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Bamboo performing a protective role for soil management

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Abstract

Over 1400 species of the varied plant genus bamboo can be found in tropical, equatorial, and semitropical biomes all over the world. It creates essential and diverse habitats with a variety of characteristics, depending on the species and the overall ecological conditions. Most bamboo species have a good development and colonization potential, indicating that they can become invasive in some temperate settings. As may be seen by looking at mature bamboo forests in mountainous places with very steep slopes, the nature and characteristics of some bamboo communities can have a significant potential to preserve and stabilize soil and slopes. Bamboo, on the other hand, is a valuable basic construction material in many areas due to the structural features of specific woody bamboo species. When you consider the plant's entire life cycle, which takes 5 to 6 years to grow and can be harvested annually without pesticides or heavy fertilizers, it almost appears too wonderful to be true. However, there is no reason to deny bamboo's enormous potential as a substitute for logging, steel, and plastics. Bamboo's ability to minimize carbon emissions while also improving soil health and growing habits. Bamboo's versatility as a building material can help us minimize our reliance on more carbon-intensive materials like plastic and concrete. Simultaneously, we must continue to monitor the methods used to grow, harvest, and process it. Only in this way will we be able to ensure that bamboo continues to be an important climate solution.

Keywords: Bamboo performing, protective role, soil management

Introduction

Bamboo builds important and diversified habitats with different specificities, according to the nature of the species and the general ecological conditions. Most bamboo species show a very strong development and colonization ability, determining that in some temperate habitats, they can assume an invasive character. The nature and characteristics of some bamboo communities can present an important ability to soil and slope protection and stabilization, as one can easily confirm by observing developed bamboo forests in mountainous areas with very steep slopes. On the other hand, the structural characteristics offered by some woody bamboo species make bamboo a valuable basic construction material in many regions (e.g. India, China and Southeast Asia).

These characteristics determine that these species and communities can be of high interest for soil and slope protection and reinforcement works, particularly in areas where the bamboo is native. They can be used integrated and fostering natural communities, ensuring efficient soil cover and reinforcement functions through their high, lightly dense culms and their dense and resilient root systems. These functions are also of particular interest for soil bioengineering because bamboo has biological characteristics such as a high vegetative propagation ability (making its reproduction very easy) and a rapid growth (allowing for a quick effect on soil cover and root consolidation). Moreover, the structural and physical characteristics of the stems of certain bamboo species turn them into a very effective construction material for complementary soil bioengineering support structures. Therefore, bamboo in its different forms and associated communities, and also in terms of particular species, is of high interest for nature and biodiversity protection (and therefore ecosystem restoration) as well as for slope protection and stabilization.

Bamboo has so many practical uses; it's like nothing else in the plant kingdom. Beginning thousands of years ago, people were using bamboo to make paper, spears, and primitive housing structures. More recently we have discovered how to make beautiful flooring and exquisite fabrics from bamboo.

As a plant, bamboo is also extremely useful for privacy hedges and erosion control.

As an alternative to retaining walls and other man-made structures, bamboo can serve as an excellent means of erosion control. Whether you're dealing with grades and terraces on a sloped property, or the loss of topsoil to river beds and irrigation run-off, the mighty roots of a well-established bamboo plant will provide a remarkable solution to erosion and other related problems. While some people are apprehensive about growing bamboo on their property, for fear of the damage it can do, bamboo can also be effective in holding your property together. Given the great diversity of species, certain varieties of bamboo are naturally more beneficial than others in terms of erosion control.

The importance of bamboo

Bamboo is one of the many unique plant species found around the world and is a crucial natural resource. With a brief development life cycle and remarkably swift growth, bamboo is widely recognized for its adaptability. It is a perennial grass belonging to the Poaceae family Liese, (1987) ^[11]. There are many different environments and meteorological situations that bamboo species can adapt to. Although tropical and subtropical locations often support high levels of bamboo diversity, they can be found in a variety of environments, such as wet deciduous, semi-evergreen, tropical, and temperate places. There are 87 genera and about 1500 species of bamboo worldwide Ohrnberger (1999) ^[15]. However, bamboo resources are distributed unequally across continents. They could be found in all continents except for Antarctica and Europe, and bamboo resources are especially rich in Asia, with approximately 900 bamboo species under 65 genera Canavan *et al.*, (2016) ^[3]. For example, China has the highest bamboo biodiversity in the world, followed by Japan and India.

Bamboo is also widely used for multiple purposes, such as the essential materials for construction and decoration purpose, furniture, flooring, textiles, fiber, food, utensils and music instruments, due to its quality and versatility. It is said that bamboo can not only replace wood, but also substitute plastics, steel, cement and composite materials in structural and product applications Phimmachanh *et al.*, (2015) ^[16]. Bamboo also has significant environmental benefits. Its soil-grabbing roots could help prevent soil erosion and maintain soil stability. Also, its roots could leach heavy metals from the soil, and efficiently draw water closer to the surface due to its strong water absorption capability. As a result, environment that is inhospitable to other plants could be modified and improved, although this important role of ecological engineering by bamboo is often less understood or appreciated. During its growth, bamboo could also take up high amounts of nitrogen from the soil and carbon dioxide from the air, which, undoubtedly, would help alleviate water and air pollution problems. Obviously, promoting the development of bamboo resources not only enhances community livelihood, but also improves environmental quality and increases ecosystem functioning.

Bamboo roots: A force of nature

Some gardeners struggle with bamboo, as the plant can grow so vigorously, sometimes becoming invasive. Indeed, if you plant a running bamboo when you should have chosen a clumping bamboo, you may end up battling a force of nature. At the same, you can also harness the power and

tenacity of these bamboo roots and put them to good use. One of the best uses, as we have seen, is for controlling erosion and restricting landslides. Agronomists have recognized these beneficial properties for a long time.

With a little planning and forethought, the most intimidating features of bamboo can make the plant an ally rather than an adversary. The aggressive rhizome roots of bamboo plants are famous for how quickly they can spread, and for how difficult they can be to remove. Once the plant is established, the running rhizome roots can quickly infiltrate your entire garden, becoming nearly impossible to eradicate. If you're trying to maintain a pristine flower bed or an undisturbed lawn, free of weeds and dandelions, an aggressive bamboo plant could become your worst enemy. In this case, you'll be far better off keeping your bamboo in a large container, or planting a clumping variety. A flourishing clumper can make a great addition to any garden, either as an accent or a centerpiece.

Bamboo Binds the Soil

Bamboo plays a protective role in decreasing soil degradation, including the reduction of biodiversity, soil nutrient depletion, and soil erosion Chen, (1996) ^[5]; Lou and Wu (1997) ^[12]. In one study in a longterm monitoring experiment of bamboo, planting revealed that bamboo can decrease topsoil erosion in sloping croplands Lu *et al.*, (2018) ^[13]. However, the intense management of bamboo has a negative effect on the soil microbial functional diversity and soil microbial activity, which are indicators of soil quality Xu *et al.*, (2008) ^[19]. However, the results of other studies reported that bamboo as a fine biochar had a positive impact on increasing the microbial community related to size, impacting C cycling by decreasing their soil enzyme activity and led to increasing (higher) CO₂ emissions Chen *et al.*, (2017) ^[6]. On the other hand, the lack of right management in the annual harvest of shoots and timber for economic purposes led to a decreasing rate of output nutrients to input nutrients in the soil, which, according to the different structures of bamboo compared to other forest plants with high nutrient absorption, can convert forest soil to poor soil. Many studies have reported that the biochar is a good application for emendation and decontamination in soil Cao *et al.*, (2009) ^[4]; Buss *et al.*, (2012) ^[2].

Additionally, with some mechanisms, such as increasing pH in soil, the biochar can lead to the immobilization of heavy metals such as Cu, Cd, Pb, and Zn in the soil Lu *et al.*, (2017) ^[14]; Houben *et al.*, (2013) ^[8]. In one study, Wang *et al.* indicated that bamboo as a biochar can reduce mobile fractions of some heavy metals, such as Cd, Cu, Mn, Ni, and Zn, in soil and enhance the physiological efficiency in soybean exposed to soil contamination by increasing the number and weight of nodules of soybeans in contaminated soil Wang *et al.*, (2018) ^[18] which has shown that bamboo species have phyto-remediation potential to detoxify soils contaminated with heavy metals with the characteristics of high metal tolerance and extreme biomass production Li *et al.*, (2017) ^[10]. Bamboo charcoal has an important role in adjusting soil pH, enhancing nutrient absorption, and improving soil structure Sun *et al.*, (2015) ^[17]. Additionally, bamboo, as a natural material, can improve the ductility and strength of the soil structure. In one study with a combination of bamboo chips with cement, the results showed that bamboo could increase erosion resistance and improve soft ground Huang *et al.*, (2011) ^[9]. In general, studies have shown that

bamboo can play an important role in improving the soil structure or can bind to the soil.

When to use bamboo for erosion control

Bamboo provides a natural, inexpensive and effective solution to control erosion and preserve terrain in a wide variety of situations. It has proven effective around the world, in Asia, Africa, Europe and the Americas. Live bamboo, especially its vigorous root network, works in different ways to:

- consolidate topsoil
- stabilize slopes
- preserve river beds
- prevent runoff
- discourage trampling
- reduce evaporation

From small-scale residential settings, to large-scale habitat preservation projects, bamboo has what it takes to hold the terrain in place. Bamboo grows easily in many climates and soil types, on flat terrain or on slopes. From warm tropics to the hillsides of the Himalayas, there are species which will thrive in nearly any environment. As the unpredictable effects of climate change continue to present new environmental challenges, including droughts and floods, resilient methods of erosion control are becoming ever more useful and necessary. Planting bamboo along water ways is a particularly effective way to limit the loss of land into riverbeds as the weather patterns change, bringing more erratic typhoons and hurricanes. Harvested bamboo is also useful as way of preventing erosion. Those long, sturdy, lightweight poles provide an ideal material for building cost-effective retaining walls in rural areas.

Erosion remedies for Indian

India has also felt its share of climate disruption, with unprecedented storms and floods, and they too are looking at bamboo for stability. The Kasaragod district has proposed the Bamboo Capital project to encourage more widespread cultivation of bamboo as a way of preventing or minimizing more landslides in the future. Given bamboo's great potential as a cash crop, policy makers recognize that using bamboo for erosion control will also confer other economic benefits to the region. Local farmers can begin harvesting bamboo within five or six years, to sell as a commodity or to use for all manner of light construction.

Best bamboo varieties for erosion control

The best kinds of bamboo for erosion control are generally those with most vigorous rhizome systems. Usually this means runners, whose roots will spread far and wide to form a web-like network that can hold the land in place. If you've ever tried to eradicate an established grove of bamboo, then you probably already know how hard it is to break up such a network. But even more important, for reducing erosion, is the depth of the roots. And some clumping bamboos, while less inclined to spread outward, actually have roots that go deeper downward.

Some of the best bamboo species for residential erosion control are dwarf varieties, which behave more like a ground cover. There are a number of them which can spread quickly and put down deep roots, without overshadowing your garden with towering culms.

Arundinaria gigantea: Giant cane bamboo or river can

bamboo is one of the only species native to North America. This running variety once covered great swaths of the Deep South, but now only grows in more limited areas. It's a relative cold hardy species with deep roots, and slender canes than grow 15-20 tall.

Arundinaria tecta: Another species native to North America, this is the shorter version, which only grows about 6-8 feet tall.

Bashania fargesia: Also known as "windbreak bamboo", because of its long, sturdy culms. Leaves are long and thick, and the culm internodes are unusually long. This cold hardy variety is good in zones 7-10, and gets about 20-25 feet tall, with culms up to 2" thick. Beware, this species is an especially fast-spreading runner, with long rhizomes, quite capable of becoming invasive.

Bamboo leaf ash use as stabilizer for soft soil treatment

The soil settlement problem, preventive measures have to carry out by strengthening the soft soil. Bamboo leaf ash will act as a stabilizer to improve the strength of the soft soil. A mixture of bamboo leaf ash, ordinary Portland cement and soft soil can be applied as the treatment method to the soft soil. Bamboo leaf ash and ordinary Portland cement will acts as a cementitious material which will improve the shear strength of the soft soil. The increase of shear strength will make the soil capable of resisting load that act on it. Thus, the problem related to soil settlement can be prevent. Therefore a stabilizer is needed to be fused with the soft soil in order to stabilize the soft soil and help to achieve the standard strength for the construction of structures. Stabilizer is a substance that can change the properties of the soft soil in order to meet the standard requirement for engineering purpose. Bamboo is a type of plant and natural resource that have high rate of growth and high yield strength.

Recent study shows that Bamboo leaf ash can act as a stabilizer to the soil. Bamboo leaf ash contains a pozzolanic material that is the main component that will produce the cementitious component when reacts with the ordinary Portland cement. The process of this action is called pozzolanic reaction. Pozzolanic reaction is a reaction that will produce additional calcium silicate hydrate in the mixture of bamboo leaf ash, ordinary Portland cement and soil. Result from the reaction will make the soil denser which is more suitable for the construction and fulfil the standard requirement soil strength.

Soft soil is a type of soil that is found on the bed and onshore of ocean. Recent study shows that there is a lot of deposited soft soil especially marine clay at the Malaysian costal. Marine soil can be classified as the soft soil and has characteristics of high void ratio, poor consistency, very high compressibility and low value of shear strength. As for the physical characteristic, marine clay has high value of moisture content. Marine clay is considered as uneconomical. The presence of this clay is very problematic. There are many cases where the major contribution of soil settlement is from the soft clay. Clay needs to treated in order to strengthen the soil.

Why is bamboo so good at carbon sequestration?

Carbon sequestration refers to that process which happens in conjunction with photosynthesis. Like all plants, bamboo takes in sunlight, water and carbon dioxide, and turns it into

vital nutrition (i.e. sugar) and releases essential (to humans) oxygen. Carbon remains as a bi-product of this miraculous formula, and gets stored, or sequestered, in the roots of plants and trees. The carbon, stored inside the plant's biomass, is called a carbon sink. Carbon sinks are a crucial to the earth's ecosystem and for keeping the atmosphere in equilibrium. As carbon levels in the atmosphere continue to rise, the dangers associated with climate change grow more severe.

Bamboo leads to the way towards net-zero carbon

Net zero refers to the desired balance between the quantities of carbon and greenhouse gases being released into the atmosphere and being removed from the atmosphere. Because of its tremendous capacity for capturing and storing carbon, bamboo can play a vital role in the move towards net-zero carbon. And with more and more corporations, countries and municipalities setting net zero goals, we can be sure that bamboo will only grow in popularity.

Pursuant to the Paris Climate Agreement of 2016, the European Union and a number of countries like Canada and Chile have pledged to achieve net-zero climate-neutrality by 2050. Other countries, like Austria and Finland, have set even more ambitious goals, to be carbon neutral by 2040 and 2035, respectively. The state of California aims to be neutral by 2045.

One way for companies to achieve carbon neutrality is through what's called carbon trading. This market-based solution allows business who are carbon negative (capturing more than they emit) to earn carbon credits and sell them to businesses which are carbon positive. In this way, companies with higher emissions can still achieve carbon neutrality by supporting carbon positive enterprises.

Conclusions

The ability of bamboo to improve soil quality and growth habits while reducing carbon emissions. Bamboo can lessen our reliance on more intense carbon emitters like plastic and concrete because it is a versatile building material. Governmental agencies and international efforts can aid in spreading knowledge of bamboo. It can draw on lessons learned from the leading nations in this area, like China, in this regard. The worldwide bamboo market is anticipated to expand significantly over the next few years as a result of the strong demand for the use of environmentally friendly green products.

On the other hand, using bamboo as a cheap building material encourages nations to use bamboo in the construction of towns and cities, which can significantly advance the growth of the global bamboo trade. The authors' objectives in writing this review article were to explain how bamboo plants are used in modern society, explain some of the processes that contribute to bamboo's strength and growth, and bring to light some previously unmentioned but crucial contributions bamboo plants have made to reducing climate change and global warming.

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