- Fifty six soybean germplasms along with check varieties JS-7105 (drought tolerant), JS-9752 (drought tolerant), JS-9560 (drought susceptible) and NRC-37 (drought susceptible) procured from ICAR-IISR, Indore were evaluated for drought tolerance related traits.
- Twenty eight soybean germplasms along with check variety along with check varieties JS-7105, JS-9752 were grown in pots and evaluated for waterlogging tolerance.
- Soybean germplasms (325 Nos.) along with check varieties JS-7105 (drought tolerant), JS-9752 (drought tolerant), JS-9560 (drought susceptible) and NRC-37 (drought susceptible) were grown at ICAR-NIASM research farm.
- The germplasms will be evaluated for traits such as canopy temperature, PS-II efficiency, canopy greenness and relative water content, shoot biomass and yield related parameters under irrigated and drought stress conditions.

Targets for next month:

- Evaluation of 50 soybean genotypes along with check varieties for Root system architecture in PVC Pipes.
- Generation of VIGS plants for silencing 1-Aminocyclopropane carboxylate synthase (ACS) gene in soybean using in vitro transcripts inoculation.
- Evaluation of soybean germplasms (325) along with check varieties under field conditions in NIASM experimental research farm for drought adaptive traits such as canopy temperature, PS-II efficiency, NDVI value, and water status (RWC).
- Plant DNA isolation from 50 soybean germplasm for GWAS studies through NGS to identify genes associated with drought and waterlogging tolerance.

EAP 2. Evaluation of halotolerant rhizobium and PGPB based biomolecules for alleviation of drought and salt stress (Funded by: AMAAS, NBAIM, Mau)

PI: Kamlesh K. Meena; **Co-PI(s):** Goraksha C Wackchaure, Satish Kumar



Iron sequestration by a bacterial strain isolated from Sambhar lake, Rajasthan-India

K-mobilizers from Sambhar salt lake, Rajasthan, India

Outputs

- Quantitative analysis of iron-sequestartion and phosphate solubilization ability and nitrogen fixation ability of the candidate bacterial strains, obtained from Sambhar salt lake and halophytic weed rhizosphere to establish a correlation of their performance under field conditions as nutritional bio-supplements.
- Potash mobilization ability of the bacterial strains was measured by semi-quantitative method.
- A manuscript entitled" Mitigation of salinity stress in wheat seedlings due to the application of phytohormone-rich culture filtrate extract of methylotrophic actinobacterium Nocardioides sp. NIMMe6" in Frontiers in Microbiology.

Targets for next month:

- To analyze the microbial colonization results from the previous field trial of the biopolymer from maize-soybean cropping system.
- To generate UHPLC profiles of culture-filtrate extracts of the candidate microbial strains.
- To estimate quantitative IAA production ability of the resilient P=solubilizing, K-mobilizing, and N-fixing bacterial strains.
- To sketch a layout for field validation experiment of a halotolerant rhizobium strain (to be conducted in plot C2).

EAP 3. Climate Smart Management Practices (Funded by: IRRI)

PI: Mahesh Kumar; **Co-PI(s):** Jagadish Rane, Amresh Chaudhary, Himanshu Pathak

Growing of rice cultivar 6444 with and without weeds

Outputs

- Rice cultivar Annada is having maximum Chlorophyll fluroscence efficiency compared to others whereas BRRI 70 has lowest efficiency under direct sown rice (DSR).
- Cultivars like 6444, XRA 37923 had reduced quantum yield if grown with weeds compared to without weeds under DSR.

Targets for next month

- Weed suppression trait will be phenotyped based on shoot architectural responses captured by phenomics tools.

EAP 4. Conservation Agriculture for Enhancing Resource-Use Efficiency, Environmental Quality and Productivity of Sugarcane Cropping System (Funded by: CA Platform ICAR)

PI: Kamlesh K. Meena **Co-PI(s):** Goraksha C Wakchaure, Mahesh Kumar, Paritosh Kumar, Amresh Choudhary, Aliza Pradhan, Himanshu Pathak

Installation of sub surface drip irrigation

Outputs
- Sugarcane planting material (var. 86032) was procured and was transplanted on field according to the layout-plan of the treatments.
- Basal fertilizer dose was applied to each main as well as sub plot following the treatment schedule.
- The phenotypic characteristics of the ratoon sugarcane were monitored.
- The fertilizer dosage was applied as per the treatment-schedule in experimental plot A2 and B3.

Targets next month
- Measurement of growth and physiological attributes of sugarcane.
- Maintenance of all the newly transplanted sugarcane plots for weed control, disease management, and gap-filling.
- Measurement of soil characteristics from conservation and conventional sugarcane cropping systems.

EAP 5. Phenotyping of pulses for enhanced tolerance to drought and heat (Funded by ICAR-NICRA)

PI: Jagadish Rane; **Co-PI:** Mahesh Kumar


Phenotyping of mung bean

Outputs
- A total of 12 mung bean genotypes were passed through near Infrared and Visible sensors daily to record the response of these genotypes under normal and moisture stress conditions.
- IACs have been developed for image analysis.
- Another experiment initiated with 16 genotypes of pigeon pea to study the response under depleting soil moisture conditions.

Targets for next month
- Develop an algorithm for differentiation of the genotypes on thermal imaging based calculated parameters.

EPA 6: Abiotic stress detection from field to landscape scale in different crops using remote sensing tools (Funded by ISRO-SAC)

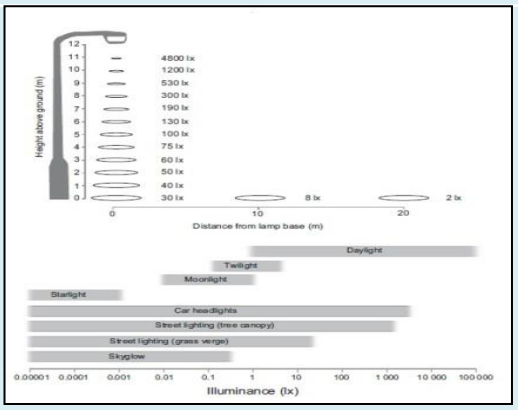
PI: Jagadish Rane; **Co-PI:** Ram N Singh

Outputs
- Online interactions to strategize and execute ground data analysis.
- Tabulation and analysis of hyperspectral signatures of wheat and sugarcane & thermal images of wheat chlorophyll fluorescence.
- Exploration of nearby farmers' fields for taking observations of sugarcane and wheat for discrimination of healthy and stressed crops using remote sensing data.
- Submission of project technical progress report including budget utilization.

Targets next month
- Literature review for analysis of spectral data to segregate narrow and broad bands to discriminate healthy and abiotic stressed crop.

Insights from Global Research: Effects of artificial light at night on insect-plant ecosystem

Pravin B. Taware , Sr. Technical Officer (Farm)



Illuminance measured in the horizontal plane from a typical street light and comparison of measured illuminance from natural sources of light to artificial light sources (Bennie et al., 2016)

Artificial light at night (ALAN) is an increasingly important but neglected abiotic stressor. The rapid spread of outdoor electric lighting across the globe has caused an unprecedented disruption to natural light cycles. Artificial light is widespread in the environment, varying in intensity from faint sky-glow reflected from distant sources to direct illumination of vegetation. In many cases, ALAN is sufficiently bright to induce a physiological response in plants, affecting their phenology and growth. The physiology, behaviour and ecology of herbivores and pollinators are also likely to be impacted by artificial light. Thus, understanding the ecological consequences of ALAN is critical to determine the impact of human activity on ecosystems (Bennie et al., 2016). Long-term records show that insect abundance has declined significantly over time, with worrying implications for terrestrial ecosystems. The majority of investigations into the vulnerability of nocturnal insects to artificial light have focused on the flight to light behaviour exhibited by select insect families. However, ALAN can affect insects in other ways as well (Owens and Lewis, 2018). Nocturnal Lepidoptera are globally important pollinators, and it is predicted that pollen transport by moths may get disrupted by lighting. On the contrary, it has been reported that flowers under full night (FN) lighting had higher pollination success than flowers under either part-night (PN) lighting or unlit controls. However, the quality of light significantly affected pollination and it confirms that street lighting could affect plant reproduction through indirect effects mediated by nocturnal insects, and further highlight the possibility for novel lighting technologies to mitigate the effects of ALAN on ecosystems (Macgregor et al., 2019).

References:

Bennie, J., T.W. Davies, D. Cruse, and K.J. Gaston. 2016. Ecological effects of artificial light at night on wild plants. J. Ecol. 104: 611-620.

Macgregor, C. J., M. J. O. Pocock, R. Fox, and D. M. Evans. 2019. Effects of street lighting technologies on the success and quality of pollination in a nocturnally pollinated plant. Ecosphere 10(1): e02550.

Owens ACS, SM Lewis. 2018. The impact of artificial light at night on nocturnal insects: A review and synthesis. Ecol Evol. 8:11337–11358.

A leaf from history: Honey Bees: Sign of Well-functioning Ecosystem

Mr Rajkumar, Scientist (Agricultural Entomology)

Out of the 20,000 different kinds of bees, we often recognize honey bees as the most charismatic representative of the species. Honey bees are super pollinators; they are very good at helping flowers and plants to reproduce. It's a win-win relationship; the bee gets important nutrients from the flower's nectar and pollen, while the flower gets a chance of reproduction. The greatest contribution of bees and other pollinators is the pollination of nearly three quarters of the plants that produce 90% of the world's food. Apart from pollination, bees are renowned for their role in providing high-quality food in the form of honey; a natural sweetener of many products, beeswax; used in pharmaceuticals, Royal jelly; as a source of protein, Bee venom; used to cure Rheumatism and Arthritis.

There are three well known species of true honey bees which can be domesticated (belonging to genus Apis) in the world along with the wild ones. Domesticated species of honey bee are- Little bee: *Apis florea* (Smallest of all species), Indian bee: *A. cerena indica*, Italian bee/European bee: *A. mellifera*. Wild species of honey bees are- Rock bee: *A. dorsata* (Largest of all species), Himalayan bee or cliff bee: *A. laboriosa*, Black dwarf bee: *A. andreniformis*. Development of modern beekeeping has its origin between 1500 and 1851 when many attempts were made to domesticate bees in different types of hives but were not successful. The discovery of the principle of bee space in 1851 by L. L. Langstroth in USA resulted in first truly movable frame hive. This bee space was 9.5 mm for *Apis mellifera*. This discovery was followed by subsequent innovations like comb foundation, honey extractor, smoker, etc., which helped in the development of modern bee keeping we see today.

In India first attempt to keep bees in movable frame hives was made in 1882 in Bengal and then in 1883-84 in Punjab. In south India, Newton during 1911-1917 trained several beekeepers and devised a hive for indigenous bee, *Apis cerana indica* based on principle of bee space. The exotic bee, *A. mellifera* was successfully introduced for the first time in India by Dr. A. S. Atwal in 1962 at Nagrota Bagwan, which has a potential to gather plenty of honey and for which Dr. A.S. Atwal is referred as "Father of Modern Bee Keeping" in India. India is producing approximately 70,000 metric tons of honey annually from all the four species of honey bees.

Out of the 20,000 different kinds of bees, we often recognize honey bees as the most charismatic representative of the species. Honey bees are super pollinators; they are very good at helping flowers and plants to reproduce. It's a win-win relationship; the bee gets important nutrients from the flower's nectar and pollen, while the flower gets a chance of reproduction. The greatest contribution of bees and other pollinators is the pollination of nearly three quarters of the plants that produce 90% of the world's food. Apart from pollination, bees are renowned for their role in providing high-quality food in the form of honey; a natural sweetener of many products, beeswax; used in pharmaceuticals, Royal jelly; as a source of protein, Bee venom; used to cure Rheumatism and Arthritis.

"A sustainable agriculture is one which depletes neither the people nor the land."

-Wendell Berry