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Vision 2050

National Research Centre for Banana

Indian Council of Agricultural Research

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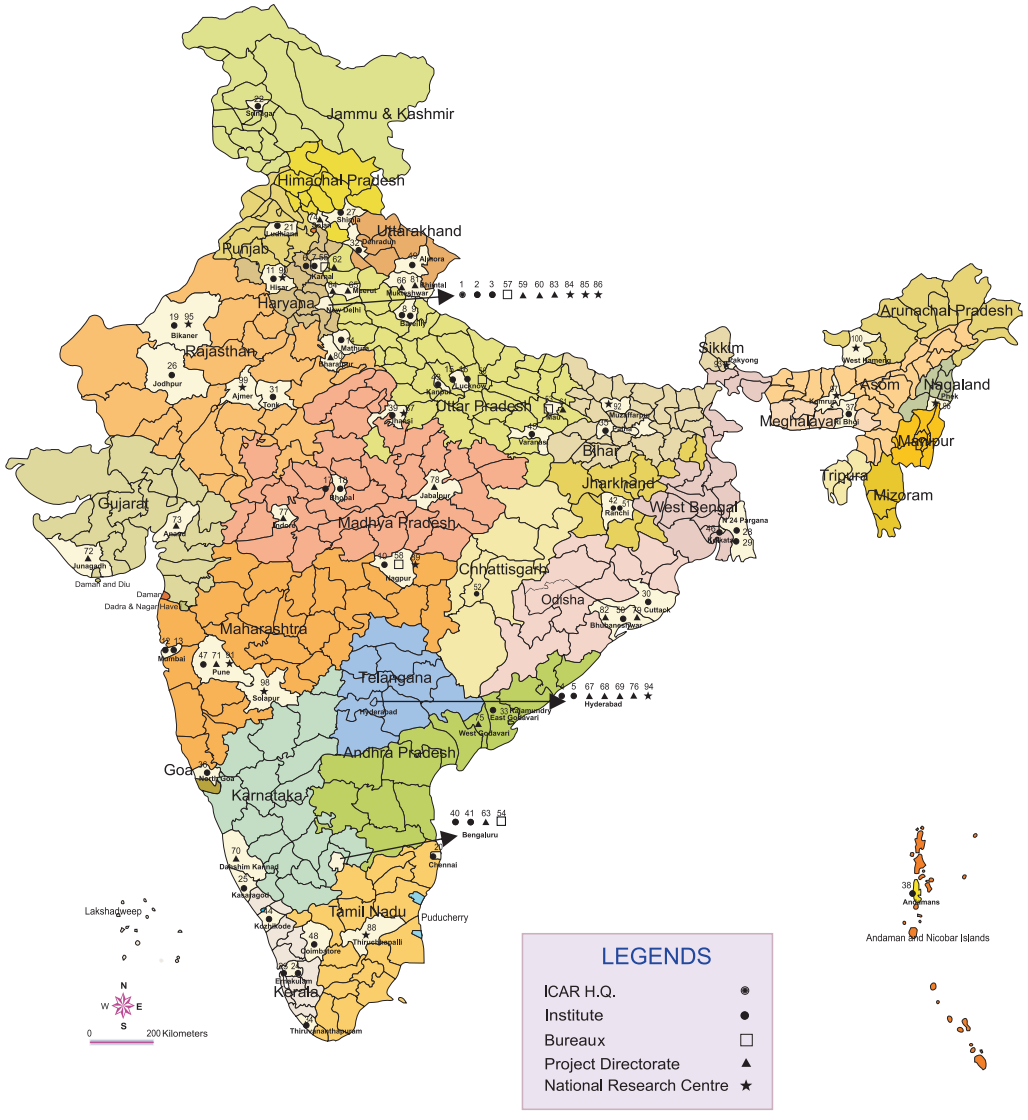

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities

Vision 2050

National Research Centre for Banana
(Indian Council of Agricultural Research)
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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-National Research Centre for Banana (NRCB), Tiruchirappalli has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

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Preface

Banana and plantains, the major staple food crop for millions of people in the developing countries of tropics, have an antiquity of over 4000 years dating back to 2020 BC. Banana is native of India and is widely grown in tropical, subtropical and coastal region of India. In the recent years, there has been a growing recognition of the importance of banana and plantains as house hold food, nutritional and social security in many parts of the world. In India, there has been a significant increase in terms of area, production and productivity in the last two decades. It is grown in more than 130 countries across the world in an area of 5.00 million ha producing 103.63 million tonnes of banana and plantain (FAO, 2013). India is the largest producer of banana in the world, producing 29.7 million tonnes from an area of 0.802 million hectares with a productivity of 37 MT/ha (NHB, 2013). Although India accounts for only 15.5 per cent in area, it accounts for 25.58 per cent of world's production. Thus banana has emerged as one of the important fruit crops, which is in the easy reach of common man. It is envisaged that the demand is ever increasing and 60 million tonnes of banana is needed to meet the domestic demand in 2050. There is also a considerable scope for the export of banana and its products, which further enhances the demand.

Bananas and plantains are continuously exhibiting a spectacular growth worldwide. It's year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favorite fruit among all classes of people with good export potential. World banana production is concentrated in Africa, Asia, the Caribbean and Latin America because of the climatic conditions.

During the last two decades, production and productivity has considerably increased with appreciable area expansion due to the growing awareness of banana in nutrition, high economic returns and its export potential. Due to urbanization and erosion of wild bananas in their natural habitat, there is a need to conserve the available genetic diversity. Musa wild species and its allied genera form an important source for resistant genes for biotic and abiotic stresses. Biotic and abiotic stresses are the main constraints which reduces the productivity considerably. Production constraints also vary from region to region; however, many problems are similar in nature. This complexity of problems warrants

basic, strategic and adaptive research to maximize the productivity. Breeding banana and plantain has its inherent complex problems and recent biotechnology tools/approaches help in breaking the jinx to achieve the projected results, and the real impact can be expected in the near future. With a production target as 60 million tonnes in 2050, the major production constraints like increasing input costs like fertilizers, irrigation and management of insect pests and diseases are to be solved to maximize the production. Decreasing soil health and substrate dynamics management is becoming a great challenge which needs attention to maintain a better eco-system and environment.

In this vision document, new initiatives have been envisaged to give a fillip in the areas like genetic engineering, molecular breeding, substrate dynamics, organic farming, integrated pest and disease management, physiological, bio-chemical and genetic basis for biotic and abiotic stress management, post harvest technology and value addition. I am sure the vision embodied in the document will form the base for strengthening research and opening up new vistas to fulfill its mandate in banana research and address the future challenges for higher growth and development so as to achieve the goal set for 2050.

I extend my sincere thanks to Dr. G.L. Kaul, chairman and other members of the Research Advisory Committee for their constructive criticism for developing the document.

I am grateful to Dr. S. Ayyappan, Secretary, Department of Agricultural Research and Education and Director General, Indian council of Agricultural Research, for valuable guidance, insight and thought provoking ideas. I am also thankful to Dr. N. K. Krishna Kumar, Deputy Director General (Horticultural Science) and Dr. S.K. Malhotra, Assistant Director General (Horticultural Science), for the cooperation received in the form of encouragement and critical suggestions. I am also thankful to my colleagues for their insight, inputs and contributions in bringing out the "Vision 2050" document.

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Director
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Context

Banana is the most important fruit crop in India and accounts for 36.6 per cent of the total fruit production. It is widely cultivated in varying agro-climatic regions under different systems of production. The banana research in India is directed towards increase in production and productivity with a vision to become the world leader in banana industry. However, banana cultivation continued to face several pests and diseases problems which have affected the production and productivity. Nevertheless, conservation and characterization of genetic diversity, improvement of cultivars resistant to biotic and abiotic stresses, production technology for high productivity with good quality fruits and post-harvest technology needed more systematic research. The growing awareness of banana in human nutrition, high economic returns per unit area, export potential and production constraints due to biotic and abiotic stresses have warranted systematic research in banana.

The production and productivity in banana is confronted with various biotic and abiotic stress factors. The production constraints also vary from region to region, however many problems are similar in nature across the banana producing states in India and also among the different countries. The complexity of problems needs basic, strategic and adaptive research to attain the maximum production and productivity in banana with an interdisciplinary and holistic approach without affecting the existing ecosystem. The vision of the ICAR-National Research Centre for Banana (NRCB), Tiruchirappalli is to increase the production and productivity and to sustain the growth achieved during the last two decades. Banana has registered 209 % growth in area expansion while the production has witnessed a fourfold increase during the same period. This tremendous growth could be achieved mainly due to the adoption of improved high yielding varieties and production technologies. However, the average national productivity (37), is far below the productivity obtained in some states like Maharashtra, Gujarat and Tamil Nadu (>60-70). Therefore the priority is the

production constraints in low productivity banana growing states need to be addressed in systematic and multidisciplinary approaches so as to increase the overall production of banana. With a projected population of 1600 million people in 2050, and more than half of the population living in urban areas with high income status, a change in the food basket is anticipated. To meet the demand of ever growing population and to achieve from present 10.5 kg to projected annual per capita consumption of 30 kg banana fruits, a projected target of 60 million tonnes in 2050 AD is the goal of the Centre.

The ICAR-National Research Centre for Banana (NRCB) was established at Tiruchirappalli, Tamil Nadu on 21st August, 1993 which started functioning effectively from 1st April 1994 to strengthen the basic and strategic research and to improve the production and productivity of banana in India.

The ICAR- National Research Centre for Banana has significantly contributed for banana research and development. The Centre has developed many new technologies on improvement, production, protection and post-harvest management and value addition sin banana. ICAR-NRCB has disseminated its new technologies to the farmers and entrepreneurs which have been adopted widely by the farming community. All the technologies and trainings have considerable impact on the improvement of rural economy by generating rural employment.

Salient Research Achievements

- A banana field gene bank has been established with 361 indigenous accessions. Evaluation and screening of Musa germ plasm for various biotic and abiotic traits led to the identification of resistant gene sources for major a/biotic stresses. Sigatoka leaf spot tolerant (11), pseudo-stem weevil (11), seven for lesion nematode, nine for root knot nematode and seven for drought tolerance.
- Udhayam, a high yielding banana cultivar was released during the year 2005.
  Improved NRCB Sel-8 (Saba-ABB) has a distinct superiority over local cv. Monthan for drought, salt tolerant and high yield.
- Twelve wild species have been used in the breeding program. Hybrid plants have identified for resistance against fungal diseases and nematodes. Full length of chitinase gene from M. acuminata was isolated and confirmed through sequencing.
- Developed DUS guidelines successfully for banana, useful for registration of new varieties, hybrids, farmers' varieties and extant varieties with PPV & FRA.

- ICAR-NRCB, Trichy has been accredited by DBT, New Delhi both for genetic fidelity testing and virus indexing under the National Certification System for Tissue Culture Production Units (NCS-TCPU).
- Identification of ornamental Rhodochlamys members of Musaceae for floriculture industry. Indigenous species like M. ornata, M. laterita, M. velutina, M. rosaceae, M. aurantiaca, M. sanguinea for its beautiful, erect inflorescences with attractive colours and long shelf life were identified for cut flower industry.
- Planting banana at 2 × 3m spacing with three plants per pit (5000 pl ha^{-1}) with 75% RDF fertigation recorded the highest total hectare yield.
- Modified high density planting system of "planting three suckers $hill^{-1}$ at 1.8m × 3.6m (4630 plants ha^{-1}) and with 75% N and K fertigation recorded highest bunch weight with maximum total ha yield. This system is particularly useful under fertigation, which reduces the number of laterals and in addition, with 25-30% saving of water, and fertilizers. Drip irrigation of 20 litres day^{-1} and fertigation with 200g N and 300g K $plant^{-1}$ was optimum with higher individual bunch weight.
- For organic banana production, application of 2.5kg compost + 1 kg vermi compost +1 kg neem cake + 2.5 kg poultry manure plant-1 at 3, 5 and 7 MAP recorded vigorous plant growth, maximum bunch weight and higher yield. The sigatoka leaf spot and nematode infestation was significantly less in plants under organic nutrition and in addition, the organics significantly increased the organic carbon content and decreased the Na content, EC and soil pH.
- Application of 20 kg FYM + 0.9 kg neem cake + 2.0 kg vermicompost + 0.9 kg groundnut cake recorded the highest bunch weight in BSV infected Poovan banana with the highest TSS (26.4o B), pulp: peel ratio and lowest fruit acidity.
- Application of 300gN and 400g K2O in ratio of 7:2:1 N and 4:3:3 K2O at vegetative, flowering and bunch development stages respectively recorded the earliest fruit maturity and also produced the highest bunch weight with highest TSS 31.2oB in Udhayam banana.
- Application of 25% N FYM + 50% N as Neem cake + 25% N as inorganic were found optimum and recorded maximum growth parameters, shorter crop cycle, T.S.S. and highest yield in Rasthali, Robusta and Poovan cultivars. In addition, organic nutrition reduced soil pH, improved the soil physico-chemical properties like bulk

density and porosity, with higher organic carbon and K/ Na ratio.

- For nutrient requirement of tissue cultured banana, application of 300g N and 400 N&K in 7 splits at 30 days interval recorded maximum bunch weight. For the production of 1000 kg Grand Naine banana, 5.3kg N, 0.3kg P2O5 and 7.98kg K2O are required.
- Fertilizer tailoring equations for Poovan, Karpuravalli, Ney Poovan, Poovan, Karpuravalli and Grand Naine bananas were developed and validated. A Diagnosis Recommendation Integrated System (DRIS) chart has been developed for monitoring the status of N, P and K in 'Nendran' banana.
- A micronutrient mixture 'Banana Shakti', was developed by the centre, is effective for correcting the micronutrient deficiencies in banana. Soil application of 5g FeSO4 and foliar application of 0.5% solution ZnSO4, Borax and sulphur increased the bunch weight by 41% in Ney Poovan and 109.7% in Nendran.
- Saba, Karpuravalli, Mannan, Nattu Poovan recorded higher ECW content and Poovan, Nattu Poovan, and Ladan recorded higher Relative Water Content (RWC). Under soil moisture deficit stress, priming of banana plants with 0.1mM ASA or 100 ppm ABA reduced drought injuries.
- Saba (ABB) and Karpuravalli (ABB) were identified as salt tolerant varieties based on the chlorophyll stability index, Na+, K+, higher proline, epicuticular wax content and days taken for senescence.
- Pre-harvest spraying of bunches with 2.0% Potassium sulphate solution along with wetting agents a week after the emergence of the last hand followed by a second spray 30 days later and covering the bunches with non woven polypropylene bunch sleeves improved better finger filling with increased bunch weight, bunch grade, fruit quality and advanced the fruit maturity by 7-10 days.
- The critical temperature for storage of bananas was 13.5oC for Cavendish varieties like Robusta and Grand Nain, Rasthali (Silk), Ney Poovan (AB diploid) and Poovan (AAB), while it was 12oC for Nendran (Plantain, AAB) and 15oC for Pachanadan (Pome).
- Integration of all post-harvest treatments like de-handing of bunches, Bavistin dip at 500 ppm concentration, modified atmosphere packaging using 400 gauge polyfilm, use of ethylene scrubber and storage at 13.5 oC extended the green life of Robusta for 110 days, Grand Nain up to 90 days and Rasthali up to 120 days. Ethylene gas (100 ppm) is safely used for commercial ripening of banana.
- Development of various value added products such as Fig, Juice, Bar, Jam and Sweet Chutney from pulp of ripe banana; Flour, Baby

Food, Health Drink, Sauce, Pickle and Chips from pulp of unripe banana; Pickle from flower (male bud) of banana; Candy and Pickle from centre core stem of banana.

- Combination of NaOH as retting agent and citric acid as bleaching agent gave the best fibre with good color and fine texture and tenacity, which was suitable for yarn making.
- Distribution maps of India for Radopholus similis (burrowing nematode), Pratylenchus coffeae (lesion nematode), Meloidogyne incognita (root-knot nematode), Helicotylenchus multicinctus (spiral nematode) and Heterodera oryzicola (cyst nematode) and corm weevil, stem weevil and banana aphid were prepared.
- Developed nematode management strategy using Carbofuran 30g or Rugby 10G 10g or Caldan 4G 10g or Cadusafos 10G 10g, one at the time of planting and application at 3 monthly intervals. The technology using biocontrol agents like Pseudomonas fluorescens, Paecilomyces lilacinus, Verticillium chlamydosporium, Bacillus subtilis and Verticillium lecanii was developed for the management of major nematodes infesting banana.
- Two promising bio-control agents viz., Paecilomyces lilacinus and Pseudomonas fluorescens were released as NRCB Nemacinus and NRCB Nemacens for the effective management for nematodes in banana.
- Banana longitudinal split stem as a trap and as a delivery system for entomopathogenic fungi (Beauveria bassiana) and nematodes (Heterorhabditis indica) for weevil management was developed
- Identified three semio-chemicals viz., Sc.No.1 for corm weevil and Sc.No.2 and 3 for attracting stem weevil. Verticillium lecanii NRCB VL-7 has been identified as a promising isolate for banana aphid control.
- Incidence of a new Fusarium VCG 0124 causing wilt disease in Cavendish banana was recorded. Spraying mineral oil 2.5% with Propiconazole (0.05%), Companion (0.05%), Carbendazim 0.05 %, Calixin 0.05% and Mancozeb 0.12% gave good control of leaf spot disease in Robusta (AAA) and Nendran (AAB) banana and increased the yield up to 20%.
- Soil application of Penicillium pinophilum recorded zero incidence of Fusarium wilt disease at shooting stage of banana cv. Grand Naine. Culture filtrates of bacterial and fungal isolates recorded 100% inhibition of spore germination and 95% inhibition of mycelia growth of Mycosphaerella eumusae under in-vitro condition.
- Roving survey for viral disease conducted in Tamil Nadu, Kerala,

Andhra Pradesh, Maharashtra and Bihar revealed the incidence of BBTV in Jalgaon, Theni, Kodur and lower Pulney Hills. Poovan recorded the highest incidence of Banana Streak Virus.

- Complete genome of Banana Bunchy Top Virus (BBTV) infecting Hill Banana (HB-TN isolate), Banana Streak Mysore Virus (BSMYV-TRY) infecting cv. Poovan (Mysore, AAB), and Banana Bract Mosaic Virus (BBrMV) infecting cv. Nendran (BBrMV-TRY isolate) were studied.
- A multiplex Reverse Transcriptase PCR technique has been standardized for the simultaneous detection of four viruses viz., BBrMV, CMV, BBTV and BSMYSV. New detection techniques such as Rolling circle amplification (RCA) to detect BBTV and BSMYV and Real time PCR technique for detection of BBTV using TaqMan and SYBR have been developed
- A technology has been developed by application of 25 kg organic manure and 125-150 % RFD fertilizers for the viral diseases BSV and BBMV susceptible cultivars like Poovan and Nendran compensated the yield loss and increased the productivity of virus infected plants.

With a production target of 60 million tonnes in the year 2050, the major production constraints like increasing input costs of fertilizers, irrigation and management of insect pests and diseases are to be solved

Nutrients in a banana

Vitamin B6 – 0.5 mg
Manganese – 0.3 mg
Vitamin C – 9 mg
Potassium – 450 mg
Dietary Fiber – 3g
Protein – 1 g
Magnesium – 34 mg
Folate – 25.0 mcg
Riboflavin –0 .1 mg
Niacin –0 .8 mg

- Banana helps to overcome depression due to high levels of tryptophan, which is converted into serotinin - the happy-mood brain neuro-transmeter.
- Eat two bananas before a strenuous workout to pack an energy punch which sustain blood sugar.
- Protect against muscle cramps during workouts and nighttime leg cramps by eating a banana.
- Counteract calcium loss during urination and build strong bones by supplementing with a banana.
- Improve mood and to reduce PMS symptoms by eating a banana, which regulates blood sugar and produces stress relieving relaxation.
- Bananas reduce swelling, protect against type-II diabetes, aid weight loss, strengthen the nervous system and help with the production of white blood cells, all due to high levels of vitamin B-6
- Strengthen blood and relieve anemia with added iron from bananas.

for maximizing the production and productivity. Declining soil health and substrate dynamics management is becoming greater challenge which needs higher attention to maintain a better eco-system and safe environment in the scenario of poor soil health and organic banana growing. The changing climate and its consequential effect on the production and emergence of new pests and diseases may also pose a great challenge to the researchers to develop new mitigating strategies to sustain the gain obtained. There is a need to forecast the new challenges, which would create preparedness to anticipate and develop new technologies to make the banana industry a viable and highly profitable venture.

Challenges

The major challenges faced by the banana industry is the small holding cultivated by small and marginal farmers and no concern over the quality of the product and has no control over the market. Due to the un-planned growth of banana industry and production of many banana varieties in low volumes catering to the small local markets with poor infrastructural facilities for storage, and involvement of many marketing channels. Due to the nature of unorganized marketing sector, the farmers are experiencing severe financial crisis due to low price during the market glut or adverse climatic conditions. Though, India is the number 'Uno' in area and production but its export market share and its International presence is highly negligible (0.01%). Due to urban expansion with shrinking cultivable land and water resources, likely impact of changing climate on banana growing regions due to global warming, non-availability of farm laborers pose a great challenge to the Indian banana industry.

Currently, the per capita consumption of banana is around 10.5 kg annually which needs to be increased to 30 kg in the year 2050 due to the affordability, awareness, availability of fruit basket and changing food habits. In addition, there are also new challenges in banana cultivation experienced under non-traditional areas due to extreme unfavorable climate and need for technological back up to face overcome the climatic change. Further, the national average productivity is much below the potential productivity in most of the states also a serious concern unlike the higher productivity obtained in some states. These require focused research activities to increase production and productivity and by efficient harnessing of resources. Banana being a long duration crop (12 to 15 months) and the lag period required for adoption of new technologies varies from five to six years also pose a great challenge in the dissemination and adoption of improved technologies.

Gaps and short comings

Research

- Non availability of quality planting material and planting of diseased poor quality planting material continuously result in drastic

reduction in productivity with poor quality fruits. This is a great challenge to the sustainability of banana in many traditional banana cultivars.

- There is a need for an in-situ, cheaper and quick detection molecular technologies for testing viruses in the planting materials by the farmers themselves. Indiscriminate use of poor quality, diseased planting materials pose a serious threat for the spread of many insects and fungal diseases especially in non-traditional areas.
- Lack of awareness and adoption on improved water and fertilizer use efficienct technologies in banana.
- Indiscriminate application of inorganic fertilizers caused severe nutritional imbalances especially of micro-nutrients, affecting quality of the fruits. There is a need to improve the substrate dynamics of banana growing soils.
- Since major biotic constraints like insects, nematodes, diseases and viruses cause severe economic losses in banana production, which needs management technology.
- Reduction in post-harvest losses and development of new value added by-products to reduce loss and to generate more profitability.
- Need to develop research for domestic, retail and export market standards with traceability and quality certification for organic produce.
- Technology for management of available resources. Development of banana EUROGAO and INDIAGAP standards for traditional banana varieties without degrading environment to meet the export.

Development

- The major production constraint faced by the farmers is the non availability of good quality, high yielding and disease free planting material in Cavendish and mainly in other traditional banana varieties.
- There is a need to develop sufficient infrastructural requirement along to meet the planting material requirement with certification program. The requirement of Grand Naine tissue culture plants is estimated approximately around 200 million plants per year.
- Marketing is another major problem faced by the farmers. In most cases, banana farmer often fails to get remunerative price due to poor quality produce.
- Region specific markets are to be developed with sufficient infrastructural facility for pack houses, transport, and refer-container with cold storage and artificial ripening facilities for better quality, keeping the perishable nature of the fruit.

- Creating awareness and providing training to farmers, entrepreneurs and self help group members on value addition to generate additional income and rural employment.

Greater vision and focuses are needed to address the challenges by systematic research approaches in basic and strategic areas.

The thrust of ICAR-NRCB should be on the basic and strategic researches which include molecular genetics, genetic engineering and biotechnological approaches to address the breeding constraints. Development of better genotypes including transgenic plants with high nutrient contents like vitamin A, iron and antibodies for immunity, high yield potential and resistance to major biotic and abiotic production constraints should be the major thrust areas.

Immediate attention should be to address climate resilient production technologies, cultivars identification for higher productivity, efficient water, fertigation, clump management to increase the production and productivity with an eye on cost reduction. With the growing awareness on the environment and ecosystem, efficient integrated management technology for pests, nematodes, fungal, bacterial and viral diseases needed. For additional income and to over-come the marketable glut, better markets with better infra-structural facilities like market intelligence, for transportation, handling, cold storage for whole sale and retail marketing for quality banana to the consumers and for export market also. Value addition and processing of banana into different by- products for better utilization and also export of banana need special attention.

❑

Operating Environment

National Scenario

In India banana and plantain are widely grown in both tropical and subtropical regions comprising Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Orissa, Bihar, eastern U.P., West Bengal, Assam and North eastern states with considerable socio-economic and cultural importance. Banana is the most consumed fruit crop accounting for 36.6% of total fruit production from 11.1% arable area, with a total production of 29.7 million tonnes banana from 29.7 M ha. Bulk of the produce is consumed with in the country with a meager export share of only 0.1%.

Growth of Banana Industry

There has been a more than ten fold increase in production of banana during the last 25 years while the last decade has witnessed a steep growth due to banana research and development. The area has increased from 0.20 million ha in early 70's to 0.802 million ha in 2014's, while banana production has recorded a giant leap of 9 times from 3 million tonnes to 29.7 million tonnes. The productivity has also increased from a meager 9 tonnes to 37 tonnes, while in some states; the productivity is as high as 120 tonnes. This significant increase in the production and productivity of banana is due to adoption of improved research technologies and development activities in banana and plantain. This could be achieved due to availability of high yielding genetic material especially Cavendish group of bananas, improved production system and adoption of efficient protection technologies for the control of major pests and diseases under different climatic conditions have contributed to the fast growth of banana industry in the country.

Banana is popular on global scale not only for its nutritional value but also because of its economic importance especially to smallholding farmers in the developing countries. Bananas and plantains are the fourth most important staple crop in the world and are critical for food security in many tropical countries. They are grown in more than 130 countries across the world in an area of 5.00 million ha producing 103.63 million tonnes of banana and plantain (FAO, 2013).

Statewise Area, Production and Productivity of Banana

Area in '000 HA, Production in '000 MT and Productivity - MT/HA

	2011-12			2012-13			2013-14		
State	**Area**	**Production**	**Pdy.**	**Area**	**Production**	**Pdy.**	**Area**	**Production**	**Pdy**
Tamil Nadu	130.4	6736.4	51.7	111.36	5136.20	46.1	118.04	5650.00	47.9
Maharashtra	82.0	4315.0	52.6	82.00	3600.00	43.9	83.00	4830.60	58.2
Gujarat	65.0	4047.8	62.3	70.58	4523.49	64.1	66.50	4225.49	63.5
Andhra Pradesh	82.8	2899.6	35.0	92.65	3242.80	35.0	90.48	3166.90	35.0
Karnataka	91.6	2351.5	25.7	97.40	2529.60	26.0	102.71	2675.63	26.1
Madhya Pradesh	24.8	1379.2	55.6	25.76	1701.00	66.0	26.27	1735.00	66.0
Bihar	32.1	1580.5	49.2	33.06	1702.41	51.5	34.31	1435.78	41.8
West Bengal	43.7	1054.0	24. 1	44.70	1077.80	24.1	45.50	1097.50	24.1
Assam	49.1	745.3	15.2	51.51	837.02	16.2	50.81	857.72	16.9
Odisha	27.5	506.2	18.4	27.49	521.31	19.0	25.06	476.60	19.0
Others	167.5	2839.5	17.0	139.49	1637.47	11.7	159.89	3573.33	22.3
Total	796.5	28455.1	35.7	776.0	26509.1	34.2	802.6	29724.6	37.0

Source: All India 2013-14 (Final Estimates), Department of Agriculture & Cooperation

World banana production is concentrated in Africa, Asia, the Caribbean and Latin America because of the climatic conditions. Bananas and plantains are continuously exhibiting a spectacular growth worldwide. It's year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit among all classes with good export potential. India alone produces 29.7 million tonnes from an area of 0.802 million ha.

Banana is a crop of tropics and subtropics requiring hot and humid climate. Broadly, banana is widely grown between 30° latitude N and S of the equator. In India, banana is grown in the regions from humid tropics to humid sub-tropics and semi-arid tropics and from the sea level up to an elevation of 2000 m above mean sea level. Favourable factors for banana production are: rainfall in excess of 100 mm per month and a temperature range of 10-40°C with an optimum between 25°C.

Area, Production and Productivity of Banana

Year	Area	% of Total	Production	% of Total	Productivity
	(in '000 HA)	Frt. Area	(in '000 MT)	Frt. Production	(in mt/ha)
1991-92	383.9	13.4	7790.0	27.2	20.3
2001-02	466.2	11.6	14209.9	33.0	30.5
2002-03	475.3	12.5	13304.4	29.4	28.0
2003-04	498.6	10.7	13856.6	30.4	27.8
2004-05	589.6	11.9	16744.5	34.0	28.4
2005-06	569.5	10.7	18887.8	34.1	33.2
2006-07	604.0	10.9	20998.0	35.3	34.8
2007-08	658.0	11.2	23823.0	36.3	36.2
2008-09	709.0	11.6	26217.0	38.3	37.0
2009-10	770.3	12.2	26469.5	37.0	34.4
2010-11	830.0	13.0	29780.0	39.8	35.9
2011-12	796.5	11.9	28455.1	37.2	35.7
2012-13	776.0	11.1	26509.1	32.6	34.2
2013-14	802.6	11.1	29724.6	33.4	37.0

NHB 2013

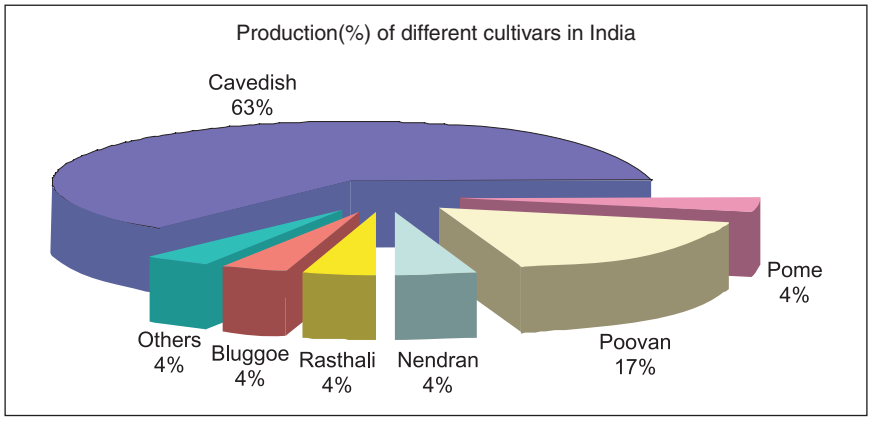
Important banana varieties cultivated in different states of India

State	Varieties grown
Andhra Pradesh	Dwarf Cavendish, Robusta, Rasthali, Amritapani, Thellachkrakeli, Karpoora Poovan, Chakrakeli, Monthan, Yenagu Bontha
Assam	Jahaji, Chini Champa, Malbhog, Borjahaji, Honda, Manjahaji, Chinia (Manohar), Kanchkol, Bhimkol, Jatikol, Digjowa, Kulpait, Bharat Moni.

Bihar	Dwarf Cavendish, Alpon, Chinia, Chini Champa, Malbhog, Muthia, Kothia, Gauria
Gujarat	Dwarf Cavendish, Lacatan, Harichal (Lokhandi), Gandevi Selection, Basrai, Robusta, Grand Naine, Harichal, Shrimanti
Jharkhand	Basrai, Singapuri
Karnataka	Dwarf Cavendish, Robusta, Rasthali, Poovan, Monthan, Elakkibale, Rajapuri, Red banana
Kerala	Nendran (Planain), Palayankodan (Poovan), Rasthali, Monthan, Red Banana, Robusta
Madhya Pradesh	Basrai, Grand Naine
Maharashtra	Robusta, Safed Velchi, Rajeli, Nendran, Grand Naine, Shreemanti, Red Banana
Orissa	Dwarf Cavendish, Robusta, Champa, Patkapura (Rasthali)
Tamil Nadu	Robusta, Red Banana, Poovan, Rasthali, Nendran, Monthan, Karpuravalli, Virupakshi, Matti
West Bengal	Champa, Mortman, Dwarf Cavendish, Giant Governor, Kanthali, Singapuri, Lacatan, Monthan

N H B, Year Book 2013

India is home of wide range of Musa cultivars with varying genomic status with diverse agro-climatic conditions, which has encouraged the development and sustenance of large number of varieties catering to local needs.



Though, more than 20 varieties are grown commercially, Cavendish bananas form the main stay of Indian banana Industry, owing to its high yield, wide market acceptability, short crop duration and high economic returns per unit area. Poovan is another cultivar grown commercially in different regions for its wider adaptability and tolerance to drought and diseases. Rasthali is grown in some specific regions due to its premium price in the market. Ney Poovan is becoming commercially importance in South India. Virupakshi, Monthan and Karpuravalli bananas are

also grown to a large extent in many states. Nendran is commercially grown in Kerala and Tamil Nadu due to the local preference for table and processing industry. The varietal situation prevailing in different states/regions indicated regional adaptation, sustainability and preferences.

India produces 29.7 million tonnes of bananas and plantain per year, but the post harvest losses are estimated around 20-24%, valued about Rs.3000 crores per annum. This losses are basically due to faulty handling procedures like improper transportation, lack of packaging, cold chain and post-harvest storage infra-structural facilities.

In the banana processing sector, only 3-4% of the total production is processed. The banana processed products mainly consists of banana chips which is produced to a tune of over one lakh tonnes a year. Majority of the chips are produced from Nendran banana, however, Robusta and Monthan banana fruits are also being processed as chips to some extent in Maharashtra and Tamil Nadu states. Other products popular in the market are banana puree and powder.

The export of banana from India is negligible while a small quantity of plantains (Nendran type) is exported to Gulf countries mainly from Kerala and southern Tamil Nadu. Recently, attempts have been made by Maharashtra and Tamil Nadu farmers for export of Robusta banana to Gulf countries.

Banana Export Status (Value in lakhs and Quantity in Mt.)

Country	2009-10		2010-11		2011-12	
	Qty.	Value	Qty.	Value	Qty.	Value
U.A.E.	18644	4744	11674	2774	15134	3794
Saudi Arabia	9416	2427	8954	2140	5014	1246
Iran	5204	1167	9352	1958	4126	951
Kuwait	5552	1616	5474	1213	3196	718
Bahrain	2890	1071	10965	656	2437	584
Nepal	6559	347	5929	332	9766	514
Quatar	2684	843	1802	450	2053	493
Oman	1977	526	1537	347	2228	485
Maldives	648	105	981	136	913	178
Korea Republic	0	0	0	0	147	47
Others	745	179	872	226	560	144
Total	54319	13025	57539	10232	45573	9154

Source : APEDA, 2013.

International Scenario

Banana and Plantain is the 4th important food crop in the world in terms of gross value. It is produced in >130 countries in tropical and sub-tropical regions of the world of mostly developing economies. Globally, banana and plantain are cultivated in 5.00 million hectares with a total production of 103.63 million tonnes (FAO, 2013).

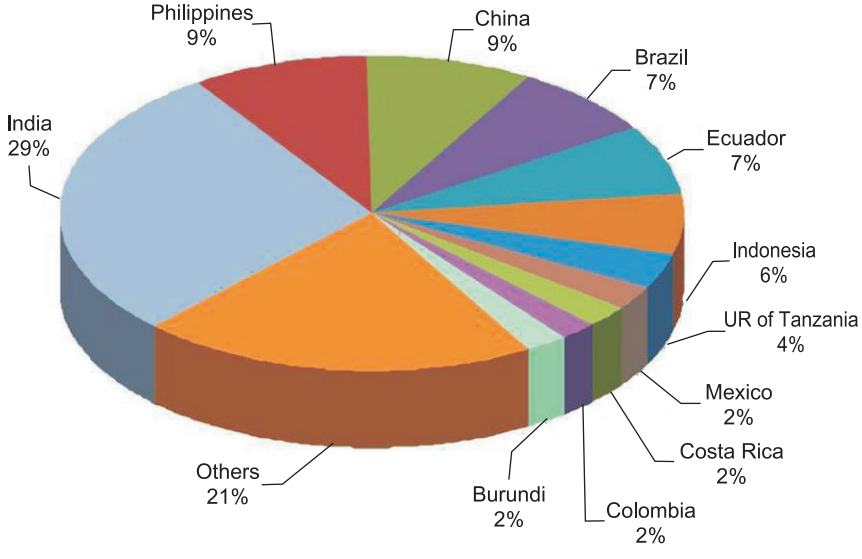
Country	Area (million ha)	Production (million tonnes)	Productivity (t/ha)
World	5.00	103.63	20.7
India	0.802	29.724	37.0

NHB (2013) World banana production is concentrated in Africa, Asia, the Caribbean and Latin America because of the favorable tropical climatic conditions. Bananas and plantains are continuously exhibiting a spectacular growth worldwide. It's year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit among all classes with good export potential. In most of the banana and plantain growing countries, it is grown perennially with single or two cultivars dominating the whole economy. Due to the tropical nature, these countries are receiving plenty of rains with good soil and the perennial system of cultivation is followed in large areas. Due to the non-availability of labour, mechanization is commonly adapted with aerial spraying for plant protection measures. In the banana republic countries and Central America, Cavendish group are grown commercially for export to USA, European and UK markets. In Brazil, pome group of fruits are commercially grown in large areas. In the West African countries, plantain is the most preferred variety grown for local and export trade. In the east African countries, high land AAA bananas are commonly grown with Cavendish and cooking bananas.

India is the largest producer of banana not only in Asia but also in the world contributing 25.57 per cent to global production from 15.5 per cent area followed by China (9.8 per cent) and Philippines (8.9 per cent) (NHB, 2013). Although Brazil has the second largest area under bananas (0.481 million ha), the country ranks only fifth in terms of production due to lower productivity. Interestingly, there has been an appreciable increase in productivity of banana between 2001 and 2009 in India, owing to technological adoption resulting in higher production. Same is the case with China, while production in Ecuador, Columbia and Costa Rica has shown a declining trend during this period.

India, China, Philippines and Indonesia are the major banana

producers in the South, South-East Asian and Pacific region. India contributes 48% of the total production in Asia from 37% of total area. China contributes almost 17% production from 15% area. Among various continents, Asia has the lion's share of 60% in global banana production. In the South East Asian countries, like India, polyclonal system of cultivation is adopted for local and export market. In this region, Philippines, Indonesia and Malaysia are the major banana growing countries while in Australia, Cavendish banana are grown in a larger extent. The area and production of top 10 bananas and plantain growing countries is presented below.



Leading Banana Producing Countries

Banana and plantain consumptions were maximum in African countries with 40-45 kg/year/individual as against 10.5 kg/year in India. Banana and plantain are the main staple food in East and West African countries. Most of the plantains grown in West Africa are exported to France and European markets. Thus banana and plantain cultivation forms the food security of the millions of people and also sustenance of the small and marginal farmers in African and Asian countries.

New Opportunities

The production and productivity in banana during the past 2-3 decades has faced a tremendous growth in India and also at global level. To meet the large demand of the planting material, micro propagation techniques provided an easy tool for mass multiplication by the private sector meeting bulk of the demand. However indiscriminate multiplication on a large scale, without any certification, resulted in complaints about the genetic fidelity, quality, disease freeness etc of the planting materials supplied to the farmers resulting in the decline of the adoption of the new technology. This situation has warranted a new legislation to certify the planting material produced and also certification of the tissue culture companies in the banana trade. Consequently, indiscriminate use of poor quality planting material has lead to the spread of diseases like viruses, bacterial head rot, nematodes and bract mosaic viruses in non-traditional areas where banana is grown for the first time. This warranted systematic quarantine regulations in the movement of planting material in to these areas. Inter-state quarantine legislation is needed to curtail the movement of planting materials from one area to other areas.

The demand to increase the production and productivity has lead to indiscriminate use of inorganic fertilizers at the cost of organic fertilizers. This situation has lead to the depletion of organic matter in the soil affecting the soil health, soil micro flora, soil water pollution and depletion of micro nutrients to the plants contributing to lower productivity. Due to greater awareness about the organic banana in the west, there is a change to grow banana organically for better quality fruits without inorganic fertilizers and pesticides usages. Therefore, research approaches and new initiatives at ICAR- NRC Banana have been directed to develop a technology for organic banana production and also use of bio-fertilizers and natural alternate resources effectively for better soil health, substitute for inorganic fertilizers and use of micronutrients. Similarly, use of pesticides and fungicides has created soil and environmental pollution affecting soil, water and ecosystem. This has warranted concerted efforts at reorienting research priorities of the ICAR-NRC Banana in developing integrated pests and disease management strategies involving use of bio control agents, botanicals, and beneficial micro organisms for the control of soil borne pathogens

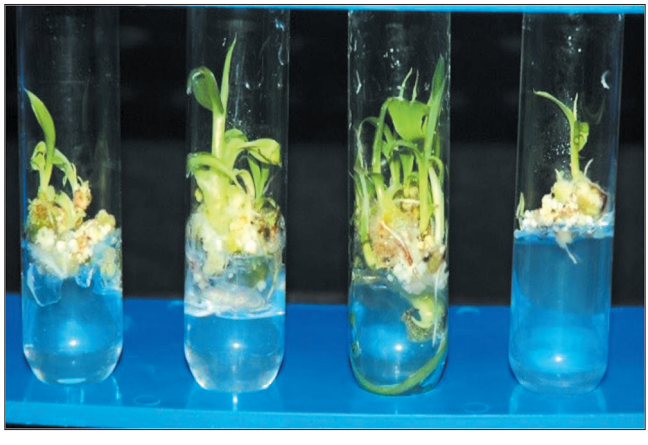
and other pests and diseases. This has opened a new vista of research priorities in use of beneficial bio-control and micro-organism for the control of harmful insects and pathogens and also improving the plant growth and yield in banana.

Banana being a highly perishable commodity influenced by the weather conditions, the post- harvest losses are estimated around 25-30%. Being a seasonal crop and to get a better price during the glut season, better storage, processing and value addition play an important role in marketing and better price realization. The ICAR-NRC Banana has developed 15-20 value added products in banana and plantain utilizing fruit, pulp, peel, flower, unripe fruit etc. The technologies have been transferred and are being adapted commercially in different parts of the country for better marketing and profit. In addition, the fibre extracted from the pseudostem also has great potential in the local and export market.

Though, India is the largest producer of banana, the quantum of export is very negligible due to the small holdings and non-availability of export standard good quality produce throughout the year in large quantity. The technology in handling, harvesting, transporting, storage, shipment, artificial ripening and packaging needs attention for the export trade. The ICAR-NRC Banana has standardized the pre and post harvest technologies like maturity index, better harvesting, handling, storage, packaging, and artificial ripening for export in Cavendish bananas. There is a need to develop technologies for the traditional banana varieties also and to create awareness for the traditional yellow bananas grown in India which has great potential for export as "niche" bananas to cater to the needs of the Indian ethnic population in the Middle East, South East Asian countries and also to European market. This area needs more attention and marketing strategies to popularize the Indian niche varieties to the consumers and in to the foreign markets by the Commerce Ministry and APEDA has to play a big role in this endeavor by organizing Banana Festivals and shows to popularize these banana and plantain grown largely in India, which has a very huge export market.

There is a need to develop the post-harvest infrastructural facilities for domestic and export markets like: transportation, storage, handling, ripening at the production sites and marketing of bananas on weight basis using carton boxes instead of selling whole bunch which creates environmental pollution and waste disposal is a big problem in the collection points and collection yards. There is a need to develop retail marketing strategies and better out-lets to reduce the post harvest

losses and also the availability of quality bananas to the consumers. This sector development is very vital for the banana industry since banana being a highly perishable commodity and the trade is highly fluctuating depending on the season and other fruits arrival. There is a need to develop value addition and by- product industry to utilize the excess production/glut in the market and also to stabilize the price fluctuation. There is great scope to develop various by-products from banana fibres and other wastes in to value added products.



Goals/Targets

Strengthening of on-going research areas

Genetic resources available in banana and plantains are huge and it is suspected that most of them are synonyms, which has to be identified and removed. The clear genetic status of all the collections is very essential for breeding programmes. To overcome these problems molecular characterization of these accessions is essential. The development of molecular markers and marker-assisted selection would enhance the efficacy on selection of improved cultivars for defined traits such as pests and diseases resistance, abiotic stress tolerance, and quality and its post harvest fruit characteristics. Very little knowledge is available this area of research.

The complete genomic knowledge in banana, which covers the complete sequence information, its genes, their expression, recombination and diversity are very important for the improvement of this crop. The genetic maps of banana will be useful to improve the selection of qualitative traits also allow better selection of parents for breeding programmes. The knowledge in banana genomic is very little.

The breeding in most commercially acceptable bananas is very difficult due to its parthenocarpic nature, triploidy and low fertility. Further, the hybridization is complicated by combination of different ploidy levels and by female restitution associated with the formation of unreduced female gametes.

There is an increasing threat of loss of valuable genetic resources at the centers of diversity due to the Jhum cultivation, deforestation, landslides etc in their natural habitat. Similarly, drastic climate change can also contribute to the loss. Hence effective conservation measures either by ex-situ or in-situ conservation methods would need to be initiated for effective protection and also development of database of the available germplasm. There are likely chances of loosing the claim for valuable gene sources of Indian origin due to the absence of database under the IPR and WTO regime.

Ever decreasing fertility status of soil causing low productivity due to excess use of inorganic manures has resulted in changes in the soil physical properties causing steady declining of bunch weight in all cultivars. There is a need to develop a strategy for organic banana

cultivation for local market as well as for export trade.

Due to shrinking land and water resources, and banana being a high water demanding crop, concerted efforts are needed to increase the productivity with less cost of production. Also, there is a great concern about the deteorating quality of available water on the soil and productivity of banana. The changing climate and rainfall coupled with increasing temperature has both positive and negative influence on banana production. Availability of water for irrigation and poor soil health are the serious environmental and production threat in different banana growing states in coming future. The nutrient supplying capacity and release pattern are not coinciding with the nutrient requirement pattern of banana due to poor soil conditions like soil salinity, sodicity, acidity, poor drainage and moisture deficit conditions. Although considerable efforts have been made on the use of micro - irrigation, fertigation and water conservation, still these areas need to be addressed properly.

Insect pests, plant parasitic nematodes and fungal and viral diseases are major production constraints in banana. The losses caused by these biotic stresses are very high, in addition the changing climate also influences the incidences of pests and diseases through change in rain fall pattern and rise in temperature. Though, considerable success in research have been achieved to offset the losses due to biotic constraints, non-adoption of proper technology and their improper management by the banana farmers has aggravated impact of these constraints on overall production and productivity. This would need to be addressed more seriously and systematically. Indigenous strip kits for virus testing need to be developed for all banana viruses by the farmers' in the field itself would help in the elimination of viral/ fungal diseases in the planting material. Hence, certification standards for TC / sucker plants and strict internal quarantine procedures would need to be developed for inter and intra–state movement of plants which is not available at present.

There is a need for more capital investment and technology should be designed to have a shift from subsidy driven mode to farmers driven mode to achieve the production target and quality fruits for domestic and export market. Non-availability of financial support for the cost intensive processing industries, without collateral, is prohibiting several first generation entrepreneurs from entering the processing of banana.

New Initiatives

Under the present WTO regime, the whole world has become a single market; the focus has to be on quality produce with traceability,

diversification, value addition and export. To meet the nutritional requirement of the people, the banana production has a target of 60 million tonnes by 2050 and the industry has to be competitive, quality conscious and diversified. Therefore, the following areas have been identified as the priorities of research, strategies and new initiatives.

Broadening of genetic base

Exploitation of genetic variability from introduction, natural variability, clonal and somaclonal selection. Development of natural hybrids and trait specific transgenic plants.

Development of database of various "mics" for banana

Development of information and database for genomics, transcriptomics, proteomics, metabolomics for various specific traits in banana

Organic farming

Strategy should be identification of organic nutrient sources, enrichment of soils, bio-agents for biological control, botanicals for disease and pest management and integration of different components and development of resistant varieties against major abiotic and biotic stresses.

Precision farming

Inventorization of natural resource base, choice of the variety, development of monitoring indices for various inputs through plant and soil analysis and threshold level of parasites and use of different input as per standards developed.

Efficient input management

Identification of sources, integrated approach to make inputs is cost effective and environmental friendly.

Development of efficient mass multiplication production system

Availability of good quality, diseases free high yielding true to type planting material is the major production constraint and also high cost is limiting the use of tissue culture plants in banana. Diagnostic kits for identification viruses at various stages (Mother plants, during proliferation, primary hardening) will have to be developed and utilized. Export technology

Maturity indices, technique for harvest, handling, transportation,

grading, cleaning and packing for local whole sale and retail market. Technology and creation of zones for export market.

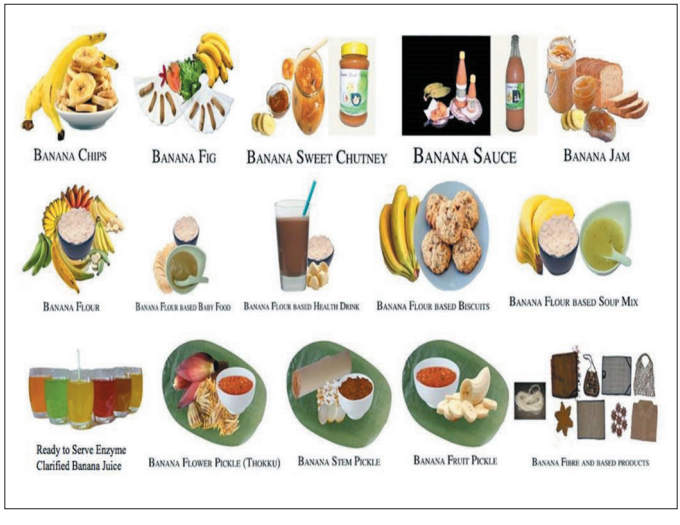
High value Food development

Technology for functional, nutraceutical and high value foods. Quality standards development for products for local market and export market including organic products.

Identification of factors of resistance

Studies on rhizosphere microorganisms for soil quality, biotic stress management and exploitation as bio-control management. Also biochemical mechanism of resistance. Detection techniques for viruses

Development of in-situ diagnostic tools for cheaper, easy to handle and faster identification of major viruses. Development of cheap and quick molecular diagnostic tools for all banana viruses also.



Way Forward

The production and productivity of banana and plantain recorded a significant increase during the last two decades, which could be accomplished due to the research and development activities done by ICAR, SAUs and state departments. The projection for the year 2050 is to be tune of 50 million tonnes and this goal is achievable due to the availability of improved varieties, production technologies on water management, nutrition management and integrated management of nutrition and water, effective plant protection strategies involving integrated pests and diseases management using bio-control agents, botanicals etc. With better post harvest handling and processing technologies the farmers could get better profit and through value addition, the waste could be converted into by-products like pickles and thokku from banana flowers, immature fruits and peel.

The availability of fruits throughout the year, and due to the varying climatic and growing conditions in the country, has made India as the major banana producing country in the world. With opening up of the trade and also the growing demand for organic bananas and other than Cavendish group for export purposes has opened up new vistas in the export trade. The ethnic Indian populations in the Gulf and European Union countries have opened up the export trade for Indian bananas. Due to the constraints in tax structure and export tariffs the banana export trade is heavily burdened.

The research priorities should be focused to achieve higher production and productivity with minimum cost of cultivation. Escalation in the input cost like water, fertilizers and quality planting material coupled with plant protection measures are the major limiting factors in improving the production of bananas. To overcome this hurdles the priority should be given to high yielding bananas with resistance to major biotic stresses. Therefore, major emphasis need to be collection of genetic diversity and identification of resistant gene sources using advanced biotechnological tools. Technology for increasing the efficiency for water and nutrient use with better cropping system has to be evolved. To improve the soil health and substrate dynamics, suitable technologies involving integrated nutrient management and organic farming has to be given priorities.

Integrated management of insect pests, nematode and diseases

involving bio-control methods, botanicals, PGPR has to be given priority to safeguard our ecosystem without polluting the environment. In view of greater awareness about the organically produced bananas in local and export markets, detailed experimentation on these aspects is warranted. To overcome these hurdles, greater importance has to be given in evolving plants resistant to major biotic and abiotic stresses using molecular breeding and genetic engineering techniques incorporating resistant genes from wild Musa gene sources. In this regard, highest priority should be given for conservation of the available genetic wild material from the centers of diversity using molecular tools, needs utmost attention in the era of IPR regimes.

Variability in *M. acuminata*

M.acuminata

M.acuminata wild

M. ac. ssp. *burmannicoides*

M.ac. ssp.*burmannica*

Pagalaphad wild

Good resistant gene sources for
All leaf spot diseases including Sigatoka
Fusarium wilt
Nematodes

Good breeding material

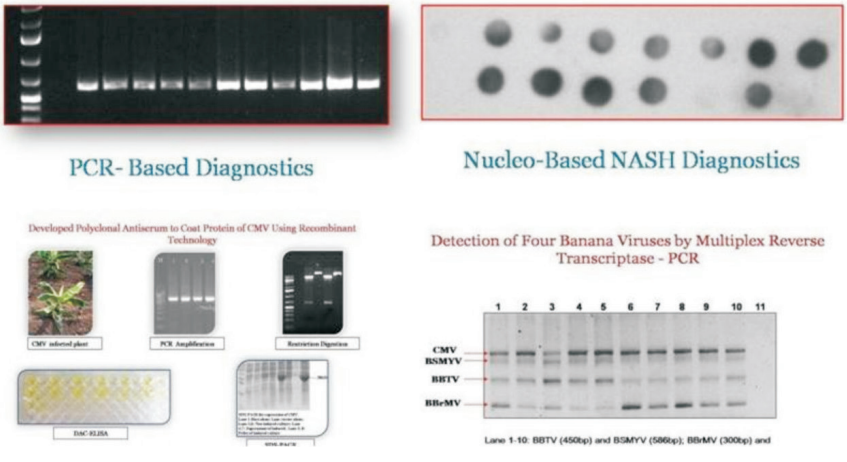
Genus Ensete

Ensete glaucum

Section Rhodochlamys

M. velutina *M. ornata* *M. aurantiaca*

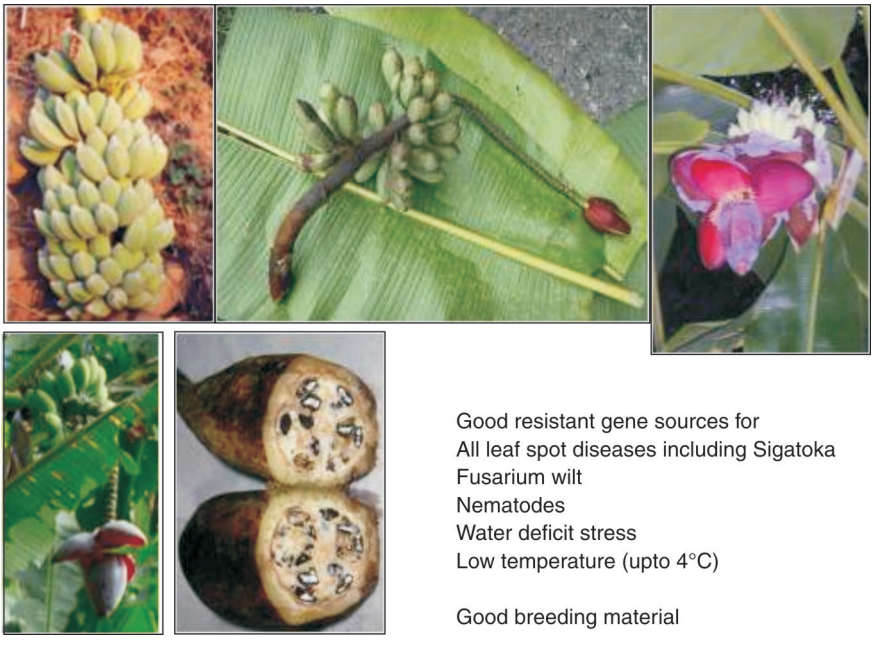
M. laterita *M. rubra*



Molecular diagnostic tools for virus detection

Ornamental bananas with potential for floriculture industry

DIVERSITY IN Musa balbisiana (BB)



Good resistant gene sources for
All leaf spot diseases including Sigatoka
Fusarium wilt
Nematodes
Water deficit stress
Low temperature (upto 4°C)

Good breeding material

Diploid acuminata (AA) landraces of Indian origin






Parthenocarpic diploids (AA)
Female fertile genotypes
Offer resistance to Fusarium wilt
Leaf spot diseases
Earliness
Dwarfism

AAA – sub group


Robusta


Grand Naine


Red Banana


Raja Vazhai

Udhyam Banana

AAB – sub group

Nendran

Rasthali

Ladan

Poovan

Hill Banana

Embryogenic cell suspension cultures

Banana varieties

High Density Planting

High yielding banana plantation

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