AGRIPRENEURSHIP THROUGH BANANA-BASED TECHNOLOGIES

C. Karpagam, Sagar Surendra Deshmukh,
P. Giribabu, A. Mohanasundaram, P. Ravichamy,
S. Uma

2022








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(ICAR-NRCB) Tiruchirappalli, Tamil Nadu
National Institute of Agricultural Extension Management
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This e-book is a compilation of resource text obtained from various subject experts for the collaborative online training programme of ICAR-NRCB & MANAGE, Hyderabad, Telangana on "Agripreneurship through banana-based technologies: An avenue for Atmanirbhar Bharat" held from 15-17, June 2022. Neither the publisher nor the contributors, authors and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/ editor/authors. The publisher and editor do not give a warranty for any error or omissions regarding the materials in this.

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FOREWORD

India is the global leader in banana production with 22.5 percent share of total banana production. In India, banana is being cultivated under nine lakh hectares with a production of 36.66 million tonnes, contributing 2% of Agricultural GDP. The banana production system as a whole contributing not only to the production alone but also to the nutritional security, alternative food system, export eco-system, labour market, and others.

ICAR- National Research Centre for Banana, Tiruchirappalli, Tamil Nadu has disseminated several technologies into the public domain for the benefit of entrepreneurship in India. The improvement, production, and protection technologies *viz.,* climate-resilient banana varieties, tissue culture protocols, macro-propagation, ornamental banana, micronutrient mixture, site-specific nutrient management, biocontrol agents for pest and disease control and development of robust virus diagnostic kits etc. play a vital role and recommended across the country to make the banana industry viable and sustainable, while, Post-Harvest Technologies and products are fulfilling the needs of entrepreneurship scope in India.

Apart from research, extension plays a vital role in entrepreneurship development. Horticultural crops, especially banana, requires a different extension approach like shift from production extension to market-led extension, individual extension to the group-led extension, cultivation technologies to export technologies, capacity development programs, co-ordination to the organizational convergence of Institutions, etc.,

In the above context, ICAR-NRCB conducted a three days online capacity development programme on "Agripreneurship through banana-based technologies – An avenue for ATMANIRBHAR BHARAT" sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India for the benefit of different stakeholders during 15-17 June, 2022. The course modules are exactly designed to expose the participants to various aspects of Agripreneurship and business opportunities available in the banana ecosystem.

I would like to take this opportunity to congratulate the team from MANAGE, Hyderabad, and ICAR-NRCB, Tiruchirappalli for their fruitful collaboration towards benefits to the stakeholders in the banana production system. I also congratulate the course directors, course coordinators and associates for their untiring work and high level of enthusiasm.

(S.UMA)
Director
ICAR – NRCB

Date : 17 June, 2022
Place : Tiruchirappalli

PREFACE

In extension research and development, entrepreneurship plays a vital role in market let extension. This e-book is an outcome of the collaborative online training programme on "Agripreneurship through banana-based technologies – An avenue for ATMANIRBHAR BHARAT" jointly organised by ICAR-NRCB and MANAGE during 15-17 June, 2022. The editors' main aim is to provide insights to all the stakeholders *viz.,* agripreneurs, progressive farmers, KVK officials, Central and State Govt. agricultural department staff, researchers, and students about Agripreneurship opportunities available in the banana production system. The three days event was organized with the objectives to promote entrepreneurship and business ventures in banana cultivation, providing capacity building through technological backstopping, facilitating innovative business solutions in the untouched areas of banana cultivation, and as the follow-up linkage mechanism between NRCB and trainees.

The editors opined that the experience and ideas of resource persons in this training programme should be clubbed together to form a unique proposition on Agripreneurship through Banana-based Technologies. 'Seeing is believing' is an old adage. The digital documentation of the information will enhance the quality as well as the authenticity. It makes any stakeholders easily understand and refer to the technologies or practices. This is the maiden effort in banana research and development to pool the views of different experts about the agripreneurship opportunities in the banana production system and made it an e-book available for different stakeholders. The experts and resource persons contributed immensely and tirelessly to develop various chapters of this e-book *viz*., newly developed banana varieties, macropropagation, bioreactors for micropropagation, *Banana shakti* – a micronutrient mixture, virus diagnostic kits, post-harvest management, and value-added products, Government initiatives and support to promote startups, licensing procedure for establishing agribusiness venture and agripreneurial ecosystem. The editors extend their sincere thanks to the all experts who have contributed valuable time and put sincere efforts to develop this e-book.

We undertook due care to compile the information and made a strenuous effort to document the same. If there is a need for any suggestions or modifications observed by the readers, you are most welcome to provide your feedback to us for further improvement of the e-book.

The editors are extremely thankful to the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India for the financial support for the training programme. The editors express gratitude towards the Director, ICAR-NRCB, and Director General, MANAGE for their constant encouragement and support for this training and e-book creation for the participants. The editors express thanks to Mr. Ajit Kumar who has designed the settings and graphical layout of the e-book. The editors hope that this e-book will help to explore the business opportunities available in the banana production system.

Editors

CONTENTS

Agripreneurship - Dynamics, scope and potential of banana improvement technologies for business ventures

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Agripreneurship refers to entrepreneurship in agriculture. Entrepreneurship is a concept that encompasses transforming an idea or vision into a "new business or new venture creation or the expansion of an existing business, by an individual, a team of individuals, or an established business" (Reynolds et al. 1999). But entrepreneurship, as opposed to self-employment, is also defined by the *spirit* of the entrepreneurs. Entrepreneurs are usually creative, take opportunities and accept risks, and can quickly change business strategies to adapt to changing environments. They are often innovators (Kahan, 2012). While usually being innovative and creative, farmers often lack experiences, access to services, people, or markets, and skills to have realistic chances to succeed as entrepreneurs (Wongtschowski et al. 2013).

Entrepreneurship *vs.* Entrepreneur

Entrepreneurship is the act and art of being an entrepreneur or one who undertakes innovations or introduces new things, finance and business acumen in an effort to transform innovations into economic goods. The most obvious form of entrepreneurship is that of starting new businesses; however, in recent years, the term has been extended to include social and political forms of entrepreneurial activity.

The word "Entrepreneur" is derived from the French verb 'entrepredre'. It means 'to undertake.' "An entrepreneur is an economic agent who unites all means of production; the land of one, the labour of another and the capital of yet another and thus produces a product. By selling the product in the market, he pays rent of land, wages to labour, interest on capital, and what remains is his profit". Thus, an entrepreneur is an organizer who combines various factors of production to produce a socially viable product.

The government of India positively promoted the agripreneurship by providing incentives to develop agribusiness activities in rural areas.

Competencies of a good entrepreneur – 14 points scale

- Enjoy your work
- Strategic plan *vs* contingency plan
- Aim for a profit with the risk of BEP (Break-Even Point)
- Know & honour your customer
- Self-promotion is the best promotion
- Project a positive business image.
- Be an expert in technical aspects
- Master the art of negotiations
- Design your workspace for success
- Organised work
- Follow-up constantly
- Concern for High Quality of Work
- Sees and Acts on Opportunities
- Commitment to Work Contract

In India, after globalization and liberalization, the economic picture has changed drastically. The service sector plays a vital role in economic development. This leads to more employment opportunities in the service sector, which is centered in an urban area and neglects the employment opportunities for rural forces. This situation leads to the migration of the rural population to urban areas. Employment opportunities have to be generated in the rural area to retain the population in the agriculture and allied sectors.

Nutritive importance of Banana

Bananas are a cheap energy source. It contains 27% carbohydrate, 1.0% protein, and 0.3% fat, providing 116 kcal of energy per 100 g of flesh. It has plenty of micro and macronutrient. Banana is a highly nutritious fruit, and the pulp (edible portion) of ripe fruit is rich in vitamin A, B-complex (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and folic acid), ascorbic acid vitamin E and micro (iron, copper, and zinc) and macro minerals (potassium, calcium, phosphorus, and magnesium). Due to its value, banana is made into powder and can be used as a major ingredient in preparing baby foods and healthy drinks. The fruit is easy to digest and free from fat and cholesterol. It helps in reducing the risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis, and kidney disorders. Low glycemic, pre-biotic products can be made from banana flour with a considerable amount of resistant starch.

Banana: Potential crop for entrepreneurship

Several viable technologies of the centre have already been disseminated into the public domain and created good scope for entrepreneurship. Bunch sleeves, micronutrient spray (Banana Sakti- Institute product), high-density planting, site-specific nutrient management, development of Biocontrol agents, pest and disease control, and development of diagnostic kits are some of the technologies the institute pioneered and recommended across the states to make the banana industry viable with the gross value of Rs. 50,000 crores.

More than 30 processed products are being developed from raw bananas, ripe bananas, and biomass waste like pseudo-stem sheath, central core stem, flower, bracts, etc. The outer sheath of banana offers fibres that could be used for making various handicrafts and has the potential to use even in textiles.

Among the NRCB-released varieties, with its long years of existence, 'Udhayam', has spread to many states due to its high yield and quality attributes coupled with disease tolerance/resistance. There is also a massive demand for quality, disease-free planting material (suckers/tissue culture plants). Several technologies developed at the Centre on improved post-harvest handling practices, value addition, and waste utilization have been successfully disseminated to the farmers, field and extension functionaries, traders and various other stakeholders.

With this background, the opportunities and scope available for entrepreneurship in banana, especially with the banana improvement technologies, is discussed in this chapter.

SCOPE. 1. New climate resilient banana varieties for entrepreneurship

Name	Details	Key features
Udhayam	40% higher yield than local Karpuravalli	High TSS makes it suitable for fig making. Field tolerant to Sigatoka. Suitable for long-distance transport
Kaveri Kalki	Dwarf dessert banana (lesser height than Local Kapuravalli) no propping is required. Short duration, suitable for annual cropping system and high-density planting.	High TSS content (10 % higher TSS content than Kapuravalli). Highly fertilizer and water responsive, highly resistant to leaf spot disease
Kaveri Saba	Dual-purpose. It produces a 20 % higher yield and 20-25 days earlier than Monthan. Tolerant to drought. Suitable for saline-sodic soils. High market preference, high keeping quality with a green life of 7-8 days	Tolerant to Fusarium wilt Race 2. Suitable for flour making and resistant starches, which could be used in health and soup mixes, bakeries and extruded products like pasta, noodles, etc.
Kaveri Sugantham	High yielder. Plant stature is robust and the height of the plant ranges from 4- 4.5 m height and 90cm girth. It is tolerant to Eumusae leaf spot disease. The pulp is cream in colour, sweet with a good aroma. Crop duration is 13-14 months.	This is recommended for cultivation in higher altitudes, especially for Kolli hills and Palani hills of Tamil Nadu.

Kaveri Haritha	Clonal selection from Bangrier, 20-25 days earlier than Monthan, wastage of fruit parts is lesser in Bangrier than Monthan. High and stable yield in both main and two ratoon crops	Suitable for all types of soil, including marginal soils. Suitable for Tamil Nadu, Kerala, Andhra Pradesh, Odisha, West Bengal
Kaveri Kanya	Dual-purpose cultivar. It is a medium-tall and robust plant. Crop duration 365-380 days. The fruit pedicel attachment is strong. Field tolerant to *Fusarium* wilt race 1.	Best suited for staggered harvesting, suitable for kitchen and backyard gardens. This variety is suitable for cultivation in Tamil Nadu, Kerala, Andhra Pradesh, West Bengal, and Karnataka

Kaveri Saba *Kaveri Haritha* *Kaveri Kalki* *Kaveri Sugantham* *Kaveri Kanya*

New climate resilient banana varieties - Scope for entrepreneurship

SCOPE 2. Diversity of banana for up-scaling as a business venture

Food processing is the sunrise sector, and with the surplus production of various products, the processing is the option that could provide an entrepreneurship option. Institute has developed varieties that could be suitable for various processing needs.

Name of processing Variety	Special Character	Value addition from the variety	Processing standards	Product description	Nutritional facts
Udhayam NRCB selection 01	High yielding (45kg/ bunch as against normal 25kg) with high TSS (28-32°B as against Grand Naine with 25-26°B) Moisture (%) : 74-76% Diameter(cm): 3-3.5 cm Protein: 1.3% Crude fat: 1.57% TSS: 28-32°B Acidity: 0.58%	Juice preparation Juice alone or in combination with pineapple, mango and lime	50% Clarified banana juice TSS: 12-15 °Brix Acidity: 0.25 – 0.30 %	It can be blended with other strong flavors to change the taste. When served chill it is a good thirst quencher and gives instant energy.	Energy: 59.48 Kcal/ 100ml Total carbohydrate: 14.6% Vitamin C: 114 mg/ 100g
		Banana fig	Moisture: 18-20% Total carbohydrate: 40-60% Light brown to golden brown colour	Banana fig is a dehydrated fruit prepared from ripe fruits of banana. The product is tasty, nutritious and stable up to three months at room temperature. The figs are highly nutritious and help in providing nutritional securit by supplying all the nutrients of banana in a concentrated form.	Energy: 165 Kcal/ 100g Total carbohydrate: 65% Fat: 0.81% Acidity: 1.28%
		Flower pickle		The banana male bud is a waste material produced during crop production with less economic value. It is converted into a high value added product by making pickle (*thokku*). The process involves removal of pistil, blanching, grinding and addition of spices and oil.	Energy: 384 Kcal/100g CHO: 14% Fat: 35% Protein: 3.9% Acidity: 1.89%

Kaveri Saba (Introduction from Philippines through ITC)	Drought and salt tolerant variety Suitable to marginal lands **Unripe** Moisture (%): 69-71 Diameter (cm): 4.8-5.4 Starch (%): 22.2-22.34 Protein (%): 0.10-0.12 Crude fat (%): 0.22-0.25 TSS: 2.52-2.61 Acidity (%): 0.39-0.42	**Chips making**	Thickness: 1.5 – 2.0 mm Diameter : 4 cm Crude Fat : 20-25%	Banana chips/crisps are made by deep-frying of raw banana slices in a suitable cooking medium	Energy: 434.4 Kcal/100g. Total carbohydrate: 46.7% Protein: 0.38% Acidity: 0.18% Oil content: 27.4% Acid value: 2.0mg (KOH)/g.
		Banana flour from mature fruits used for making flour based products like Baby food, health drink, soup mix etc.	Moisture: 5-9% Starch : 65-75% TSS : 2.5- 3.5 °Brix	The banana flour can made from unripe banana by slicing and drying in air oven then powdered. Used to making several products.	Energy: 248.0 Kcal/100g Total carbohydrate: 60% Protein: 1.25% Acidity: 0.48%
		Soup mix	Carbohydrate :10-12 % Protein :<1% Fat : Trace	Green banana flour mixed with other ingredients like corn flour, dried vegetables and spices. It can be prepare easily and marketed.	Energy: 124 Kcal/100g
		Starch	Moisture: 4-6% Starch : 92-95% Colour : white	Green banana starch can be isolated by ground banana pulp with water and sieved to remove protein, fat and sugar. White precipitate was separated and dried in air oven. Used to textural properties of various food products	Total sugar: 0.2% Fat: 0.03% Resistant starch: 63%
		Baby food	Moisture: 5-9% Starch :40-55% Protein :6-8%	Baby food made by fortifying of green banana flour with nutrient rich sources like milk, green gram and sugar. It is highly energetic and nutritious.	Energy: 184 Kcal/100g. Total carbohydrate: 40% Fat: 0.8% Vit-C: 6.6% Acidity: 0.46% Total sugar: 20.7%

Kaveri Saba (Introduction from Philippines through ITC)		**Health Drink**	Moisture: 6-8% Carbohydrate :55-65% Protein :3-5%	Highly nutritious health drink formula has been developed by fortifying banana flour with suitable natural sources of proteins, minerals, fats and vitamins.	Energy: 257.36 Kcal/100g. Fat: 0.78% Vit-C: 9.4mg/100g Acidity: 0.31%
Kaveri Sugnatham	Fragrant dessert banana Suitable of >1350mMSL Resistant to Fusarium wilt **Ripe** Moisture (%): 71-72. Diameter (cm): 4.5-5.0 Starch (%): 2.8 Protein (%): 0.42-0.50 Crude fat (%): 1.95 TSS: 24 Bx Acidity (%): 0.53	**Ice cream**	Banana pulp: 25-30 %		Energy: 229.3 Kcal/100g Carbohydrate: 30.1% Fat: 11% Sugar: 26.5% Cholesterol: 35.3 mg
		Juice	50% Clarified banana juice TSS: 12-15 °Brix Acidity: 0.25 – 0.30 %	It can be blended with other strong flavors to change the taste. When served chill it is a good thirst quencher and gives instant energy.	Energy: 59.48 Kcal/ 100ml Total carbohydrate: 14.6% Vitamin C: 114 mg/ 100g
Kaveri Kalki	Dwarf, Short duration Moisture (%): 76-78 Diameter(cm): 3.5-3.8 Starch (%): 3.10-3.12 Protein (%): 0.70-0.73 TSS: 25.2-25.3 Acidity (%): 0.40-43	**Juice** preparations (Juice alone or in combination with pineapple, mango and lime)	50% Clarified banana juice TSS: 12-15 °Brix Acidity: 0.25 – 0.30 %	It can be blended with other strong flavors to change the taste. When served chill it is a good thirst quencher and gives instant energy.	Energy: 59.48 Kcal/ 100ml Total carbohydrate: 14.6% Vitamin C: 114 mg/ 100g

		Banana fig	Moisture: 18-20% Total carbohydrate: 40-60% Light brown to golden brown colour	Banana fig is a dehydrated fruit prepared from ripe fruits of banana. The product is tasty, nutritious and stable up to three months at room temperature.	Energy: 165 Kcal/ 100g Total carbohydrate: 65% Fat: 0.81% Acidity: 1.28%
		Stem pickle		Banana stem is a waste material produced during crop production with less economic value. It is converted into a high value added product by making central core stem pickle.	Energy: 437 Kcal/ 100g CHO: 14.33% Fat: 41.70% Protein: 1.28%
Kaveri Haritha	High yielding (20% over local Monthan) Yield stability (over 4years with 5 crops) Moisture (%): 72-75% Diameter: 4.2-4.4 cm Starch: 22-24% Protein: 1.3% Crude fat: 0.57% TSS: 3.8 Bx Acidity : 0.34%	**Banana flour** Banana flour from mature fruits used for making flour basedproducts like Baby food, health drink, soup mix etc.) Mainly for culinary purposes	Moisture: 5-9% Starch : 65-75% TSS : 2.5- 3.5 °Brix	The banana flour can made from unripe banana by slicing and drying in air oven then powdered. Used to making several products.	Energy: 248.0 Kcal/100g Total carbohydrate: 60% Protein: 1.25% Acidity: 0.48%
		Starch	Moisture: 4-6% Starch : 92-94% Colour :White	Green banana starch can be isolated by ground banana pulp with water and sieved to remove protein, fat and sugar. White precipitate was separated and dried in air oven.Used to textural properties of various food products	Total sugar: 0.2% Fat: 0.03% Resistant starch: 63%

		Baby food	Moisture: 5-9% Starch : 40-55% Protein : 6-8%	Baby food made by fortifying of green banana flour with nutrient rich sources like milk, green gram and sugar. It is highly energetic and nutritious.	Energy: 184 Kcal/100g. Total carbohydrate: 40% Fat: 0.8% Vit-C: 6.6% Acidity: 0.46% Total sugar: 20.7%
		Health Drink	Moisture: 6-8% Carbohydrate : 55-65% Protein : 3-5%	Highly nutritious health drink formula has been developed by fortifying banana flour with suitable natural sources of proteins, minerals, fats and vitamins.	Energy: 257.36 Kcal/100g. Fat: 0.78% Vit-C: 9.4mg/100g Acidity: 0.31%
Popoulu (Introduction from PNG through ITC)	High yielding (25-30% higher over Nendran) Annual crop (350-360 days) Good quality mealy texture of fruits, cylindrical and bold fruits **Unripe** Moisture (%): 74.8-75 Diameter(cm): 5.5-6.2 Starch (%): 21.3-21.4 Protein (%): 0.17-0.19 Crude fat (%):0.15-0.17 TSS:3.90-3.92 Acidity (%): 0.27-0.29 Rich in Provit-A 1350ug/100g of fresh fruit as against 1200ug//100g in Nendran),	**Chips** For good quality Chips, Used both as dessert and cooking purposes .	Thickness: 1.0 – 1.5 mm Diameter :5-6 cm Crude Fat : 20-25%	Banana chips/crisps are made by deep-frying of raw banana slices in a suitable cooking medium	Energy: 434.4 Kcal/100g. Total carbohydrate: 46.7% Protein: 0.38% Acidity: 0.18% Oil content: 27.4% Acid value: 2.0mg (KOH)/g.

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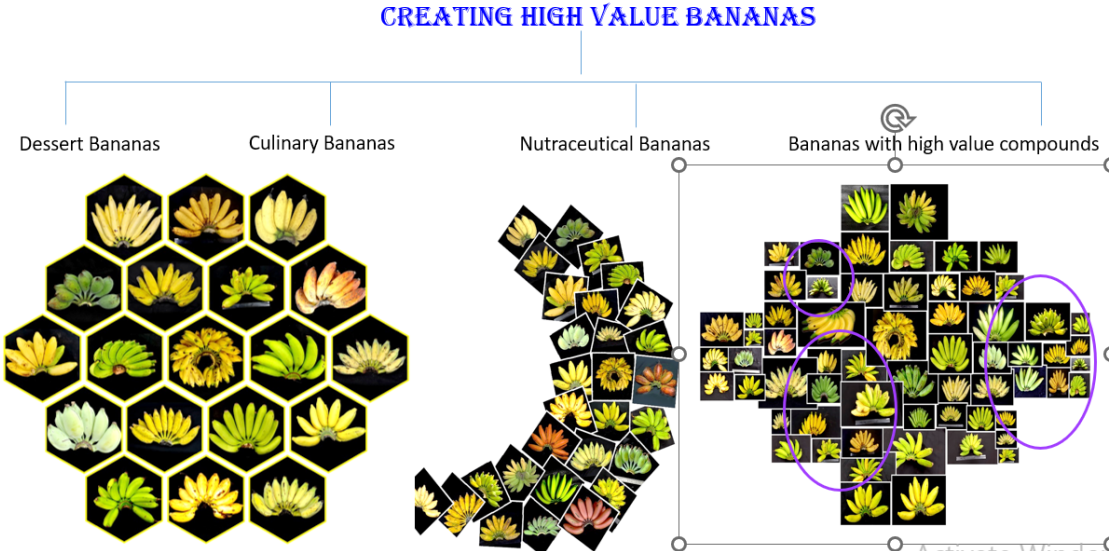
		Starch	Moisture: 4-6% Starch : 92-94% Colour : Bright white	Green banana starch can be isolated by ground banana pulp with water and sieved to remove protein, fat and sugar. White precipitate was separated and dried in air oven. Used to textural properties of various food products	Total sugar: 0.8% Fat: 0.03% Resistant starch: 63%



Prominent techology for upscaling

SCOPE 3. Low-cost tissue culture protocol- Entrepreneurship option for small and medium enterprises

At present, tissue-cultured plants are popular as they are free from diseases with higher yield potential but expensive (Rs 15-35/plant) and not affordable by small and marginal farmers. ICAR-NRCB has successfully identified low-cost alternatives such as RO water in place of double-distilled water, table sugar in place of Sucrose, and Sago/ Isabgol/ carrageenan instead of Agar, which drastically reduced the cost of growth medium by 85 to 95% with a high-cost benefit ratio of 1: 2.70. Adoption of this technology by the tissue culture companies is expected to reduce the cost of tissue culture (TC) banana production by >25%, making it accessible for small and marginal farmers. Therefore, if the rural youth are trained in the production of low-cost tissue culture protocol, it will certainly be a profitable business venture for small and marginal farmers.

SCOPE.4. '*Kelavruddhi*' - Macro-propagation for multiplication of traditional varieties- Entrepreneurship opportunity for small and marginal farmers

It is a rapid method of multiplication of true-to-type plantlets of a variety of choice, elite clonal selections and new hybrids. A good alternative in between conventional and tissue culture technology. By choosing a healthy mother plant, macro propagation can produce healthy planting material to replace the diseased plants of the same variety in a short span of time. However, the success of macro propagation depends on the method followed, the variety tried, and the choice of initiation media in case of *ex situ* multiplication.

***Kela vruddhi* - Macro-propagation technology**

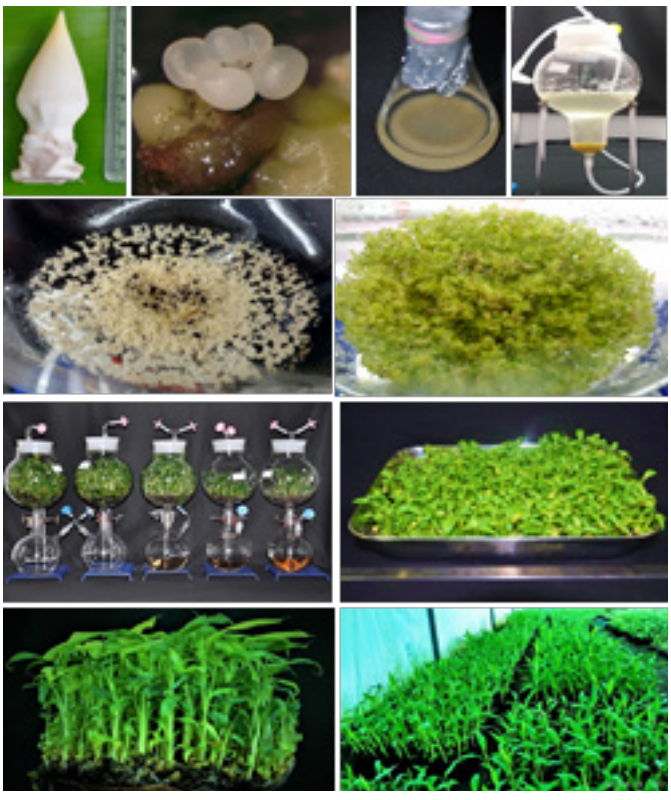
Features of the technology

Technically less demanding with the availability of mother plants, the user can kick start the production of planting materials to meet his own requirements and sell. About 40 - 45 shoots could be produced per sucker in a short time span of 3-4 months.

SCOPE. 5. Bioreactor – Scope for business opportunities for the corporate sector

Next generation plant tissue culture system using bioreactors

With the growing demand, ICAR- NRC Banana developed high throughput protocol. ECS can yield approximately 4000-4500 plants from 1 ml of cell suspension with a potential of approximately 60,000-1,00,000 plantlets per litre. ICAR-NRCB has developed protocols for production of Embryogenic Cell Suspension (ECS) in commercial cultivars (Grand Nain, Nendran and Rasthali) to cater to the need for quality planting material in a large scale with minimum cost and in a short span of time. ICAR-NRCB has designed an immersion bioreactor setup, which is capable of producing 8-fold higher ECS than the conventional method. It is also suitable to germinate the somatic embryos up to 10,000 numbers in a single vessel.



SCOPE. 6. Ornamental hybrids for flower industry – Silverline for small scale entreprises

NRCB, to develop novel ornamental hybrids with short stature, attractive bracts, and wider adaptability using *Musa laterita, M. ornata,* and *M. siamensis*. Different ornamental banana hybrids belongs to *M. rubra* × *M. acuminata* subsp. *zebrina* , *M. ornata*× *M. rubra* , *M. ornata* × *M. acuminata* subsp. *zebrina*, *M. ornata* × *M. ornata*, *M. ornata* × *M. velutina* subsp. *markkuana* were made. More than 10 potential hybrids with better vase life characteristics and plant characters were identified.

Conclusion

During the past 25 years, ICAR- NRCB has developed approximately 75 technologies to improve the production systems in bananas, in different spectrum of crop improvement, production, protection, handling, processing and value addition. The major impact of technologies on banana is an increase in national acreage by 7.5%, production by 6.8% and productivity by 17.2% in the last five years, which has taken our nation to a greater height contributing to 21% of the total banana produced with an annual business turnover of Rs.1,000,000 crores.

In spite of technological advancement and health benefits of banana, processing potential is not fully utilized by the entrepreneurs. In order to make the country as number one destination for start-ups, Government of India (GoI) has introduced a campaign called '**Standup India**' aimed at promoting entrepreneurship among women and helping start-ups with bank funding. Through the combination of farmer's cooperation, technological up-gradation, reduction in postharvest loss the establishment of processing industries, utilization of the Internet of Things (IoT) and favourable policies, the banana trade from India could make more impact and footprint in the world trade including the domestic trade across states. Ultimately, branding and boosting entrepreneurship through incubation platforms, marketing intelligence, and handholding for technological backup are pre-requisites in the coming days to sustain banana production and promote value addition.

Business opportunities for farmers and FPOs in banana production technology – Experience from "Banana Shakti – A Micro nutrient mixture"

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Nutritional deficiencies and imbalances are emerging as major threats nowadays in the Indian Banana Production System. Lack of awareness about the importance of balanced fertilization has led to the indiscriminate application of certain nutrients, which caused a deficiency of micronutrients. In addition, the non-availability of good quality organic manures is also one of the factors for poor soil health. Particularly, the micronutrients are very much neglected among the banana farming community in India, and the essentiality of micronutrients in banana production has been gaining importance in the recent past. Keeping this as a challenge, the ICAR-National Research Centre for Banana, Tiruchirappalli, under the Indian Council of Agricultural Research (ICAR), New Delhi, has focused its research programme on micronutrient requirements of banana and based on extensive survey and various research findings enunciated from different soils and locations, has formulated a micronutrient mixture, named 'Banana Shakti', in 2007. Now, this mixture has been widely accepted and gained popularity among the farmers in many banana-growing states *viz*., Tamil Nadu, Maharashtra, Karnataka, Andhra Pradesh, Kerala, Gujarat, Uttar Pradesh, and Bihar. This is the only banana micronutrient mixture suitable for foliar spray and soil application. For the past 10 years, a total of 50,000 acres of banana have been applied with Banana Shakti and an additional net profit of about Rs. 350 crores have been generated in these states. The data/ feedback collected on variety-wise yield increase in banana due to the application of Banana Shakti in these states is given the table 1.

Composition of Banana Shakti

Iron : 4.75%; Zinc: 5.25%; Boron: 2.50%; Manganese: 4.50%; Copper: 2.40%

Mode of application

If the soil p^H is more than 8.5, foliar spray of 2% Banana Shakti at 4, 5 and 6 months after planting is recommended. If the soil p^H is less than 8.5, soil application of 10g Banana Shakti per plant at 3 months after planting is recommended.

Advantages of Banana Shakti

It corrects the micronutrient deficiency and increases the availability of macro and micro nutrients to banana crop, thereby increasing productivity by 15-20%. Its application increases the TSS of fruit by 2°Brix (without Banana Shakti, TSS is 28°Brix and with Banana Shakti, TSS is 30.4°Brix) and decreases the acidity of fruit by 0.03% (without Banana Shakti, acidity is 0.23% and with Banana Shakti, acidity is 0.20%) in cv. Ney Poovan leads to improvement in taste, flavour, and aroma of fruit.

Table 1. Variety wise increase in bunch weight and profit due to spraying of 2% Banana Shakti in Banana*

Cultivar	Avg.bunch wt. without BS spray (kg)	Avg. bunch wt. with BS spray (kg)	Increase in bunch wt. (kg)	Market price of 1 kg (Rs.)	Additional profit per bunch (Rs.)	Additional profit per hectare (Rs.)
Grand Nain	30	34	4	30	120	3 lakhs
Ney Poovan	13	18	5	40	200	5 lakhs
Nendran	12	15	3	20	60	1.5 lakhs
Karpuravalli	28	32	4	20	80	1.9 lakhs
Rasthali	18	21	3	20	60	1.5 lakhs
Poovan	18	23	5	15	75	1.9 lakhs
Red Banana	15	18	3	40	120	2.7 lakhs
Monthan	15	18	3	15	45	1.1 lakhs

*Based on the feed-back collected from the banana farmers of Tamil Nadu, Kerala, Karnataka, Maharashtra

Chinnamanur, Theni District, Tamil Nadu

Chinnamanur, Theni District, Tamil Nadu

Interview with the banana farmers on benefits of Banana Shakti at Pachchur, Tiruchirappalli

Sirugambur, Tiruchirappalli District., Tamil Nadu

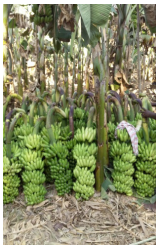
Pazhur, TiruchirappalliDistrict., Tamil Nadu

Effect of Banana Shakti on cv. Nendran at Nochchiyam, TiruchirappalliDistrict, Tamil Nadu

Effect of Banana Shakti spray on Grand Nain

Doubling the farmers' income by application of Banana Shakthi

S. No.	Farmer's Details	Yield without Banana Shakti	Yield with Banana Shakti	Photograph of field / bunch with application of BS
1.	Mr. T. Linganatham, Odhiyadikkuppam, Cuddalore district, Tamil Nadu. (Var. Ney Poovan) Mobile: 99762 32697	24 t/ha	40 t/ha	
2.	Mr.Rajagopal, Vazhichodanaipalayam, Cuddalore district, Tamil Nadu. (Var. Ney Poovan) Mobile : 63820 96929	26 t/ha	39 t/ha	
3.	Mr.Sendhil, Sathyamangalam, Erode district, Tamil Nadu (Var. Nendran) Mobile : 97503 44445	36 t/ha	54 t/ha	

4.	Mr.Vadivel Gandarvakottai, Pudukkotai district, Tamil Nadu (Var. Rasthali) Mobile: 98653 19924	31 t/ha	45 t/ha	
5.	Mr.Asokan, Anandhimedu, Lalgudi, Tiruchirapalli, Tamil Nadu. (Var. Poovan) Mobile : 80721049634	45 t/ha	62 t/ha	
6.	Mr.Selvakumar, Chinnamanur, Theni district, Tamil Nadu. (Var. Grand Naine) Mobile : 99437 25125	84 t/ha	105 t/ha	

So far, this technology has been taken by KVKs, entrepreneurs and self-help groups. ICAR-National Research Centre for Banana, Tiruchirapalli, Tamil Nadu licensed and transferred the Technology - *"A Micronutrient Mixture - Banana Shakti"* to four Stakeholders, *viz*., KVK, Namakkal, Tamil Nadu on 11 February, 2022; Tamil Nadu State Rural Livelihood Mission (TNSRLM), Kanyakumari, Tamil Nadu on 12 February, 2022, KVK, Karur, Tamil Nadu on 28 February 2022 and M/s. Ecophytocare India Pvt. Ltd, Mysuru on 11 May, 2022.

The transfer of Technology is aimed at enhancing the Banana production system in Tamil Nadu

The liquid formulation of Banana Shakti has also been developed at ICAR-NRCB and it was released by the DDG (Hort. Sci.), New Delhi, during the International Conference on Banana – (ICB-2020) – Innovations in Sustainable Production and Value Chain Management in Banana, held at Tiruchirappalli during 22-25, February, 2020.

Liquid formulation of Banana Shakti (A micronutrient mixture for banana)
Product launched by DDG (Horticulture) during ICB-2020

Composition of Banana Shakti

Iron : 4.75%; Zinc: 5.25%; Boron: 2.50%; Manganese: 4.50%; Copper: 2.40%

Mode of application

Foliar spray of 2% Banana Shakti at 4, 5 and 6 months after planting is recommended.

Advantages of Banana Shakti

It corrects the micronutrient deficiency and increases the availability of macro and micro nutrients to banana crop, thereby increases the productivity by 15-20%. Increases the TSS of fruit by 2°Brix (without Banana Shakti, TSS is 28°Brix and with Banana Shakti, TSS is 30.4°Brix) and decreases the acidity of fruit by 0.03% (without Banana Shakti, acidity is 0.23% and with Banana Shakti, acidity is 0.20%) in bananas leading to improvement in fruit taste, sweetness, flavour and aroma.

Now the ICAR-NRC for Banana, Tiruchirappalli in collaboration with the SASTRA (Deemed to be University), Thanjavur is in the process of developing Nano-Banana Shakti with financial support from the Department of Bio-technology, Ministry of Science and Technology, Government of India. With the development of this Nano-technology, an improved mode of application with increased efficacy of Banana Shakti is being expected with only half the dosage of the present powder or liquid formulation of Banana Shakti, in banana cultivation.

Licensing procedure for establishing agribusiness venture

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Agribusiness is the integration of activities involving production, post-production handling, processing, and distribution of agricultural or horticultural produce/livestock products with higher efficiency and scale of economy. Agricultural/horticultural production requires support from various industries like fertilizer & pesticide manufacturers, tractor and farm machinery manufacturers, irrigation equipment manufacturers/ suppliers, and logistics providers. Similarly, post-production activities are supported by marketing intermediaries, logistic providers, processors, packaging material industry and retail network operators. Success or viability and profitability of agribusiness depend on incremental value addition at every step of operations and distribution of cost across the products in the chain, ultimately making it affordable for the consumer and profitable for stakeholders.

Being an agrarian country, India's growth story since its civilization mainly depended on national and international agricultural trade. High-value agricultural commodities like spices, attracted the invaders to the shores of India, resulting subsequently in subjugation and foreign rule. As a result of large-scale plunder and regressive misrule by foreigners, agriculture and farmers lives were almost decimated in over a century prior to independence. After independence, agricultural trade grew exponentially first through food self-sufficiency and then through exports. Today agricultural sector is valued at US$ 370 million in India, contributing almost 20% to national GDP, which is the fifth-largest economy in the world. The recent evolution of digital technology in farming will further accelerate growth by ensuring higher crop yields and enhanced sustainability by reducing water consumption and less use of agro chemicals. The spin-off in the form of primary and secondary processing and value chain is resulting in increased employment and entrepreneurial opportunities. The changing global geo-political landscape is bringing opportunities to the doorstep of Indian farmers and traders to flourish.

Rules of the game!

However, the knowledge revolution during the 21st century, reset the rules of game in domestic and international trade. Today the quality of goods and services is paramount in trade, with well set standards and SOPs. Licensing is one of the tools used to regulate the quality by the state, which besides ensuring the confidence in products/produce of any country, also accrue revenue to the concerned government. The rainbow revolution has ushered horticulture into the forefront, due to its climate resilience, high input efficiency, lesser investment in manpower and high value of the commodity. The entrepreneurial opportunity in horticulture is enormous. The following are a glimpse of self-employment opportunities in horticulture.

Opportunities in micro food processing industries in India (Fruits & vegetables)

India is the second largest producer of fruits and vegetables in the world with a production of 311.17 million tonnes. Maharashtra, Andhra Pradesh, Uttar Pradesh, Gujarat and Karnataka are the leading producers of fruit (51%) and West Bengal, Uttar Pradesh, Bihar, Madhya Pradesh and Gujarat are the major vegetable-producing states (55%) in India.

Market: By 2023 the Indian fruit and vegetable processing industry is expected to reach a size of INR 256 Billion in terms of value @ 7.62% cumulative annual growth rate. Though currently only 2.2% of total production is processed, the level is expected to increase.

Exports: During 2018-19, India exported fruits and vegetables worth Rs. 10236.93 crores/ 1,469.33USD Millions which comprised of fruits worth Rs. 4817.35 crores/ 692.01 USD Millions and vegetables worth Rs. 5419.48 crores/ 777.25 USD Millions. Grapes, Pomegranates, Mangoes, Bananas, Oranges account for larger portion of fruits exported from the country while Onions, Mixed Vegetables, Potatoes, Tomatoes, and Green Chilly contribute largely to the vegetable export basket. The major destinations for Indian fruits and vegetables are Bangladesh, UAE,

Netherland, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar.

Supply chain of fruits and vegetables

Supply chain of perishable food products or fresh fruits and vegetables constitute the Processes from production to delivery of the agri-fresh produce (farmer to customer). The supply chain of fresh fruits and vegetables is complex compared to other supply chains due to the perishable nature of the produce, high fluctuations in demand and prices, increasing consumer concerns for safety and quality and dependence on climate conditions. The supply chain involves different people such as farmers/producers/importers, local traders/ wholesalers/commission agents, transporters, processors, retailers, exporters etc. The fruit and vegetables reach the consumer through a chain of intermediaries who carry out different functions such as transfer of ownership of commodities, mov ement, maintenance or preservation of quality and quantity, payments and delivery to consumer. All these links or intermediaries constitute the supply chain of the fruits and vegetables. Several models of investment are now coming into Supply chain management of fruits and vegetables like logistics, credit, insurance, etc. A typical postharvest supply chain starts from primary processing.

Primary processing

Pack house

The pack-house is the site or location where, postharvest treatments are applied and quality standards are monitored. Pack houses can be used by producers, importers, co-operatives or clusters, traders, exporters and processors. Pack house have certain benefits such as; increased productivity of workers, extend produce shelf life and improved produce quality. Receiving, maturity assessment, trimming, sorting and grading, sizing, delatexing / desapping, cleaning/washing, surface drying, waxing, ripening/degreening, curing, packaging, precooling, storage, treatments for disease control, quarantine treatments and labelling.

Secondary processing & tertiary processing

The secondary processing involves production of intermediary products like pulps, puree, paste, concentrate, etc. and the tertiary processing includes making use of products of secondary processing and making ready-to-drink juices, RTC & RTE foods, etc.

Setting up of either primary or secondary or tertiary processing unit requires compliance with certain regulatory requirements.

Mandatory legal compliance

- To start with have a name for your enterprise and a physical address (own or rented).
- Identify the contact person (yourself or your nominee-spouse, son, with or without partners, etc.).
- Register the firm under Shops and Establishments Act
- Register with DIC (as micro, small or medium scale industry).
- Register with Tax agencies (PAN, TAN/ GST, ST, Labour Act / ESI / EPF / Met Dept / Design & Trade Mark /
- Licenses (NOC from local administration authority – Panchayat / Muncipalty / Corporation / PCB Clearance /FSSAI

These aspects and others would be discussed in detail in the presentation.

Virus diagnostic kits for banana industries, farmers, and nurseries for ensuring the quality planting materials for enhanced production in a banana production system

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Introduction

Globally bananas and plantains are the most important fruit crops. These fruit crops serve as a staple food as well as an instant energy source for the 400 million people living in the tropical and sub-tropical regions of the world. Millions of resource-poor banana farmers across the world eke out their livelihood of millions on bananas and plantains. India is the world's largest producer of bananas, contributing 22.5 % of global banana production with 36.66 million tonnes per annum (NHB, 2021). Diseases are the major production problem in bananas, as evidenced by the fact that approximately 35-40 aerial sprays are given using air jets to control the Sigatoka leaf spot diseases in the Central and Latin American countries which are the dominant players in the export of banana. The tropical Race 4 of Fusarium wilt becoming a menace for the cultivation of export banana, Grand Nain in most of the Asian and South Asian and some African countries.

The banana bunchy top disease remains a global issue in reducing the production and posing a danger to the biosecurity of natural banana reserves. Sucker-borne diseases and pests are threatening the yield of bananas owing to their spread along with the planting material, especially the suckers. The introduction of tissue culture plants of banana in India was in the early 1990s, till that time-suckers or corms were widely used as the planting material. These corms or rhizomes or suckers normally carry all types of pathogens including nematodes, weevils, and sometimes mealybugs. In tissue culture (TC) plants, viruses can pass through as shoot tip culture is adopted for mass propagation and If TC plants are infected with viruses, that will lead to a greater loss.

In this article importance of virus detection and diagnosis of viral pathogens and diseases and the detection kits developed at our centre and how there aspects may useful for entrepreneurship have been discused in details

Viruses - A serious threat to the banana industry

Bananas are affected by four major well-characterized viruses such as Banana bunchy top virus (BBTV), Banana streak Mysore virus (BSMYV), Cucumber mosaic virus (CMV), and Banana bract mosaic virus (BBrMV) which cause severe economic losses to the banana growers across the banana-growing regions. Banana bunchy top disease (BBTD), caused by BBTV is one of the most serious globally recognized viral diseases in bananas. In India, BBTV has been believed to be introduced from Sri Lanka to Kerala and slowly spread to the entire Kerala state and then to the adjoining lower Pulney regions where the famous 'Hill Banana' (syn. 'Virupakshi', AAB, Pome) has been grown as a shade crop in coffee plantations. In the 1970's BBTV infection in Hill banana was noticed and within a decade of its introduction, this disease forced the 'Virupakshi' banana to the verge of extinction in the lower Pulney hills of Tamil Nadu. The area under this banana was dwindled to 2000 ha from 18,000 ha. An outbreak of BBTD in tissue culture (TC) plantations in Jalgaon, Maharashtra, and Kodur, Andhra Pradesh, India, in 2007–2011, caused an annual loss of production worth US$50 million (Kumar *et al*., 2015). This outbreak was suspected to be due to the use of non-indexed mother cultures for mass propagation. Though the certification of tissue culture banana was operative in India, some of the non-recognized CPUs were not adopting the system. In Kodur, Andhra Pradesh, one tissue culture banana company that imported mother cultures cv. Grande Nain from Israel, mass propagated and supplied a few million plants to the growers, but at the bunch emergence stage almost 60-90 percent of plants expressed bunchy top symptoms and ended up with 100 per cent loss. This rampant virus incidence may be one of the reasons to closing down the tissue culture company. Yield losses have been found to vary between cultivars and depending on the climatic conditions that prevail during growing seasons. BBrMD causes yield losses ranging from 30–70% in the French plantain cultivar Nendran. CMV causes mosaic or infectious chlorosis disease. An epidemic of CMV in TC plants of Grande Nain banana was

recorded in Jalgaon, Maharashtra, from 2008–to 2010, and it re-emerged in 2019-20 in Maharashtra and Madhya Pradesh causing a huge loss to the growers. BSV species are the causal agents of leaf streak disease in bananas and plantains. BSV infections cause10–90% of yield losses in various banana cultivars across the world and cv. Poovan in India (Selvarajan *et al*., 2016). These viruses are primarily transmitted through planting materials like suckers, tissue culture plants, and corms. Moreover, the planting materials which act as a reservoir for these viral pathogens also aggravate the incidence.

Need for virus diagnostics in banana

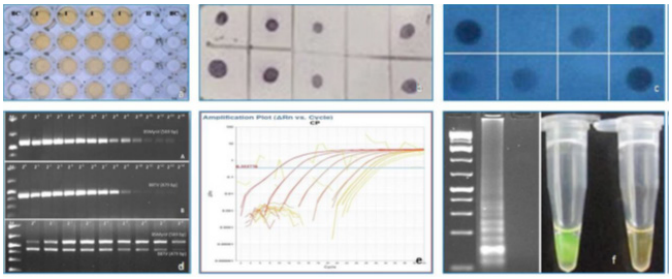
Viral pathogens cannot be eliminated through a shoot-tip culture which is a widely adopted technique by the industries for mass propagation. If the mother plants are indexed and assured to be free of viruses before micropropagation, the TC plants are undoubtedly superior to suckers. Most of the banana viruses reside in the host in latent form, i.e., without exhibiting any visual symptoms in the host for some period (sometimes for up to 2 years). Unlike other plant pathogens, there are no direct methods available to control viruses. The use of quality planting material is very important for enhanced production and productivity. The success of banana virus disease control is almost entirely dependent on the availability of accurate, sensitive, specific, low cost and simple diagnostic techniques, which enable early detection of virus infections in planting materials.

Indexing techniques for the early detection of banana viruses

Serological and molecular diagnostic techniques have been reported for the detection of plant viruses. Choosing the right method of detection is the most crucial step in indexing for plant viruses. Purification of viruses from bananas is a cumbersome process as the host has a high quantity of polyphenols, polysaccharides and secondary metabolites, which interfere in the process of purification. Moreover, viruses like BBTV occur at very low concentrations and are limited to phloem cells which is a serious barrier to viral purification. Various forms of enzyme-linked immunosorbent assay (ELISA) using recombinant antibodies raised against coat protein of BBTV, BBrMV and CMV and there are modified versions of ELISA, such as dot immune binding assay (DIBA), Tissue immunoblotting assay (TIBA), Immuno-sorbent Electron Microscopy (ISEM) have been developed and applied for detecting banana viruses in samples of field-grown and tissue culture (TC) plants. Detection of episomal Banana streak Mysore virus using polyclonal antibodies raised against recombinant viral-associated protein was developed (Selvarajan *et al*., 2016). In direct antigen-coated (DAC) -ELISA, antibodies reacted specifically to BSMYV in crude sap, up to 1: 8000 dilutions, but not with healthy leaf extracts. Lateral flow immune assay (LFIA) is used for qualitative or semi-quantitative detection and monitoring of pathogens in non-laboratory environments. They utilize specific monoclonal and polyclonal antibodies in an immunochromatographic format, incorporating antibody-bound nano-gold or latex particles.

Nucleic acid-dependent methods (targeting the genome) such as polymerase chain reaction (PCR) and reverse transcriptase (RT)-PCR have been applied for detecting banana viruses (Selvarajan *et al*., 2008; 2010; Balasubramanian and Selvarajan, 2012). Other genome targeted methods such as Immuno capture (IC) PCR (Selvarajan and Balasubramanian, 2008; Selvarajan *et al*., 2016) and IC-RT-PCR have been developed for simultaneous detection of all four banana viruses (Selvarajan and Balasubramanian, 2013). RT-PCR was more sensitive for detection of BBrMV followed by IC-RT-PCR and DIBA than DAC-ELISA. Multicomponent (all six genomic components) multiplex PCR based detection of BBTV was developed and validated (Sasireka and Selvarajan, 2014). Multiplex RT–PCR has been developed for the detection of two DNA viruses (BBTV and BSMYV) (Selvarajan *et al*., 2011) and for all the four banana viruses. This method is applied for detecting BSVs to avoid false positives arising out of eBSV sequences. A simple, rapid and solvent-free nucleic acid (NA) extraction protocol suitable for BBTV detection in PCR has been reported (Selvarajan *et al*., 2015). The extracted NA template is suitable for detecting BBTV in quantitative PCR using SYBR Green chemistry and loop-mediated isothermal amplification assay. Methods based on nucleic acid spot hybridization (NASH) using DNA probes have been applied for BBTV and BSMYV and RNA probes for BBrMV and CMV (Selvarajan *et al*., 2008; 2010). Quantitative detection of banana viruses has been reported using real-time polymerase chain reaction (PCR) assay with SYBR green and TaqManTM chemistries (Selvarajan and Winter, 2010). Among the two methods, TaqMan® probe was more sensitive than

SYBR Green chemistry which was validated using infected samples (Balasubramanian and Selvarajan, 2014). A methodology to detect all the six genomic components of BBTV in real-time PCR assay using SYBR Green chemistry has been developed.



Pictorial representation of virus indexing techniques developed at Molecular Virology Lab, ICAR-NRCB.(a) ELISA; (b) DIBA; (c) NASH; (d) Multiplex RT-PCR; (e) Quantitative PCR; (f) LAMP assay- Agarose gel electrophoresis (Left) & Visual Diagnosis (Right)

Table . List of indigenous virus detection kits / technologies developed at ICAR-NRCB

Sl.No.	Detection techniques	List of viruses
1	ELISA	BSMYV, BBrMV, CMV
2	DIBA	BSMYV, BBrMV, CMV
3	PCR, RT-PCR, IC-PCR and IC-RT-PCR	BBTV, BSMYV, BBrMV, CMV
4	NASH	BBTV, BSMYV, BBrMV, CMV
5	Multiplex-RT- PCR	BBTV, BBrMV, BSMYV, CMV
6	Quantitative PCR	BBTV, BSMYV, BBrMV, CMV
7	Loop mediated isothermal amplification	BBTV, BSMYV, BBrMV, CMV
8	Lateral flow immuno assay	BBrMV and CMV
9	Recombinase polymerase amplification	BBTV, CMV, BBrMV, BSMYV

Commercial application of Indigenous virus detection kits

This Centre has developed ready to use indigenous indirect ELISA kits for detection of banana bunchy top virus (BBTV), banana bract mosaic virus (BBrMV), banana streak Mysore virus (BSMYV) and cucumber mosaic virus (CMV) and ready to use ELISA kit for simultaneous detection of banana bract mosaic virus and cucumber mosaic virus. The coat protein genes of BBTV, CMV and BBrMV of Trichy isolate and viral associated protein of BSMYV were prokaryotically expressed and purified to immunize rabbits to produce polyclonal antiserum. This kit is highly sensitive and very specific in detection and the results are available within 6-7 hrs. The kit can test 90 samples and the reagents are stable for up to one year at 4°C. The developed ELISA and LFIA kits are rapid sensitive, specific, and cost-effective for virus detection in laboratories and could prove to be a boon to the banana industry. This kit is highly sensitive and very specific in detection. This kit contains high-quality recombinant antiserum, ELISA plate and buffers, positive and negative control, and protocol. The kit can be stored for up to one year. It can be used for indexing banana mother plants under the NCS-TCP system being operative in India. The cost of the testing is 10 times cheaper than imported kits. This kit can be made available to DBT and NABL accredited laboratories. This kit can be used to detect the viruses and is suitable for indexing mother plants used for mass propagation by tissue culture. At ICAR-NRCB, this kit is being used for routine testing and certification of mother cultures of banana plants.

Triple antibody sandwich ELISA (TAS-ELISA) kit for Detection of banana bract mosaic virus and cucumber mosaic virus

The enzyme-linked immunosorbent assay (ELISA) is a serological solid-phase method for the identification of diseases based on antibodies and colour changes in the assay. ICAR-NRCB ELISA kit is a rapid, sensitive, and economical serological assay for the detection of Banana bract mosaic virus (BBrMV) and CMV. This product is intended for the qualitative detection of the target analyte *via* a direct, triple antibody sandwich protocol. Upon successful completion of the test, samples containing the target analyte will turn yellow, due to the alkaline phosphatase enzyme label, while negatives will remain colourless. The absorbance of each well is read at 405 nm, and the absorbance values are compared with negative control to determine virus infections. The kit offers all reagents and both positive and negative control to be used

as standards in the ELISA detection kit. This TAS-ELISA CMV kit can be used not only for banana but also for any crop which is known to get infected by CMV. Ornamentals and vegetables like chillies and tomatoes are also can be tested for CMV infection

PCR based detection of BBTV, BSMYV,BBrMV, and CMV

ICAR-NRCB has developed the PCR-based technology for the detection of BBTV, BSMYV, BBrMV and CMV for indexing of banana mother plants used for micropropagation by tissue culture (TC) industries and quarantine purposes against all four viruses. In this technology total, DNA/ RNA must be extracted with special buffers from samples to be tested. The PCR has been performed with virus-specific designed primers (oligos) and the resulting products can be resolved in agarose gel electrophoresis positive samples can be identified and virus free quality banana TC plants can be ensured using this technology. Banana farmers and TC industries will be benefitted. Banana productivity can be increased by minimizing yield loss due to viruses. This technology has been commercialized to the commissioner of Horticulture, Biotechnology Centre, Government of Andhra Pradesh, Hyderabad.

Indigenous lateral flow immunoassay (LFIA) kit for onsite detection of banana bract mosaic (BBrMV) and cucumber mosaic virus (CMV)

Bananas and plantains are affected by two RNA viruses namely cucumber mosaic virus and banana bract mosaic virus. Cucumber mosaic virus (CMV) affects bananas and plantains and in addition, it also infects more than 1000 plant species including vegetables, spices, and ornamentals. BBrMV infects bananas and cardamom. For on-site field detection, dipstick kits were developed for BBrMV and CMV. It can be used by farmers or any person having no technical knowledge and the results will be ready within 5-10 minutes in the field itself. This kit is based on lateral flow immunochromatography using specific antibodies. The cost is approximately Rs 50/- per piece. The kit contains 5 or 10 immunostrips packed with desiccant sachets containing aluminium pouches, sample extraction buffer, positive control, and negative control. This LFIA showed very high sensitivity and specificity. The developed LFIA kits are rapid sensitive, specific, user's friendly, and cost-effective for virus detection in laboratories and infield and could prove to be a boon to the banana industry.

LAMP-based diagnosis of banana viruses in banana samples

This kit is the product to detect BBTV, BSMYV, BBrMV, and CMV developed by ICAR-National Research Centre for banana, Tiruchirappalli. The LAMP Kit is designed to provide a simple, one-step solution for Loop-Mediated Isothermal Amplification (LAMP) of DNA / RNA targets. LAMP is a commonly used isothermal amplification technique that provides rapid detection of a target nucleic acid using LAMP-specific primers and a strand-displacing DNA polymerase. LAMP primers were designed based on the conserved RT/RNASE H gene of ORF III. The target sequence of BBTV, BSMYV, BBrMV and CMV was amplified at a constant temperature of 65°C for 45 min. and the amplified LAMP products were visually detected in a closed tube system. This kit is supplied with the LAMP 2X Master Mix, which contains a Bst 2.0 DNA Polymerase in an optimized LAMP buffer solution. LAMP reactions were performed in a simple dry bath. A fluorescent dye/color dye is also supplied to enable real-time fluorescence measurement of LAMP. When compared with PCR, the diagnostic sensitivity and diagnostic specificity of this assay were 100%. The LAMP Kit is compatible with multiple detection methods, including turbidity detection, real-time fluorescence detection (with LAMP fluorescent dye) and end-point visualization.

This kit is cost-effective, simple, rapid, sensitive, specific, and user-friendly and can be performed consistently with minimum laboratory skills.

Impact of virus indexing in bananas in India

Virus indexing and certification: Indigenous virus diagnostics kits developed at ICAR-NRCB are used in the certification program for the supply of quality tissue culture banana plants. The virus incidence has come down drastically over the years of the implementation of certification programs for tissue culture bananas in India. Since 2003, the Molecular Virology lab, ICAR-NRCB, with an aim to manage the viral diseases of bananas in India, has been offering virus indexing services to tissue culture production units and to the farmers. The lab has also supplied a large volume of polyclonal antisera to the banana tissue culture industries, state horticultural departments, ICAR-AICRP- Fruits centres having banana germplasm and tissue culture production units (Selvarajan, 2009. Selvarajan, 2011; Selvarajan *et al*., 2011, 2014: Balasubramanian and Selvarajan, 2018). We have performed virus indexing of banana samples collected during the surveys and tested more than 1.93 lakh tissue culture samples were received from tissue culture industries under the certification program besides supplying recombinant protein-based antiserum to TCPUs and research stations working on the banana. Though the ICAR-NRCB has been accredited by DBT, Govt. of India in 2007, in the initial years of accreditation, certification and issuing of labels were not implemented by DBT and from 2013 to 2018, the certification and issuing of labels have started in India and we certified a total of 295.98 million TC plants. Timely detection and elimination of positives have helped the farmers and TCPUs incurring the loss due to viral diseases and stopped the further spread of the virus through TC plants. Indexing has been done for the 25 different banana cultivars including Grande Nain, Hill banana, Monthan, Nendran, Ney Poovan, Poovan, Robusta, Red banana, and Williams etc. Testing was also done for the banana germplasm samples received from different states for the timely elimination of infected virus plants.

Rejuvenation of GI labelled Hill banana

ICAR - NRCB has tested Hill banana (Virupakshi, Geographical Indications 0124) against the banana bunchy top virus disease for the hill banana rejuvenation programme of Govt. of Tamil Nadu and supplied virus-free hill banana to the growers and TCPUs. Now around 5 lakhs of BBTV free Virupakshi tissue culture plants have been planted at lower pulney hills. The federation received the plant genome saviour award for saving the Hill banana from the Protection of Plant Varieties & Farmers Right Authority (PPV&FRA). The banana production in India was 18.9 million tonnes in 2005 and increased to 33.73 million tonnes in 2021. This production increase is mainly attributed to the adoption of quality TC planting material supplied by TC industries.

Conclusion

Ensuring TC banana plants free of viruses is foremost quality criteria for improving the yield and decreasing the spread of viruses in banana. The kits developed at our centre are available for sale and this technology could be used to test and certify the tissue culture raised banana plants and mother plants free of four major viruses. This technology could be adopted for other crops also especially for CMV and BBrMV which are known to infect other crops also. The cost details of the technologies are available at ICAR- NRCB website and could be obtained as per the PSF rules of ICAR.

Start-up- Government initiatives and support to promote the Agripreneurship in India

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In the recent past, agriprenureship got different momentum with the word "Start-up". It is not only changing the scenario of agribusiness in India but also changing the scenario of the place where the startup grows. Anonymous (2021) reported that Start-ups have a direct impact on the cities where they make their homes. Look at how Infosys has changed Bangalore, Alibaba impacted Hangzhou, Microsoft changed Redmond and Google transformed Mountain View, California. They directly impact the growth of cities in which these start-ups grew. India has the 3rd largest startup ecosystem in the world; expected to witness the growth of consistent annual growth of 12-15%. India has about 50,000 start-ups in India in 2018; around 8,900 - 9,300 of these are technology-led start-ups 1300 new tech start-ups were born in 2019 alone implying there are 2-3 tech start-ups born every day (https://www.startupindia.gov.in).

Startup- the dimensions

According to Investopedia, "a startup is a young company that is just beginning to develop. Start-ups are usually small and initially financed and operated by a handful of founders or one individual. These companies offer a product or service that is not currently being offered elsewhere in the market, or that the founders believe is being offered in an inferior manner" (Anonymous, 2018a).

Are You a Startup – the criterias:

Age of the entity**:** The business entity may have a time period that the period of operations does not exceed 10 years from the date of incorporation

Type of entity: Private Limited/Registered Partnership Firm/ Limited Liability Partnership

Annual Turnover of the entity: Should have an annual turnover not exceeding Rs. 100 crore

Original entity: Should not form by splitting up/ reconstructing an already existing business

Innovative & Scalable: Improvement of a product, process, or service / have a scalable business model with high potential for the creation of wealth & employment

(Source: www.startupindia.gov.in)

Start-ups – 4 W's

When it was started: On 15 August 2015, Hon'ble PM announced a new vision for the Indian economy. on 16 January 2016 "Startup India" Action Plan was announced

Who started the programme: Department of Promotion of Industry & International Trade (DPIIT), Ministry of Commerce & Industry, GOI.

For What: To tap the entrepreneurial potential with a vision to convert the talent, and idea into game-changing ventures

With: The programme has been started with 19 action items under 3 key areas, they are

- Key area 1. Simplification and handholding with 6 action points
- Key area 2. Funding support and incentives with 8 action points and
- Key area 3. Industry-academia partnerships and incubation with 5 action points

DPIIT launched Startup India Online Hub in June 2017, a one-stop online platform to bring together all the Startup ecosystem players. Further, the startup Yatra was planned and executed by the GOI for creating awareness among the people. Apart from the national level partnership, the following international partnership was also planned.

- Indo-Israel Innovation Bridge
- India Singapore Entrepreneurship Bridge
- India Portugal Startup Hub (IPSH)
- India Sweden Start-ups sambandh
- Indo-Dutch #StartUpLink

Startup – Online hub

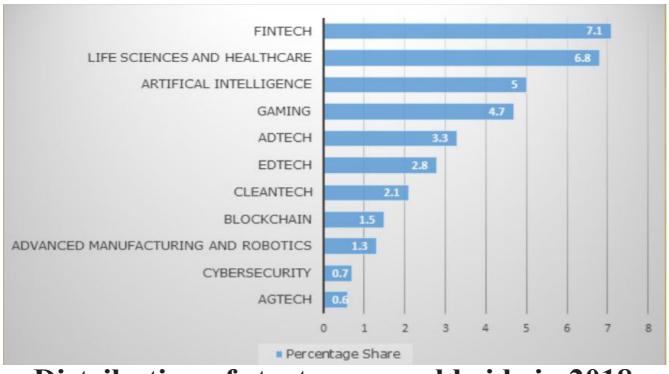
Startup-Yatra

Mode of funding for start-ups

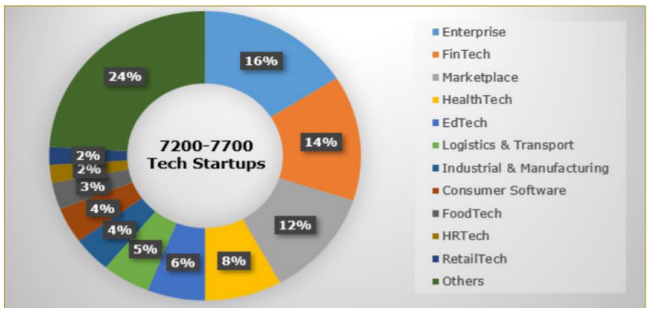
In the current scenario, there is no limitation on funding. There are many ways to generate funding for initial start-ups. They are;

- Bootstrapped
- Grants: Grand challenges, Hackathons, Ideation events, Various Government schemes
- Equity-based funding resources
- Angel Investors and VCs/PEs, corporates, Crowdfunding, and accelerators/Incubators
- Debt-based Loans from banks CGTMSE loans up to INR 1 cr without collateral

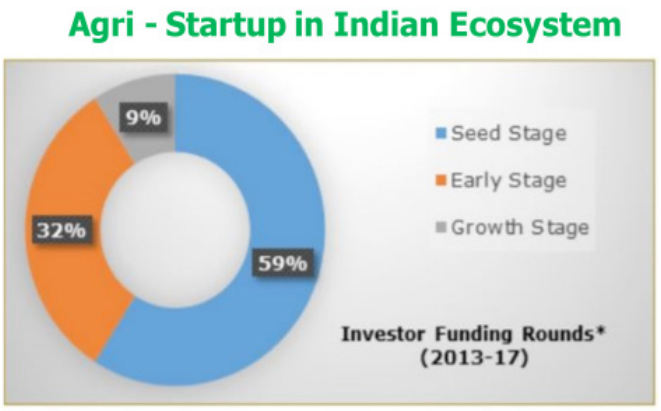
Key facts about start-ups – A critical view



Distribution of start-ups worldwide in 2018

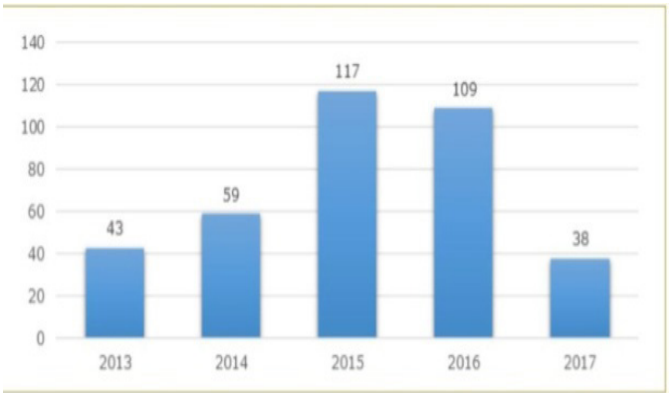


Distribution of start-ups in Indian ecosystem 2018, by Industry wise

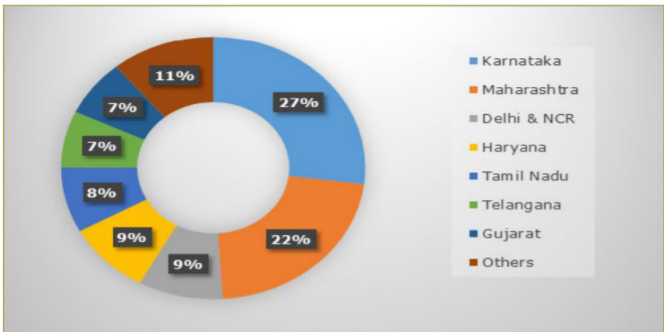


Distribution of Agritech start-ups

Key locations of start-up hubs in India



Number of Agritech start-ups (2013-17)



Key Indian states focusing on agritech start-ups

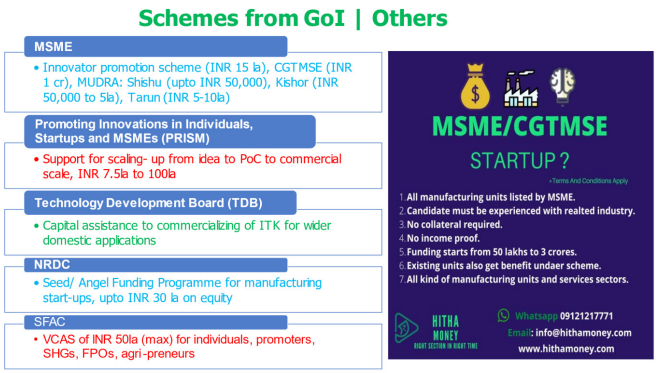
(Source: Agritech start-ups : The ray of hope in india agriculture : Discussion paper 10 : MANAGE)

Recent initiatives by GOI for promoting start-up ecosystem

Govt of India wants Micro, Small and Medium Enterprises schemes (MSME's) contribution to India's GDP to reach 50% by 2024, from the current 29%, and provide jobs to 15 crore Indians, up from 11 crores currently. This is why the Ministry of MSME's has introduced several Government schemes for start-ups , and small businesses, which aim to provide them with more resources and a platform for triggering more growth. Start-ups and MSMEs are the foundation based on which the AtmaNirbhar mission and Make In India vision will succeed – Generating more employment, increasing exports, improving the standard of living for millions of Indians, and making India strong globally. When it comes to start-ups , especially tech start-ups , India ranks among the fastest-growing ecosystems. Last year, Venture Capitalists infused a record-breaking $48 billion into Indian companies and ideas for expanding their presence. Hence, right now, India is in a unique position wherein both Govt and private investors want Indian entrepreneurs and start-ups , MSMEs to succeed and make their presence felt across the world. In this endeavour, the Govt of India and the Ministry of Micro, Small, and Medium Enterprises have launched several unique Government schemes and programs designed to empower start-ups and MSMEs in India (https://www.msmex.in).

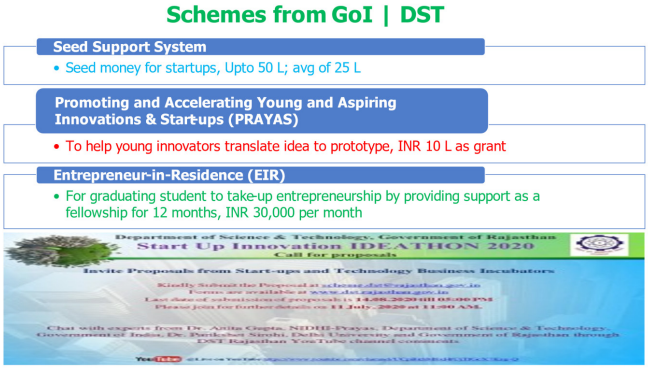
Ministry of Micro, Small and Medium Enterprises schemes for entrepreneurs in India (https://www.startupindia.gov.in).

- Prime Minister's Employment Generation Programme
- Credit Guarantee Trust Fund for Micro & Small Enterprises (CGTSME)
- Financial Support to MSMEs in ZED Certification Scheme
- ASPIRE - A Scheme for Promotion of Innovation, Rural Industries and Entrepreneurship
- Support for International Patent Protection in E&IT (SIP-EIT)
- Single Point Registration Scheme (SPRS)
- Credit Linked Capital Subsidy for Technology Upgradation (CLCSS)
- Raw Material Assistance Scheme
- Coir Udyami Yojana
- Procurement and Marketing Support Scheme (P&MS)
- Entrepreneurial and Managerial Development of SMEs through Incubators
- Credit Facilitation Through Bank



Ministry of Science and Technology (DST, DBT)

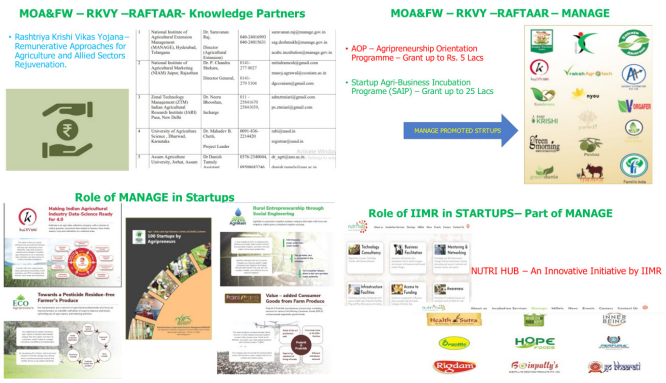
- Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM)
- Biotechnology Ignition Grant (BIG)
- Small Business Innovation Research Initiative (SBIRI)
- Biotechnology Industry Partnership Programme (BIPP)



Ministry of Food processing industries

- Creation / Expansion of Food Processing & Preservation Capacities
- Agro Processing Cluster Scheme
- PMFME - One district one product scheme

Role of MANAGE & ICAR institutes in promoting start-ups



Scope for start-ups in banana cultivation

- Export & Import data analysis informations in common platform
- GI based banana production system for the new initiative
- Input based network platform for small & marginal farmer for easy access to the inputs
- Market intelligence for banana availability for consumption and export
- 40 different types of banana-based (post-harvest) products
- Successful existing Agri Business Incubation (ABI) for upscaling
- Custom hiring center for mechanization
- Digitalized linking of banana-based FPOs for marketing and promotion

SWOT analysis of Start-ups

Strength

- In the year 2020 – 55,000 start-ups are in India and 3200 start-ups received 63 billion dollars investment. Support from Govt. polies. (Start-ups &Standup India, Skill India)

Opportunities

- 50 polices decision were taken by GOI and India is in 2nd place in World startup Industry

Weakness

- Sustaining is the major issue –In 2018 Walmart purchased Flipkart (from 2007 famous e-commerce). Further, Covid 19 makes end up for few start-ups and dominance of big business companies like Walmart purchased Myntra, Phonepe, ekart

Threats

- Big players purchasing the growing and successful small start-ups. For example, TATA digital tries to purchase 64% of BigBasket startup, TATA group invested in 24 start-ups (Ola, Paytm, Cure,fit) and Reliance industries captured 14 start-ups (Future retail)

Agripreneurial ecosystem: An overview from India and Ethiopia

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Entrepreneurial ecosystems drive local economic vibrancy and national economic growth by building fertile environments for new and growing companies to thrive. The ecosystems view acknowledges that firms do not operate in a vacuum and are in fact embedded in the broader social, cultural and institutional context that shapes their growth and contributes to their chance of success (Isenberg, 2011). The entrepreneurship ecosystem usually consists of six individual domains:

- A conducive culture,
- availability of finance,
- enabling leadership and policies,
- human capital,
- markets that are venture friendly for products, and
- various kinds of support.

There are eight pillars making up an ecosystem, and each pillar has individual components;

- Accessible market
- Human capital/Workforce
- Funding and finance
- Support system
- Regulatory framework and infrastructure
- Education and training
- Major universities as catalysts
- Cultural support

Entrepreneur's perception on the eight pillars of entrepreneurial ecosystem differs around the globe. In countries like US and North America, almost all the components are readily available for the entrepreneurial ecosystem whereas in developing parts of world like Asia, majority of the components are under constraints.

Based on prior research, 16 different growth accelerators and growth inhibitors for company growth are identified.

They are;

- Market opportunity- Customers and competitive landscape
- Top Management/Boards/Networks
- Human resources/people/organisation culture
- Funding and finance
- Strategy/Business model/pricing
- Operations Management/execution/systems
- Marketing/branding
- Sales/distribution
- R & D/ New product development/technology/patents
- Products/Services/after sales related
- Partnerships/joint ventures
- Acquisitions/mergers
- Capital market/financial reports
- Legal/lawsuits
- Gov./ regulatory/ infrastructure/ taxation
- Macro-economic /social/ political/ events and impacts
-

Growth challenges

As with growth accelerators, entrepreneurs in many parts of world, face a similar set of growth challenges.

The top 5 challenges identified were,

- Funding,
- customers,
- market,
- companies and
- products

The state of agriculture in India

About 58% of India's population depends on agriculture for subsistence (271.2 Mn estimated farmers). Farming accounted for over half of all agriculture value in FY20. With the largest livestock population, livestock was the second largest contributor to gross agriculture value added in FY20. According to Indian Brand Equity Foundation (IBEF), the gross value added (GVA) or GDP contribution by agriculture, forestry and fishing is

estimated to be $ 276.37 Bn in FY20 (PE). Growth in the GVA in agriculture and allied sectors stood at 4% in FY20.

- Total market opportunity in terms of turnover: $170Bn
- Addressable market opportunity when adjusted for net revenue to normalise across segments: $24Bn
- Overall agritech market potential: $204mn
- Current market size of agritech is ~1%

The stronger the ecosystem, the higher the chance of success for firms operating in that ecosystem.

The entrepreneurial ecosystem in India is the third largest and the fastest growing ecosystem in the world (World Economic Forum, 2014). The number of new companies incorporated under the Companies Act rose 26 per cent to over 1.55 lakh in 2020-21 as compared to the previous year.

"Sustained government efforts in this direction have resulted in increasing the number of recognised start-ups from 726 in FY 2016-17 to 65,861 in FY 2021-22 (as on 14th March 2022). "Indian start-ups have raised $42 billion in 2021, up from $11.5 billion in the previous year.

India's agritech startup ecosystem has flourished in the past couple of years and the funding for this sector has also burgeoned. As per Inc42 analysis, India is home to over 150 agritech start-ups . In 2021, agritech start-ups raised $684 Mn across 47 deals. The total funding for agritech between 2014 and 2021 has crossed the $1 Billion mark.

India's agriculture landscape over time

1. Green revolution (1967-78)
2. Rise of agritech start-ups (2010-2019)
3. India's agritech moment (2020 onwards)

Agritech in India

- In 2020, market linkage had $12 Billion market opportunity, followed by Lending/ financial segment.
- Market linkage remains an investor favourite in Agritech space overall. Market linkage start-ups have bagged $305.2 Million through funding from 2014 to H1 2020.
- Over 467 Million invested in agritech start-ups from 2014 to H1 2020. Indian Agritech funding grew By 192.5% From 2014-2019.
- Bengaluru leads Agritech funding with over $256.5 Million raised till H1 2020. Chennai and Pune are among the top three startup hubs for agritech.
- Bengaluru leads among Startup Hubs for Agritech funding. Delhi NCR and Pune followed in the agritech funding race in terms of number of funding deals during 2014 to H1 2020.
- B2B Agritech model attracts greater investor interest funding in agritech. B2B models have grown at a CAGR of 96.5% from 2015 to H12020 with a total of $229.1 Million invested.
- Agritech Start-ups in B2B2C segment grabbed the most number of funding deals between 2014 and H12020. B2B2C funding in India grew at a CAGR of 24.2% in the past five years.
- Seed Stage Start-ups growing in prominence in terms of funding deals. Seed stage funding has grown in 2020 after a lackluster 2019 for the agritech sector.
- Despite Covid-19's impact, late stage deals dominated agritech funding. Growth stage funding grew by 55.6% while late-stage deals contributed to over half of all finding in 2020 so far.

Key Sub sectors within Agritech in India

- Market Linkage
- Precision agriculture & Automation
- Farm inputs
- Farming as a service
- Financing

Organizations/Agencies

NABARD is mandated to promote agriculture and rural development through financial and non-financial intervention for fostering rural prosperity. Apart from credit and promotional activities, an alternative method has been evolved to meet the objective through the investment in Alternative Investment Funds (AIF), which facilitates contributing to the capital of the enterprises working for the benefit of agriculture and rural development. The capitalisation through AIF is expected to benefit the enterprises for development of new innovative products, develop linkages between the market and producers and help increase the net income of rural people.

New Generation Innovation and Entrepreneurship Development Centre (NewGen

IEDC) is a programme launched by National Science and Technology Entrepreneurship Development Board (NSTEDB), Department of Science & Technology (DST), Government of India. NewGen IEDC will aim to inculcate the spirit of innovation and entrepreneurship amongst the young S&T students, encourage and support start-up creation through guidance, mentorship and support. This startup scheme provides a limited, one-time, non-recurring financial assistance, up to a maximum of INR 25 Lakh.

Aspire envisions setting up a network of technology centers, incubation centers and also to promote start-ups for innovation and entrepreneurship in rural and agriculture-based industry.

One-time grant of 100% of cost of Plant & Machinery other than the land and infrastructure or an amount up to Rs.100 lakhs whichever is less to be provided ***a-IDEA*** - It is a food & agribusiness accelerator organised by NAARM, a-IDEA and IIM-A, CIIE in partnership with Caspian Impact Investment and supported by DST. The program focuses on catalysing scale-up stage Food & Agribusiness start-ups through rigorous mentoring, industry networking and Investor pitching

Beneficial government policies for budding entrepreneurs

- Atal Incubation Centre (AIC)
- MSME Business Loans in 59 Minutes
- National Small Industries Corporation Subsidy
- MSME Market Development Program
- MUDRA Loans
- Swarojgar Credit Card
- Coir Udyami Yojana
- Refinancing by NABARD
- The Women Entrepreneurship Platform
- Stree Shakti Package
- Venture Capital Scheme
- End to End Energy Efficiency Scheme
- Credit Link Capital Subsidy Scheme
- Standup India

What's driving agritech growth in India?

- Need For Climate Resilience Tech
- Ease In Access To Farmer Inputs
- Post-Harvest Losses And Supply Chain Inefficiency
- Increased Internet Penetration In Rural Area

Issues & Challenges in Indian Agritech Market

- Rigid Traditional Agri Models
- Lack Of Commercial Guidance
- Lack of Subject Matter Experts
- Climate Change

Ethiopian scenario

Ethiopia, Africa's second most populated country, is forecasted to be the fastest growing economy in Sub-Saharan Africa. With a population of over 112 million people, Ethiopia has a huge untapped potential market for entrepreneurs to satisfy. Agriculture accounts for 32.8% of the GDP, 85% of the country's workforce, and 90% of export revenue.

In 2020, Ethiopia's Startup Act was published and includes establishing a National Startup Council that will be chaired by the Minister of Innovation and Technology, tasked with overlooking and supporting the country's startup ecosystem.

Two specific opportunities identified for Ethiopia to succeed on this pathway (Unleashing value from agriculture) are building a Digital Agriculture platform; an integrated system that offers new insights that enhance the ability to make decisions and subsequently implement them, and supporting and incentivizing Ag-tech entrepreneurship as these will ensure innovations, jobs, export in agriculture and related sectors, and inclusivity within the thriving Ag-tech entrepreneurship sector in Ethiopia. In Ethiopia, entrepreneurs have few options to get their start-ups funded. Specialized investors are rare, and banks are not geared towards the needs of start-ups. There is a limited investment to capitalize on potential projects. The share of manufacturing is still less than 6%, much lower than the African and low-income countries' average (16%).

Where Ethiopia can succeed: Opportunities

The following is an extract in regard to the Agricultural sector:

1. Enhance productivity of small-holder farmers and pastoralists through provision of modern inputs and services
2. Develop a legal framework that will allow farmers to lease land use rights and become shareholders in large commercial farms
3. Modernize livestock production through improving veterinary infrastructure, research and innovation, and establishing linkages with other industries

4. Establish effective linkage between agriculture producers and commodity markets as well as the commercial value chain
5. Encourage private sector investment in agricultural R&D and exploring PPPs to expand medium and large-scale irrigation infrastructure
6. Develop a legal framework for agriculture-specific financial services such as micro lending, crop insurance, and forward contracts.

Challenges in the Ethiopian entrepreneurial ecosystem

- High demand for foreign currency by the Government of Ethiopia's infrastructure projects is creating foreign exchange shortages. Businesses can expect delays of weeks or months to exchange currency because they must apply and be approved by the government
- Accelerators and incubators have most of their operations in Addis Ababa, so innovative businesses outside of Addis Ababa do not get as much support as their city counterparts
- Lack of access to finance is a major constraint for local businesses, especially for SGBs
- While the number of mobile subscribers and internet users has been increasing, only half of the population are mobile subscribers and less than 15 percent of the population have access to Internet, according to the CIA World Factbook.
- There is a lack of clear information on how foreign investors can invest in local businesses.
- Many organizations working to promote entrepreneurship in Ethiopia are duplicating efforts, creating inefficiencies in the entrepreneurship support system.
- Entrepreneurship education and entrepreneurial activities are in their infancy at Ethiopian universities. The courses are more theoretical than practical and do not build entrepreneurs' abilities to innovate.

Key organizations in Ethiopia

The journey to mapping Ethiopia's entrepreneurial ecosystem started in February 2017, with support from the Department for International Development (DFID), at an Aspen Network of Development Entrepreneurs (ANDE) event that brought together a select group of investors, capacity development providers, and funders who support small and growing businesses (SGBs) in Ethiopia

- Addis Ababa Angels – Addis Ababa Angels Network is a group of individual investors who have come together to draw on their experiences and consolidate their financial resources to back early-stage technology and tech-enabled innovative businesses.
- Renew LLC: Based in Addis Ababa, Renew is an impact investment firm that manages and serves the Impact Angel Network, a global network of investors that seeks to realize both social impact and financial returns on their investments in small and medium enterprises (SMEs) in Africa.
- Addis Ababa University: Addis Ababa University is the country's top University, considered by relevant experts to be among the top 1,000 in the world. The university offers entrepreneurship courses in economics and engineering, and boasts a Technology Business Incubation Center for faculty and students.
- Ministry of Science and Higher Education – The Ministry of Science and Higher Education is responsible to lead the development of science, higher education as well as technical and vocational education and training (TVET) in Ethiopia.
- Ministry of Innovation and Technology – The innovation and technology ministry is one of the organizations pushing for innovation in Ethiopia.

Opportunities in the Ethiopian entrepreneurial ecosystem

- Ethiopia is the second most populous country in Africa and has one of the fastest-growing economies in the world, which, with the right kind of policies and ways to ensure that growth is not just concentrated at the top, could result in an expanding middle class with more purchasing power.
- A relatively young population is an advantage that is yet to be fully utilized. Entrepreneurship programs could focus more on developing the entrepreneurship abilities of young people.
- Equity funds and venture capitalists are showing interest in the country. Many Ethiopians in the diaspora are also investing in the country.
- The Sustainable Development Agenda, adopted by the Ethiopian government, is a good road map for the government to work on various initiatives in the entrepreneurship

sector, which would then lead to a conducive entrepreneurial environment.

- The Government of Ethiopia is committed to promoting entrepreneurship – a case in point is the roll-out of the 10 Billion Birr revolving fund that is administered by Commercial Bank of Ethiopia (CBE).
- The Government of Ethiopia is spearheading access to finance through lease financing.
- The government is also promoting entrepreneurial culture by introducing entrepreneurship courses in TVET institutions.

Recommendations

- Investment Requirements: The government should consider relaxing some foreign investment requirements. For example, reducing the cap on foreign investment, or creating space to negotiate sensible, mutually beneficial investment policies could encourage foreign investment in the country.
- Credit Guarantee: More affordable capital should be made available to entrepreneurs by developing a national credit guarantee specifically for entrepreneurs.
- Entrepreneurship Curriculum: There should be an entrepreneurship curriculum that is entrenched in the education system, ideally starting from elementary education.
- Market Gaps: The Government of Ethiopia could setup an independent entrepreneurship development agency or institution to address market gaps.
- Practical Training: Educational institutions should also shift from purely theoretical training to practical entrepreneurship training that promotes a culture of entrepreneurship.

Post-harvest management of banana fruit and leaf production – Scope for business venture and ABI for agri-preneurship

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Bananas and plantains form the staple food for millions of people across globe, providing a balanced diet than any other fruit or vegetable. It is endowed with a rich source of carbohydrate, vitamins and minerals and potassium. Being fat free, it has a calorific value of 90 kcal per 100 g fruit. The dessert bananas are generally eaten as fresh fruit, while plantains or cooking bananas are boiled, steamed, fried or roasted. Banana plants are considered as the symbol of 'prosperity and fertility'. It has greater socio-economic value and multifaceted uses, hence referred as '*Kalpatharu'* (Plant of Virtues). India is the largest producer of banana in the world, producing 32 million tons from an area of 9.00 lakh hectares with a productivity of 36 MT/ha. India exported 2.0 lakh MT valued at Rs. 1000 crores. Adoption of recent varieties/technologies in production, post-harvest management, and processing has significantly contributed for increasing production and productivity of banana with improved quality. Of late, banana is emerging as an industry and has greater contribution to the economy through livelihood and nutritional security.

Post harvest management

The post-harvest life of fruit starts from the time it is cut from the mother plant. Being a climacteric fruit, banana is highly perishable and has got a short shelf-life after harvest. The post-harvest losses are high (to the tune of 25%) due to faulty handling adopted by farmers, traders and retailers. In terms of value, it is more than Rs. 2,500 crores annually.

The post-harvest losses are estimated to be highest at retailer's level (10-15%). The loss at farmers' level is due to mishandling during harvest and loading which is estimated to be about 8-9%. Besides these losses, there is an invisible loss due to the physiological loss in weight (PLW) during ripening phase. In order to reduce the post-harvest losses and to enhance the shelf life, it is essential to adopt scientific technologies of post-harvest handling of fruits.

Maturity and harvesting

The quality of bananas is influenced by many factors. The stage of maturity is of prime importance which depends on whether the fruit is meant for long distance transport or local consumption. Bananas to be marketed locally can be harvested at a higher maturity stage than those to be transported for long distance markets. Generally, fully mature bunches (90-95%) are harvested for domestic market, while for regional markets, the fruits have to be harvested at 80-85% maturity. For long distance transportation and export, the harvesting has to be done at 70-75% or 75-80% maturity, where the fruits have well defined angles.

Maturity indices

Several parameters have been suggested for determining the maturity of banana fruits based on their external appearance and chemical constituents at the time of harvest. These indices also differ considerably among different varieties and even strains of fruits. Some of the indices used in different parts of the world are as follows:

1. **Age after shoot/ flower emergence**: It takes 90 to 140 days depending on variety and prevailing climatic conditions.
2. **Angularity of the fingers**: The disappearance of the angularity (prominent edge) of the fruits attaining the maturity is the criteria for most of the varieties in banana.
3. **Diameter and Length of fingers (Caliper grade)**: Both the parameters increase towards the maturity of the fruits. Finger with minimum of 14 cm length and 2.7 cm diameter is suitable for export.
4. **Heat Units**: It is measured in degree days. The fruits attaining maturity upon accumulation of about 1200 to 1500 degree days, depends on cultivar and climatic conditions.

Harvesting and field handling

Banana bunches are harvested with a curved knife leaving about 6-9 inches of stalk attached to the bunch which serves as a handle for carrying. Improved handling methods have greatly reduced bunch injuries. In some cases, the harvested bunches

are carefully placed on 10-12 cm thick bed of banana leaves on ground or a thick foam bed to allow the latex to flow from the cut ends. After latex flow ceased, the bunches are carried to the packing shed in baskets lined with foam, if it is nearby, whereas for the long-distance market, *de-handing* is done in the field itself and packed in plastic crates by covering the hands with foam sheet and taken to pack house.

De-handing and pre-storage treatments

De-handing is cutting off the hands from peduncle of the bunch. In order to avoid crown rot and finger drop, it is essential to cut the hands along with a portion of peduncle. Care should be taken not to inflict any injury on the fruits. Usually, sickle is used for de-handing purpose. However, recently 'Banana - comb/hand cutter' developed by ICAR-CIPHET, Ludhiana (Punjab) is being used. The hands may further be trimmed into required number of fingers based on the size and shape of the packaging cartons. The cut hands or fingers are to be placed on the banana leaves or foam / rexin sheets on tables or ground in such a way that the tips of the fingers and cut end portion of the hand rest directly on the floor or table. The latex from the cut end should not stain the fruits. The de-latexing can be done by allowing the latex to ooze out or it can be floated in a tank containing detergent or sodium hypo chlorite solution where the latex gets washed out. In India, for domestic market, de-handing is not commonly practiced. But, for export trade, de-handing is essential by which defective, damaged and underdeveloped hands are culled out. Selected hands are then washed in tanks containing 10 ppm chlorine and systemic fungicide solution for at least 5 minutes as a prophylactic measure against crown rot and anthracnose diseases during transport and storage. The hands are dried using the blast of air from pedestal fans or blowers. Care should be taken not to leave any droplets of water on the surface or in between fruits.

Packaging

First, the hands are graded based on size and quality and then packed in layers in special ventilated cartons with plastic polyurethane foam (PUF) padding to minimize bruising. In Indian banana marketing system, the concept of packaging is yet to be practically adopted. A major quantum of bananas is traded either naked or just wrapped with banana leaves. No systematic grading and packaging is followed while it plays a very important role in marketing of the produce and appropriate packaging can lead to high price realization. In some cases, for domestic market, hands are packed in plastic crates while for distance/export market, it is done in 5-ply corrugated fibre board (CFB) boxes by placing two sachet of ethylene scrubber and partially vacuuming.

Pre-cooling and storage

Rapid cooling after harvest is generally referred as pre-cooling and particularly benefits rapidly respiring fruits like mango, banana, etc. Pre-cooling is essential as refrigerated ships, land vehicles and containers are not designed to handle the full load of field heat but are designed to merely maintain pre-cooled produce at the selected carriage temperature. Out of various methods of pre-cooling, forced air cooling is widely practiced in banana. Banana after packaging in carton should be pre-cooled in pre-cooling chambers till the core temperature of banana attained the storage temperature (13-14°C). Care should be taken to ensure that pre-cooling should be done gradually for a period of 4-6 hours to avoid internal damage of the tissue. Pre-cooling or storage below 13°C predisposes the banana fruit to chilling injury. Generally, pre-cooling is not adopted for banana.

Storage life of banana can be extended by packaging in sealed polyethylene bags with ethylene absorbent and placing at 13-14°C with 85% relative humidity. Harvesting of bunches at 75 – 80% maturity, storage at low temperature, modified atmosphere storage, packaging in film bags of 400 gauge thickness to create modified atmosphere, pre-treatments with fungicides and chemicals and coating the skin with waxes are some of the methods highly useful in extending the storage life of bananas up to 2 – 3 months.

Ripening

Fruit ripening is a natural process. However, intentional exposure is primarily used to ripen harvested fruits. When the un-ripened fruit reaches physiological maturity in the plant, it starts ripening. Ethylene is considered as safe fruit ripening hormone, which is present in the physiologically matured, un-ripened fruit ranging from 0.1 to 1.0 ppm. Since ethylene produced naturally within fruit is not sufficient to ripen quickly and uniformly, exogenous application of additional ethylene @ 100-150 ppm for 18 to 48 hrs is recommended to merely accelerate the normal ripening process. There is no health risk associated with fruits ripened with ethylene, because it is a natural gaseous hormone, which triggers

only the fruit ripening process and escapes into the atmosphere without leaving any harmful residue in the fruit tissues. Hence use of ethylene gas to promote ripening of fruits and vegetables is sanctioned under FDA Regulation 120.1016. However, use of ethrel/ ethephon in the form of dip or spray is banned for ripening of fruits as per FSSAI Act.

Flow chart for improved post harvest handling

Select uniform bunches having 75-80% maturity and carefully harvest them

↓

De-hand the fruits without inflicting damage

↓

De-flower and give a clean cut to the crown

↓

Wash hands in a tank of clean water to remove latex and dirt from the surface

↓

Wash in another tank having permitted fungicide

↓

Air-dry the surface moisture.

↓

Pack in corrugated fibre board (CFB) boxes lined with polyethylene film

↓

Pre-cool the fruits in boxes using forced air coolers to 13-14°C temperature

↓

Transport through air or sea port in a refrigerated container

↓

Store it in a cold store at air port or sea port, if there is a delay in air lifting or shipping

↓

Load into temperature controlled reefer container maintained at 13-14°C temperature

↓

Unload at the destination port into refrigerated transport vehicles

↓

Store in cold store till further retailing based on market demand

↓

Take out from cold store and allow sweating

↓

Ripe using ethylene gas @ 100-150 ppm for 18-24 hours

↓

Take out from the chamber once color breaks

↓

Send it r retail marketing

Banana - Leaf industry

It is a customary practice in South India to serve food in banana leaf. Banana leaves are predominantly used by Hindus and Buddhists as a decorative element for auspicious functions, marriages and ceremonies in India and Southeast Asian countries. The Indians also believe that banana leaf gives special taste to the food served on it. Banana leaf production has gained business status in Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. The annual turnover of the leaf industry is estimated to be around Rs. 130 million, approximately equivalent to the one-seventh annual turnover of banana industry. Currently the annual turnover is estimated as Rs. 250 million. Use of banana leaves as biodegradable dining plates has both cultural and ecological significance. Banana leaf industry has become a source of livelihood for several marginal and small farming communities. Banana leaf production / harvesting has become commercial venture for most of the banana growers due to its continuous demand for leaves throughout the year and providing year-round sustained source of income for farming families and ability to balance the price-fluctuation faced by the farmers in fruit industry to a greater extent and its applicability to adopt to various production systems. There are no commercial varieties / cultivars available exclusively for leaf production. Commercial varieties / cultivars such as Poovan, Karpuravalli, Sakkai, Naadu / Elavazhai, Monthan, etc. are exploited for leaf purpose in addition to dual utilities as dessert and culinary. In recent times, banana leaves are exported in bulk and the demand is on rise. Hence, there is a need to evolve cultivars specific for leaf industry in near future to meet the growing demand in the domestic as well as international markets and to develop techniques to preserve the green leaves and drying techniques as well. Farmers can earn net income of Rs. 1.00 to 1.25 lakh per acre by selling leaves.

Agri-business incubation centre (ABI)

Agri-Business Incubation (ABI) Centre, hosted at ICAR-National Research Centre for Banana, Tiruchirappalli was sanctioned in the year 2019 and funded by "National Agriculture Innovation Fund" - Component II. The main objective of ABI is to encourage, nurture and support technocrats, scientists and innovative agribusiness ideas into sound, commercial and sustainable ventures.

ABI envisages facilitating incubation of new entrepreneurs and initiatives for new technologies by providing need based technical, physical, business and networking support, facilities and services to assess and validate their venture before successful establishment of enterprises.

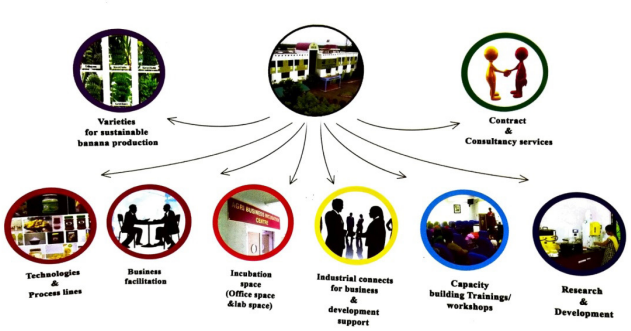
Mission

ICAR-NRCB - ABI acts as a hub for knowledge sharing and creation of entrepreneurs. ABI provides customized services, consultancy, technological guidance for innovative products and formulations from banana.

Objectives

- To organize awareness programmes to stake-holders.
- To develop, produce and promote viable technologies through skill development and commercialization.
- To promote innovation, entrepreneurship and business creation in Horticulture and allied sectors.
- To provide access to knowledge and networking support services in innovation and entrepreneurship development.
- To impart training and capacity building to prospective entrepreneurs in business promotion.
- To provide incubation facilities and technical assistance to the entrepreneurs for agri-business development.
- To scale up the technologies in collaboration with stakeholders.
- To facilitate evolution of Start-Up ecosystem by value added services.

What we offer



How to Register?

Entrepreneurs can enroll as member by paying prescribed minimal registration fee (?), security deposits and signing MoU. ICAR - NRCB is providing incubation facilities to the entrepreneurs / start-ups for a period of minimum of three months to maximum of one-year depending upon the space availability and number of incubatees after completion of transfer of technology / training.

Both banana and plantain provide food, nutrition and social security to millions of people across the globe. Profitable banana farming can be done by adopting high yielding varieties coupled with modern and hi-tech production and post-harvest technologies. Post harvest losses can be minimized by adopting improved post-harvest handling practices in integrated pack house, processing and value addition; thereby the fresh banana and processed products can be stored for long time without deterioration in quality. Export of fresh bananas and by diversification into product development will create additional rural employment, revenue generation and also improve the nutritional and livelihood security of banana producers and consumers. In addition, Agri-Business Incubation (ABI) Centre will function as a platform for converting smart ideas into smart start-ups and developing successful entrepreneurs.

Covering the bunches with
de-handing of the bunches non-woven poly
propylene cover

Washing in fungicidal solution

Trimming of hands

Drying the surface moisture
Packing in CFB box

Ripe banana in sales board

Sea protocol for export of banana

Innovative start-up opportunities in banana based processed products

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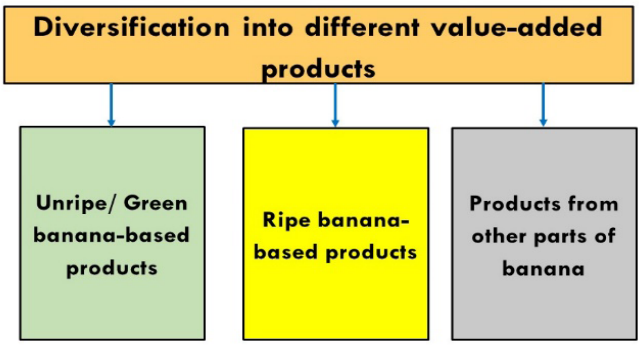


Green banana based products

Minimally processed banana slices

With the emergence of quick service restaurants (QSR), convenient foods are catching up. Similarly, the banana slices, with its loads of nutrients, plays a major role in the diet of Indian population. Minimal processing of Monthan slices pre-treated chemicals like potassium meta bisulphite (KMS, 0.5%) and citric acid (0.5%) enhanced the shelf life up to 10 days when

Low- fat banana chips

Surface treatment of unripe banana slices (Nendran/ Popoulu) with hydrocolloids can render less oil absorption during deep fat frying and reduce oil percentage by 25%. HDPE pack with nitrogen flush can maintain the chips' nutritive and sensory attribute up to 30 days.

Green banana flour

Utilization of green banana and plantain for its flour is of interest as a possible resource to make healthy functional products with its higher resistant starch and low glycemic index. By simple dehydration of raw banana slices in hot air oven and grinding it can yield green banana flour with high resistant starch content for its functional properties, green banana flour could be considered as an ideal supplement in the products such as pasta, bread, spaghetti, cookies, noodles and baby foods. Dessert banana flour could be used in variety of industrial applications with its lower thermal characteristics and thus requires lesser cooking time than the other flour.

Raw banana pickle

Pickling of steamed raw banana dices with suitable spices, can give it a shelf life of about 6 months. Addition of vinegar and vegetable oil can improve its sensory acceptability.

Banana starch

The large quantity of green cull bananas has the potential of being used to improve banana economics and eliminate the large environmental problem. Raw banana is a potential resource for industrial processing and starch production. Banana starch with very low GI can be stored in HDPE packs up to 6 months.

Nutraceutical and functional health mixes

The potential of exploiting green banana flour for weaning food has tremendous potential. A combination of malted maize and soybean, roasted groundnut and cooking banana can be recommendable weaning food for infants aged between 6 months and 2 years. Other products like health mix drink and soup mix paves way to market shelves for its health benefits.

Bakery products and extruded products

Green Banana flour with high starch content (available and resistant) can be blended with other cereal flours and can be used as a potential ingredient for bakery products containing slowly digestible carbohydrates. Supplementation of banana flour to wheat flour aided in increasing resistant starch and phenolic content of wheat breads. It is a preferable replacement of all-purpose flour (up to 40%) in preparation of bread, cookies, biscuits and cold extruded products (pasta and noodles).

Ripe banana based products

Dehydrated ripe banana

Dehydrated ripe banana popularly known as 'Banana Fig' is high in demand in the market. Varieties with high TSS (23 °Brix) (Udhayam and Karpuravalli) are suitable for making banana figs. The economic viability of the end product, quality and certification is essential for successful venture in export market.

Basil seed suspended banana RTS

Enzymatic hydrolysis can yield clarified banana juice. Commercially banana ready to serve (RTS) juice with basil seed suspension is least available. The TSS, acidity, optical density and shelf life of banana RTS beverage increases with increase in sugar levels. The complication in suspending basil seeds is that, due to density differences with beverage, it is common tendency for seeds to either settle at the bottom or to float at the top. With the use of suitable stabilizing agents, basil seed can be uniformly distributed. With proper pasteurization and packaging condition the products can be stored up to 1month.

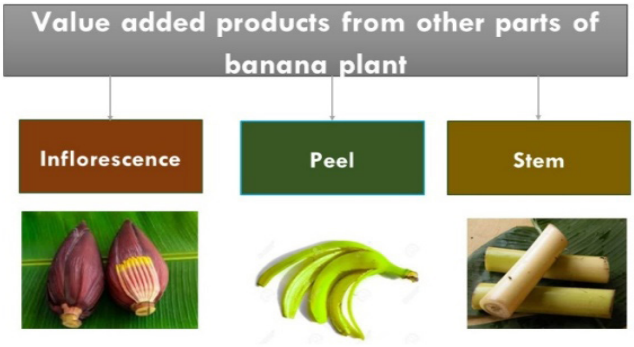
Ripe banana powder

The natural matrices of ripe banana powder contain a high amount of carbohydrates and bioactive compounds with potential pre-biotic beneficial effects on human health and can be used as functional ingredient in food preparation. With conventional driers, ripe banana pulp takes long time to dry, due to their dense physical structure and high sugar content. The technology developed by ICAR- NRCB, makes the banana pulp more porous, which will facilitate quicker drying.

Wine and vinegar

Aerobic fermentation of clarified banana juice with *Saccharomyces cerevisiae* can yield banana wine with high phenol content. Further, anaerobic fermentation of banana wine with *Acetobacter aceti* can produce banana vinegar. With the increase in global demand for fruit vinegar, banana vinegar has good market potential.

Utilization of other parts of banana



Low sodium banana stem and inflorescence pickle

The banana male bud and central core stem are least utilized after harvestof the bunche. It can be converted into a high value-added product by making flower (thokku) and stem pickles. The process of flower pickle involves removal of pistil, blanching, grinding and addition of spices and oil. The steps of preparing central core stem pickle comprises extraction of stem from pseudostem, slicing and cutting into small pieces, removal of fibre, blanching, and addition of spices.

Products from banana peel

Pickling technique had also been adopted for processing banana peel for its edible usage. Explorations revealed that, there is a set of antioxidant activity in banana peel. Preparation of banana powder and incorporating them in different bakery and extruded products have provided promising output.

Banana central core stem candy

Pre-treatment in sugar solution of sliced tender central core stem and further drying can produce sweet banana stem candy with a shelf life of 30 days in HDPE packs.

Low-calorie banana stem RTS beverage

In indigenous system of medicine, pseudostem juice is a well-known remedy for urinary disorders, stomach troubles like diarrhoea, dysentery and flatulence. It can be prepared by grinding sliced central stem and filtering it with muslin cloth. Sucralose recorded low starch hydrolysis when compared with other treatments. Juices prepared with the composition of Sucralose is therefore could be an alternative for people with special caloric requirements and it is suggested for diabetic patients. Addition of ginger extract can improve its acceptability. It can be stored safely up to 3 months without any spoilage. Cookies from the central stem powder could add dietary fibre content in the biscuits and cookies.

Banana fibre: Potential by-product to double the farmer's income and entrepreneurship opportunities

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In comparison to the synthetic fibres the natural fibres are with added advantages for their stiffness, readily availability, low cost, and with renewable properties. India is the top most banana producer, grown in an area of about 8.3 lakh ha, every year at least half the areas under banana are getting replanted. It is therefore, potentially, one billion pseudostem are available for the extraction. With the extractable pseudostem fibre yield of 400 kg fibres per hectare, 16 crores kg worth 3000 crores of fibre could be extracted which is otherwise dumped as a waste in India after harvesting the bunches. Therefore, banana biomass can be used as resources for natural fibre apart from its nutritive value. Currently less than 2% of these wastes production is used for human consumption and for production of fibre, the remaining are incinerated and wasted. The usage of banana fibre for textile purposes predates written history. The evidence of this can be found in epics like Ramayana where Sita and Rama wore "Naravastra" clothes made from banana fibres. Apart from India, past history and references reveal that the banana fibre cloth was earlier made around 13th century in Japan. Japanese currency, the Yen, is made out of banana fibre.

Extraction methods for banana fibre

Banana fibre can be extracted by different methods viz. chemical, mechanical and biological by which heavily coated, non-cellulosic gummy material from the cellulosic part of plant fibres get removed and render them clean and spinnable. Manual extraction needs loads of time and waste of human resource. Mechanical extraction uses Raspador machine, which is eco-friendly way to get fibre of both good quality and quantity.

Banana pseudostem

Sheaths from pseudostem

Raspador machine for fibre extraction

Shade drying of extracted fibre

Collected scuture waste

Central core stem

Application of banana fibres

There exists a great scope for effectively utilizing the pseudostem waste for the preparation of whole range of products like marine cordages, high quality paper card boards, tea bags, string thread, high quality fabric material and paper of currency notes. Banana fibre being easily biodegradable, due to increasing environmental consciousness, it can be used in number of ways. Pseudostem sheath can be used for making plates, disposable cups, baskets etc.

Textiles and handicrafts

Relatively higher tensile strength and stiffness of banana fibre make it promising fibre material. Longer fibres of banana results in more yarns production. Moreover, the higher yarn strength of banana fibre facilitate for blending with other natural or synthetic fibres for production of blended fabric and textiles. Most of the fibres from banana are used for handicraft products, textiles. Banana fibres can be blended with jute and cotton to make banana blended fabrics. Banana-fibre yarns make the cloth brighter, impart better dyeing properties and can also be bleached, for good commercialization a steady bulk supply is necessary.

Reinforced composites

Natural cellulose-based fibres originated from bio resources had enough potential and it is in need of new composite formulation in order to enhance their mechanical properties. Banana fibres possess good specific strength properties comparable to those of conventional materials like glass fibres. It shows good specific strength, high toughness, good thermal insulation, less abrasion, minimal dermal and respiratory irritation, biodegradability and naturally abundant and it holds several disadvantages like high moisture uptake, low thermal stability and low bonding with polymers.

Cellulose and personal hygienic products

Cellulose fibres were applied in the field of textile industry, as a adsorbent, chemical filters, as reinforcement biocomposites which showing similar objective of engineered fibres and acid hydrolysedfibres produces nano cellulose. Nano cellulose also named as nano crystalline cellulose (NCC), micro fibrillated cellulose (MFC). The functional requirement of sanitary napkins is introduced to avoid the usage of cloth and for retain the menstrual fluid in a hygienic manner. Major concern of using regular sanitary napkin that contains super absorbent polymers (SAP) namely, polyacrylate used for more absorption and toxic chemicals which lead to problems like itching, rashes, cervical and ovarian cancer. Banana products can be an alternative material for usage of synthetic fiber-producing non-biodegradable napkins as well; it can be a good cost-effective, eco-friendly and sustainable end product.

Natural adsorbent and bioremediation agent

Banana fibre can act as a natural adsorbent. The fibre has high porosity and natural capillary action making it better in action. Banana fibres can be used in sorbent socks, pillow and booms or as a loose fibre to clean up spills. The fibre is considered to be good on account of its durability, strength and resistance to changes in temperature and moisture and the waste generated can be disposed of easily.

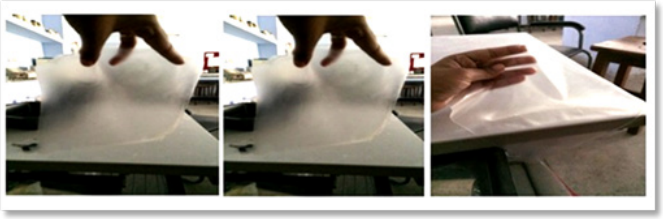
Water purifier

Banana fibre can be used as a filtration agent in the wastewater treatment industry. The natural affinity of banana fibre to oils and organics and its tendency to repel water, makes it a natural alternative for filtration agent for industrial and municipal waste treatment. Wastewater is often contaminated with oils and other organic materials.

Banana starch film reinforced with cellulose nanofibre

Bioplastics that are made from renewable resources which can be easily broken down by microorganism represent a new generation of plastics that can reduce the dependence of fossil fuels

also at the same way can reduces the impact to the environment. Development of biofilms using banana flour was made using casting method by formulating with different plasticizers like (Poly vinyl alcohol, glycerol, ascorbic acid, gelatin, CMC and arabic gum) along with reinforcement of cellulose



Cordage industry

Banana fibres have been used in cordage industry. The machine processing of banana fibre was quite satisfactory and comparatively better than normal industrial processing, as there being no spinning breaks. Ropes containing 40% banana fibre were somewhat better in colour .Bananaplants can be good source for cordage industry. Being tolerant to saline water, it is even used for making marine cordages.

Biomass / briquettes

Biomass briquettes are mostly made of green waste and other organic materials. They are commonly used for electricity generation, for heat and as cooking fuel. These compressed compounds contain various sorts of organic materials, including rice husk, bagasse, ground nut shells, municipal solid waste, agricultural waste, or anything that contains a high nitrogen content. The actual composition of the briquettes varies by area due to the availability of raw materials. The raw materials are gathered and compressed into briquette in order to burn longer and make transportation of the goods easier. Compared to fossil fuels, the briquettes produce low greenhouse gas emissions because the material used is already a part of the carbon cycle. Banana field residues are brilliant source of biomass as maximum power of 80.52 MW can be obtained from direct combustion and 869.13 MW from anaerobic digestion, giving rise to an estimate of 949.65 MW of power.

Bioethanol production

There has been increasing worldwide interest in alternative sources of energy. This is because dwindling supply of fossil fuel to meet the energy requirement for modern society. Banana waste can be used effectively for biogas and bioethanol production.

Conclusion

Entrepreneurship development in farm sector will be a key driver for promoting and sustaining the momentum of growth in rural area of India. Non availability of skilled people on knowing the technical knowhow and absence of incubation centres handicapped the spread of banana industry and one of the reasons for such a huge waste in banana and non-utilization of its parts. Mankind has been strongly dependent on plant fibres for all kind of purposes. The synthetic fibres are non- degradable and cause serious pollution problems. The research for the use of natural fibres has seen an tremendous growth because of their low cost, easy availability, excellent mechanical properties, high specific strength, Non-abrasiveness, eco-friendly and biodegradable characteristics. With the huge potential of availability of banana fibre it is pre-requisite for the development of integrated package for promoting handcraft from banana fibre and supporting MSME enterprises. Developing replicable models across regions, having diverse and convergence of ideas, design and technology development workshops, promoting farmer producer organizations (FPOs) and business friendly atmosphereare essential for promoting and utilization of banana fibre.

வாரி பெருக்கி வளம்படுத்து உற்றவை
ஆராய்வான் செய்க வினை.

– Thirukkural – 512

வருமானம் வரக்கூடிய வழிகளை விரிவாக்கி, வளங்களையும்
பெருக்கி, இடையூறுகளையும் ஆராய்ந்து நீக்கிட வல்லவனே செயலாற்றும் திறனுடையவன்.

**Let him do the work who can enlarge the sources (of revenue),
increase wealth and considerately prevent the losses**

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