21. National Agricultural Innovation Project

Indian Council of Agricultural Research (ICAR) initiated National Agricultural Innovation Project (NAIP) with the assistance of the World Bank and is being implemented since July 2006. The project became effective on 18 September 2006. The closing date of the project was extended to 30 June 2014. The specific objective of NAIP is to accelerate the collaborative development and application of agricultural innovations between public research organizations, NGOs, farmers, private sectors and other stakeholders. To address project objective, research agenda is divided into four components, namely (*i*) ICAR as the catalyzing agent for management of change in the Indian National Agricultural Research System (NARS); (*ii*) Research on production to consumption systems; (*iii*) Research on sustainable rural livelihood security; and (*iv*) Basic and strategic research in the frontier areas of agricultural sciences. In addition, three subprojects under Component 3 are funded by the Global Environment Facility (GEF) Trust Fund of the World Bank.

ICAR as the catalyzing agent for management of change in the Indian NARS

The NAIP initiated many activities which are showing impacts and have potential to act as catalyzing agent to improve the system-wide efficiency, effectiveness and productivity. It has five sub-components, namely information, communication and dissemination system; business planning and development; learning and capacity building; policy, gender analysis and visioning; and remodelling financial and procurement system with 43 approved sub-projects. Some of the salient achievements include development of world class state-of-art infrastructure and National Agricultural Bioinformatics Grid (NABG) for hosting different types of ICT applications including genome sequence data and their management are in progress. A total of 327 e-courses in Agricultural Sciences were developed on Moodle (an e-learning platform). An online central repository of doctorate dissertations in agriculture, *Krishi Prabha*, consisting of 7,627 abstracts and 6,000 full texts was created.

Under the sub-project on Agropedia, KVK-Net (Krishi Vigyan Knowledge Network) and vKVK (virtual Krishi Vigyan Kendra) were developed to help farmers and extension workers. KVK-Net provides a platform to the officials of the KVKs to share and discuss their experiences and issues and vKVK is for disseminating tailor-made information to the farmers on their mobile phones in local languages. Under the sub-project on Mobilizing Mass–Media Support periodic media meets/ interactions were organized in which 207 media persons and 1,123 farmers entrepreneurs participated. Dissemination of information on new innovations/ technologies was carried out through 600 news clippings and 276 TV/Radio programmes.

A 24×7 Rice Knowledge Management Portal (RKMP) was e-launched. The RKMP is equipped with 20 platforms with more than 12,000 pages on content, 3,000 minutes of audio and 50 video clips.

About 361 NARS scientists availed international training in 27 cutting-edge areas of science. Further, 268 scientists obtained international training under approved consortia. About 73 national trainings involving international experts have also been

Impact of CeRA

Consortium for e-Resources in Agriculture (CeRA) facilitates 24×7 online access with approximately 3,000 scholarly journals from 7 major publishers and catering to about 142 institutions under the NARS. After setting up of CeRA an annual increase of about 18.5% in the number of publications in NARS during 2011-12 compared to 2008-09 was observed. Till August 2012, the number of visitors to the site exceeded 3.5 million with total download of more than 5.0 million full text articles and 20,850 articles under Document Delivery Request Service (DDRS).

Impact of Business Planning and Development Units (BPDUs)

Established ten Business Planning and Development Units (BPDUs) equipped with modern laboratory facilities, besides having working pilot plants and office/ bench space with modern ICT facilities for the use of incubates (prospective entrepreneurs) on charge basis to develop processes/ products and/ or to gain confidence before taking up the full-fledged commercial ventures.

Technologies (78) developed by NARS generated revenue of ₹ 13.222 crore on commercialization, and 336 entrepreneurs were incubated. BPDUs also synergized with national initiatives for enhanced incubation support through Micro, Small and Medium Enterprises (MSME), DST and DBT, benefitting seven BPDs through additional funding of Rs 6.5 crore. The Zonal Technology Management (ZTM)-BPD Unit at IARI, New Delhi launched a Farmers Producer Company in the name of 'Beej India Producer Company Ltd' under Companies Act 1956. BPD–CIRCOT is promoting commercialization of *Bt* cotton detection kit in South Africa and China. The ZTM-BPD Unit, South Zone also provided technical consultancy in the area of thermal validation of seafood to M/s Mandhoo Fisheries Complex, Republic of Maldives. The BPD Unit at JNKVV, Jabalpur formed a seed consortium to promote production of hybrid seeds in the state.

completed. Trained manpower is being used to develop Centres of Excellence in cutting-edge technologies.

Gender Work Participation Disparity Index (GWPDI) was developed to characterize the gender work participation scenario on regional and all India bases. The value of GWPDI varies between 0 and 1 (greater the index value more will be the disparity). The GWPDI value for India indicates that the disparity in work participation between men and women has narrowed down over the years. Commodity price forecasts for 36 commodities were disseminated for the benefit of farmers across the country. Based on online database repository called commodity market outlook statistics (CMOS), a decision support system for agricultural commodity market outlook was developed, which is capable of generating outlooks for cereals and oilseeds on four key components of the food balance sheet, namely demand, supply, trade and prices, for next 15 years. Eleven market intelligence centres established have so far made 298 commodity price forecasts and published in 130 leading dailies besides posting on websites (www.tnagmark.tn.nic.in, http://amickau.nic.in) and also communicated directly to 160,000 farmers through mobile. A carbon tool kit for sustainable agro forestry clean development mechanism (CDM) projects was developed. Energy-based household interventions like replacement of traditional electricity bulbs with CFL bulbs, introduction of energy-efficient cook stoves (*chulhas)* and solar lanterns were introduced.

Production to consumption system

Fifty-one value chain consortia covering all commodities, viz. horticulture, crops, animal sciences and fisheries are covered under this component and significant achievements are given here.

Sorghum-based products were popularized by road shows-cum-nutritional campaign in Hyderabad. *Jowar* products with DSR's Eatrite brand were launched.

Clinical trials on foxtail millet based diabetic food confirmed that it is beneficial to diabetic, obese and heart patients. The diabetic mix was well received by diabetic patients.

A vacuum filtration system for production of clarified sweet sorghum juice was developed. The produced syrup can be used as a sugar replacement in developing value-added food products.

Polythene mulching technology in tomato controlled weed, diseases and pests, reduced evaporation of irrigation water, helped in better utilization of applied nutrients, and protected the crop from sudden and excess rainfall etc., resulting in better-quality fruits with improved yield. Thus integrated crop management in tomato reduced the cost of cultivation to the tune of ₹ 17,525/ha and increased yield by 20.2%.

Techniques for off-season flowering in malligai (*Jasminum sambac*) through physiological intervention under open and protected conditions were standardized. As value added products of jasmine combined with tuberose have high demand in the market, tuberose spikes were tinted with different acid dyes.

The broodstock development of cobia in sea cages was standardized by using standard feeding protocols with sardine and squid at *ad lib*. levels. Filleting technology of murrels and use of gelatin obtained from murrel wastes was popularized among the entrepreneurs for manufacturing pharmaceutical products. Methods were standardized for masking fish smell, removal of excessive oil from the fried products and softening pin bones to palatable consistency.

Testing of fuel-efficient propellers (developed in the sub-project on Responsible Harvesting of Small Pelagic) on 21 vessels confirmed that it saved 19% fuel. With this intervention the sector having about 1,100 vessels saved around 14–19 million litres of diesel per annum worth around ₹ 63–78 crore.

Installation of sub-surface drainage system in the saline soils of Maharashtra improved production of soybean, sugarcane, Bengal gram and wheat by 74 to 114%. Simultaneously, drain water collected in ponds was utilized for fish culture which provided substantial income to the farmers. Fish grew to 950 to 1,100 g in 10 months indicating that growth in sub-surface drain

Success story

Biomass-based power generation

Energy shortage remains the major constraint in the development of agro industries and services in the rural sector. Two units of power plant (50 kW) capacity were installed and commissioned at sites for establishment of biomass-based decentralized power generation using gasification route. The generated power is used for operating the briquetting plant and water pump of the municipal corporation of Raisen (Madhya Pradesh). Developed a commercial granular charcoal filter to treat the waste water of biomass-based power plant of 20 kW capacity, reducing chemical oxygen demand (COD) to 60%.

World's first cloned pashmina goat — Noori

Goat embryos were cultured to blastocyst stage in the laboratory and transferred to many Pashmina goat recipients at the SKUAST farm. Two goats got pregnant and first Pashmina goat-kid produced through hand-guided technique was christened as 'Noori'.

water is at par with normal freshwater ponds.

Strengthening potato value chain: Model chain for French fries was strengthened in Gujarat in collaboration with private sector. Kufri Frysona recorded yield of 54.2–56.8 tonnes/ha which is 11–42% better over other varieties besides the improvement in quality. No internal defect was observed in tubers, dry matter ranged between 21.5–23.4% and variety had excellent fry colour. In storage studies, line testing of stored tubers also exhibited very good results having only 1.1–1.6% of internal defects (limit, 5%), 9.9–10.9% external defects (limit, 12%) and total defects 11.5–12% (limit, 12%). K. Frysona had 22.1–23.6% solids, excellent fry colour without any sugar end.

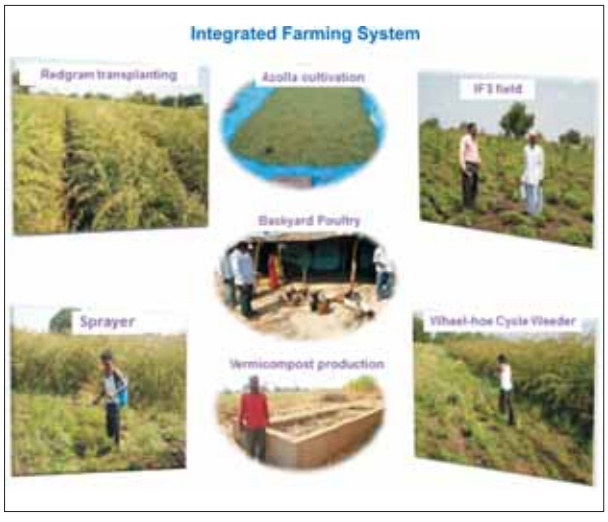
Market development and branded oyster products : Two new value chains were developed, viz. Fresh depurated oysters for live consumption in high-end restaurants and value-added-products of farmed oysters were intensified.

Little millet based sports food: The suitability of little millet sports food for growing children and athletes was established. The product is available at affordable cost of ₹180/kg.

Research on sustainable rural livelihood security

The major objective of the component is to improve livelihood security of the rural people living in selected disadvantaged regions through technology-led innovation systems. The consortia focused on identification of new beneficiaries, demonstration of various interventions among these beneficiaries, continued support to beneficiaries covered during pre-extension phase and data analysis. Some of the significant interventions were also reported.

IFS model for Bidar district: An innovative idea of transplanting of red gram was demonstrated in 400 ha area in Bidar, Karnataka. The major advantage of transplanting was contingent measure due to erratic rainfall and reduced water requirement with higher yield. Accordingly, red gram transplanting based model for 1 ha area and backyard poultry with 10 birds was integrated to give a net return of ₹ 153,200.



Water harvesting based livelihood model for Vindhyan region: In Eastern Uttar Pradesh the Vindhyan region faces the problem of availability of irrigation water due to surface run-off of rain water and water underutilisation of river sources leading to low productivity and cropping intensity.

Check dam constructed under the project, Mirzapur

Watershed based farming system modules with the interventions, viz. construction of eight check dams and 24 water harvesting bunds (WHB), distribution of plastic delivery pipes (2.5" PVC delivery pipes to 121 farmers' groups) and diesel pumps (30 water lifting pumps to 30 farmers' groups) were initiated.

These interventions resulted in an increase of 37.7% in irrigation water facility; and increase in area under winter season pulses and oilseeds. Similarly, near the check dams, area under rice in rainy season and wheat during winter has increased due to prolonged availability of water. Near some check dams in cluster II, it was possible to cultivate summer vegetables, pulses and fodder crops. With the enhanced availability of irrigation water and appropriate crop varieties, the cropping intensity improved up to 188.7, 193 and 183.4% in cluster I, II and III, respectively, recording an overall enhancement of 36.1% as compared to baseline value. The average water table near the water harvesting structures has risen to 1.12 m.

Availability of irrigation water accompanied with the use of quality seeds, better input use and production technology improved yield of cereals, pulses and oilseeds over two-folds in the vicinity of water harvesting structure. Near check dams productivity enhancement of field crops was higher than water harvesting bunds because it retained water for longer periods.

Groundnut, a viable second crop, for small and marginal farmers: In 15 villages of Lodhashuli cluster, *kharif* groundnut was adopted by 1,706 farmers in 165.62 ha and *rabi* groundnut by 802 farmers in 90 ha. The groundnut production of 2 to 2.5 tonnes in *kharif* and 3.5 to 4 tonnes in *rabi* was very high over the baseline value of 1–1.5 tonnes/ha. This innovation helped to build the trust among the farmers of the project area resulting in adoption of the technology and increased production of groundnut (600 kg/ha)

Groundnut is a viable second crop for small and marginal farmers of Lodhashuli, Midnapore

and an additional income. A marketing outlet was also established in Midnapore town for sale of produce.

An innovative irrigation technique for vegetable cultivation: Shri Ramesh Bariya in Jhabua, Madhya Pradesh, raised bitter gourd, and sponge gourd in late summer season but delayed monsoon affected the crop in early stages. This prompted him to take up an innovative method of drip irrigation i.e. using empty saline bottles. Six kg of empty saline bottle @ ₹ 20/ kg procured could save this crop getting a net profit ₹ 15,200. This indicated the possibility of getting ₹ 1.5 to 1.7 lakh/ha by vegetable cultivation using this innovative drip irrigation technique.

An innovative irrigation technique for vegetable cultivation

Patents: Three patents, namely Low cost technology for prevention and treatment of sub-clinical mastitis in bovines; Mineral based-technology for estrus induction and synchronization in bovines; and Low cost multiplication of media for plant bio-enhancers, were filed.

GEF funded sub-projects

In Sundarban region of West Bengal, 42.5 ha area was covered under land shaping which has the potentiality of harvesting 169,980 m^3 of rain water. About 34 ha of additional (monocropped) area was brought under multi-crop cultivation through irrigation in dry season and about 8.5 ha land was brought under aquaculture. The gross income of farmers increased by ₹ 48,000–52,000/year/household (HH). Paddy-cum-fish cultivation/integrated farming was introduced in 19.69 ha, which improved the gross income of farmers by ₹ 45,000–49,000/year/HH. About 144.68 ha of land was brought under cultivation of improved/salt-tolerant varieties of vegetables (cabbage, cauliflower, knol-khol, beet, brinjal, chilli, spinach, okra, cucurbits, basilia, etc.), pulses (moong), oilseed (sunflower, sesame), cotton and *kharif* and *rabi* rice. In the area of crop nutrient management, 74.4 ha land was covered under improved nutrient management practices like green manuring, integrated nutrient management (INM), vermin-composting, etc.

Bioresource inventorization programme for plant, animal and fish resources in Chamba (Himachal Pradesh), Udaipur (Rajasthan) and Adilabad (Andhra Pradesh) is being carried out effectively with multiplication of prominent landraces and species. Community Gene Banks were created for distribution of seed of local landraces to farmers. Biodiversity registration was initiated to help the farmers in terms of enhanced income levels. Market linkage was developed with a private group for the targeted production of 200q each of the traditional landraces of redgram and rice from Adilabad district. This would help in conservation as well as enhanced income to the beneficiary farmers.

Interventions on animal health and nutritional feeding immensely benefited farmers in managing livestock and also enhance milk production meaning thereby that the local breeds may become cost-effective. This would help in conserving the local breeds. Owing to vaccination against foot-and-mouth disease (FMD), peste des petits ruminants (PPR) and haemorrhagic septicaemia (HS) and blackquarter (BQ), no major disease outbreak was observed in the target areas.

The intervention on laser levelling and water delivery system such as groundwater pipeline and sprinkler system led to improved efficiency in water transport and delivery system.

Through an innovative service called ‘m-Krishi-Fisheries’, in one village of 32 fishing boats, diesel saving of 70,000 liters per month could be attained amounting to saving of 150,000 kg of CO_2.

Climate change characterization of past weather and agriculture in Dhar, Mewat, Ganjam and Raigarh districts was done. The Integrated Coastal Management (ICM) introduced in flood-prone area proved very beneficial to the farmers, as they got 51% higher yield than their own practice. Demonstration of System of Rice Intensification (SRI) resulted in 5.20 tonnes/ha grain yield which is 13.5% higher than traditional practice with 20% saving in water. Short-duration rice varieties tolerant to moisture and temperature stresses were introduced in 50 famers’ fields covering 11.5 ha. Owing to this intervention, farmers gained an additional net income of ₹ 15, 000 to 31,000 in addition to assured food security for the family.

Basic and strategic research in frontier areas of agricultural sciences

Abiotic stress tolerance in agriculture: It is functionally validated *in planta* that *OsFBK1* gene confers stress tolerance; however, its expressivity in transgenic rice plants also altered expression of some agronomic traits. A variant allele of *cry1Aa* gene from a microbial isolate NB7 was cloned in expression vector pET28a. Five isolates of *Bacillus* and derived genera and 23 archaebacteria tolerant to saturated NaCl conditions were described; isolate AKS07 has potential for use as a broad spectrum bio-agent for control of various crop pests- and/or vector-borne diseases since it harbours multiple insecticidal genes [9 cry genes and 7 other (cyt, vip, chit, etc.) genes].

Resistance to biotic stresses in agriculture: Allele mining of *Avr-Pita* gene was completed from 80 isolates of rice blast causing organism, *Magnaportheoryzae*, collected from different parts of India, and allele specific markers developed from the available sequence thus variation. Isogenic lines of Pusa Basmati-1 were developed, pyramiding 1-3 resistant *Pi-* genes in their genetic background; using 7 genes which are resistant against different races of the pathogen.A triple gene fusion construct was developed to build-up broad spectrum diagnostic tool to simultaneously detect papaya ring spot virus (PRSV), cucumber mosaic virus (CMV) and groundnut bud necrosis virus (GBNV).

Isogenic lines of Pusa Basmati-1 carrying major blast resistance gene(s)

Four polyclonal antibodies developed against cucumber mosaic virus (CMV), papaya ring spot virus (PRSV), groundnut bud necrosis virus (GBNV) and peanut mottle virus (PeMoV) were extensively validated on wide-ranging (17) crops. Biochemical test keys for differential identification of entomopathogenic nematodes, *Xenorhabdus*, *Photorhabdus* and *Provedencia*, were simplified. Two root-specific nematode responsive promoters were identified; one of these promoters is expressed exclusively at the feeding site (gall). RNAi approach extended to migratory nematodes has revealed function of two genes involved in muscle contraction, wherein RNAi of these genes leads to complete paralysis of worms.

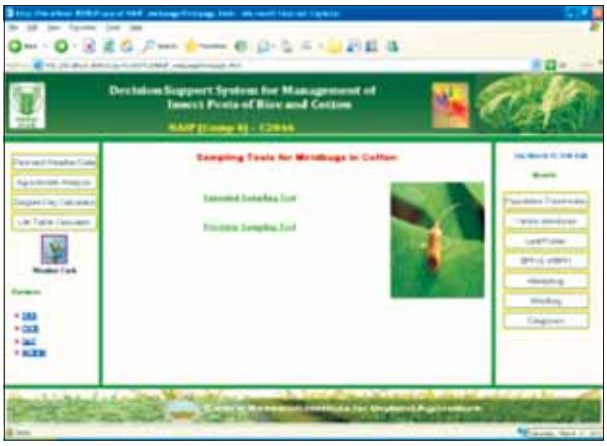
Molecular genetics and breeding: Functional characterization of a cotton fibre related gene, *Aquaporin*, was done by *Agrobacterium* mediated genetic transformation of cotton (*G. hirsutum*) var. coker 310. Eleven full length gene clones of genes involved in cotton fibre development, including *Aquoporin*, were developed in transformation vectors. Structural proteins involved in cotton fibre cell initiation and elongation were isolated and characterized. Sesame recombinants with more than 2% higher linoleic acid content were identified from crosses of cultivated *S. indicum* with the donor *S. mulayanum*. Three collections of *Cucumissativus* field resistant to *Alternaria* fruit rot and 7 carotenoid rich collections of cucumber were discovered. New, convenient agro-techniques for mass cultivation of medicinal plants, *Hedychiumspicatum, Origanum vulgare, Valerianajatamansi* and *Gymnemasylvestre*, were developed.

Biodiversity: Mango phenology data analysis system was developed to infer from phenological data matrix of off-season mangoes. Ten promising ecotypes with consistent mango fruit yield in off-season in Kanyakumari area were identified. Farmer's field demonstration was conducted for the paclobutrazol-application time in Alphonso mango trees to advance their flowering by 2½–3 months (September–October) and early harvesting (mid-January to mid-March) along west coast of Konkan. PCR based method for differentiating *kusmi* and *rangeeni* strains of lac insect was developed. Morphometrics for 7 female lines (30 specimens each) was completed with 60 characters. DNA sequence data of 25 specimens of *Lamellidens* and *Parreysia* were generated to confirm the identity of freshwater bivalves.

Nanotechnology: Two fungal isolates of *Aspergillus* capable of synthesizing the ZnO nanoparticles and one isolate for use in extracellular synthesis of Fe nanoparticles were identified. Molecular identification of efficient fungal isolates capable of iron oxide nanoparticle synthesis was achieved. The 32 KDa extracellular proteins from different fungal species helped in the biosynthesis of nanoparticles. Starch nano-composite film was validated for major criteria in food packaging such as improvement in mechanical and barrier properties, and good sealing-ability of pouches.

Precision farming: A ground-based integrated sensor and instrumentation system was developed to measure real time crop conditions, and interfaced with a differential GPS receiver, which supports multi-source information acquisition and management in the farming field.

GIS application in agriculture: Mealy bug stress indices in cotton for area-wide assessment of crop infestation and damage through remote sensing were developed. Fixed precision sampling plans were devised for assessment of cotton mirid,



Crenotiadesbiseratense, population density in *Bt* cotton at user defined levels to help in accurate estimation of timing for pest management interventions based on a set economic threshold.

Natural resource management: Multiple microbial diversity indices for the soils of Indo-Gangetic plains and brown soil regions were derived; and estimated values of saturated hydraulic conductivity were used for generating quantitative soil drainage maps.

Structures and processing engineering: Quantification of impact of rubber check-dams installed in Odisha have shown availability of upstream water for 6–7 weeks more at two locations, i.e. up to first week of May, where the nearby streams had dried up by mid-March. Common maturity index was developed for 9 cultivars of mangoes (*Alphonso, Dushehri, Langra, Maldah, Chausa, Mallika, Kesar, Banganpalli, Neelam*). Indigenously produced spiral wound membranes were adopted for separating disaccharides, pentoses, hexoses, furfural derivatives and organic acids.

Social sciences in agriculture: Four participatory rural appraisals (PRAs) were prepared to meet the information need of farmers in West Godavari, Krishna and Nalgonda Districts of Andhra Pradesh. A Wine Grape Insurance Structuring Automation Tool (WIGISAT) was developed and tested in a stakeholders interface dialogue.

Animal reproduction and health: Three embryonic stem cell lines are being maintained and regularly confirmed for their pluripotency. Use of soymilk extender in cryo-storage of spermatozoa was more effective in maintaining mitochondrial membrane potential, and comparable in pregnancy rates on first insemination compared to the conventional egg yolk extender. A biochip capable of detecting mastitis-causing pathogens and specific virulence genes was developed. A herbal acaricide formulation was characterized for safety, stability and activity against acaricide resistant ticks. At 5× concentration the formulation did not show any unwanted reaction on animals. The extract was stable up to 120 days at room temperature without any change in efficacy. Pen trial on crossbred male calves gave nearly 70% protection against repeated high challenge infestations. Large scale validation of two herbal formulations in 3-phase clinical trials in different states was successfully done. 3D model of rohu TLR2 was constructed to analyze its biological function, and critical domains that recognize bacterial PAMPs were identified.

Milk and dairy production: A prototype microfluidics device was fabricated for online analysis for multi-analytes (residues and contaminants) in milk**.** A novel micro-technique for detection of bacteria (*enterococci*) in milk was also developed. A field portable biochip device for ultrasensitive analysis of aflatoxin M1 in milk, and novel enzyme-substrate based bio-assay for real time detection of *Listeria monocytogenes* in milk were developed. A real time enzyme substrate assay for detection of *E. coli O157:H7* in milk was optimized. Large scale awareness on various milk detection kits developed for adultrants (detergent and urea) was created among stakeholders through field demonstrations. Cell envelope proteinase (*PrtR*) gene from *Lactobacillus rhamnosus* was cloned.

Rumen physiology and ecology: *In vitro* experiments using recombinant microbes improved digestibility. *In vitro* trials conducted with recombinant yeast gave a maximum of 54.6% of dry matter digestibility of paddy straw, which is an improvement of over 13.8% over the control. Feeding of nitrate @ 3% of diet to buffaloes reduced methane emission 34.1%, and significantly improved feed conversion efficiency and average daily body weight gain by 9.6%.

Meat production: A stable myoblast cell line was developed through Lentiviral mediated gene transfer, using backbone of pLKO.1 sh2 construct, shRNA construct integration in the genome of myoblast cells was confirmed.

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