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Green gold as super power potential in for green India and mystery behind bamboo blossom

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Abstract

This review paper is based on the versatile and numerous uses of bamboo grass plant. They are some of the fastest growing plants. Bamboos as construction material are associated with south and east Asia. Bamboos long life make it symbol of uprightness in china and symbol of friendship in India. It is used by rural people for food, housing and other domestic purposes. Its varied flowering habits, its economical consequences, profuse seed production, short viability, germination of seeds and potential as source of income to boost economy and mystery behind its flowering.

Keywords: Viability, germination, profuse flowering, seed production, economy

Introduction

The “Poor man’s timber” which grows profusely in Asian countries of the world. Bamboo is ubiquitous in Chinese culture. Bamboo is a tribe of flowering perennial evergreen plants in the grass family *Poaceae*, subfamily *Bambusoideae*, tribe *Bambuseae*. The importance of bamboo as an ecofriendly raw material capable of meeting multifarious needs of the people at large is gaining global acceptance. From a raw material known as poor’s man timber, bamboo is currently being elevated to the status of “the timber of the 21st century. The bamboos in India cover an estimated 8.96 million hectare of forest area which constitutes 11.7% of the recorded forest area and 14.01% of forest cover of the country .In India, the eight states that lie at the foot of the Himalayas together make up about two-thirds of India’s total bamboo production. “Bamboo is in abundance in the northeastern states and it grows everywhere. Bamboos are distinct and fascinating plants (tree-grasses) with a wide range of values and uses. They are indicators of high biodiversity, play a significant role in soil conservation and extensively used for soil and water management. They are important for biomass production and play an increasing role in local and world economies. About 2.5 billion people in the world depend economically on bamboos ^[5] and international trade in bamboos amounts to about US\$2.5 M ^[5]

It has been traditionally used as fuel, food, rural housing, shelter, fencing and various other purposes. It is being used as industrial raw material for pulp and paper, construction and engineering materials, panel products, etc. However, the valuable bamboo resources are dwindling in their natural habitat due to gregarious flowering, forest fire and over exploitation for various end uses, which may have resulted in loss of their genetic resources without sufficient documentation.

The longest of the grass family, also known as green gasoline, to produce 60 million liters of ethanol every year in the tea producing state of Assam. That’s enough to meet mandatory requirements for blending with gasoline in the entire northeastern region. “It will be a big transformation for us and for the country.”Record growth in Indian oil consumption means Prime Minister Narendra Modi is turning to everything from sewage water to crop residues to blend with diesel and gasoline, poor carbon fibre. What began as a late-20th Century wonder material for military aircraft was then nobly adopted by the motorsport world for strength, low weight and energy dissipation. Apart from keeping up with the country’s surging demand for fuel, It will try to fulfill the meet of a 10 per cent reduction in the nation’s energy imports by 2022. As a result, the biofuels industry is set to explode into a \$15 billion market by 2020 with government backing. Indian oil companies are investing in biofuel refineries to boost ethanol production from non-molasses sources such as agricultural residues and even petrochemicals. But usage of the contemporary fuel has been slow to catch on. Just 2.1 per cent of gasoline is being blended with ethanol, while very little biodiesel is mixed with diesel. The goal this year is 5 per cent blending for both.

Potential of Green gold

Bamboo will play a role in India's energy security and promote green fuel use. In fact, the plant has had a profound impact on the daily life, culture and spirituality of the Chinese. In the past, a wide variety of products were made from bamboo - from roof tiles and rafts, to shoes, furniture and agricultural tools. But despite the close relationship between Chinese-speaking societies and the natural material, Taiwan's bamboo industry has suffered a decline in recent decades^[8]. It nearly collapsed because of people's preference for more modern-looking products, or just cheaper plastic goods - and the impact of less expensive bamboo imports from China and South East Asia. However, an earthquake and strong resolve on the part of the government and industry to continue using bamboo have led to a revival and transformation in its use. In recent years, bamboo has been used to make items never before associated with the plant - from shampoo and insect repellent, to socks, gloves, and even roasted peanuts. This reinvention of how bamboo is used has made it possible for the small family businesses which make up the industry to stay alive and to start reversing the decades of decline. Technology stands still for no one. But could nature provide carbon fibre's replacement. It's a trend reflected in other parts of Taiwan - only about 240 bamboo-products businesses remain on the island. Real carbon fibre, is still just as wondrous as it was in the last century, even if a bit more commonplace in road cars. Bamboo is wealthy inside minerals and pricey inside fiber, which can troth a colossal addition to any nutritious, nonetheless balanced diet. Bamboo offers a product of poles apart amino acids, including eight styles of amino acids that humans must get indulge in a cuisine source, since the body attains not manufacture these most amino acids within the body. Bamboo shoots contain high protein but less fat, moderate dietary fiber, having essential amino acids, selenium, potassium, a potent antioxidant and minerals for healthy heart^[13]

Bamboos provide us the three basic necessities of life i.e. food, shelter and clothing. They are put to over more than 1500 different uses^[10]. Infact, no other plant benefits us in so many ways as bamboos. They are distinguished from other member of the family by having woody culms, complex branching and generally robust rhizome system and infrequent flowering. In India, the main areas of bamboo distribution include north- eastern states, Western Ghats and the Andaman and Nicobar archipelago. Over 58 species of bamboo belonging to 10 genera are distributed in the North-eastern states of India alone.

Economic value

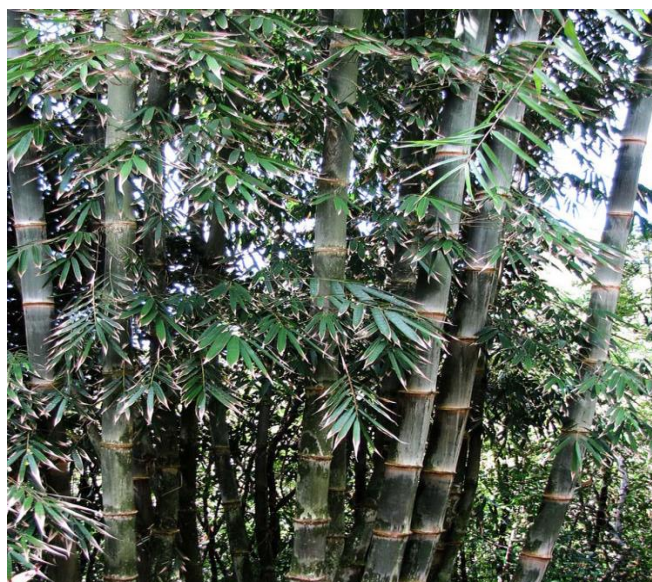
Bamboos are indeed one of nature's miracles and their strength and structure enables them to be put to diverse uses. Bamboo possesses a vast advantageous usage scheme which is environmental friendly, in respect to trees (wood) which are gathered within 10–30 years^[9]. Bamboos can be collected within 3–5 years, likewise a 10–30% of biomass contrasted with 2–5% of bamboo (American Bamboo Society, 2014). In Asia, bamboos are the essence of life for many communities, and it is no exaggeration to speak of a 'Bamboo Civilization' in the region^[7]. Bamboos are too extremely useful grasses which are in high demand throughout Asia. However, because of the bulkiness of culms and the high freight- value ratio of bamboo, the radius of economical transport is limited and hence, most bamboo is used near the centres of production.

The most comprehensive information of commercial use of bamboo products come from countries in which bamboo is an important economic asset. Bamboo has been chosen to be used as a raw material in construction due to its environmental friendly attributes and readily availability.

It is also a very important food for the giant pandas in China because they survive only on bamboos. Many bamboos are praised because of their beauty and are popularly used as ornamental plants to beautifying home gardens and commercial establishments^[12] Bamboo forests mitigate climate change as carbon markets start to recognize and reforestation to sequester carbon at rates better than trees. Because of its extensive rhizome and root system, bamboo is useful for soil erosion control, road and steam embankment stabilization. Bamboo is a grass that grows to maturity in 3-5 years and can be procured to produce high quality non timber products for global industries. Bamboo regrows after harvesting, unlike trees that need re-planting. It can be propagated from rhizomes, Culm/branch cutting or by multiplication of nursery- raised seedlings^[14].

Bamboo propagation

Bamboo can be extremely important in providing vegetative cover to deforested areas. It produces leafy mulch to the soil surface, its foliage provides shade and protection against rains, and its habit of producing new culms from rhizomes enable the culms to be procured without disturbing the soil. Perhaps the most peculiar feature of this plant is its flowering which is cyclic phenomenon and depending on its species, cycle varies between 5 to 120 years. This genetically controlled flowering is so profuse that the whole plant is transformed into a giant .Vegetative propagation in bamboos is practised through offsets but these rhizomes and propagules are cumbersome. Continous flowering has been reported in *Bambusa arundinaceae*^[11] a bamboo that flowers normally after a period of about 30 years. Vegetative propagation in bamboos is practised through offsets but these rhizomes and propagules are cumbersome.



Dendrocalamus strictus

*Bambusa bambos**Dendrocalamus hamiltonii*

Bamboo Flowering Habits: There does not exist much scientific evidence and study about why and when bamboo flowers, mainly because the flowering intervals of bamboo can be several decades apart.

While the vast majority of herbaceous bamboos flower annually, most of the woody bamboos flower very infrequently. In fact, many bamboos only flower once every 20 to 120 years and may die in part or completely due to some possible causes.

There exist 3 types of flowering in bamboo which largely depend on species and circumstances:

1. Continuous Flowering
2. Sporadic Flowering
3. Gregarious Flowering

1. Continuous Flowering

Continuous or annual flowering happens with most herbaceous bamboos and in some cases also with woody bamboos (*Schizostachyum*). Some species keep flowering year after year without any effect on the plant itself, although the produced seeds are rarely viable.

Continuous flowering may also occur in different individual plants of a forest over different periods of time, with not more

then one or two month intervals. It is possible to find year-round flowering bamboos in a forest but without causing vegetative delays much less death of the stands.



Continuous flowering in bamboos

2. Sporadic Flowering

Sporadic flowering bamboo only occurs on individual stems (culms) of the same clump in a forest. As the name suggests, there is very little pattern to this type of flowering and it seems that it may be induced by environmental factors such as drought or cold instead of genetics.

Many species of bamboo, including *Guadua angustifolia*, may flourish both gregariously and sporadically. When sporadic flowering occurs on individual culms, the plants very rarely die but most of the seeds aren't viable either.

Adverse Conditions

It has been noted that severe attacks of pests or disease, injury, malnutrition, or long periods of prolonged droughts and floods coincide with the presence of flowering in grooves that were under these circumstances.

These adverse causes inevitably produce reactions and mechanisms in the plants which leads them to flower with the objective to preserve the species. The seeds are then utilized as a unique system of self-perpetuation. Sporadic flowering can also occur when bamboo forests or plantations are heavily exploited.



Sporadic flowering in bamboos

3. Gregarious Flowering

Most woody bamboo species are subject to gregarious flowering which means that all plants of a particular species flower at the same time, regardless of differences in geographic locations or climate conditions, and then die a few years later. Intervals in the gregarious flowering cycle varies depending on the species, but in general bamboo flowering intervals can be as long as 20-120 years.

In other words, when a certain bamboo species starts to flower gregariously, they do this all over the world for a several year period until the entire forest has died. In some species, only the bamboo stems die, while rhizomes become activated again to start the natural regeneration of the species. However, this happens very rarely and is rather the exception than the rule.

Gregarious flowering often happens in different stages because mature stems start to produce seeds first. When the seed ripen and eventually fall off, the bamboo plant loses all its leaves and the culm starts to dry up from top to bottom until it finally dies. Every bamboo forest contains culms in different stages of development, therefore this entire process can take several years (3-7 years) until the forest has completely died.

Gregarious flowering is easily observable when it happens because of all the dried bamboo stems (straw like color) and the thousands of spikes in their branches. These spikes bear the seeds which are usually very similar in appearance to rice, wheat or barley^[3].

Unlike sporadic flowering, gregarious flowering isn't triggered by environmental aspects, which leads us to believe that there must exist some sort of genetic alarm clock in each bamboo cell that signals the diversion of all energy to flower production and the cessation of vegetative growth. This mechanism, as well as the evolutionary cause behind it, is still largely a mystery. Apparently, once a particular species reaches its life expectancy, it will start to flower which is then followed by the development of seeds.

The two most probable explanations for why bamboo dies after flowering (there exist many theories) is that seed production requires an enormous amount of energy which stresses the bamboo plant to such an extent that it will actually die. A second explanation could be that the mother plant is creating an optimal environment for its seedlings to survive. In other words when the mother plant dies, the bamboo seedlings will have full access to water, nutrients and

sunlight that would otherwise be used by the mother plant.

Consequences of gregarious flowering

The mass flowering of bamboos and consequential seed setting also have economic and ecological consequences. The huge amount of seeds in forests attract large populations of rats and other rodents which may consume all available food crops and may cause severe spread of diseases in surrounding villages^[2]. Furthermore, when bamboo stems die, local people lose access to a vital building material for their homes and agricultural activities.

Various methods have been tested to revive flowering bamboo but only a few have been effective in some cases, many have not. Much more study needs to be done, but until bamboo reveals some of its secrets, the mystery will remain.



Gregarious flowering in bamboos

Micropropagation is an expensive technology and therefore seeds serve as the best source of propagation on large scale. seeds serve as the best material for large – scale plantation, germplasm conservation and improvement of genotype. However bamboo seeds, have very short viability of 1-3 months and are therefore useful as propagules for only a short period of time. The present study shall look into some aspects of this problem so that viability and related problems are understood.

Profuse Bamboo Flowering



Mystery behind flowering

Bamboos are the fastest-growing plants on Earth. A typical bamboo grows as much as 10 centimeter in a single day. Certain species grow up to a meter during the same period, or about 1 millimeter every 2 minutes. You can actually see the plant grow in front of your eyes. Most species of bamboo reach maturity in just 5 to 8 years. Compare this to other popular hard woods that barely grow an inch in a week. Trees such as oak, can take up to 120 years to reach maturity. But when it comes to flowering, bamboos are probably one of the slowest plants in the world.

Mystery behind bamboo flowering

The flowering of bamboos is an intriguing phenomenon, because it is a unique and very rare occurrence in the plant kingdom. Most bamboos flower once every 60 to 130 years. The long flowering intervals remain largely a mystery to many botanists.

These slow flowering species exhibit another strange behavior — they flower all at the same time, all over the world, irrespective of geographic location and climate, as long as they were derived from the same mother plant. Most bamboos are exactly that — they are 'division' taken from the same mother plant at some point. These divisions were re-divided over time and shared across the world. Although the divisions are now geographically in different locations, they still carry the same genetic makeup. So when a bamboo plant in, say, North America flower, the same plant in Asia will do the same at roughly the same time. It is as if the plants carry an internal clock ticking away until the preset alarm goes off simultaneously. This mass flowering phenomenon is called gregarious flowering.

According to one hypothesis, mass flowering increases the survival rate of the bamboo population. The hypothesis argues that by flooding the area with fruit, there will still be seeds left over even if predators eat their fill. By having a flowering cycle longer than the lifespan of the rodent predators, bamboos can regulate animal populations by causing starvation during the period between flowering events. The hypothesis still does not explain why the flowering cycle is 10 times longer than the lifespan of the local rodents.

Once a bamboo species has reached its life expectancy, had flowered and produced seeds, the plant dies, wiping out entire swaths of forests over a several year period. One theory is that seed production requires an enormous amount of energy which stresses the bamboo plant to such an extent that they actually die. Another theory suggests that the mother plant dies to make room for the bamboo seedlings. The mass flowering events also attract predators, mainly rodents. The sudden availability of fruits in huge quantities in the forest brings in a tens of millions of hungry rats who feed, grow and multiply at alarming rates. After they devour the bamboo fruit, the rats start consuming crops — both stored as well as on fields. A bamboo flowering event is almost always followed by famine and disease in nearby villages. In the northeastern India's state of Mizoram, the dreaded event occurs almost like clockwork every 48 to 50 years, when the bamboo species *Melocanna baccifera* flowers and fruits. The phenomenon, which occurred last in 2006 to 2008, is known in the local language as *mautam* or "bamboo death."

Most people believe that After flowering the bamboo plant has a danger of dying however this is not the case although many of them do die more so those that species that displays gregarious flowering. The flowering of bamboo produces seeds of large quantities that are typically suspended end to end. This production of new seed may lead to a new bamboo

generation which has the same features or may have a different one to those preceded the flowering. Fruiting in the bamboo plant can also have both direct and indirect effect on the ecological balance. One of the effects is that there is the production of new species.

Due to the production of many bamboo seeds, this seeds can attract many rats and rodents in the garden, and this may lead to spread of some diseases to people who are near the farm and hence endangering the life of human beings. Also, the seeds that are produced may be eaten by this rodents, and this may lead to an imbalance of bamboo in the farm. One of the positive scientific effects of bamboo flowering seed is that it increases fertility in rats and also rat litter viable is increased. There are about 110 genera and more than 1,500 species of bamboos in the world^[5]. Luckily there are only three types of bamboo seeds, which are recognized by the external appearance (morphologically). The first type is known as caryopsis in which, the pericarp is membranous, thin, soft and adhered to the seed coat. It is thin like a membrane and stuck to the seed coat which is the next structure below. The fruit has an apparent ventral suture- a depression which is nearly as long as the whole fruit. The second type of seed is known as Glans, it has hard, smooth, crustaceous pericarp separated from seed coat and no ventral suture. The third type is known as Bacca in which the pericarp is fleshy and thick and separated from seed coat. Seeds of bacca type are large. Largest bamboo seed, seed of Muli bamboo (*M. baccifera*) is of this category. Seeds of *B. polymorpha* are very small and about 125,000 seeds weigh a kilogram, whereas some are so big that only 15-20 seeds weigh a kilogram like those of *M. baccifera*. In the year following the flowering of the bamboo or years in the case of gregarious flowering, blooms tend to be concentrated in the months between November and April. Seeds are generally available from March to April onwards. However, seeds in the period May to July tend to have better viability and reproductive ability. Germination, in majority of the bamboo species, is epigeal with some exceptions like *Ochlandra* with hypogeal germination^[2] High percentage of germination (80-100) is obtained, if seeds are sown soon after collection under shade. Germination period is four to twenty days in orthodox seeds, while for recalcitrant seeds of *Melocanna* and *Ochlandra* it may be less. Germination in fresh seeds of bamboo is high like 90-95 per cent in *B. bambos*, 75-80 per cent in *D. asper*, upto 75 per cent in *D. strictus*, 55- 90 per cent in *Ochlandra* spp^[3].

Seed germination

Bamboo seeds need to be collected immediately before rains set in as seeds lose viability rapidly on exposure to excess moisture^[6]. The deterioration of seed quality depends on two environmental factors – relative humidity that regulates seed moisture content and temperature and both influence by affecting the metabolic rate of seeds for long-term storage huge earthen bins commonly called Kulukkai are used and its mouth is sealed by mud and cow dung to protect against rodent attack. As a prophylactic measure, leaves of *Azadirachta indica* and *Pongamia pinnata* are used.). The viability of *B. arundinacea* seeds was prolonged by storing the seeds over hydrated lime or over charcoal under refrigeration.

Seed viability can be extended by reducing the moisture content before storing. *Thyrsostachys siamensis* seeds stored at room temperature lost their viability within 21 months^[4]. Recalcitrant seeds of *M. baccifera* could be stored upto 60 days by storing in dry sand^[1]. *Thyrsostachys oliveri* seeds

can be stored at -4°C without losing viability upto 18 months [15]. Seeds in general play a vital role in man's life since they serve as a source of food, fibre, spices, beverages, oil and drugs. At the commercial level, bamboo utilization suffers from Lack of protocols for scientific methods of propagation and cultivation of bamboos on commercial scale. Inadequate infrastructure for large scale harvesting, storage and consumption of bamboo culms in event of gregarious flowering, Lack of post harvest treatment and technology for preservation and product development. Due to all these factors, it is essential for bamboo researchers to study metabolism at various stages of storage, to devise storage methods to increase their shelf life and to come out with methods to increase their viability and vigour depending on the time of ageing. When seeds deteriorate, they lose vigour and become more sensitive to stresses upon germination. Eventually seeds lose the ability to germinate. The factors which determine the rate of this 'ageing' include the temperature and moisture content at which seeds are stored and an ill-defined parameter i.e. the seed quality. The process of ageing is complex in all organisms, more so in seeds which themselves have been called 'Physiological enigma'. While it has been known for many year that manipulation of these factors influences the longevity of seeds, the precise interactions among them are so poorly understood as to preclude the prediction of longevity for a particular seed lot. Seed viability, ageing and seed deterioration are complementary and connected processes. Bamboos flower infrequently and after long intervals.



Seed germination in bamboos

Bamboo is an interesting group of tree-grasses due to their peculiar flowering and seeding behavior. Large quantity of seed is required for bamboo improvement programmes and large-scale afforestation but lack of observation on flowering, seeding patterns and germplasm and cohort collection in many species, renders this work difficult. Also scientific knowledge through research programmes on the lifecycle, seed morphology, seed handling, germination and longevity of bamboo seeds for germplasm conservation is important for their proper utilization at the time of their availability after gregarious flowering.

Conclusion

Research has revealed that bamboo shoots have various health benefits. So, it is necessary to promote bamboo cultivation through appropriate methods. Its diverse flowering habits, seed production and germination of different species vary.

Various methods have been tested to revive flowering bamboo but only a few have been effective in some cases, many have not. Much more study needs to be done, but until bamboo reveals some of its secrets, the mystery will remain. Its knowledge can help us to grow bamboos at laboratory conditions so that its diverse use

Conflict of Interest: Authors declare there is no conflict of interest

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