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Roles of mulberry tree

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Abstract

The silkworm, being a phytophagous insect feeds exclusively on mulberry leaf during its larval stages which account for nearly half of its total life span. Mulberry leaf is the sole food plant of silkworm (*Bombyx mori* L). Mulberry is a perennial, woody deciduous plant. Besides being food to silkworm, the roles of mulberry trees in prevention and control of desertification, water and soil conservation, management of saline land besides as forage for livestock, fruit for preparation of jam and jelly, leaf for preparation of green tea. Mulberry has very strong root system. Its roots form a greatly crossed and densely network in soil. Mulberry plantation is highly capable of suppressing sand storm and conserving water and soil. Mulberry root system can effectively improve the shear strength of soil and increase anti erosion capacity of soil. The transpiration coefficient of some drought resistant mulberry varieties is low as 274, being lower than that of *Populus diversifolia* (300), *Elaeagnus angustifolia* (383), seabuckthorn (483) and poplar (513). The wilting coefficient of some drought resistant mulberry varieties is 9, being lower than that of wild apricot (13), white elm (13) and Poplar (13), demonstrating that mulberry adapts to dry climate. Mulberry plants contains moranolin (DNJ), Moran (glycopeptides), hydrophobic flavonoids (flavones and flavonone) and 2-arylbenzofuran which play main role in hypoglycemic action. Mulberry leaf has many kinds of mineral substances especially high content of K and Ca. In 100 gram dry mulberry leaf, there are 3101 mg K and 2699 mg Ca, which is higher than the Calcium content in red shrimp (2.2%) or fish powder. Mulberry plant is one of the traditional herbs which are used in medicine from centuries before. Due to its pharmacological properties mulberry is used as medicine currently in many countries. Mulberry is proved in protecting liver, improving eyesight, facilitating discharge of urine, lowering of blood pressure, anti-diabetic and controlling weight in humans as well as animal models. It is the need of the hours to explain its medicinal value by Indians. Therefore, the scope of sericultural industry increases besides a very important role in pharmaceutical industry. The present review paper introduces the economical values as well as the applications of mulberry trees.

Keywords: Silkworm, economic value and mulberry tree.

Introduction

Mulberry leaf is the sole food plant of silkworm (*Bombyx mori* L). Mulberry is a perennial deep rooted, woody deciduous plant. The primary role of mulberry is that its leaves are used as a food for silkworm. The other roles of mulberry trees in prevention and control of desertification, water and soil conservation, management of saline land besides as forage for livestock, fruit for preparation of jam and jelly, leaf for preparation of green tea. Therefore, the scope of sericultural industry increases. Mulberry which belongs to genus *Morus* of the family *Moraceae* comprising of about 36 species (Seth and Lal, 2000) is a hardy plant found globally in almost all types of agro climates extending from tropical to temperate regions. Mulberry is a perennial, broad-leafed and is one of the earliest woody plants under cultivation. Great progress has been achieved on mulberry variety, reproduction, cultivation, pests and disease control in both basic and practical studies. Mulberry as a plant with broad geological distribution mulberry has abundant ecotypes due to natural selection. The roles of mulberry trees in the prevention and control of desertification, water and soil conservation, saline-land management. The usage of mulberry as forage for livestock, for fruit and tea preparation has been gradually explored. Therefore, an innovation occurred in the management of mulberry industry. Basically mulberry is a special economic plant which was originally under kept in the order urticales in plant taxonomy. In October 2009, *Botanical Journal of Linnaean Society* modified its classification to the order of *Rosales*, family of *Moraceae*, genus of *Morus* L. Therefore, during long term natural selection and artificial breeding there formed greatly abundant and diversified mulberry germplasm resources. Mulberry cultivation also yields mulberry fruit as a major product other than leaves for feeding silkworm.

Mulberry fruit is big and sweet. When the fruit matures, harvesting mulberry fruit is a featured local event. Fresh mulberry fruit is used for preparation of mulberry jam or squeeze juice to decoct sugar. The fruits are dried for self-consumption and for marketing. There are enterprises purchasing mulberry fruit and process them into brandy, mulberry fruit sweet wine, mulberry fruit juice and other products. Mulberry is a unique plant resource throughout the world. The leaves not only used for feeding to silkworms but also having medicinal values. The fruits of mulberry are tasty, sourish, sweet and pleasant. The contents of total flavonoid, reduced sugar, total sugar and vitamin in medicinal mulberry are all higher than other mulberry fruit. It is completely feasible and very necessary to fully utilize desert mulberry resources to develop mulberry industry for amelioration and ecological restoration of desertified land and salinated land. Meanwhile, through development of ecological mulberry industry, economic benefits of local farmers can be increased, ecological environment, economic development and social stability and develop Seri cultural industry.

Improvement in air quality and microclimate

Mulberry trees acts as good carbon sink plants. It is estimated that 1 mu mulberry trees can absorb about 4162 kg of CO₂ (equivalent to 135 kg of carbon) and release 3064 kg of oxygen each year (1 ha=15 mu). Mulberry is an ideal tree species for city landscape due its excellent features in tree form, leaf colour, growth vigour, tenacity and resistance. Mulberry is drought and flood resistant. In addition, mulberry leaves have capacity to absorb air pollutants such as Cl, HF, SO₂. Mulberry is a first-class resistant tree species against sulfur dioxide pollution. It has also high resistance to chlorine pollution. It can be planted along river sides, at field edges, on slopes, at garden corners, along roadsides, in public parks and other recreation places. The gardener's plant mulberry along the boundaries of apple orchard with the aim that rats don't damage their apple trees and it is proved right because mulberry roots release some chemicals which kill the rats. Mulberry plants are grown as street trees in some cities. Liu *et al.* (2004) reported that soil temperature of terrace land with mulberry embankment was 0.8-1.0°C higher than that without it during raining season of July to August. This confirms that mulberry tries to optimize the soil temperature depending upon environmental conditions and thus keeps the favorable conditions to promote growth and increase in yield of the crop. The 0-20 cm earth temperature was 1.7 °C lower and the maximum water holding capacity of the soil was 20.57% higher (Xiao and Shi 2006). Mulberry embankment reduces air temperature and increases air humidity. It also increases air temperature while the climate turned to cold. The mulberry trees were planted in the ridges of the terrace land for three years, compared to agriculture land without mulberry plantation, erosion ditches of the land with mulberry embankment were 35.7% less, 59.2% shorter, 61% narrower and 64% shallower (Liu *et al.*, 2007).

Conservation of water and soil consolidation

Mulberry has very strong root system. Its roots form a greatly crossed and densely network in soil. Mulberry plantation is highly capable of suppressing sand storm and conserving water and soil. Mulberry root system can effectively improve the shear strength of soil and increase anti erosion capacity of soil. As per Nan *et al.* (2011) soil shear strength was increased from 75.2kPa to 138.4kPa while soil layer was

deepened from 0-10 cm to 30-40 cm in mulberry field. Mulberry is highly capable of resisting drought and other natural hazards. It is also very effective in resisting wind and consolidating sand and soil. At present mulberry, has been used as an ecological tree species for water and soil conservation and management of ecological environment. Mulberry trees can flourish in deep, porous and fertile soil but also grow in barren soil with poor nutrients (Han 2007) [13]. Under P_H value of 4.5-8.5 and salt content 0.2% they still grow normally (Su 1998). That is the reason mulberry trees have wide distribution and vigorous growth. Mulberry trees have very strong vitality. In arid or semiarid desert area with annual rainfall less than 300-600mm, they still grow under natural condition. Even in desert area with annual rainfall less than 150 mm, they could also grow and develop (Dai *et al.*, 2009) [4, 5]. Owing to long period natural and artificial selections mulberry ecotypes with different drought resistance features have been detected. Under abundant soil moisture supply the transpiration coefficient of mulberry trees was 350-450 (Lv, 2008) [17, 18]. Under drought stress net photosynthetic rate transpiration rate and water utilization efficiency of mulberry leaves were decline (Ji *et al.*, 2004) [14]. The transpiration coefficient of some drought resistant mulberry varieties low as 274, being lower than that of *Populus diversifolia* (300), *Elaeagnus angustifolia* (383), seabuckthorn (483) and poplar (513). The wilting coefficient of some drought resistant mulberry varieties is 9, being lower than that of wild apricot (13), white elm (13) and Poplar (13), demonstrating that mulberry adapts to dry climate (Hu and Zhou, 2010). Investigations showed that adult mulberry trees could survive from an inundation of 20d during their growth period. This is very rare among other xerophytic plants. Mulberry trees have very strong endurance to waterlogging in dormant stage. Mulberry being a tree species with best growth after emergence of the hydro fluctuation belt (He *et al.*, 2007) [10]. Mulberry trees can resist chilling and freezing of -30°C and endure high temperature of 40°C (Zhao 2009) [31]. Dormant mulberry trees have highest resistance against chilling and it has also certain resistance against chilling at growth stage (Chen *et al.*, 2006) [3].

Beneficial utilization of mulberry and sustainable development

Mulberry is an ecological tree and not only brings good ecological benefit but also yields high economic income. Nothing goes waste in sericulture industry, the mulberry leaf, fruit, stem and bark can be utilized and easily integrated with other industries. The mulberry plant is the only food to silkworm (*Bombyx mori* L.) Which produces silk, the queen of textiles. Mulberry leaves are major harvested product from mulberry tree cultivation and have been used as forage for silkworm larvae. In 2000, FAO of United Nations held an Internet conference on "Mulberry for Animal Production". Mulberry leaf is a kind of forage resource with complete nutritional composition. One mu mulberry field produces 500-800 kg of dry leaf (fresh mulberry leaf contains about 70% moisture). Crude protein content is approximately 22 -25 % in dry mulberry leaf. It is thus calculated that one mu mulberry leaves would yield 110 kg protein, equivalent to protein content in 200 kg of soybean. In addition, dry mulberry leaf contains about 6% of crude fat and about 25% soluble carbohydrates. The nutritional value of mulberry leaf is 80%-100% higher than grass and 40%-50% higher than leguminous pasture (Xu, 2004; Sanchez, 2001) [28], [21]. Its

nutritional composition is close to that of alfalfa, an excellent forage grass. Experimental data show that crude protein, crude fat, crude fiber, nitrogen-free extract, crude ash and calcium content in mulberry leaf are all obviously higher than three green forages, namely alfalfa, fresh corn stalk, and corn silage. Mulberry leaf has many kinds of mineral substances especially high content of K and Ca. In 100 grams, dry mulberry leaf, there are 3101 mg K and 2699 mg Ca, which is higher than the Calcium content in red shrimp (2.2%) or fish powder (Xu, 2004; Sanchez, 2001) ^[28], ^[21]. Although total crude protein and amino acid content in mulberry leaf are lower than soybean powder, the composition of each amino acid in mulberry leaf is close to that of defatted soybean powder. Mulberry leaf has high content of the essential methionine whereas defatted soybean powder contains very little. Moreover, mulberry leaf is rich in vitamins including flavonoids, flavonoid glycosides, steroids, volatile components and microelements, being favorable to improve disease resistance of livestock and poultry (Liu *et al.* 2001) ^[18]. Livestock has very high digestion rate to mulberry leaf, which generally reaches 70%–90% palatability (Ye and Ye 2001) ^[29]. When mulberry leaf is used as the supplementary feed to milk-producing cows, milk output was increased and forage cost was reduced. Dry mulberry leaf is not only used to feed cattle's and goats but also to mix with other forage for feeding other livestock. Generally, the suitable amount of dry mulberry powder is 5%–10% for chicken and 10%–15% for rabbit (He *et al.* 2005). The utilization of mulberry leaf as livestock and poultry forage has broad perspective, especially in ecologically vulnerable areas. It is believed that combine mulberry cultivation and livestock husbandry can lead to coordinated development of both ecological and economic benefits.

Mulberry fruit

Mulberry fruit has several different colors and the fruit is generally 2-5 cm long and 1.2-1.6 cm thick. Its pulp is white or purple and tasty and refreshing, sweet, and free of toxin. It is a special fruit with unique flavor in fresh fruit market. Mulberry fruit is listed as the third-generation fruit. It is rich in nutrition and complete with all nutritional indexes significantly higher over other common fruits. Its vitamin and niacin contents are several times to those of apple, which is a natural and nutritious product for health. Mulberry seeds are rich in fatty oil ranging from 25% to 32%. The oil is mainly composed of linoleic acid and oleic acid, both of which are essential fat of human body and have broad perspectives for further development and utilization. Fresh mulberry fruit contains 16 kinds of amino acids, 7 kinds of vitamins, minerals such as zinc, magnesium, calcium and microelements which are deficient in human body. It also contains carotene, pectin and cellulose as well. In addition, during the growth period of mulberry fruit generally no pesticide is applied in mulberry field. Hence, mulberry fruit is a kind of ideal "green food" (He *et al.* 2005) ^[11]. Mulberry fruit tastes sweet and succulent. It is good to the internal organs and the joints of human body. It has various healthcare and medicinal effects such as nourishing liver and benefiting kidney, consolidating yin and nourishing blood, alleviating rheumatism and treating dizziness, and promoting saliva generation, and releasing thirst. Modern medical studies indicate that mulberry fruit is used to increase the percentage of macrophage and the phagocytic coefficient, promote transformation of lymphocytes, and improve T-cell mediated

immune function. Mulberry fruit can obviously help the growth of hematopoietic cells, facilitate the recovery of injured and reduce red blood cells and hemoglobin proteins to normal level within a short period, and promote the recovery of hematopoiesis. The resveratrol existing in mulberry fruit can stimulate the expression of some human genes to inhibit the growth of cancerous cells, to prevent cell mutations caused by carcinogen, and to release hydrolyases from lysosome to disassemble cancerous cells (Du *et al.* 2007) ^[6].

Mulberry for tea and medicine

Mulberry buds and leaves are used to prepare good taste mulberry tea. Crude protein in mulberry tea contains 17 kinds of amino acid, among which 15 are essential ones to human body. Mulberry tea also contains carbohydrate, fat, vitamin, chlorophyll and rutin, all of which can be easily absorbed by human body and are favorable to human health. Mulberry tea has the effects of calming liver, improving eyesight, and evacuating wind-heat, being a healthcare drink suitable to all ages (Wang *et al.* 2011) ^[26]. Multiple parts including its root, root bark, leaf, twig and fruit of mulberry tree have much significance in traditional Chinese medicine. In recent years, many clinic application studies have discovered that the chemical components of mulberry tree have various pharmacological functions such as reducing blood sugar level, reducing blood lipid level, lowering blood pressure, anti-bacteria, anti-virus, antitumor, delaying aging, anti-filariasis, spasmolysis and antiulcer (Su, 2010; Guo, 2008) ^[24] ^[8].

Applications of mulberry trees in vulnerable ecological environment

Mulberry planting in ridges of terrace land has significant effects in preventing soil erosion, water conservation, and soil resources and improving soil nutrients. Compared to psammophytes such as *Salix mongolica* and *Caragana korshinskii*, mulberry trees on ridges of terrace land effectively reduce runoff volume and soil erosion, reduce soil nitrogen runoff loss, and increase soil moisture utilization ratio. The combination of mulberry and grass alleviate erosion of rainwater, effectively intercept surface runoff on the slope, and change surface runoff into underground seepage. Meanwhile, the fallen leaves and shoots cover the soil to increase soil moisture containment and fertility, providing sufficient water and nutrient supply for mulberry growth. This cultivation pattern has played important roles in water controlling and soil erosion, collecting rainfall water, increasing soil moisture containment, and gathering fertilizers. As per investigation, mulberry intercropped with grass on back side of level ditches could reduce soil erosion by 124.5 tons per hectare, increase moisture content of 50–100 cm soil layer by 13%–15%, and increase organic substance content by 3%. Mulberry is very effective in preventing wind and consolidating sand. In arid and semi-arid areas, wind erosion is the primary factor that causes land desertification. Mulberry clusters are grown in shrub form on sand plots of a large area divided as per landform. Mulberry cluster is very effective in preventing wind and consolidating sand. In arid and semi-arid areas, wind erosion is the primary factor that causes land desertification. Mulberry clusters are grown in shrub form on sand plots of a large area divided as per landform. The cluster has high tillering ability. Their shoots can be bent into sand and regenerate roots to form new plantlets to expand outwards. Mulberry clusters have very strong root system. Root system occupies a room

7.9 times to that of tree crown, bringing a very good effect in preventing wind and consolidating sand. Mulberry trees are frequently grown as protection forest. Mulberry has well-developed root system and stretched crown, can reduce wind velocity, repressing wind and sand movement, and protecting crops in farmland. As per records cotton crop in farmland with protective mulberry suffered a loss of output by 47.57%, wheat by 23.03% and corn by 44.43%, while cotton, wheat and corn crops in farmland without protective mulberry were devastated and lost productivity by over 90%.

Mulberry for other purposes

Mulberry tree is used in food and chemical industries (Hua *et al.* 2007) [13]. The food additives and cosmetics made from mulberry leaf and fruit have been available in the market. A special edible carbon made from carbonization of mulberry root and stem has been widely used as food additive. Recombined wood boards and bars made from mulberry branch can be used to substitute wood logs for making floor boards, door jambs, and wooden models of buildings, furniture, and parts of wooden structures. Mulberry branches substitute miscellaneous woods or cotton seed hulls for producing various edible fungi such as mushroom such as *Lentinus edodes*, *agaric*, *Ganodorma lucidum*, *Flammulina velatipes*, and *Pleurotus ostreatus*. Meanwhile, it is an excellent raw material for paper making and active carbon production. Mulberry branch has quite high unit combustion value, being an excellent biomass fuel. Mulberry twigs are used to make skin care agent. Mulberry bark fiber has excellent characteristics of natural fiber, being good raw material for making high rank paper (Dai *et al.* 2009; He *et al.* 2005; Lin *et al.* 2008; Qin *et al.* 2010) [4, 5] [11] [17] [20].

Perspectives

Mulberry is a fast-growing woody plant characterized by deep roots, flourish leaves, high resistances to pollution, wind, sand, drought, and salinity with strong adaptability and easy cultivation. The broad ecological adaptability of mulberry to light, temperature, water, soil and other natural conditions objectively enables it to have multiple ecological protective functions in water and soil conservation, wind resistance and sand consolidation, water source preservation, and air refreshment. As a traditional economic woody plant, mulberry also has great values for comprehensive development and utilization. It is an excellent tree species with both ecological and economic benefits for water and soil conservation and ecological environment construction. Thousands of years of experiences in mulberry cultivation and silkworm rearing have accumulated rich achievements in mulberry genetic resources, mulberry biological characters, and mulberry cultivation technology and mulberry industry development. At the present, ecological safety has become one of the important components of national safety and ecological mulberry industry has a good opportunity for advancement. Development of ecological mulberry industry not only plays important roles in comprehensive control of ecological environment but also realizes higher level sustainable development of nature-resource-economy-society in ecologically vulnerable areas. In the future, mulberry ecological industries of different patterns will be established as per the local land condition and market demand in different ecological areas. Through optimized and comprehensive utilization of mulberry resources, a positive feedback mechanism will be established. That is, to achieve

optimization of ecological effect and maximization of economic benefit of mulberry ecological industry. Thus, a successful example on vegetation restoration with both ecological and economic benefits will be set and referenced for environmental control of typical ecologically vulnerable areas and for sustainable development of ecological environment and economic construction in different ecological areas (Qin *et al.* 2010) [20]. The traditional medicinal systems which are based on herbal plants. Mulberry is used as herbal medicine for reducing blood serum glucose (Andallu *et al.*, 2001) [1]. The extracts of leaves and roots of mulberry plants having hypoglycemic properties and it is used in the treatment of diabetes (Andallu and Varadacharyulu 2002, Kelkar *et al.*, 1996) [2] [16]. Mulberry plants contains moranolin (DNJ), Moran (glycopeptides), hydrophobic flavonoids (flavones and flavonone) and 2-arylbenzofuran which play main role in hypoglycemic action (Singab 2005, Fallon 2008) [22]. Katsube (2006) [15] conducted a study on mulberry leaf extract and found that mulberry leaf extract acts as a natural inhibitor of α -glucosidase due to deoxyojirimycin (DNJ) and its derivatives. The pharmacological properties of *Morus Alba* include anti-platelet, anxiolytic, anti-asthmatic, anthelmintic, antidepressant, cardio protective, and immunomodulatory activities. Clinical trials on the efficiency of *M Alba* extracts in reducing blood glucose and cholesterol levels and enhancing cognitive ability have been conducted. The photochemistry and pharmacology of the different parts of the mulberry tree confer its traditional and current uses as fodder, food, cosmetics, and medicine. Overall *Morus Alba* is a multifunctional plant with promising medicinal importance. Wang *et al.* (2014) isolated three new alkaloids, mulbaines A (1), B (2) and C (3). The structures of these compounds were elucidated on the basis of spectroscopic methods. Singhal *et al.*, (2010) [23] methanolic extract of mulberry leaves shows efficient cytotoxic behavior against cancer cells. They identified many compounds like Kuwanon S, 8-granilapigenin, Ciclomulberrin, Ciclomorusin, Morusin atalantoflavones, and kaempferol with the action strong cytotoxic cell lines HeLa, MCF-7 and Hep3B. Zhang (2009) [30] conducted a short-term study on root bark of *Morus Alba* and isolated a flavanics i.e. glycoside, 5, 2 - dihydroxiflavanone-7, 4-di-O-D-glucoside, which prevents cell proliferation of human ovarian cancer cell HO-8910. Therefore we suggest that mulberry plant is a —kalpavrakshal which can be utilized for making silk and pharmaceutical's. Further research is needed for explained its highly useful medicinal properties.

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