



Banana – A plant with myriad of uses

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Abstract

Banana, a herb under Musaceae family, is commercially grown as a fruit and vegetable crop across the world. Fruits of the dessert cultivars of the plant are delicious, and rich in starch and readily utilizable sugars for quick energy. Those of the plantains are used in culinary and making fast food delicacies. Edible cultivars are mostly triploids with imperfect flowers and are propagated vegetatively through their suckers. Tissue culture is also being increasingly used, especially in largescale commercial cultivation. The fruits of the dessert cultivars are in high demand, both in domestic market and international trade. Other plant parts too do have economic uses. Most of them including fruits can be converted to a wide range of valueadded products tagged with high market price.

Keywords: Fingers, parthenocarpy, genome, triploids, tissue culture, resistant starch

Introduction

Banana occupies a high place in Indian culture, and rural economy. Adaptability of the crop to diverse climates and soils, round the year availability of the delicious fruits (dessert banana), often referred to as 'fingers', suitability of the fruits of some cultivars for use in culinary (plantains), economic use of other plant parts, notably the leaves, central pith and the inflorescence, and post-harvest processing of the fruits and other plant parts to a wide range of value-added products make the crop all the more remunerative for the growers. The fruits are in high demand in global export market. India is a front ranking country in both production and acreage under banana, and yet not a formidable player in its international trade. Some of the principal causes for the dismal performance are low yield, lack of adequate storage facility and transportation network, and high post-harvest losses. The potential of banana as a crop plant needs to be tapped in generating rural income, employment, livelihood, and valuable foreign exchange through export of its fruits. This paper describes different aspects banana as a crop plant *viz.* origin, botany, propagation, genomics, uses, practices for high fruit yield, export of the fruits, and post-harvest processing of the fruits and other plant parts.

In Indian Culture and Ethos

Banana is one among the few plants deeply woven into Indian culture, values, and psyche. According to Hindu mythology, Rishi Durvasa, in a fit of rage, cursed his wife Kadali and reduced her to ashes for her slip of not waking him up from his siesta for performing his evening rituals. The sage, much known for his irascibility, regretted later, created the banana plant from the ashes, named the plant 'kadali' (banana in Sanskrit), and assigned the plant a high place for reverence in ceremonies and rituals. The holy plant in Indian ethos is associated with divine feminine power, fertility, mother earth, endurance, prosperity, and good fortune. The fruit of the plant features prominently in devotees' offerings to God, while the whole plant forms an essential ritualistic component of many religious and cultural festivals such as Vinayaka Chaturthi, Sankranti, Bihu, Chhath, and Ayudha puja. In Durga puja, a tender

banana plant after a ceremonial bath is installed on the right of the idol of Ganesha symbolising His bride. The sacred plant represents the spirit of a new beginning with eternity and is thus ubiquitous in wedding venues. In Buddhism, the plant stands for impermanence, while for Vaishnavites, the plant is indicative of grace.

Economic Significance

Banana in terms of production is the fourth most important food crop plant, next only to rice, wheat and maize, and one of the most popular fresh fruit the world over. The plant is grown in more than one hundred and fifty countries across the world and is in high demand for its fruit even in countries without its domestic production. Globally, a thousand billion bananas are eaten every year. In India, banana as a fruit crop ranks second, next only to mango. India is the leading producer of banana with more than one-fourth of the global produce and is trailed by China, Indonesia, Nigeria, Ecuador and Brazil.

Banana is a unique plant as every part of the plant does have use, market value and generates income for the growers with practically no waste from the plant. The ripened fruit is delicious and nourishing, while the raw one is used as a vegetable in preparing healthy culinary dishes and fried delicacies. The leaves are in much demand for wrapping prepared food dishes to be sent outward, in steam cooking, and for use as traditional green, hygienic and ecofriendly food plates for the guests in large gatherings like marriage ceremony and similar social events, countryside eateries and at times in home too. The white coloured pith of the centrally placed pseudostem that opens out by removing the leaf sheaths of the harvested plant is used as a raw vegetable in making curries, especially in the eastern states.

The inflorescence, often incorrectly referred to as the banana flower in routine parlance, does serve as a salad and a raw vegetable in making various dishes savoured with principal meals. Banana thus turns out to be an important subsistence crop ensuring food and financial security for the growers. Banana is grown as an ornamental plant too to add more to the décor to the surrounding. In rural India, village folk often rightly say that one with three hundred and sixty-

five banana plants in his garden is assured of an income enough for the family's monetary sustenance.

Suitability of raising a new banana crop round the year, high market demand of its delicious fruit among all classes of the population, its large varietal range to suit its end users with diverse tastes, utility of all plant parts, and a high range of edible and nonedible value-added products from different plant parts attract the farmers to go for its cultivation for sustained income generation and meeting the basic necessities of livelihood. Farmers, however, need to grow other crops along with and in that context too, banana rightly fits in. A wide ranging short height crops serve as ideal intercrops with banana. These intercrops include among others lady's finger, chilli, spinach, marigold, cabbage, cauliflower, Colocasia, and a number of tuber crops. The herbaceous plant can be grown in mixed cropping too for which taller ones like coconut, areca and oil palm are ideally suited.

Origin

Available documentary evidence suggests the revered plant to have its origin somewhere in Southeast Asia some ten thousand years back and was first domesticated in Kuk valley in New Guinea almost two thousand years later. The plant later reached Indo Burma region, and its cultivation began principally for its fruits. Arthashastra, Kautilya's alltime great compendium on economics, cites the practice of growing banana around 250 BC. From India, the plant reached many other countries, mostly through traders, travellers, explorers and invaders. Alexander the Great relished the taste of banana and carried the plant from India to Middle East. There, it was named '*banan*', meaning 'finger' in Arabic. Over time, the name '*banan*' changed to 'banana'.

Taxonomy, Morphology, Botany and Principal Types

Banana, a large herbaceous monocot plant under the Order Zingiberales, belongs to the family Musaceae. The latter is a small family of flowering plants with a total of 94 species categorized under three genera viz. *Musa*, *Ensete* and *Musella* comprising 85, 8 and 1 species, respectively. The two principal edible banana species now common in most parts of the world belong to the genus *Musa*. They are *M. acuminata* and *M. balbisiana* (*M. sapientum* and *M. paradisiaca*). Bananas of commercial significance are of two types. The one that bears sugar rich delicious fruits is the 'dessert' banana. The other one used as a vegetable in culinary preparations and other dishes is referred to as 'plantain'. These two apart, there is also Hill banana that grows at high altitude (> 2000 m) and bears reddish thicker-skinned aroma rich yummy fruits.

The tall plant (2 to 9 m high and 20 to 50 cm dia.), ideally suited to humid tropics, is perennial and does have an underground corm, a trunk (pseudostem), and 8 to 12 long and broad enough glossy majestic leaves. The plant despite its large height is classified as a herb and not a tree because of its nonwoody fleshy stem and resting on a pseudostem. The latter ceases to exist after fruit bearing. In commercial cultivars now in cultivation, the plant forms sterile unisexual flowers. Fruits in banana develop from imperfect ovaries of the female flowers by parthenocarpy and are thus seedless.

The fruits of the plant are referred to as 'fingers', while a circular cluster of 'fingers' in a bunch is called a 'hand'. A bunch for a moderate market price should have not less than

ten hands, each with more than ten fingers. Factors fetching high price for a bunch are arrangements of the hands, characteristics of the fingers e.g. length, thickness and sugar content or sweetness, uniform ripening throughout the bunch, and absence of blemishes, bruises and other defects noticeable on fruit surface. The fruit is climacteric by nature (continues ripening even after removal from plant), unlike sweet orange, grapes and pineapple which are non-climacteric. Therefore, for more time at disposal for reaching the last buyer, the bunch is advantageously harvested at near to half ripening stage. The rest is allowed to be completed during storage and transportation. For hastening up and uniform ripening throughout the fruits for a large harvest carried out in ripening chambers, ethylene, a plant growth regulator, is often used.

Propagation

In edible banana cultivars, pollination in flowers takes place and yet, the fruits are formed without fertilization leading to seedless fruits. Very small brown speckles of vestiges of ovules present in the central part of the edible pulp can be noticed in overripened fruits as a relic of the past. Since, the fruits are seedless, the next generation plants are raised through vegetative propagation. Most wild cultivars however, bear fruits formed by fertilized ovules. Upon germination, the seeds sourced from the fruits of such plants form new plants.

Researchers are delving into to explore when, how and why this trait of seed to plant mode of reproduction was lost in botanical transition of the plant from the wild to modern cultivars.

Modern cultivars of banana with no potentially viable seeds thus resort to vegetative means of reproduction. After the fruits have been formed and reached the maturity stage, new plants commence emerging from the suckers (daughter plants, 5 to 25 a plant in its lifetime). The latter extending out from the underground mat (rhizome) are like the seed. Once a new plant emerges, the old one dies, thus completing its life cycle. Harvesting in large banana garden requires decapitation of the mother plants to make way for the young suckers to replace the former at the same spot for more space, water and nutrients. And so, the banana cycles continue perpetually. Banana thus becomes a single harvest plant. Subsequent plants from the same mat of the subterranean stem life after life contributes to perenniality of the plant. This way apart, tissue culture technique is also being increasingly used in largescale commercial gardens, especially for Grand Naine, Gros Michel and Shrimanti varieties. Healthy leaves (3 to 4) in pots are used for raising new plants, initially in a partially shaded spot for about six weeks and then in the open for about two months. Vegetative propagation by either method helps preventing dilution of the genetic stock passed on to the scion and, *ipso facto*, narrows down the scope for natural cross breeding and improvements associated with.

Genomics

M. acuminata and *M. balbisiana* are the two major progenitor species of most of the domesticated cultivars. The two minor ones are *M. schizocarpa* and *M. textilis*. Edible cultivars thus carry four genomes viz. A, B, S and T corresponding to the respective species. These four genomes, either alone or in combination, determine the traits of the plant viz. shelf life of the fruits, disease

resistance, salt tolerance, pulp to peel ratio, peel colour and aroma of the fruits. Banana cultivars are thus often referred by their genomic constitution *viz.* AB, AAA and AAAB, corresponding to the di, tri and tetraploid cultivars. The diploids ($2n = 2x = 22$), mostly wild cultivars with normal seeded fruits, are commercially less significant and have been largely replaced by the triploids with improved quality attributes. Important ones are (i) AA (sucrier ones); (ii) AB (Ney Poovan); and (iii) BB (Bhimkol). The triploids ($2n = 3x = 33$) include most of the edible banana cultivars, form sterile seedless fruits by parthenocarpy due to irregular meiosis, and suckers serve as the seed material. They include (i) AAA - The largest genomic group among the triploids; mostly the dessert bananas; ex. Cavendish, Gros Michel, Grand Naine, Robusta, Williams, Valery and Red Banana; (ii) AAB - Both dessert banana and plantains; ex. Horn Plantain, Poovan, Malbhog and Nendran; and (iii) ABB - Many of the plantains or the culinary bananas; some are dual purpose too; ex. Karpoorvali, Monthan, Kanchkela, Saba and Samsi Awak. The tetraploids ($2n = 4x = 44$) are mostly man-made for use in breeding programme for further improving the quality attributes of the triploids *viz.* disease resistance, increased vigour and better fruit quality. Only few are of commercial significance. Important ones are (i) AAAA ex. Monalisa; (ii) AAAB ex. Gold Finger; and (iii) AABB ex. Kalamgol.

It is worth mentioning in the context that the genome of *Musa acuminata* is the first non-grass plant of which the genome has been sequenced in entirety. Genome sequencing - in entirety or in segment - provides the much required molecular information contributing to a particular character to be transferred (or removed) to a new variety in varietal development programme.

Composition and Nutritional Aspects

The fruit pulp is rich in carbohydrates (12 to 16%) *viz.* starch, readily utilizable simple sugars, dietary fibre, small amounts of lipids and proteins, antioxidants, antiinflammants, a wide range of nutraceuticals, vitamins, and minerals, notably potassium. Water to the extent of 70 to 80% constitutes the rest. The fruit because of its ample readily metabolizable sugars is the fruit of choice by overworked sprinters, athletes and sportspersons for quick calories after their exhaustive schedules. Interestingly, unlike many starch rich fruits, a good portion of the total starch in banana is present in the form of 'resistant starch'. The latter is not easily metabolized and requires long time for its catabolic processing to its utilizable monosaccharide constituents. Eating ripe banana thus gives a feeling of satiety and yet, does not result in any sharp rise in sugar level. Banana does have many health benefits too. The pulp because of its high potassium content helps countering excess sodium by flushing it out from the body and is thus good for hypertensive persons. High dietary fibre of the pulp helps digestion by promoting bowel movement of the intestinal system. The pulp and peel of the fruit contain dopamine and serotonin, both neurotransmitters and mind-altering chemicals. Plant parts of banana do have medicinal uses too and are in use by village folk as home remedy for a range of health ailments.

The fruit pulp is rich in secondary metabolites too *viz.* carotenoids, tannins, pectin, organic acids and esters. Some of them confer the characteristic properties of the fruit. Malic and citric acid contribute to the tartness of the unripe

fruit. Tannins present in raw pulp bind to the proteins present in saliva responsible for the lubricating action of the tongue. Eating raw banana thus makes the tongue dry (astringency). When cut, the phenolics in raw fruit and peel undergo enzymatic oxidation causing browning of the exposed tissues that keeps a difficultly washable brown stain on cotton clothes.

There are few points on the minus side too. The fruit contains very less of proteins and fat. Besides, some taking more of it in a single serving feel temporary discomfort due to bloated abdomen. Regular high intake may in some individuals lead to hyperkalemia (excess potassium) and distortion of sodium-potassium balance of the body, temporary muscle weakness and fatigue. These effects are, however, transient and overcome on their own in a short time.

Compositional Changes with Ripening

Composition of banana fruit pulp changes with ripening mediated by several enzymes acting in concert. Along with, the properties too change. Tannins, polyphenols and organic acids disappear with progress in ripening and so is the decline in astringency and tartness. Hard green skin of the fruit turns yellow due to chlorophyll degradation, unmasking the yellow of the carotenoids. In some cultivars however *e.g.* Dwarf Cavendish, this chlorophyll degradation process remains hindered and so the fruit peel continues to remain green even at maturity. The hard pulp and the peel are softened by breaking of the pectin and polysaccharides into simpler constituents. Amyl and butyl esters along with some other simple organic molecules formed from large organic constituents as ripening proceeds ascribe the fruit's distinct aroma and flavour. And most importantly, starch, a polysaccharide, is progressively degraded to simple sugars like sucrose, glucose and fructose, making the pulp increasingly sweeter and delicious, eventually taking the degradation process to a point at complete maturity where practically no starch is left out, barring the resistant starch. Interestingly, this starch to sugar conversion process in pulp is conspicuously absent in plantain cultivars, leaving the pulp to be used as a vegetable.

Crop Management Practices for Increased Yield

Current fruit yield in India ranges from 30 to 80 ton/ha with normal plant density.

Each plant in its life cycle bears only one bunch weighing 10 to 60 kg with 75 to 250 fingers. The figures are indeed dismally lower than those in many other countries. There is much scope to increase fruit yield per unit land and plant as well. The starting point is the right pick of the variety taking into count the local climate, soil, water availability and particular requirements of the prospective buyers. For Dessert banana, Dwarf Cavendish, Robusta, Karpooravalli, Rasthali and Grand Naine are some among the varieties with good yield. Monthan is good for culinary use, while Nendran is for dual purpose. Red banana and Virupakshi with good yields are right for high altitude and hilly areas. New promising ones are Kaveri Vaaman released by BARC, Udhayam, Kaveri Kanchan (rich in carotenoids) and Kaveri Sugantham. The last one sells fast for its high aroma. Integrated Nutrient Management taking care of major, micro and beneficial nutrients, and pest management practices are to be attached high priority. Along with, to make banana growing more remunerative, the current high cost of

cultivation due principally to irrational use of costly inputs *viz.* fertilizers, water and labour must be slashed. To make it so, only the required amounts of fertilizers right in time when they are needed and in right proportion are to be applied based on the results of soil test or plant tissue analysis as envisaged in DRIS (Diagnosis and Recommendation Integrated System) concept. Likewise, water requirement is to be met through drip system coupled with automated scheduling based on time and volume of requirement.

Adopting State of the Art Farming in Harnessing Yield Potential

State-of-the art farming technologies in harnessing the yield potential of banana in addition to those already mentioned, nonetheless less important in the context of today's modern farming, are adopting precision farming, satellite and drone based healthy monitoring of the crop with follow up remedial measures whenever required, use of plant growth regulators, improvement in fruit preservation techniques, and exploiting biotechnology and gene manipulation in evolving new varieties with desirable traits *viz.* plants with high yield, lodging and disease resistance, salt tolerance, shorter production cycle, and fruits with desired colour, aroma. Sugar content and longer shelf life. Some more factors in reaping a good financial return from the harvest are taking into count the craze and demand of the local market for any particular variety, considering the demand supply chain criterion in determining acreage, exploring new market for better prices, and faster transport network.

Export

Dessert banana (sweet banana) is a jewel commodity in global export market for agricultural commodities and ranks the first among the fruits followed by grapes, apple, avocado and orange. Demand far exceeds the supply. Countries like Ecuador and Philippines are earning much foreign exchange through export of banana fruits. India, despite being the top producer and accounting for more than a quarter of the global produce, is only a minor player in the context, notwithstanding India's favourable climate and nearer assured export destinations, particularly the Middle East and Gulf countries *viz.* UAE, Saudi Arabia, Qatar, Oman and Bahrain. India's export share is less than even 1% of the total produce and its rank in global banana trade hovers between 14th to 18th for which high domestic demand, rewarding local market price, and low total produce due to less crop acreage and poor yield are some of the principal responsible factors. The export potential of banana should be tapped for which a clear roadmap is to be drawn. Much of the crop is now grown with inadequate agronomic practices, injudicious application of fertilizers, especially micronutrients, and lack of plant protection measures, all contributing to lower than potential yield. In realising a higher yield, fruit quality, a parameter of paramount significance in export market, must also not be sidelined. Harvest is to be scheduled in tune with the demand. Post-harvest losses which currently account for nearly one-fourth of the total produce must be prevented for which there must be adequate storage and packaging facility, and rapid transportation grid and shipping lines for faster export. Further, unlike the major banana exporting countries *viz.* Ecuador, Costa Rica and Philippines, a sizeable fraction of

the plant is grown in India by small and marginal farmers in an unorganized way lacking the spirit of a commercial garden or plantation crop as is the case with coffee, tea, cashew, oil palm and rubber. An impetus is required at this point.

Post Harvest Processing and Conversion to Value-Added Products

The fruit of banana is highly perishable, with a shelf-life of about a week. This necessitates a rapid transportation network to reach its destination point for its last point sale or export chain for high returns. Both are however, not in the growers' reach. Fortunately, to salvage, there are a good number of value-added products. Most of them are made from the pulp and peel and last for months. This conversion can counter the ill effects of a glut and other eventualities resulting in delay in shipment, especially when local demand is not high. Some of these products are delicious and 'ready to eat', while some are packaged for sale in departmental stores. The products include banana flour, puree, chips, jam, jelly, juice, halwa, wine, and energy drinks. Some of them in turn serve as start materials for further value addition to the products. Thus, the flour is used in making bakery products, pastries and confectionaries *e.g.* cakes, muffins, biscuits, cookies, bars, wafers, chocolates, and fruit salad. The puree is used in layering sandwiches and in making candy, yoghurt, ice cream, salad topping, food drink, squash and baby food. Vinegar and alcoholic beverages are made from fermented fruit pulp. Starch is extracted from the pulp of plantains and raw dessert banana for its use in various industries *e.g.* food, pharma, textiles, and paper. The nonedible peel that accounts for 25 to 30 per cent of the fruit weight generates a large volume of waste. Research efforts are on to turn this waste to wealth by making useful substances *viz.* biofuels *e.g.* bioethanol, enzymes *e.g.* amylases, biosorbents, especially for use in wastewater treatment, bioplastics, Single Cell Protein (SCP), tensile food wrappers, disposable cups and glasses, herbal cosmetics and medicines, intermediates for pharmaceuticals, paper, yarns and ropes, handicrafts, wall hangers, animal feed, and concentrated organic manures. The pseudostem apart from its culinary value is used in making yarn, fabric, paper, candy, fish feed and manure, while the flower is used in making enticing pickle.

Summary

Banana, the all-season fruit crop with multiple uses of all plant parts, is a crop plant with much promise and potential in raising the standard of life of the growers. It's cheap, delicious and nutrition rich fruit available round the year helps mitigating malnutrition and generating income for livelihood. The plant does have high potential in generating foreign exchange through export of the fruits and processed products. The crop plant a large part which is now grown in the backyard and kitchen garden of Indian homes and homestead gardens largely for home and local consumption, and in a limited scale in small and medium gardens by commercial growers for organized marketing and export needs a strong push for its cultivation in commercial perspective, marketing, export, and for processing for high price fetching value added products made from the fruit pulp, peel and other plant wastes.

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