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The role of soil properties and it's interaction towards quality plant fiber: A review

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ABSTRACT

In recent years, the use of plant fibers has increased tremendously due to the remarkable variations in chemical and physical properties. Plants require light, water, and nutrients for growth, reproduction and efficient crop production. Plant nutrients are mostly absorbed by plant roots from soil. For satisfactorily plant growth, it is urgency that soil provides a favorable environment for root development that can exploit the soil sufficiently. Water exists in soil as a thin film which has very different properties to that of a bulk volume of the same water. The organic part forms complex interactions with the water, minerals, solute, and microorganisms of the soil, compounding the complexity of the system. Furthermore, soil is a dynamic open system, continually subject to inputs and losses of energy, water, organic and inorganic materials, and supports the plant structurally. The physical, chemical and biological properties of soil lead to a series of physiological, biological and chemical changes along with growth, yield and quality of the plant biomass, and thus of fibers. The purpose of this review is to summarize the impacts of the soil properties on the physical and morphological structure of plant fibers growth. The present study further demonstrated the interaction effects and sustainability of soil properties to produce quality plant fibers.

Contents

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1. Introduction

Plant fibers have recently gained researchers attention due to the environmental concerns, sustainability. technological advancement, flexibility and availability for diversified industrial products including pulp and paper, rope, cords, reinforcement in composite matrices [1]. The uses of plant fiber reinforced composites have been increasing significantly because of their improved property, which is competitive to the synthetic composites [2,3]. Moreover, the natural fibers have become promising viable alternatives to glass fibers either alone or in combination with many other materials [4]. Each fiber consists of long cells with thick cell walls which make them stiff and strong with low density due to the presence of cellulose. Like other biological products, it has also a wide range of variations in their properties coming from various sources such as genotype, soil, climate and agronomic practice, which influence the chemical composition and structural organization of the cell wall polymers and thereby the fiber properties [5].

Soil is one of the most important natural resources for crop production [7]. For efficient crop production, it is important to understand the soil environment to identify the limitations of the environment and ameliorate the possibility without damaging the soil quality. Soil consists of mainly clay, silt, sand, gravel sized particles, organic materials arising from the growth of flora and fauna [7,8]. The root system of a plant absorbs water and nutrients from soil and maintains the supply of it to the plant root for continuous growth and development of the plant. However, plant roots do not have an intrinsic ability to find water and nutrients in soil. Most plant root systems have a symbiotic relationship with soil mycorrhizal fungi, which influences on plant growth. Thus, the growth of plant largely depends on the quality of the soil where it grows, and different species respond and express their tolerance in a different ways.

Fiber growth and development is affected by most factors which influence plant growth [8]. Since the fiber is primarily cellulose, any influence on plant production of carbohydrate will have a similar influence on the fiber growth [7,8]. Moreover, the factors influence the chemical composition and structural organization of the cell wall polymers, ultimately affect the properties of plant fibers [6]. Soil is one of the most important factors which influence plant growth [7]. Soil composition, physical, mechanical, chemical and biological properties affect the plant physical, physiological and chemical properties, thus, affecting the fiber quality. There are limited studies have been conducted on the interaction effects between plant fibers and soil properties. Therefore, the present review article was conducted with the aim to evaluate how the soil and its component influence the physical and morphological properties of the plant fibers. The best soil type, which most influences the good quality of fiber, was determined. Moreover, the interaction between soil properties and plant fiber was also assessed in the present study.

2. A brief review of the plant fibers

In nature, there is a wide range of natural fibers which can be eminent by their origin. Precisely, natural fibers can be divided into three categories including animal fibers, mineral fibers, and plant fibers. Plant fibers are renewable natural resource, which are biodegradable, recyclable and eco-friendly [9]. Generally, plant fibers are sophisticated in structure. It is referred as cellulosic or lignocellulosic fibers due to compose mainly of cellulose, hemicelluloses and lignin [10]. The plant fibers consist of a group of macrofibrils arranged in the cell wall layers, which are composed mainly of elementary fibrils consisted 30–36 cellulose molecule chains that cross-linked by other components of the cell wall [11]. The schematic design of cellulose fibers and its properties is shown in Fig. 1.

Fiber derived from plants can be defined as a dead cell, hollow at maturity, exists in bundle in all types of fiber except in seed [12]. Bast fiber consists of filament groups and each group has 15–30 pieces linked by middle lamellae [4]. The middle lamellae consist of various substances including pectin, lignin, and hemicelluloses. According to Olesen and Placket [13], the structure and combination of these substances have given the plant fiber unique properties like

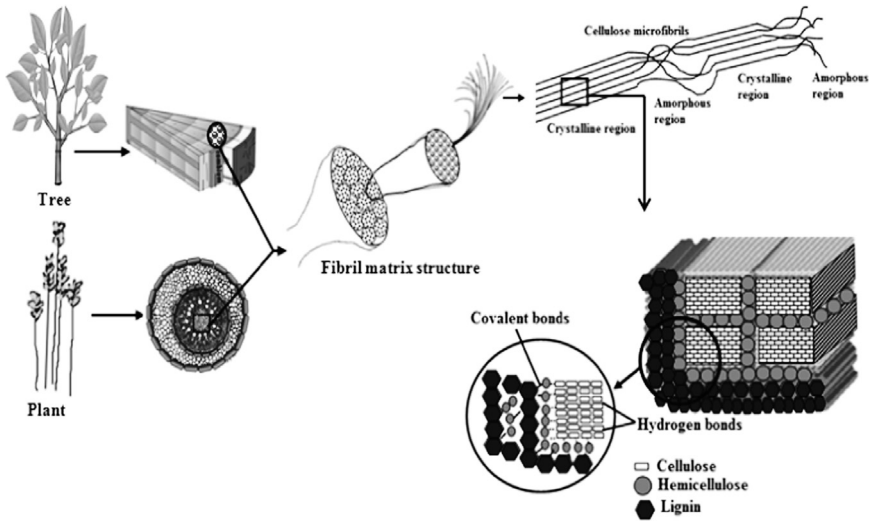

Fig. 1. The schematic design of plant fiber and its structural properties.