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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Technology for processing and waste utilization of water melon

Water melon [*Citrullus lanatus* (Thunb.) Mastu and Nakai] is an important vegetable *vis-à-vis* fruit belonging to Cucurbitaceae family. Fruits comprise of three main components *viz.* flesh, rind and seeds. Water melon constitutes approximately 64% flesh, 33% rind and 2% seeds of the total weight. The sweet, juicy pulp of ripe fruits is eaten fresh throughout the tropical and subtropical region. The fleshy part of water melon is being used for preparation of RTS drink or sweetened juice on small scale without any specific standard recipes and procedures. During the process of juice extraction nearly one third of fruit consists of rind which is usually discarded. The disposal of rind invites various problems for food industrialist due to overcoming pressures of pollution control agencies. However, the rind of water melon fruit is known to be rich source of carbohydrates (3.80%), proteins (0.98%), minerals (0.20%) and fibers and possesses several health beneficial effects. At present, the left over rind after juice extraction is dumped as

Water melon rind candy

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solid waste. So, an urgent need is being felt to utilize left over rind for preparation of value added products. The water melon rind can be used for preparation of candy and thus can help in reducing waste generation, besides providing better remuneration to farmers, food processors and more importantly will reduce the bad environmental impacts. Candy is produced from fruits and vegetables by osmo-dehydration process in which sugar is the main preservative. Osmotic dehydration (OD) is a technique applied to fruit and vegetable products to reduce their moisture content and increase soluble solids content. In osmotic dehydration, the raw material is immersed in hypertonic solution having a high osmotic pressure, thus resulting mass transfer from the region of higher concentration to the lower concentration. At present there is no standard process available for the preparation of water melon rind candy by osmotic dehydration technique. The maintenance of texture, taste and aroma are major problems in preparation of candy.

An urgent need was felt to standardize the process for preparation of water melon nectar and rind utilize for preparation of water melon rind candy. Department of Post Harvest Technology, ACHF at Navsari Agricultural University has developed the appropriate technology for utilization of water melon juice and rind for preparation of nectar and candy, respectively.

Methodology for preparation of water melon rind candy

The mature water melon of good quality, must be procured, washed thoroughly in clean water and the fruits should be cut into halves and quarters manually using stainless steel knife. The seeds and white rind along with the peel can be separated from juicy pulp. The green portion of rind can be peeled using stainless steel knife and white edible portion cut into cuboids (1.5 cmx1.5 cm) having thickness of 1.0-1.50 cm. Then cuboids must be blanched in boiling water for 5 min. After that 100g sugar should bedirectly mixed with 100g blanched rind cuboids along with 0.20% citric acid for osmotic dehydration. After 24 hours, syrup should be drained out. TSS and weight of syrup may be recorded. Then TSS of drained out syrup should be raised 10°Brix by adding table sugar and cuboids must be again kept in syrup overnight. The process should be repeated till the TSS of syrup reaches to 70° Brix. Then candy cuboids must be rinsed in boiling water for 5 to 10 seconds. Then cuboids must be air dried in cabinet drier at temperature of 60°C for 8 hours. After air dehydration, water melon rind candy can be packed in polypropylene bags (300 guage), sealed airtight and stored at room temperature.

Methodology for preparation of water melon nectar

Water melon nectar

Mature water melon of good quality, must be procured and washed thoroughly in clean water. It should be cut into halves and quarters manually using stainless steel knife. The seeds and white rind along with the peel can be separated from juicy pulp. The edible pulpy portion is cut into small pieces and passed through the fine screen juice extractor. Sugar syrup can be prepared by adding cane sugar to hot water. The strength of sugar syrup (16°Brix) should be measured using hand refractometer. 25% water melon juice should be mixed thoroughly in freshly prepared syrupon weight basis and the mixture must be boiled by adding 0.30% of citric acid to get consistent product. The prepared nectar can be filled into pre-sterilized glass bottles of 200 ml and sealed airtight with crown caps. The product must be processed at 96±1°C in boiling water for 30 minutes followed by cooling and storage at room temperature.

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Processing of *Aloe vera* for value-added products

Aloe vera (*Aloe barbadensis* Miller) belongs to Liliaceae family, traditionally being utilized as contemporary folk remedy. *Aloe vera* is a succulent, almost sessile perennial plant with multiple tuberous roots and many fibrous supporting roots penetrating into the soil. Each leaf is 30-50 cm long and 10 cm broad at the base having an indented margin. The leaves are pea green in colour. Each leaf is composed of three layers. The inner layer consists of clear gel that contains around 99% water and rest is made of glucomannans, amino acids, lipids, sterols and vitamins. The middle layer is made of latex, which is the bitter yellow sap and contains anthraquinones and glycosides. The outer thick layer consists of 15-20 cells called as rind has protective function and synthesizes carbohydrates and proteins. *Aloe vera* contains 75 potentially active constituents: vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids and amino acids. The use of gel has increased dramatically in the field of health care and cosmetics. It is being utilized as a valuable ingredient for food application due to its biological activities and functional properties. *Aloes* have long been in use for several diseases, particularly connected with the digestive system; they have also been used for wounds, burns and skin problems. The term *Aloe* stand for the dried juice, which flows from transversely cut base of its leaves. It is the best herbal answer to support the health and healing mechanisms of the body. Pharmacologically it is an immunity booster and detoxifies the system. It is recommended in adjuvant therapy with antibiotics, NSAIDs (Non-Steroidal Anti-Inflammatory Drugs) and chemotherapy to eliminate drug induced gastritis and other adverse effects. It is useful in various diseases such as Type II diabetes, arthritis, eye disease, tumor, spleen enlargement, liver complaints, vomiting, bronchitis, asthma, jaundice and ulcers. It relieves constipation, maintains a good gastric pH, help in inflammatory bowel disease, non-ulcer dyspepsia, gastric and duodenal ulcers. It is used as a dietary supplement in pre and post-operative patients, post-menopausal women and in cases of osteoporosis.

Aloe juice is utilized as functional foods especially for the preparation of health drinks. Dehydrated *Aloe vera* gel can be utilized for preparation of value added products in food, pharmaceutical and cosmetics industries. It can also be used in other food products including health foods by blending with cereals *viz.,* bread, extruded products, etc. Department of Post Harvest Technology, ACHF at Navsari Agricultural University has developed the technologies for processing and value addition of *Aloe vera* into different processed products. These include the methods for extraction of aloin free *Aloe vera* juice, utilization of *Aloe vera* juice for preparation of health drink and vermicelli and technology for dehydration of *Aloe vera* gel which can be utilized for preparation of *Aloe vera* based nutraceutical. A brief description of the technologies developed at department of PHT for preparation of different products is detailed as under:-

Methodology for extraction of *Aloe vera* juice

After sorting and washing, the traditional hand-filleting method can be used for preparation of *Aloe* leaves/ slips for juice extraction. In this method, the lower 1 inch of the leaf base (the white part attached to the large rosette stem of the plant), the tapering point (2-4 inch) of the leaf top and the short sharp spines located along the leaf margins must be removed by the sharp SS knife. After removal of base, tapering point and sharp spines, the *Aloe vera* gel can be extracted using sharp SS knife. All the green peel/ skin of *Aloe vera* leaf should be removed to avoid presence of bitter compound *i.e.* aloin content in the gel. The gel must be extensively washed with drinkable water followed by pre-treatment with soybean extract (1.5% for 12 h) to remove aloin content (US Patent, 2007). After pre-treatment, the *Aloe vera* gel should be again washed. The juice can then be extracted from gel using crusher type juice extractor.

Methodology for preparation of *Aloe vera* based blended health drink (Nectar)

Health drink in the form of nectar can be prepared from the juice/ pulp of *Aloe vera*, bitter gourd, aonla and guava. Sugar syrup can be prepared by adding cane sugar to boiling water. The strength of sugar syrup (15°Brix) should be measured using hand refractometer. 12% *Aloe vera* juice, 2% Bitter gourd juice, 2% Aonla juice and 4% Guava pulp should be mixed thoroughly in freshly prepared syrup on weight basis and the mixture

Aloin free *Aloe vera* juice in wrapping

Aloe vera based blended health drink (Nectar) must be boiled by adding 0.30% of citric acid to get consistent product (as per FPO specification). The prepared nectar can be filled into pre-sterilized glass bottles of 200 ml and sealed air tight with crown caps. The product must be processed at 96±1°C in boiling water for 30 minutes followed by cooling and storage at room temperature.

Methodology for preparation of *Aloe vera* based vermicelli

Aloe vera based vermicelli can be prepared using 24% *Aloe vera* juice, 1% *isabgol* husk and 75% wheat flour. Vermicelli can be prepared using 'Dolly extruder' by kneading the entire ingredient in feeding section of extruder followed by cold extrusion. Extruded vermicelli should be dried in dryer at 50°C temperature for 10 minutes to remove moisture up to 8% followed by cooling at room temperature, packing in 200 gauge PP bags and storage at room temperature.

Methodology for dehydration of *Aloe vera* gel

Aloe vera gel can be obtained by washing and removal of basal as well as apex part of leaf along with serration followed by separation of gel (without crushing) by the manual peeling method. All the green peel/ skin of *Aloe vera* leaf should be removed to avoid presence of bitter compound *i.e.* aloin content in the gel. The gel must be extensively washed with drinkable water followed by pre-treatment with soybean extract (1.5% for 12 hours) to remove aloin content (US Patent, 2007). After pre-treatment, the *Aloe vera* gel should be washed again. Dehydration of *Aloe vera* gel can be carried out in cabinet dryer (8.5 kg *Aloe vera* gel loaded in 12 trays) at four stage dehydration temperature (75°C for 2 hours, 70°C for 3 hours, 65°C for 4 hours and 60°C till drying) up to final moisture content of about 8 %. The drying of gel can be considered complete when there is no variation in weight of dried gel due to moisture removal during falling period of drying curve. After drying, dried *Aloe vera* gel can be packed in 200 gauge PP bags and stored at room temperature.

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Bio-intensive management of mango leafhoppers

Leafhoppers (*Idioscopus* spp., *Amritodus atkinsoni*) are the serious pests of mango and the oil formulation of *Metarhizium anisopliae* developed by ICAR-IIHR was effective against them @ 0.5 ml/l which gave 85% reduction of pest population.

Managing pests and nematodes in broccoli under protected conditions

Regular use of ICAR-IIHR technologies of Neem soap and Biopesticides (*Trichoderma viride* + *Pseudomonas fluorescens* + *Pochonia chlamydosporia*) enriched Farm Yard manure/neem cake had successfully controlled insect pests and plant parasitic nematodes, respectively in broccoli under polyhouse conditions. Shri Raju, a progressive farmer from Doddaballapur, Karnataka adopted these eco-friendly technologies and accrued an income of ₹7.5 lakh per acre and fetched 30% more yield than chemical methods. It effectively reduced insect pests and root-knot nematode population by 90%.

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Role of ozone in extending shelf life of strawberry

Strawberry is a non-climacteric fruit, famous for its attractive appearance, taste and high nutritional value. The fragile fruit, susceptible to attack by post harvest pathogens, results in significant losses. Conventionally, synthetic fungicides are applied to protect this crop from post harvest pathogens as well as to maintain its quality during storage. Harmful residual effects of these chemicals lead to health problems. Moreover, in the present era consumers have become health conscious and prefer natural foods with less chemical residues. This perception has stimulated interest in research for natural, eco-friendly, effective alternative measures of food preservation. Ozone is one such compound that has the capacity to reduce the microbial as well as pesticidal load from the fresh produce and prolong their storage life. With its approval as a GRAS ingredient by USFDA in 2001, application of ozone (O_3) has gained recognition as a sanitizing agent. Ozone inactivates cells as a result of oxidative stress caused by reactive oxygen species (ROS) such as $OOH^{\cdot}$, $OH^{\cdot}$ and H_2O_2 which are produced by ozone decomposition. Ozone is used for delaying ripening process, sanitizing agent for barrels in wine industry, water sterilization as well as surface sanitizer in fruits. This work was done to study the effects of ozone in aqueous mode on post harvest disease incidence and maintenance of quality during storage of strawberry cv. Winter Dawn.

Results

- Lesser decay incidence and microbial growth was observed in ozone treated fruits.
- Untreated fruits showed nearly 37% and 50% higher decay incidence in low and ambient storage conditions respectively than the ozone treated ones.
- Treated strawberry fruits showed 50% lesser colour change in 14 days of low temperature storage and 15% lesser colour change in 2 days of ambient temperature storage.
- Exposure of strawberry fruits to aqueous ozone could successfully extend storage life of strawberry fruits till 14 days under low temperature and 2 days under ambient storage conditions with minimal decay and suppressed changes in fruit quality.

Procedure

Sorting and grading strawberries

Strawberries being prepared for ozone treatment

Aqueous ozone treatment apparatus

Dipping of strawberries in aqueous ozone

Ozone treated strawberries packed in punnets

Ambient condition storage (25±2°C and 45-50% RH)

Low temperature storage (2±1°C and 90% RH)

2 days after storage at ambient temperature; control (*left*); treated *(right)*

14 days after storage at low temperature; control (*left*); treated *(right)*

- Aqueous ozone is a potential technology for enhancing storage life and safety of fresh produce.

Advantages of ozonation technique

- It is an eco-friendly technology.
- Ozone has been recognized as GRAS.
- It does not leave any toxic residues.
- Ozone is generated on site, thus a fewer safety problems associated with shipping and handling.
- It is highly reactive, can kill pathogens in seconds.
- It is effective over a much wider spectrum of microorganism.

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Harvesting table size hilsa

Freshwater pond cultured table size hilsa *Tenualosa ilisha,* was harvested for the first time on 14 June, 2018 at ICAR-CIFA, Kalyani Field Station of RRC, Rahara, West Bengal. The techniques of artificial fecundation of wild caught hilsa in the river and then incubation of fertilized eggs, larval rearing and subsequently raising fry and fingerling at the research station were developed by a team of scientists (Dr DN Chattopadhyaya, Dr RN Mandal and Mr A Das) under the recently completed ICAR-NASF funded project entitled, "Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)".

This stock of hilsa was raised starting from artificial fecundation of wild caught hilsa from the Hooghly river during March, 2016 and subsequent hatching and rearing of larvae under controlled condition in FRP tanks followed by culture of fry to fingerlings stage in concrete ponds. For further growth, the advanced fingerlings of the size 146-196 mm/29.5-68.4 g were stocked in an earthern pond of 0.2 ha, where they grew to the size of 230-309 mm/120-310 g after nine and a half months of culture.

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Molecular characterization of NKEF gene in rohu

NKEF gene was functionally characterized by using MIC assay, insulin assay and analysis of expression pattern in lecukocyte samples treated with Con A and *Aeromonas hydrophila*. Up-regulation of NKEF transcripts expression was observed in leukocyte samples isolated from head-kidney treated with *A. hydrophila* and Con A. The recombinant protein of NKEF was able to inhibit the bacteria *A. hydrophila, Edwardsiella tarda* and *Staphylococcus aureus* at a concentration of 100 µg at 24 h post incubation. In insulin reduction assay, the turbidity was increased from 20-140 min in dose dependent manner at different concentration of rNKEF with DTT (15.62 µg, 31.25 µg, 62.5 µg and 125 µg). From the above results it was concluded that rNKEF has both anti-microbial and anti-oxidant activity.

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Exploration of maize, chilli, brinjal and wild *Solanum* sp. germplasm from Chhattisgarh

Chhattisgarh in the South Eastern part of India, is a mineral and agro-biodiversity rich state predominated by tribal population (31.8%) viz. Kol, Gond, Bhunjia, Korwa, Rajgond, Baiga, Kawar, Bhaiyana, Binjwar, Dhanwar, Munda, Oraon etc. Its diverse topography, forests and climate have evolved and support the natural growth of many wild relatives of crops including belonging to Solanaceae family. Taking into account the possibility of collecting unique germplasm and collection gaps, an exploration trip was conducted from 21st to 30th September, 2017 in Jaspur, Korba and Koriya districts of Chhattisgarh. During the exploration, a total of 85 accessions belonging to 10 species were collected. The collected species comprised of *Zea mays* (43), *Capsicum frutescens* (7), *Capsicum annuum* (12), *Solamum melongena* (3) and *Oryza sativa* (2) while crop wild relatives include *Solamum xanthocarpum* (7)*, Solamum nigrum* (3), *Solamum viarum* (6), *Solamum torvum* (1) and *Ocimum basilicum* (1).

Maize germplasm represents considerable diversity in qualitative and quantitative traits of cobs and seeds. The cob color ranged from light yellow, dark yellow, white to dark purple. Other traits viz. the cob length (7.33-26.67 cm), cob girth (8.00-16.33 cm), number of rows per cob (8-18), number of seeds per row (12-45), cob weight (25.45-204.88 g) and 100 seed weight (9.74-38.66 g), showed considerable variability among the accessions. Cob weight, seed weight, number of seeds per row and cob length have high variability, while cob girth and rows per cob showed moderate variability. Similarly high diversity was observed in germplasm of *Capsicum annuum* and *Capsicum frutescens.* Accessions of both these species differ significantly in fruit shape, size and in pungency. A few landraces (*Dhan mircha, Gach mircha, Gol mircha* etc.) of highly pungent chilli were also collected, among these "*Dhan Mircha*" is popular landrace of *Capsicum frutescens*. This is a small fruit sized, perennial and highly pungent chilli, mostly planted in the backyards for domestic consumption. Besides these, two early maturing named landraces of rice viz. "*Chaina dhaan*" and "*Daani dhaan*" were also collected.

The wild species of Solanaceae family were mostly found in and collected from forests, hills, wastelands, river banks and dam sites. *Solamum xanthocarpum* is called by various names like *bhainskateyiya*, *ghaskatiya* and used in cough, asthama and toothache by the locals. It was reported to be very effective for these ailments. *Solanum viarum* was collected from high altitude (>1000 msl) of Jaspur viz. Rauni, where it was found sporadically in the forests and forest peripheries. Its broth is used in cold and cough by local people. *Solanum nigrum* was found in a variety of habitats i.e. natural wild, farmer's fields, village streets and wastelands areas etc. Its small, black, round, juicy fruits are edible and relished particularly by the children. *Solanum torvum* has a

S. viarum *S. niigrum*

S. xanthocarpum

wide distribution among different habitats. However, it was most common in natural wild hilly terrain. Unripe fruits of *S. torvum* are oil-fried into vegetable and liked very much by the locals. Herbarium specimens of fifteen species of crop wild relatives viz. *Solanum viarum*, *Solanum torvum*, *Solanum insanum*, *Solanum nigrum*, *Tephrosia purpurea*, *Abelmoschus ficulneus*, *Atylosia scarabaeoides*, *Crotalaria* sp., *Vigna hainiana*, *Vigna vexillata*, *Abelmoschus tetraphyllus, Solanum surattense, Oryza nivara, Abelmoschus pungens and Costus speciosus* were collected and submitted to National Herbarium of Cultivated Plants (NHCP). These areas have large diversity in rice, millets, vegetables, pulses and horticultural species, and need interventions to sustainably support and conserve on-farm diversity.

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Soil quality management through Zero Budget Natural Farming

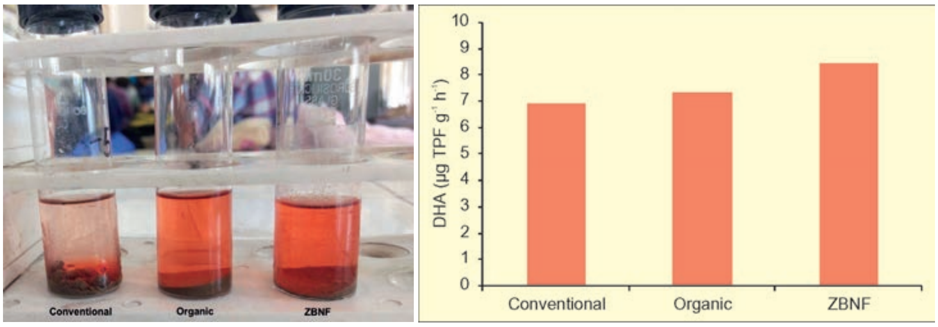
Imbalanced and indiscriminate use of chemical inputs in the present day agriculture has adversely affected the soil quality and crop ecosystem and threatens future food production by reducing biodiversity, declining factor productivity, and contributing to environmental degradation of the existing system. Further, the ever-increasing crop production costs and farmer distress poses a big challenge to the scientists and planners to achieve the objective of the Union Government to double the farmers' income by 2022.

Mountainous agro-ecosystem of Himachal Pradesh is one of the most vulnerable ecosystems, which needs to be supported by sustainable farming practices without any adverse effect on soil and environment. Indigenous a cow based 'Zero Budget Natural Farming' (ZBNF) is a holistic farming technique, which will reduce crop production costs, market dependency on farm inputs, and will increase farm carrying capacity to sustain the vital livelihood source of resource-poor farmers. ZBNF focuses on utilizing cheap and local inputs with absolutely no place for fertilizers and plant protection chemicals.

Soils provide numerous ecosystem services, and enhancing soil quality is important for sustaining crop productivity and environmental quality. The agricultural practices like cow-urine and cow-dung based ZBNF are expected to improve the soil quality. Among biological indicators, enzyme activities are important dynamic indicators of soil quality because of their quick response to changes in soil environment and management practices (pesticides, fertilizers, amendments, land use, different management and farming systems etc) and the metabolic activity of soil microorganisms, which influence soil fertility, nutrient cycles and transformations. Dehydrogenases (DHA) are intracellular enzymes that are involved in microbial oxido-reductase metabolism and their activity is considered an indicator of microbial oxidative activity, which is closely correlated with respiratory activity and organic matter decomposition. It is used to determine the influence of various chemicals (like pesticides or excessive fertilization) and management practices on the soil.

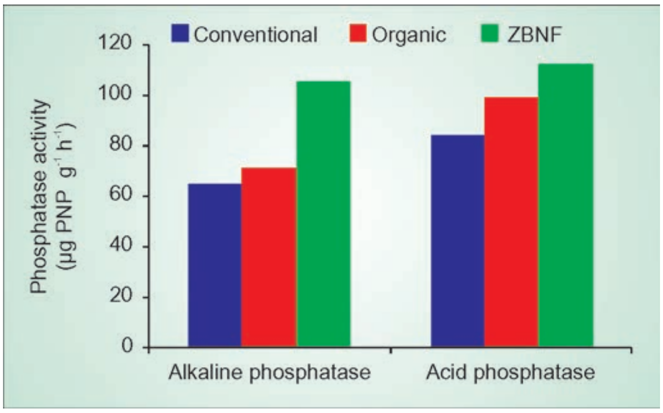

Beejamrit


Jeevamrit



Effect of farm management practices on dehydrogenase activity (DHA)

Strong negative impact of intensive fertilizer and pesticide use on DHA has been reported in literature. Phosphatase catalyses the hydrolysis of both organic phosphate esters and anhydrides of phosphoric acid into inorganic phosphorus (P) and are crucial in accelerating the cycling of P between soil organic matter and plant uptake.



Effect of management practices on phosphatase activity

Pea crop under Zero Budget Natural Farming

In 2018, the Himachal Pradesh government launched ZBNF project to prevent soil degradation, promote climate resilient agriculture practices, increase farm income and make the farmers' self-reliant. Keeping this in view, the short-term effects of ZBNF on soil quality indicators (DHA and phosphatase activity) as compared to conventional (recommended fertilizers and pesticides) and organic farming (FYM) under pea (var. P-89) cultivation were studied at Dr YSP UHF, Nauni. The initial soil pH of the experimental field was 6.3 and soil organic carbon was 7.50 g kg^{-1}. The available nitrogen, phosphorus and potassium were 329, 13.4 and 154.6 kg ha^{-1}, respectively. The inputs used in the ZBNF were *beejamrit* and *jeevamirit*. *Beejamrit* was used for seed treatment. *Jeevamirit* was applied twice a month in the irrigation water or as a 10% foliar spray. *Jeevamrit* provides nutrients and acts as a catalytic agent that promotes the activity of microorganisms in the soil. The yield obtained under ZBNF (10 t ha^{-1}) was comparable to that in conventional farming.

The ZBNF increased the enzyme activity, indicator of soil quality, in comparison to the conventional and organic farming. DHA increased from 6.9 µg TPF g^{-1} h^{-1} under conventional farming to 7.3 µg TPF g^{-1} h^{-1} under organic farming and was highest under ZBNF (8.4 µg TPF g^{-1} h^{-1}).

A similar response pattern was observed in the alkaline and acid phosphatase activity. Under ZBNF the alkaline phosphatase activity increased to 105 µg PNP g^{-1} h^{-1} in comparison to 65 µg PNP g^{-1} h^{-1} and 71 µg PNP g^{-1} h^{-1} under conventional and organic farming, respectively. The acid phosphatase activity was also highest under ZBNF (112 µg PNP g^{-1} h^{-1}) followed by organic farming (99 µg PNP g^{-1} h^{-1}) and conventional farming (84 µg PNP g^{-1} h^{-1}). Thus, the ZBNF practice showed an improvement in soil quality within a single cropping season, as indicated by increase in the activity of soil enzymes (DHA and phosphatase).

The studies need to be continued to assess the long-term sustainability of the ZBNF and its impact on soil, crop and environmental quality. This has opened new vistas to scientific community for further validation and refinement of the low cost and eco-friendly ZBNF system in present farming scenario.

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ERRATUM

ICAR NEWS, April-June 2018, Photograph on page 4 pertains to "New Indigenous ornamental fish species *Parasilorhynchus swaini* discovered in Odisha" on page 7 of the same issue.

ICAR-The Central Arid Zone Research Institute (CAZRI)

Pioneering research on combating desertification

The Central Arid Zone Research Institute (CAZRI) owes its origin to the Desert Afforestation Research Station, which was established in 1952 at Jodhpur which was upgraded to the Desert Afforestation and Soil Conservation Station in 1957. In order to put appropriate emphasis on arid zone research and development, Government of India in 1958 sought the advice of UNESCO expert, Mr CS Christian, upon whose recommendation the Institute came into existence on October 1, 1959.

The Institute conducts multi- disciplinary research to seek solutions to the problems of arid zones (hot and cold) which occupies about 12% geographical area of the country. About 32 million ha area in the states of Rajasthan, Gujarat, Punjab, Haryana, Karnataka and Telangana comprises the hot arid regions and about 7 million ha in the states of Jammu & Kashmir and Himachal Pradesh comes under the cold arid region of the country. Interestingly approximately 61% of the hot arid zone of the country is in western Rajasthan which includes the vast Indian Thar desert, the most densely populated desert of the world.

MANDATE OF INSTITUTE

- Basic and applied research on sustainable farming systems in the arid ecosystem
- Repository of information on the state of natural resources and desertification processes
- Livestock-based farming systems and range management practices for the chronically drought-affected areas
- Generating and transferring location-specific technologies.

Organisational structure

The Institute is located at Jodhpur in Rajasthan state and comprises of six research Divisions. It has five

Regional Research Stations across different states: three of these are situated in Rajasthan at Pali, Bikaner and Jaisalmer; one in Gujarat at Bhuj; and one in Jammu and Kashmir at Leh (Ladakh). The Krishi Vigyan Kendras working at Jodhpur, Pali and Bhuj and the All India Network Project on Vertebrate Pest Management are also under the domain of the Institute. Scientists of 32 different subjects work on diverse fields of relevance to agriculture in arid environment. These include crops, trees, fruit trees, grasses, livestock, solar energy, agricultural engineering, natural resources, geomorphology, soils, and technology transfer. This gives the Institute a unique identity of being among a few agricultural Institutes in the world working simultaneously on such a wide ranging fields.

Achievements

CAZRI has strategically addressed various issues in research taking cognizance of challenges and opportunities in arid production environments. The approach of the Institute has been dynamic and currently high priority is being attached to sustainability and livelihood security of farmers. Some of the salient achievements of the Institute are given below:

Technologies for combating desertification

CAZRI has done pioneering research on combating desertification through sand dune stabilization and shelterbelt plantations. The Institute devised suitable technology for stabilizing sand dunes which included fencing/protecting the dune area; establishing micro-wind breaks and planting of adapted bush-wood material. This technology has been helpful in undertaking the stabilization of sand dunes covering over 4 lakh ha in the state of Rajasthan.

Plantation on dunes

CAZRI's recommendations for shelterbelt plantations for reducing sand movement is well recognized. Planting of shelterbelts with neem (*Azadirachta indica*), Israeli babool (*Acacia tortilis*) and desi babool (*A. nilotica*) trees have been found to reduce wind speed by 20-30% and consequently wind erosion by about 50%. This also results in conservation of soil moisture and nutrients. The technology has been adopted along 400 km in western Rajasthan and at many places micro-environment for practicing agriculture has been provided.

Integrated farming system (IFS) for sustainability and livelihood security

The Institute has identified several agroforestry, agri-horticulture, horti-pastoral and silvi-pastoral systems for livelihood security of farmers. Growing trees like *Prosospis cineraria*, *Hardwickia binata*, *Acacia senegal*, *Tecomella undulata*, *Ailanthus excels* and *Ziziphus mauritiana* in combination with different crops and grasses have been shown to give high and assured returns to the farmers under harsh climatic conditions of arid zone.

Integrated Farming System model for 7 ha land incorporating crop and system diversification and livestock component has been developed. The model can generate an employment of more than 845 man days and give net returns up to ₹2.5 lakh. The model can sustain a family of 4 persons and 7 adult cattle units. The system diversification components included in the IFS are arable cropping (15%); agri-horticulture (10%); agroforestry (35%); silvipasture (30%); and boundary plantation (10%).

Crop production technologies

Various technologies have been developed for sustainable crop production under rainfed conditions. These include

application of FYM on rows to prevent crust formation, optimum tillage to capture sufficient rainwater, paired-row planting for efficient utilization of soil moisture, intercropping to reduce risk of crop failure during aberrant weather, rainwater harvesting, incorporation of amendments and composted crop residues to improve soil moisture and fertility, application of life-saving irrigation, use of pressurized irrigation, and adoption of pearl millet-cluster bean rotation under rainfed and pearl millet-mustard rotation under irrigated arid conditions.

Varieties developed

The Institute has developed several varieties of crops, grasses and horticulture crops. These include CZP 9802 and CZ-IC 923 of pearl millet; Maru Guar of cluster bean; CAZRI Moth 1, 2, 3 of moth bean; Maru Kulthi of horse gram; CAZRI 75, CAZRI 358 and CAZRI 2178 of *Cenchrusciliaris;* CAZRI 76 of*C. setigerus,* and CAZRI Sewan-1 of *Lasiuruss indicus*. Similarly, in horticulture, Maru Gaurav in Karunda (*Carissa carandas*) and Maru Samridhi in Lasora (*Cordiamyxa*) have been identified as high yielding varieties suitable for cultivation under arid zone conditions.

A farmers' variety of wheat Kharchia Local was successfully registered under Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), India for a period of six years in 2015 by the Institute.

Technologies for efficient rainwater management

Improved designs of traditional rainwater harvesting structures like *tanka* (cistern), *nadi* (pond) and *khadin* (run off cultivation on conserved soil moisture) have been developed to maximize collection of rain water. The improved design of *tanka* developed by the Institute has

been adopted under the Rajiv Gandhi Drinking Water Mission of the government.

CAZRI has also explored several courses of their buried Saraswati and Drishadvati rivers from the Himalayas as well as other buried streams in the Thar Desert.

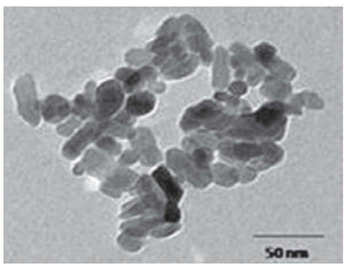
The Institute is well recognized for their work on watershed management and was awarded 'Saving the Dryland' appreciation certificate for work on Jhanwar watershed by UNEP in the year 1996.

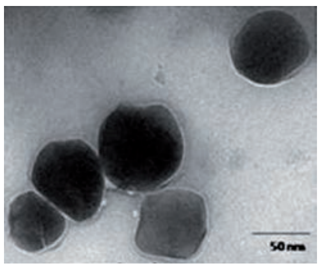
Biosynthesis of nanoparticles

The Institute has spearheaded green synthesis and evaluation programmes related to agriculturally important nanoparticles. Biosynthetic approach using specific fungi, bacteria and plant extracts for nanoparticles has been standardized and some of these technologies are under commercialization. A common protocol for synthesis of nanoparticles of many elements has been standardized.

New potassic fertilizer developed

A new form of potassic fertilizer has been developed using





low-grade feldspar and leonardite, an oxidized form of lignite that is abundantly available in the country. The response of pearl millet, wheat and mung bean to this form of potassic fertilizer has been found superior to muriate of potash (the conventional potassic fertilizer available in the country).

Introduction of new arid fruit and fodder crops

A large number of improved fruit crops and varieties of ber (*Ziziphus mauritiana*), pomegranate, aonla, date palm, lasora, karonda, bael (*Aegle marmelos*), phalsa (*Grewia subinaequalis*), napier grass, fodder beet (*Beta vulgarissub* sp. *meritima*) etc. have been introduced by the Institute for cultivation in the arid regions. Protocol for rapid multiplication of date palm plants through repetitive somatic embryogenesis has been developed.

Identification of forest trees suitable for arid region

A number of tree and shrub species from iso-climatic regions of the world have been evaluated by the Institute for fuel, fodder and other economic products. The most promising ones identified are *Acacia tortilis*, *Prosopis juliflora*, *Acacia bivenosa*, *Simmondsia chinensis*, etc. was given for work. The ICAR Team award on the improvement and multiplication of khejri (*Prosopis cineraria*) received. Air layering method for vegetative propagation of khejri tree has been developed. Technique for mass multiplication of rohida (*Tecomella undulata*) through axillary bud proliferation has been developed.

Bio-saline tree species and fodder halophytes identified

In Bikaner region under saline water logged conditions, *A. nilotica*, *A. tortilis* and Eucalyptus spp. have been identified best for higher biomass production and improving soil properties in terms of soil organic carbon and reducing ECe and SAR values. Under Bhuj conditions, based on fodder quality assessment, *Sporobolus marginatus*, *Aleuropus logopoides*, *Suaeda nudiflora* and *Cressa cretica* have been identified best palatable halophytes for the livestock of the region.

Management of plant diseases and insect pests

Soil solarization and incorporation of mustard oil-cake, *Aspergillus versicolor* and *Bacillus firmus* in the soil have been successfully used to minimize the population of soil borne pathogens. The Institute has developed a technique for the management of drying syndrome in khejri tree.

It involves the regulated application of phorate, *Trichoderma* mixed with *Prosopis julijflora* compost and *Aspergillus terreus* with onion residue near the roots of affected tree.

Neem oil emulsion has been found effective against insect pests viz. pod borer (*Helicoverpa armigera*), castor semi-

looper (*Achaea janata*) and army worm (*Spodoptera exigua*). Neem seed pellets developed by the Institute have been recommended for control of termites.

Root-knot nematode is important pest of horticulture crops, hence a simple and reliable method for aseptic screening of chilli germplasm against the nematode was developed. Biological control agents, especially *Paecilomyces lilacinus*, *Pasteuria penetrans* and Arbuscular Mycorrhizal fungus (*Glomus fasciculatum*) have been found effective in the management of root-knot nematode in chilli. Technique for mass multiplication of *P. lilacius* on locally available plant material in polypropylene bags was developed.

Vertebrate pests identified and their management

Institute has reported 18 rodent species from arid soils. The species causing damage to crops have been effectively managed through technologies evolved by the Institute that include use of Sherman traps and burrow baiting with freshly prepared pearl millet-based zinc phosphide rodenticide baits followed by bromoadiolone (0.005%) baiting.

The Institute has also reported four rodent species viz., Indian field mice, Turkish rat, Blyth's vole and Himalayan marmot from cold arid region of Leh-Ladakh. The Indian field mice reported for the first time has been identified as the major pest of crops in Leh-Ladakh region.

Plant biodiversity and conservation

The Thar Desert is endowed with number of unique plant species. Their existence is threatened due to over exploitation. These include *Commiphora wightii* (Guggal), *Acacia jacquemontii* (Bawli), *Calligonum polygonoides* (Phog), *Moringa concanensis* (Sarguda), *Ephedra ciliata*, *Caralluma edulis* (Pimpa) etc. Institute has successfully made efforts to conserve and multiply these plants in its Desert Botanical Garden.

Enhancing gum exudation from trees: An additional source of income for farmers

Technology to enhance good edible gum exudation from Kumat (*Acacia senegal*) tree without endangering plant survival has been developed. Injecting standardized dose of gum inducer, 250 g to 500 g good quality gum per tree per year in the month of April-May can be harvested. The technology has now spread to more than 45 villages in Jodhpur, Nagaur, Bikaner and Barmer districts of Rajasthan.

Animal feed block from locally available materials developed

Institute has developed economical area-specific Complete and Supplementary Feed Blocks as per the nutritional need of livestock (cattle, sheep and goat). The feed blocks have been prepared by mixing locally available feed, fodder and concentrates in fixed proportions. This includes grasses (*C. ciliaris,C. setigerus*, *Lasiurussindicus*), tree leaves (*P. cineraria*, *Ziziphus* spp., *Acacia nilotica*)

and concentrate feeds i.e. cakes/meals (castor, *Colocynthis*, sesame, mustard) along with unconventional sources i.e. urea, molasses, animal jaggery, vitamins and minerals. The feed blocks have reduced the cost of feeding lactating cows and growing goat kids effectively. The Institute has also developed multi-nutrient feed blocks to provide relief to the cattle from mineral deficiencies.

Solar devices developed

The Institute has designed and fabricated several solar energy-based devices for use in agriculture. These include the animal feed solar cooker, PV winnower-cum-dryer, collector-cum-storage type solar water

heater, solar water heater-cum-still, solar water heater-cum-steam cooker, solar cabinet dryer, solar PV duster and solar PV pump-based drip irrigation system. Several of these devices have been adopted by farmers of Rajasthan. Commercialization of the devices is underway through transfer of technical know-how to the private firms. A solar dryer (400 kg capacity) developed by the Institute for the drying of horticultural produce has been installed in Pali district.

Agri-photovoltaic system for farming, electricity generation and water harvesting

Generating electricity using photo-voltaic panels, harvesting water and cultivating crops simultaneously on a single unit of land has been conceptualized,

implemented and demonstrated by the Institute. An Agri-voltaic system has been established with 105 KW capacity power generation, 1.2 lakh litre capacity water harvesting and crop production components comprising of mung bean, clusterbean, isabgol, cumin and senna. The system can generate an annual income of ₹ 7.50 lakh per acre.

Passive cool chamber for perishable food items

Low-cost double brick-walled passive cool chamber suitable for regions with low atmospheric humidity has been designed and developed. This cool chamber reduces the ambient temperature by 8-10°C and maintains high relative humidity conditions conducive for longer preservation of fresh farm produce like vegetables, fruits, milk etc.

Farm implements for arid soils

A number of farmer-friendly farm implements have been designed and developed. These include a tractor drawn

three-furrow (six-row) multi-crop seed-cum-fertilizer drill for sowing on specially created slant surfaces to use conserved moisture, and tractor-operated two-row planter for kharif crops. A single or double-slotted weeder has been developed for increasing weeding efficiency and reducing women drudgery. It has been recommended by the Government of Rajasthan under various schemes.

Socio-economic aspects

The socio-economic aspects of the desert dwellers are continually monitored by the Institute. Various technologies developed at the Institute are also assessed for their socio-economic viability. The cost-benefit analyses of various land use systems have established that

pasture-based livestock system has positive net present value and annuity as compared to arable farming.

Transfer of technologies

Trainings, field days, farmer fairs, scientist-farmer interaction meetings and exhibitions are organized at periodic interval, both at the Institute and in adopted villages to enrich the knowledge of farmers. These events have helped farmers in interacting with the scientists and in rapid dissemination of improved technologies developed by the Institute. The technological interventions are also evaluated and fine-tuned through on-farm

research, on-farm trial and verification trials. Field days and on-farm and off-farm trainings are also organized to increase awareness amongst the technology users.

Use of ICT in technology dissemination

The Institute was among the leaders in setting up an ISRO-sponsored satellite-based Village Resource Centre for interactive and rapid communication of technological solutions to the farming community of arid zone. Now agro-advisories are being issued to the farmers on mobile through SMS using the m-kisan portal. Farmers from Jodhpur, Barmer, Pali, Nagaur, Jaisalmer, Ganganagar, Chittorgarh, Jhunjhunu, Jalore, Jaipur, Bikaner, Churu, Ajmer and Hanumangarh districts of Rajasthan are being benefitted by this mode. The Institute is also connected with the farmers through CAZRI Mobile App (CAZRI Krishi) and You-Tube. Based on the weather data, the Institute issues bi-weekly agro-advisories for farmers of the region.

A comprehensive website (www.cazri.res.in) further boosts the Institutes presence among leading Institutes of the country.

Value-added products

For increasing income of the farming community, the Institute has developed a number of technologies for value-addition of farm produce. These include preserves, juice, candies and pickle from ber, date palm and *Colocynthis*. Technologies for preparing shampoo, moisturizing cream, lotions, pickle and candy from *Aloe vera* have been developed. Institute has successfully prepared goat milk products like ice-cream, curd, cheese

and whey after removing characteristic goaty odour from the milk. The Institute has also demonstrated the value of grain pearling in increasing the shelf life of pearl millet flour and prepared nutritionally enriched biscuits of pearl millet.

Agricultural Technology Information Centre

The Institute has in operation a single window system under the Agricultural Technology Information Centre to meet the diverse needs of farmers, including improved seed material and technology information. Since its inception in 2002, more than 88,000 farmers have been benefitted.

Trainings

Apart from trainings to grass-root workers, specialized national and international trainings for scientists on relevant areas of arid zone agriculture are continually organized by the Institute. A number of training courses for research officers of Afro-Asian countries sponsored by International institutions like UNESCO, UNEP, FAO, DANIDA, etc. were successfully organized. In recent years, scientists have come to the Institute from several countries such as Sri Lanka, Egypt, Iraq and Afghanistan. During the last five years the Institute imparted training to more than 2500 farmers, farm women and youth on various aspects related to arid agriculture.

Package of practices included in the State recommendations

Many agricultural practices developed at the Institute have been adopted and recommended to the farmers of the arid zone in Rajasthan. These include the model of integrated farming system for 7 ha holding; cultivation of varieties developed by Institute, round-the-year fodder production; organic til and mung bean production; stress management in clusterbean by foliar application of sulpho-salicylic acid, nitrogen doses and irrigation scheduling in groundnut and wheat.

Consultancies

The technologies and expertise developed by the Institute are widely sought after by the government, non-government and private agencies or entities. The Institute has earned many consultancies from different organizations. Prominent among them are NTPC, Noida; Duraline India Pvt. Ltd., Telengana; Suratgarh Thermal Power Station, Suratgarh, Rajasthan; IFFCO, New Delhi; Indian Railways; Space Application Center, Ahmedabad; TCS, Pune; Barmer Lignite Mining Company, Jaipur; Hyundai Motor India Ltd., Tamil Nadu, etc. The trainings on rodent control are regularly organized with the Post and Telegraphs, Railways and the Health departments being among the important beneficiaries.

Patents

The Institute has filed 14 applications for patents. Three patents have already been granted. These are:

- Jaisalmeri preserve and candy from fruit of Tumba (*Citrullus colocynthis*)
- Preparation and method of processing of *Aloe* candy from *Aloe* species
- A novel method for isolating aloin by extraction from yellow sap of *Aloe vera.*

Linkages

Since inception, the Institute has undertaken joint collaborative research and development programmes with institutions and organizations across the world. These include institutions from USA, Australia, Japan, USSR, Europe, South East Asia and several CGIAR Institutes like ICARDA, ICRISAT, ILRI etc. At national level, the Institute has linkages with various State and central Govt. organizations (SAUs, DBT, DST, Dept. of Space, MOEF, MoES, IMD, ATMA, State Agricultural Line Departments etc.

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Impact of Hydrocolloids on nutrition of blueberry

Blueberry is a deciduous or evergreen prostrate shrub which bears the fruit from April to June. Fruit ranges from pea-to-marble in size. Fruits often have an epicuticular waxy layer on the peel known as 'bloom'. The fruit colour is red at immature stage to purple colour at ripened stage. There are mainly three types of cultivars in blueberry namely highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*) and rabbit eye blueberry (*Vaccinium ashei*). Fresh blueberries are very rich source of antioxidants than other fruits. Its fruits are rich in vitamin C, essential dietary fibres and minerals. Fruits are also major source of anthocyanins and phenolic compound, resveratrol and have low calorific value. These compounds play major role in combating inflammation, cancer and improve the gut microbes.

Now-a-days, due to health benefits of blueberry, its cultivation and demand is increasing day by day in all parts of the world. In India, some cultivars of blueberry have been introduced in hilly states such as HP, J and K, and Uttarakhand but its cultivation has not picked up because of paucity of planting material and non-availability of suitable land with ph 4.5 or so.

Like other berries, the shelf life of blueberry is only 4-5 days at ambient conditions and about 3 weeks in cold storage. Hence, there is urgent need to use postharvest management strategies to extend its shelf life for increased availability in the season. For instance, the natural waxy bloom develops in blueberry fruits during the maturation and ripening processes, which protects the fruits and keep them fresh for longer period. However, during handling of fruits, this is removed and bruising occurs in the fruits. Thus, replenishment of this natural layer with commercially available edible coating especially with hydrocolloids, is required to reduce to increase the freshness of such a valuable fruit and to reduce the postharvest losses.

The Technology

The fruits of blueberry variety 'Misty' were harvested at full maturity stage. After sorting and grading fruits were coated with four different hydrocolloids such as carboxy methyl cellulose (1%), xanthan gum (0.3%), guar gum (1.5%), gum Arabic (10%). These coatings were prepared in luke warm water and the blueberries were dipped into each coatings for 5 min. After treatment, the fruits were dried under fan and after drying, fruits were packed in plastic punnets (250 g). After packaging, fruits were stored at 1±1°C and 85-90% relative humidity for 35 days.

We observed that all the coatings were effective in maintaining quality of blueberry fruits over non-coated fruits. However, the CMC (1%)-coated fruits was found to be the best coating as the fruits maintained acceptable limits for physiological loss in weight, quality attributes and over all acceptability of fruits up to 35 days (Table 1) at 1±1°C and 85-90% relative humidity. In contrast, non-coated fruits could remain acceptable only up to 21 days.

Advantages of the technology

- It is very easy to apply coatings to fruits.
- It is a cheap and user-friendly technology.
- Coatings improve the cosmetic appeal of fruits
- It improves the glossiness of fruits.

Table 1. Quality of blueberry coated with different hydrocolloids

Treatment	Functional parameters				
	Total soluble solids (°B)	Total phenolic content (mg GAE/ 100g)	Anti-oxidant activity (μmol TE/g)	Ascorbic acid content (mg/ 100g)	Fruit decay (%)
Carboxy methyl cellulose	17.3	139.0	17.2	19.9	2.4
Xanthan gum	17.1	130.2	15.7	13.6	7.4
Guar gum	17.2	131.7	15.7	15.1	4.5
Gum Arabic	17.2	133.1	16.9	16.3	4.2
Control	17.1	119.4	15.3	12.0	8.5

- Improves the freshness of fruits for longer time.
- Hydrocolloids help to reduce the transpirational loss from the fruit surfaces.
- It helps to control the respiration rate.
- It acts as an effective physical barrier against mechanical damage.
- Hydrocolloids can be applied with different postharvest fungicides and chemicals.

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Application of Nanotechnology in agriculture

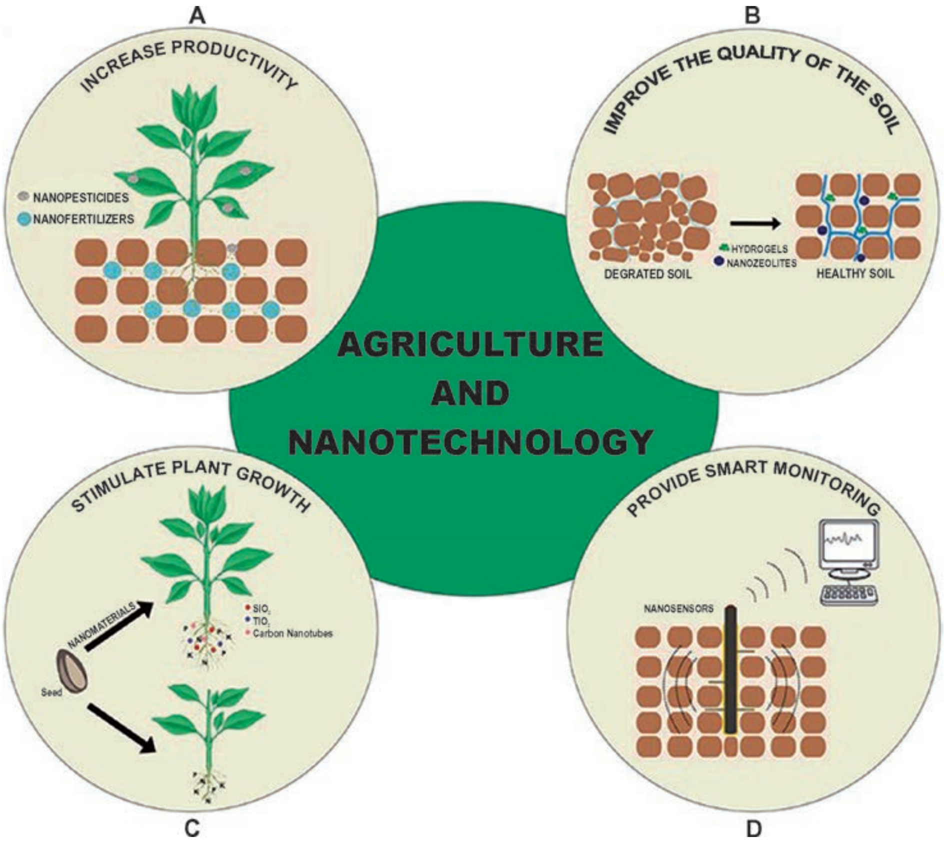
The current global population is nearly 6 billion with 50% living in Asia. A large proportion of those living in developing countries face daily food shortages as a result of environmental impact or political instability, while in the developed world there is a food surplus. For developing countries the drive is to develop drought and pest resistant crops, which also maximize yield. In developed countries, the food industry is driven by consumer demand which is currently for fresher and healthier foodstuff.

Agriculture forms the backbone of third world economics. Research in agriculture has always dealt with improving the efficiency or crop production, food processing, food safety and environmental consequences of food production, storage and distribution. Nanotechnology provides a new tool to pursue these historically relevant goals. A reappraisal of attitudes towards food security, increasing emphasis on environmental compliance and alternations to the Common Agricultural Policy, all combine to make farming and rural land owning far less profitable than in previous times. In agriculture and food systems, the fundamental life processes are explored through research in molecular and cellular biology. New tools for molecular and cellular biology are needed that are specifically designed for separation, identification and quantification of individual molecules. This is possible with nanotechnology and could permit rapid advances in agricultural research, such as reproductive science and technology, conversion of agricultural and food wastes to energy and other useful by-products through enzymatic nano bioprocessing, disease prevention and treatment in plants and animals. To excel in these and other areas of agriculture novel tools are required that allow us to work and explore living cells and biomolecules at the molecule scale. Nanotechnology holds such a promise.

Nanotechnology is manipulation or self-assembly of individual atoms, molecules or molecular dusters into structures to create materials and devices with new or vastly different properties.

Nanotechnology can work from the top down (which means reducing the size of the smallest structures to the nanoscale smallest e.g. photonics applications in nanoelectronics and nanoengineering) or the bottom up (which involves manipulating individual atoms and molecules into nanostructures and more closely resembles chemistry or biology).

The word mono meaning dwarf in Greek language refers to dimensions on the order of magnitude 10. Nanotechnology, focuses on special properties of materials emerging from nanometer size, for e.g., in biological systems, the first level of organization occurs at the nanoscale structure where all the fundamental and functions are defined systematically.



Nanotechnology in Agriculture

The definition of nanotechnology is based on the prefix “nano” meaning dwarf in Greek. In technical terms, the word “nano” means 10^{-9}, or one billionth of a meter. For comparison, a virus is roughly 100 nanometers (nm) in size. The word nanotechnology is generally used when referring to materials with the size of 0.1 to 100 nanometres.

Applications and Benefits

Nanotechnology has the potential to revolutionize the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens.

An agricultural methodology widely used in the USA, Europe and Japan, which efficiently utilises modern technology for crop management, is called Controlled Environment Agriculture (CEA). CEA is an advanced and intensive form of hydroponically-based agriculture. Plants are grown within a controlled environment so that horticultural practices can be optimized. The computerized system monitors and regulates localized environments such as fields of crops. CEA technology, as it exists today, provides an excellent platform for the introduction of nanotechnology to agriculture. With many of the monitoring and control systems already in place, nanotechnological devices for CEA that provide “scouting” capabilities could tremendously improve the grower’s ability to determine the best time of harvest for the crop, the vitality of the crop, and food security issues, such as microbial or chemical contamination.

Precision farming has been a long-desired goal to maximize output (i.e. crop yields) while minimizing input (i.e. fertilizers, pesticides, herbicides, etc.) through monitoring environmental variables and applying targeted action. Precision farming makes use of computers, global satellite positioning systems, and remote sensing devices to measure highly localized enviromnental conditions thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems.

By using centralised data to determine soil conditions and plant development, seeding, fertilizer, chemical and water use can he line-tuned to lower production costs and potentially increase production - all benefiting the farmer. Precision farming can also help to reduce agricultural waste and thus keep environmental pollution to a minimum. Although not fully implemented yet, tiny sensors and monitoring systems enabled by nanotechnology will have a large impact on future precision farming methodologies.

One of the major roles for nanotechnology-enabled devices is the increased use of autonomous nanosensors linked into the GPS system for real-time monitoring. These nano sensors could be distributed throughout the field where they can monitor soil conditions and crop growth. Wireless sensors are already being used in certain parts of the USA and Australia.

The use of pesticides increased in the second half of the 20th century with DDT becoming one of the most effective and widespread throughout the world. However, many of these pesticides, including DDT were later found to be highly toxic, affecting human and animal health and as a result whole ecosystems. As a consequence, they were banned. To maintain crop yields, integrated Pest Management systems, which mix traditional methods of crop rotation with biological pest control methods, are becoming popular and implemented in many countries, such as India. In the future, nano scale devices with novel properties could be used to make agricultural systems “smart”. For example, devices could be used to identify plant health issues before these become visible to the farmer. Such devices may be capable of responding to different situations by taking appropriate remedial action. If not, they will alert the farmer to the problem.

Scientists are working on various technologies to make fertilizer and pesticide delivery systems which can respond to environmental changes. The ultimate aim is to tailor these products in such a way that they will release their cargo in a controlled manner (slowly or quickly) in response to different signals e.g. magnetic fields, heat, ultrasound, moisture, etc. New research also aims to make plants use water, pesticides and fertilizers more efficiently, to reduce pollution and to make agriculture more environmentally friendly.

Status of Nanotechnology in India

India has allocated 22.6 million USD in its 2006 budget to the Punjab Agricultural University in Ludhiana, in acknowledgement of its pioneering contribution to the Green Revolution. Its research on high-yielding crop varieties helped boost food production in the1960s and new projects include the development of new tools and techniques for the agriculture industry.

Concerns

Whatever the major impact of nanotechnology on the food industry and products entering the market, the safety of food will remain the prime concern. This need will strengthen the adoption of nanotechnology in sensing applications which will ensure food safety and security, as well as technology which alerts customers and shopkeepers when a food is nearing the end of its shelf-life. New antimicrobial coatings and dirt repellent plastic bags are a remarkable improvement in ensuring the safety and security of packaged food. However, there is concern over the use of nanoparticles in food and its manipulation using nanotechnologies, which has the potential to elicit the same issues raised in the GM debate.

Challenges

There are new challenges in this sector including a growing demand for healthy, safe food; an increasing risk of disease: and threats to agricultural and fishery production from changing weather patterns. However, creating a bio economy is a challenging and complex process involving the convergence of different branches of science.

Future prospects

In the near future nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used. Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies and filters or catalysts to reduce pollution and clean-up existing pollutants.

Agriculture is the backbone of most developing countries, with more than 60% of the population reliant on it for their livelihood. As well as developing improved systems for monitoring environmental conditions and delivering nutrients or pesticides as appropriate, nanotechnology can improve our understanding of the biology of different crops and thus potentially enhance yields or nutritional values. In addition, it can offer routes to added value crops or environmental remediation. Particle farming is one such example, which yields nanoparticles for industrial use by growing plants in defined soils. For example, research has shown that alfalfa plants grown in gold rich soil, absorb gold nanoparticles through their roots and accumulate these in their tissues. The gold nanoparticles can be mechanically separated from the plant tissue following harvest.

Nanotechnology can also be used to clean ground water. The US company Argonide is using 2 nm diameter aluminium oxide nano-fibres (NanoCeram) as a water purifier. Filters made from these fibres can remove viruses, bacteria and protozoan cysts from water. Similar projects are taking place elsewhere, particularly in developing countries such as India and South Africa. The future will definitely show new applications of nanotechnology in the field of food and agriculture.

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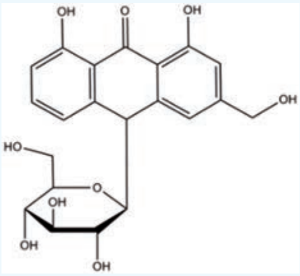
Isolating aloin from yellow sap of Aloe vera

Aloin is a non-edible bio-constituent of *Aloe vera* having systemic and therapeutic significance which is isolated through a novel method developed by ICAR-Central Arid Zone Research Institute, Jodhpur that has been granted patent.

Aloe vera a hardy perennial tropical plant that can be cultivated in drought areas in low rainfall regions with less input, has active ingredient located in three separate sections of the aloe leaf - a fillet, rind (or cortex) and the vascular bundle (yellow sap).

Aloin, also known as barbaloin, is one of the major constituents of yellow sap that is present in vascular bundle of at least 68 *Aloe* species commonly known as bitter Aloe. This is a naturally occurring bitter, lemon-yellow colored substance having medicinal value as laxative, antirheumatic, antiarthritic and other pharmaceutical properties besides being used as a stabilizer in the preparation of gold and silver



nanoparticles. They are in great demand in national and international market.

The patented method is simple and requires low inputs for isolating aloin under ambient temperature (22-35° C), directly from naturally occurring yellow sap of *Aloe* sp. as the starting material. The method gives more than 70% yield of about 95% purity.

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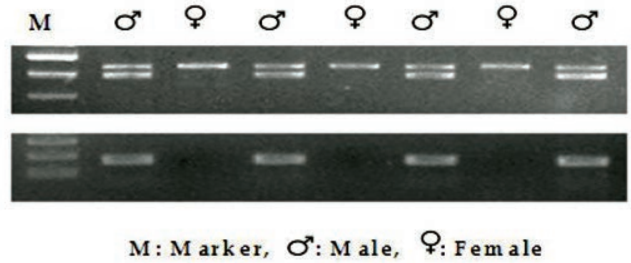
Production of desired sex embryos: an innovative approach

Producing offspring of desired sex is one of the major challenges of livestock industry in the current days. National emphasis is on semen sorting, which is necessary to get desired sexed calf. Though globally many methods have been reported for sperm sorting, however, most of them need to be scientifically validated. Further, the sorting procedure incurs alterations of sperm membrane and other changes such as pre-capacitation of the sorted sperm leading to decrease in fertility. Therefore, an alternative method to sex sorted semen is to produce sexed embryos *in vitro*.

Success of *in vitro* embryo production depends upon factors such as temperature, gas composition (O_2/CO_2), pH, media composition and air quality. Embryos produced *in vitro* are not at par with that of *in vivo* derived embryos. The oxidative status of *in vitro* embryos are always more than that of the *in vivo* derived embryos and the most common difference in both the conditions are the O_2 concentration at which embryos grow. The ambiguity is that whether all the factors determining embryo survivability affect the survivability of particular sex of embryo or not. Reports reflect male embryos develop faster than female embryos *in vitro*, but it is reverse under *in vivo* condition. Suboptimal culture conditions result in loss of female embryos *in vitro*. Therefore, it is hypothesized that differences in



Sexes of embryos determined from gDNA

ROS production (oxidative status) under *in vitro* and *in vivo* conditions might be hindering the developmental potential of particular sex of embryos. Comprehensive studies were carried out at the ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru to assess whether oxidative stress has any role on sex ratio of the embryos. Sex of the *in vitro* produced embryos was determined by the PCR based expression of sex specific genes present in the genomic DNA of the embryos.

It was observed that majority of the embryos produced *in vitro* were biased towards male. The level of oxidative stress under *in vitro* culture condition was directly related to the proportion of female embryos produced. Reduction of O_2 concentration under the *in vitro* culture environment from 20% (atmospheric concentration) to 5% (uterine concentration) doubled the proportion of female embryos produced. Further, it was observed that the addition of free radical scavenger into culture medium increased the proportion of female embryos by 7 folds. The results indicate that by manipulating oxidative status of culture condition, desired sexed embryos can be produced followed by desired sexed calves through embryo transfer. The findings are expected to have great impact under Indian scenario towards producing desired sexed animals either female offsprings to increase livestock productivity through milk production or male offsprings for meat production to address national food security.

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Management of Leaf Curl Disease of Chilli

India is the largest producer, consumer and exporter of chillies in the world. India is shares about 40% of the total world production of chilli and exports 17% of its total production. The largest importer of Indian chilli is Malaysia (30%), followed by other traditional importers like Bangladesh (20%), Sri Lanka (15%), the USA (9%) and the UAE (8%) (FAO 2014). The export is composed of chilli powder, dried chillies, pickled chillies and chilli oleoresin. However, chilli is susceptible to various pathogens including viruses, which cause heavy production losses. Chilli leaf curl disease is a major threat to chilli cultivation in India. The disease is caused by begomovirus and spread by whiteflies as vectors. Chilli leaf curl virus is the most destructive virus in terms of incidence and yield loss among other begomoviruses causing infection in chilli. In severe cases, 100% losses of marketable fruit have been reported. The typical symptoms consists of leaf curling, rolling, puckering; blistering of inter veinal areas, thickening and swelling of veins, shortening of internodes and petioles, crowding of leaves and stunting of the whole plant. Farmers resort to spraying of pesticides to control whiteflies as the only option to protect as there are not much resistant varieties or hybrids released. Due to indiscriminate spraying of pesticides, chillies sent from India to different countries such as Germany, Spain and Finland have been rejected due to presence of pesticide residues. Moreover, evasive measures have not been much successful. Exploitation of host plant resistance is effective, economical, ecologically safe for disease management, especially the ones caused by viruses.

Immune response of *Capsicum flexuousum* (*top*). Susceptible *Capsicum annuum* lines (*bottom*).
Response of *C. flexuousum* and *C. annuum* to leaf curl disease under natural epiphytotic conditions

Capsicum flexuousum with no leaf curl

Susceptible *Capsicum annuum* genotype

Leaf curl disease is also a major problem in tomato crop and considerable level of success has been

Screening of *Capsicum flexuousum* through challenge inoculation

achieved in resistance breeding programs. Resistant genes namely *Ty1, Ty2, Ty3, Ty4* and *Ty5* has been isolated from wild species like *Solanum peruvianum, Solanum chilense and Solanum habrochaites*, introgressed into cultivated background and many varieties with leaf curl resistance have also been released. Intensive genetic studies have been carried out on these resistance sources, which have so far led to the mapping of five TYLCV resistance loci for commercial breeding. The first mapped TYLCV resistance locus was the *Ty1* locus from *S. chilense* LA1969 which has been found to be a DFDGD-class RNA-dependent RNA polymerase and was later shown to be allelic to the *Ty3* locus on chromosome 6. The source of resistance locus *Ty2* was *S. habrochaites* B6013 and this locus was mapped to a 300 kb region on chromosome 11. A recessive gene *Ty5* for resistance against TYLCV was found to be originated from *S. peruvianum.* Similar efforts in this direction need to be made in chilli crop also. Till date the wild species in chilli have not been screened to identify resistance to leaf curl. Many workers throughout India are working to identify resistant sources to leaf curl disease in chilli but all lines are from *C. annuum* background. Resistance to leaf curl has been reported but immunity to the disease is still not reported.

Division of Vegetable Science, ICAR-IARI has screened different *Capsicum* species for resistance to leaf curl disease. We have identified *Capsicum flexuousum* as immune to leaf curl disease (Fig.). This species is perennial in nature and the crop stays for three years in the field without reduction in fruiting ability. It has narrow serrated leaves, height of about 1 meter and round fruits with cluster erect habit. Further the species is late flowering also. It takes approximately four months to start flowering. It was observed for its response to leaf curl disease in field for three continuous years from 2015-2017. Even after three years the plants were free of disease. We screened the species through challenge inoculation under laboratory condition using viruliferous whiteflies with Chilli leaf curl virus (ChiLCV) and Tomato leaf curl New Delhi Virus (ToLCNDV) in 2018, as they have been identified as pre-dominant viruses causing leaf curl at New Delhi region in previous studies. However *C. flexuousum* was found to be immune to both these viruses.

Capsicum flexuousum appears to be a potential source for leaf curl resistance. We attempted some initial crosses with *C. annuum* to get hybrid fruits but the crosses failed. Hence more focused and elaborate efforts need to be made to recover hybrids from cross of *C. annuum* and *C. flexuousum*. Advanced techniques like embryo rescue, use of bridging species or hormone application need to be attempted to achieve successful crosses between them.

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WAY FORWARD

EFFECTS of climate change is now being felt globally. As per latest IPCCC (AR-5) report the global average temperature has risen by 0.85°C (between 1880 to 2012) and several evidences of climate change (glacial melting, sea level rise, weather aberrations, rise in sea surface temperature, ocean acidification, increased intensity of cyclones, frequency of occurrence of heat waves etc.) were also mentioned in the IPCCC report. For Indian subcontinent the temperatures are projected to increase by 1.7 to 2°C by 2030. Apart from 'climate change' which is a long term phenomenon, 'climatic variability' is of immediate concern for Indian agriculture consisting of variable rainfall, severe weather aberrations and extreme events which are influencing agriculture production, farmers' income and livelihoods. The frequency and intensity of the weather aberrations are likely to increase in years to come which will significantly impact agriculture production in the country. In the last 18 years, 13 years received deficient rainfall with significant variability in distribution at several locations of the country. This resulted in prolonged dry spells and drought like situation impacting crop growth and production. Besides this, several parts of the country experienced heat wave, cold wave, unseasonal rains and hailstorms.

The Indian Council of Agricultural Research (ICAR) has taken up a flagship programme, National Innovations in Climate Resilient Agriculture (NICRA) in the year 2011 to comprehensively address the impacts of climatic change and variability on crops, horticulture, livestock, fisheries and aims at developing adaptation and mitigation practices to minimize losses and to enhance resilience of Indian agriculture.

The project has two components viz., research, technology demonstration and capacity building. The research component has been undertaken by 41 ICAR institutes and several universities across the country to assess the impact of climate change and develop resilient technologies for various sectors such as crops, livestock, horticulture, fisheries and natural resource management. The technology demonstration component aims at demonstrating location specific technologies to minimise impacts of climate change in farmers' fields. It is being taken up in 151 climatically vulnerable districts across the country by taking one representative village in each district.

The technologies demonstrated can be categorised into four modules viz., Natural Resource Management, Crop production and Horticulture, Livestock and Fisheries and creation of institutions in the village. The technologies for demonstration were identified based on climatic vulnerability, predominant farming systems in the village and the resource availability. Relevant stakeholders such as research institutions, state agriculture universities, line departments, NGOs, KVKs and the farmers were involved in identification of resilient technologies to be demonstrated. These demonstrations for the past six years led to minimizing the impacts of climatic variability and stabilized production leading to their adoption. Resilient practices were made accessible to all farmers in the NICRA villages leading to Climate Resilient Villages. Convergence with various developmental programmes, operational at the village level were established reach maximum farmers.

Dr T Mohapatra, Secretary (DARE) and Director General (ICAR)

In order to effectively address the concerns of climate change there is a need to consolidate these programmes at the village level so as to enhance the adaptive capacity of communities. There is a need to take multiple resilient technologies to the farmer. For example, water harvesting, improved crop variety, livestock related interventions so as to minimize the adverse effects of climate change and to stabilise productivity and income at the household level. Hence convergence of multiple interventions at the household level is essential for climate resilience. In order to effectively bring convergence of the developmental programmes at the village level and at the household level there is a need for an integrated scheme which addresses the climate change issues by merging ongoing schemes. The suggested title of such scheme could be "Integrated Climate Resilient Agriculture Programme" (INCRAP).

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