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PROSPECTS AND CHALLENGES OF *STEVIA REBAUDIANA* CULTIVATION IN BANGLADESH

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Abstract

Stevia, a non-caloric natural sweetener, is safe for people with diabetes and has medicinal value that might receive greater focus in the future. Bangladesh Sugar crop Research Institute (BSRI) has released a variety of stevia (BSRI Stevia-1) as well as the production technology for the farmers, considering the agro-climatic condition of the country, and its commercial cultivation has started on a limited scale. Stevia is becoming popular with diabetic patients with teabag as an alternative source of sugar. It requires high yielding and stress-tolerant varieties, better agronomic management technology such as fertilization, irrigation, intercultural operation, and improved post-harvest processing technologies to increase stevia production. In Bangladesh, there has not been a stevioside extraction plant yet. The farmers have been manually producing stevia powder as their final product, which is comparatively less attractive to consumers. An established marketing channel has not been developed yet. Extensive research work, extension activity, and suitable policy regarding stevia cultivation, processing, and marketing can open the door to a golden opportunity for profitable commercial stevia cultivation in Bangladesh.

Keywords: Stevia, Stevioside, Cultivation, Processing, Management.

Introduction

Stevia is a sweetener made from the leaves of the plant *Stevia rebaudiana*, which is found in the Rio Monday valley's highlands, Mexico (Katayama *et al.,* 1976). The South American indigenous people (Guaran) have been using the plant for over 1,500 years, and it has another name is ka'a he'ê, which means "sweet herb" (Misra *et al.,* 2011). Steviol glycosides (mostly stevioside) are the active ingredients, and they contain 30 to150 times more sweetness to sugar (Cardello *et al.,* 1999). The popularity of Stevia as a high-potency sweetener is growing rapidly around the world (Khan *et al.,* 2012), and its cultivation area has reached about 32,000 hectares globally, with China accounting for 75% of the total (Hossain *et al.,* 2017). Commercial stevia farming is also practiced in Brazil, Paraguay, Central America, Thailand, and Korea, and several other countries have begun to do so (Megeji *et al.,*2005; Madan *et al.*,2010). Stevioside have insulinotropic actions in pancreatic beta cells, increasing insulin production and lowering the glucose level in the blood, according to research. Due to zero calories, the plant can consider the replacement of sugar for people who are suffering from diabetes and obesity (Midmore and Rank, 2002). Stevia in its raw form, fresh or dried, helps to reduce several health complications like diabetes, allergies, digestive problems, anxiety, and high blood pressure; and stevia also contains several nutrients like vitamin C, calcium, beta-carotene, niacin, iron, magnesium, potassium, proteins, and fiber (Hossain *et al.,* 2017). Therefore, it is essential to dry the plant leaves to reduce the detrimental effects of heat and to retain the sweetening and medicinal properties of the plant (Cuervo *et al.,* 2012). Considering the significance of stevia, its production in Bangladesh has a promising future, as the sweet compounds found in stevia pose no health risk to diabetic people, as diabetes is an epidemic (King and Rewwers, 1991). Between 2019 and 2025, the global stevia market is estimated to increase at a compound rate of 3.84 %, while in 2018, the stevia market was 895 million US$ (The Global Stevia Market Report, 2019). Furthermore, stevia farming can help to the

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national economy by substituting sugar to a large amount. The prospects and challenges of stevia growing in Bangladesh are discussed in this literature study.

History and Status of Stevia cultivation in Bangladesh

Bangladesh Sugar crop Research Institute (BSRI) was the first to import stevia from Thailand to Bangladesh in 2001. At BSRI, some preliminary morphological and physiological studies were carried out (Khan *et al.,* 2012). In recent years, BSRI and the Bangladesh Rural Advanced Committee (BRAC), Gazipur have conducted a number of laboratory researches, focusing on tissue culture techniques, and developed a method for producing stevia seedlings in vitro. It is now grown in Bangladesh, and the area under cultivation is increasing. Because of its climatic requirements, it can be introduced into the hilly areas of Sylhet and Chittagong districts of Bangladesh (Uddin *et al.,* 2006). In BSRI's Biotechnology section, a methodology for micro-propagating Stevia has been developed. The Biotechnology division of BSRI has produced Ready Tea Bags, Stevia tablets, and Stevia powder for versatile Stevia utilization (BSRI, 2020). Some nurseries in Bangladesh, particularly in the Pabna and Thakurgoan regions, produce stevia seedlings of BSRI Stevia-1 for commercial production. They also produce and sell stevia leaf powder.

Agro-climatic condition

Climate

Stevia usually grows in a semi-humid subtropical region near the Equatorial region (22-23°S latitude), 200-400 meters above the sea level, having 1,500-1,800 mm of rainfall and temperature extremes varying from -6˚C to +43˚C (Antonie, 2000). It's a semi-humid subtropical plant that produces more leaves when exposed to bright light and warm temperatures. Temperature below 20^0C and day length less than 12 hours and more than 16 hours, the growth of stevia and stevioside arehampered (Metivier and Viana, 1979; Yermakov and Kochetov, 1996). According to Verma and Panda (2018), the ideal temperature for stevia growth is between 24 and 35˚C. Stevia seed germination rates rise when temperatures are between 20 and 25˚C (Esra *et al.,* 2016). High temperatures and water stress are bad for vegetative growth as they induce blooming during the growing season. Some varieties, however, appear to be photoperiod insensitive. The stevioside concentration of early flowering lines is higher, but the total yield is lower (Ranjan *et al.,* 2011).

Propagation

Stevia multiplication can be accomplished in three ways: tissue culture, stem cutting, and seed germination. In vitro propagation methodology of Stevia plants has been developed at the Biotechnology Laboratory of BSRI (Uddin *et al.,* 2006). Tissue culture necessitates highly trained personnel and a laboratory. Furthermore, Stevia seed germination is frequently low (Miyazaki and Wantenabe, 1974). Therefore, stem cutting is the simplest and most cost-effective way of stevia multiplication, and it is getting popular in Bangladesh.

Planting time and plant population

The most important agronomical elements that can affect the product quality and quantity are planting density and transplanting date (Megeji *et al.,* 2005). For stevia, however, day length is more important than light intensity. The temperature has a huge impact on it as well. From November through February, Bangladesh's day duration and temperature are quite short. As a result, stevia cultivation is not recommended during this time. In Bangladesh, the 15th of February to the $30^{th}$of April is the best period to plant stevia seedlings for higher production of leaves (Khan *et al.,* 2012). Plant to plant distance and plant population are crucial factors for optimal plant growth. The spacing between plants should be kept at 20-25 cm. This would result in a plant population of 28 to 30 thousand plants per acre (Verma and Panda, 2018). Katayama *et al.* (1976) conducted experiments in Japan and attempted planting densities ranging from 40000 to 400000 plants per hectare. They observed that raising the planting density to 83,000 and 111,000 plants per hectare increases leaf production.

Figure 1. Stevia leaves

Edaphic requirements and land preparation

The soil properties and climatic conditions of the growing region have a great impact on the nutritional dosage (Pal *et al.*, 2015). 70 kg nitrogen, 35 kg phosphorus, and 45 kg potassium per hectare are recommended under average climatic conditions and soil type (Verma and Panda, 2018). In Bangladesh, a usual dose of NPKS for stevia growing is 48, 12, 16, and 6 kg ha^{-1}, respectively (Khan *et al.*, 2012). Since the feeder roots are so close to the surface, adding compost for extra nutrients is good. Stevia sometimes shows boron deficiency symptoms, such as leaf spots, which can be remedied by spraying with Borax 6%.

Irrigation and drainage

Higher crop yield and more efficient use of water resources are elicited by understanding the water requirements of crops at different growing periods. Stevia is prone to permanent wilting when subjected to prolonged drought. It also will not be able to survive if there is a lot of water. Its healthy growth requires a moist but well-drained soil environment. Water content in the soil ranged from 43.0 to 47.6%, ideal for plant growth. After transplanting, as well as before and after harvesting the leaves, it requires liberal watering. Normally, frequent irrigation is required to keep soil moisture above the plant wilting point, which is estimated to be as high as 80% of field capacity (Oddone, 1999). Supplemental irrigation should be applied at least once a week during periods of low rainfall, as moisture stress affects leaf production (Goenadi, 1983). Throughout the year, Stevia demands a steady supply of adequate water. Due to the plant's sensitivity to drought, it's essential to irrigate it frequently (Verma and Panda, 2018). Watering should be done on a regular basis to prevent water deficiency in the plants. Mulch is an effective option to reduce the impact of drought and high temperature (Hossain *et al.*, 2017) as well as to conserve soil moisture. Stevia plants could benefit from underground trickle irrigation systems.

Weed management

Weed is one of the most vital threats that can make a 2-25% yield penalty as well as raises the cost of cultivation and production (Taak et al., 2021a). Hence, potential weed management is essential for successful commercial stevia production. Whereas Taak et al., (2021a) also found that different types of organic and synthetic mulch, along with limited use of herbicides can be an important solution of weed problem in stevia farming. They also suggested rice

straw and eucalyptus leaves as a suitable organic mulch in stevia cultivation to control weeds. Moreover, genetically modified herbicide-resistant stevia can contribute efficiently in successful weed management (Taak et al., 2021b). Tabriz et al., 2021suggested using mulch (plant residue) for weed management which is also environment friendly. However, manual weeding is a common practice in Bangladesh.

Insect and disease management

Aphids, whiteflies, trips, cutworms, slugs & snails and bugs are some harmful insects for stevia cultivation that can control by using insecticide (chemical or herbal), biological control, and cultural practices (https://growers-planet.com/stevia-pests-diseases-solutions/). Besides that, leaf spot, rust, mold, root rot, and charcoal rot are major diseases in stevia farms caused by a different pathogenic fungi, bacteria, and viruses that can control by using chemical, biological and cultural practices (Koehler and Shew 2014.; Koehler and Shew 2017a; Koehler and Shew 2018.; Koehler et al. 2017b, Lovering and Reeleder 1996.; Reeleder, R. 1999).

However, commercial stevia cultivation in Bangladesh is new and sufficient literature is not available on major insects and diseases of stevia and their control, considering the agro-climatic condition of Bangladesh. So, there is potential scope for a further study addressing insect and disease management under the agro-climatic condition of Bangladesh.

Harvesting

When the leaf is fully mature, it should be harvested. To achieve the most steviol glycoside content in the leaves, they should be harvested just before flowering (Sumida, 1980). The time takes to harvest depends on the type of land, the variety, the growing season, and proper management practices. Flowering is induced by short days. The first harvest usually occurs four months after planting, followed by a three-month interval. On average, about three commercial harvests can be obtained in a year. Harvesting stevia should begin when the plants reach a height of 50-70 cm, according to Hossain *et al.* (2017). It is preferable to cut the plants around 10 cm above the ground level to allow new flushes to sprout. Cutting the branches off using pruning shears before stripping the leaves is the easiest technique of harvesting. Because the tops of the stems contain as much stevioside as the leaves, they can be trimmed off and added to the harvest.

Drying of leaves

Drying, or removing moisture from leaves, reduces the aesthetic, organoleptic, and functional characteristics of stevia plants, affecting final quality parameters such as color, texture, aroma, essential oil content, and shape. Temperature and light duration must be optimal in order to produce a high-quality product. The drying process does not necessitate a lot of heat, but it does necessitate a lot of air circulation. High temperatures have a negative impact on the product's final quality, both in terms of medicinal characteristics and commercial value (Cuervo, 2012). The herb is dried as soon as it is harvested. This can be done in a dust-free and hygienic environment. A longer drying period will degrade the final product's quality, especially the stevioside content (Hossain *et al.,* 2017). They also suggested an efficient drying procedure considering drying procedure, time, and temperature as i) plants that have just been harvested can be hung upside down and dried in the shade. It can also be dried within transparent poly houses or clear glass roofing using simple drying racks or by blowing dry air just above room temperature, ii) in the case of large-scale manufacturing, the stem, and soft green leaf material are dried soon after harvesting using a drying wagon, a kiln, or naturally, iii) drying stevia takes roughly 24 to 48 hours at 40 to 50 degrees Celsius. During the dry season, when the sun is shining brightly, it takes around 12 hours for stevia to dry in the sun. Although sun drying is ideal, a home dehydrator can also be used. The leaves are stripped of their stems/twigs, packed, and stored in a cold, dry area after they have dried sufficiently. Artificial drying and threshing can be used in commercial production.

Nutritional components in plant leaf

Stevia leaves contain about ten sweetening glycosides (sweetest compounds), including stevioside (3-10%), rebaudioside-A (13%), and rebaudioside-B, C, D. (Singh and Verma, 2015). Other similar substances found in stevia leaves include Rebaudioside C (1-2%) and Dulcoside A & C, as well as minor glycosides such as flavonoid glycosides, coumarins, cinnamic acids, phenylpropanoids, and essential oils with antioxidant potential (Taleie *et al.*,2012; Kinghorn, 1987). Eight phytochemical properties of stevia glucosides were discovered, viz. glucosides A, rebaudioside

A-E, stevioside, and stevioside (Kinghorn et al., 1984). Furthermore, the triterpenes amyrin acetate and three esters of lupeol, as well as sterols such as stigmasterol, sitosterol, and campesterol, may be isolated from the leaves (Nabeta, 1976). Several nutritional components are shown in Table 1.

Table 1. Nutritional component of *Stevia rebaudiana* leaves

	Component	**Amount**	**References**
Sweet glycosides in *Stevia rebaudiana* leaves (% of the leaves dry weight).	Stevioside	2.0	Jaworska *et al.* (2012)
	Steviol	0.70	
	Steviolbioside	1.2	
	Rebaudioside A	5.0	
	RebaudiosideB	0.50	
	Rebaudioside C	2.0	
	Rebaudioside D	3.3	
	Dulcoside A	1.0	
	Stevioside	2.0	
Proximate analysis of dried *Stevia rebaudiana* leaves (g 100 g^{-1} dry weight basis).	Moisture	5.37	Abou-Arab *et al.* (2010)
	Protein	11.40	
	Fat	3.73	
	Ash	7.41	
	Carbohydrate	61.9	
	Crude fibre	15.5	
Fatty acid composition of *Stevia rebaudiana* leaf oil (g 100 g^{-1}).	Palmitic acid (C16)	29.5	Atteh *et al.* (2011)
	Palmitoleic acid (C16-1)	3.0	
	Stearic acid (C18)	4.0	
	Oleic acid (C18-1)	9.9	
	Linoleic acid (C18-2)	16.8	
	Linolenic acid (C18-3)	36.2	
Amino acid composition of *Stevia rebaudiana* leaves (g 100 g^{-1} dry matter).	Arginine	0.81	Li *et al.* (2011)
	Lysine	0.15	
	Histidine	0.34	
	Phenyl alanine	0.88	
	Leucine	1.30	
	Valine	0.94	
	Threonine	0.75	
	Isoleucine	0.72	
	Aspartate	1.72	
	Serine	1.02	
	Glutamic	1.90	
	Proline	1.72	
	Glycine	0.85	
	Alanine	0.95	
	Tyrosine	0.49	
Minerals content of dried *Stevia rebaudiana* leaves (mg 100 g^{-1})	Calcium	8.2	Atteh *et al.* (2011)
	Phosphorus	2.6	
	Sodium	0.7	
	Potassium	17.3	
	Iron	366	
	Magnesium	2.4	
	Zinc	20	
Water-soluble vitamins of Stevia rebaudiana leaves (mg 100 g^{-1} dry base of extract)	Vitamin C	14.97	Kim *et al.* (2011)
	Vitamin B2	0.43	
	Vitamin B6	0.00	
	Folic acid	52.18	
	Niacin	0.00	
	Thiamine	0.00	

Stevia leaves provide a calorie-free source of sugar. There are sweet components surrounded by bitter components in the veins (Maiti *et al.,* 2008). Teabags with powdered or green leaves have become increasingly popular. A mild stevia leaf tea can also help soothe an upset stomach (Goyal *et al.,* 2010). The leaves are used as a color and flavor enhancer as well as a sweetener in teas, salads, fruit, and coffee, among other things. Stevia is also utilized for the same purpose in the food and beverage industries. Stevioside derived from stevia leaves are currently consumed in Japan in significant quantities (Midmore and Rank, 2002).

Medicinal value of stevia

The many components of stevia have a significant medicinal value. The development of low acidity conditions and anti-plaque activity are two important medicinal effects of stevia's antibacterial effect (Basu, 2014). Stevia leaves are 300 times sweeter than sugar but have no effect on blood sugar, making them beneficial for hypoglycemia and type-2 diabetes (Midmore and Rank, 2002; Soejarto, 2002; Ramesh *et al.*,2006). Stevia also helps control blood pressure, prevent cavities, increase insulin production in the pancreas, and works as a bactericidal agent (Bhosle, 2004). The plant may contain cardiotonic properties, which help control blood pressure and heartbeat (Ranjan *et al.,* 2011). Furthermore, phenols and flavonoids found in stevia have significant antioxidant activity (Tadhani et al, 2007; Shukla *et al.,*2009) and function as secondary metabolites that lower the risk of heart disease and cancer (Dragovi-Uzelac *et al.,*2010). In Bangladesh, the usage of stevia as a medicinal herb is still minimal. Stevia's by-products, including stems, seeds, flowers, and even leaves, can be utilized as fertilizer or animal feed.

Prospect and challenges of stevia cultivation in Bangladesh

Around 90 varieties of stevia have emerged worldwide based on climatic requirements (Verma and Panda, 2018), with only one kind suggested for Bangladeshi farmers. That got popular for commercial cultivation to some extent in Bangladesh. In order to achieve high yield and stress tolerance, more stevia varieties are required. However, BSRI is working on releasing more varieties suitable for our agro-climatic conditions. Angelini et al. 2018 revealed that interest toward stevia as alternative sweetener increased worldwide in the last years that provides a strong incentive to explore the possibilities of cultivating stevia and producing leaves and extracts. Similarly, prospect of stevia production is also present in Bangladesh.

Furthermore, when considering economic and environmental factors, agronomic techniques and effective mechanization technologies are insufficient for the production and processing of a higher quality product. To ensure the highest output of quality leaves, several agronomic parameters such as cultivar selection, propagation, transplanting, weed management, nutrition, irrigation, harvesting technique, and post-harvest management must be improved. It also requires crop quality management throughout the production chain, as well as preferential market access for stevia products.

Conclusion

Stevia, a natural source of non-calorie sugar, is gaining popularity as a sweetener option for diabetics, and commercial cultivation is expanding in various parts of the world. Bangladesh's agro-climatic condition is favorable for stevia cultivation. This plant, including its production technology, has been introduced to Bangladesh by BSRI. In some places of Bangladesh, commercial manufacture and consumption of stevia have begun. Stevia plant multiplication is difficult because just one variety is recommended for cultivation, seed germination is poor, and tissue culture is not affordable for Bangladeshi farmers. Only stem cutting is suitable for stevia seedling production. Lack of variety, absence of a Stevioside extraction plant, multipurpose usage of stevia, and a strong marketing channel have all been identified as barriers to stevia expansion in Bangladesh. However, stevia cultivation and processing technology research and extension activities should be strengthened, as well as a viable marketing channel should be developed.

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