Sphagnum Producing Biomass

S. Sreeremya
Assistant Professor
Department of Biotechnology,
Sree Narayana Guru College, Coimbatore, Tamil Nadu
Corresponding Author's E-mail: *sreeremyasasi@gmail.com*

Abstract

Sphagnum culturing refers to the cultivation of Sphagnum mosses to synthesize Sphagnum bio mass sustainably. Peat land or wet land are the regions in which biomass can be sustainably produced. This paper discusses about the different aspects of sphagnum cultivation and its biomass production.

Keyword: - *Sphagnum, biomass, peat land, wet land*

INTRODUCTION

Peatlands are wetland ecosystems that are distributed across the boreal and subarctic regions of the world. They cover about 3%-3.5 % of the global land area, and represent at least half of the world's wetlands.

In these ecosystems, net primary production (NPP) exceeds decomposition, resulting in the typical formation and accumulation of carbon-rich peat deposits that can be up to tens of meters thick (Fig:1).

Fig: 1 Peat pellet

Since the last deglaciation, peatlands have accumulated over 600 gigatons of organic carbon (GtC) globally, which constitutes up to about a third of the global soil organic C (Rydin et al., 2013). Many paleoecological and modeling researches have shown that inter-annual, centennial, and millennial changes in peat-C accumulation rates are mainly controlled by the regional climate, and that warming might promote peat-C sequestration in temperature-sensitive regions by elating NPP more than decomposition (Rice et al., 2008).

These results point to a potential increase in the peat-C sink capacity under the ongoing and projected climate warming, which would mainly result in a negative feedback to climate change. This finding remains a matter of considerable debate, because warming is also expected to promote peat decomposition via direct enhanced microbial decomposition or indirect drying of the peat land surface (Revell, 2012).

Bioclimatic controls of peat land Sphagnum growth. Sphagnum (peat moss) forms, nearly continuous carpets that predominate the groundcover of most high-latitude peat lands. Although these bryophytes generally do not contribute the largest proportion of peat land NPP, they possess recalcitrant tissues that resist microbial break down and release phenolic compounds that inhibit microbial decomposition, making them more decay-resistant than most other peatland plants.

As a result, partly decomposed Sphagnum remnants account for approximately 50 % of the peat land organic matter. Over time, the imbalance between synthesis and decomposition leads to the formation of Sphagnum-rich peat deposits. For this major reason, Sphagnum is often referred to as the major “peat builder”, and Sphagnum might store more organic C than any other plant genus worldwide.

INFORMATIONS ABOUT SPHAGNUM

Each Sphagnum species possesses a well-defined ecological niche that is primarily based on peatland surface-moisture conditions, with dry-adapted species forming hummocks, adapted species growing in hollows, and intermediate species colonizing lawns.

In general, Sphagnum NPP aggrandizes along this dry-to-wet moisture gradient, with highest productivity under wet conditions (Reich et al., 2003). The rate of decomposition is also highest in wet microhabitats, as wet-adapted species preferentially allocate their resources into labile metabolic carbohydrates rather than in recalcitrant structural carbohydrates.

Fig: 2 Shagnum moss

Mineral nutrient richness also influence Sphagnum distribution in peat lands with (Fig: 2), in general, a higher diversity in groundwater-fed systems (fens) and less variety in acidic, precipitation-fed peat lands (bogs). Over-all, species that inhabit wet fens (e.g., Sphagnum cuspidatum) are mainly characterized by the highest growth values, whereas dry bog hummocks (e.g.,Sphagnumfuscum) have the lowest productivity (Pinheiro et al.,2014) For example, mosses growing in wet hollows reside in a less dense carpet than mosses growing on drier hummocks .

These wet-adapted species also possess less-developed capillary water transport systems and have a typically smaller water-holding capacity than dry-adapted species. As a result, mosses growing in wet hollows are majorly responsible for the largest variability in growth rate at the local scale: As soon as the water table gets closer to the peat land surface, they grow very quickly because of efficient resource al- location strategies, but they also desiccate quickly following water table draw down. Dry adapted species are more resilient to local moisture changes, mostly because of their ability to retain moisture. For example, Sphagnum fuscum and S. magellanicumare commonly considered dry-adapted species, as they gradually grow on hummocks and lawns, where they form densely packed communities to avoid desiccation (Paradis et al., 2004).

This growth form is a consequence of the preferential resource allocation to structural carbohydrates, and results in a strongly vertical growth component. Sphagnum productivity has been the object of a sequence of observational and modeling studies over the past 30 yr .

Many investigations have found a positive relationship between Sphagnum NPP and annual or summer temperature, or higher Sphagnum productivity at lower latitudes. However; several research works have found no temperature effect or even a reduction in NPP with aggrandizing temperature, possibly because of moisture stress and dehydration (Graf et al., 2012). It was also suggested that higher evapo transpiration as a result of higher temperature might paved to reduce Sphagnum NPP.

Globally, peat land ecosystems store large amounts of soil carbon (C) while occupying only 3–5 % of the entire land surface (Gaudig et al., 2013). Northern peat lands are estimated to hold 473-622Gt of organic C, which could be at risk of oxidation in future climate conditions. Current trends and climate models predict that climate change could result in these changes in water availability could lead to shifts in water tables, mainly including large mid-summer declines in water table height (Emmel, 2008). Lowered water tables resulting from drainage have been found to cause a shift in peat lands from net carbon sinks to net carbon sources. Decreased water availability and lowered water tables could initiate significant changes in carbon balances (including methane) directly by accelerating peat oxidation and altering net primary production, and indirectly by modifying plant community composition. A varying climate could alter the absolute or relative abundance of plant functional groups (PFG) with in northern peat lands, with potential feedbacks to carbon cycling. In order to understand the plant community and peat structural response to water table position and changing PFGs. Because plant community is one of the primary drivers of C cycling in these peat lands, an understanding of how the few changes in PFG affects eco-system carbon cycling is essential(Christiansen et al.,2001).

Bogs are oligotrophic and are rain-fed, nutrient poor, acidic and predominated by three major understory PFGs: Sphagnum mosses, ericaceous shrubs, and sedges. Many bogs also have a sparse canopy of trees, in North America, typically Piceamariana (Mill.) Britton, Sterns& Poggenb, that can be often considered a fourth PFG. Within a bog, small variations in micro topography can have significant influences on the water availability for vegetation. Hummocks (relatively elevated and dry), lawns (intermediate) and hollows (wet depressions) are the primary micro topographic properties in peat lands and support different plant groups due to distance to water table (Chirino et al., 2006).

CASE STUDY

The total peat land area in Finland is 9,2 million hectares. Of this area, 280 000 ha are suitable for Sphagnum moss production. Sphagnum moss collected from the top layer of the mire was dried to 20-45% moisture content, crushed and sieved (Diaz et al., 2012). The water content in peat media was higher than in Sphagnum media, but the amount of easily available water in Sphagnum media was at least at the same level as in peat media. Suppressive properties against moulds and diseases were recorded for Sphagnum (Campeau et al., 2004). Cucumber seedlings grew quiet remarkably better in Sphagnum substrate than in rock wool. The cucumber yields were the same as in peat when the coarse Sphagnum fraction (< 40mm) was used. In other projects, harvesting technologies for Sphagnum harvest both under summer and in winter conditions have been developed (Carroll et al., 2009).

Natural peatlands represent an important component of the global carbon cycle containing about one-third of the world's soil carbon despite covering only 4 to 6% of the global land area (Brassington, 1985). The accumulation of carbon in peatlands is regulated by the balance between vegetation production and decomposition rates. The latter includes the combined decomposition of live vegetation and the well to quiet weakly humified remains of vegetation (peat). Sphagnum mosses are the predominant peat-forming vegetation in northern peat lands and a key plant in the development of most Canadian peat lands (Bragazza et al., 2004).Peat extraction for horticultural or other industrial avails in North America is usually achieved by milling the peat to let it dry by the sun and then harvesting it with the aids of large vacuums drawn by tractor. The method entails the drainage of extensive peat fields and the removal of the living Sphagnum strata's. With time a differing quantity of the underlying acrotelm and catotelmpeat are extracted (Brouns et al., 2015). This industrial process causes evapo transpiration to elate and changes the physical properties of the catotelm which restricts moisture availability. Water fluctuations, retention and soil moisture tension remain higher than pre-extraction levels even when the water table mainly rises due to blockage of drainage ditches. Active management is therefore extremely necessary to restore the Sphagnum layer .Recent research indicates it is possible to reestablish

Sphagnum vegetation cover on post-extracted Sphagnum bogs. One of the stated goals for peat land restoration in Canada, is the return of cutover sites back to peat accumulating eco systems. The rate at which the carbon balance of restored peat lands will return to the natural states will depend on the rate of production and decomposition of the restored peat land. In pristine northern peat lands, Sphagnum moss productivity averages 70 to 650 g $m^{-2}y^{-1}$depending on the year. Mass losses (% of original mass) per year will generally be in the range of 8to 25% (Buscardo et al., 2010).

For production and decomposition, no value for Sphagnum moss has been published yet for restored peat lands. It is essential to assess the rates of Sphagnum production and decomposition on restored peat lands, once the mossmat is established (Blievernicht et al., 2012). This is significant from not only a scientific understanding basis but also from an ecological management perspective as well – evaluating the success (or lack thereof) of the restoration approach.CO_2exchange studies on restored cutover peat land plots suggest that Sphagnum production is similar to natural peat lands and under optimal water level states can revert there stored peat land to a net carbon sink (Boudreau et al., 1999). While net CO_2exchange measurements using chambers and infra-red gas analyzers provide detailed production data, which is essential for linking to ecosystem scale measurements and model development , the approach has limitations as a restoration assessment & approach(Bruns et al.,2010).

Sphagnum farming is the commercial cultivation of Sphagnum species ('peat moss') for harvest as living biomass. Sphagnum biomass is availed in a variety of applications including, importantly, as a substitute for 'white peat' in horticultural growing media. White peat is moderatelyhumified Sphagnum peat (also known as 'blond peat' and, confusingly, 'peat moss') which is mined from peat lands. Peat provides 86 % of the raw material required by the European Union for horticultural substrates and 91 % of the German demand (Altschul et al., 1990).

In Germany, approximately 4.1 million cubic metres of white peat is used annually for professional horticulture and hobby gardening (Amend et al., 2010). This high demand creates great potential for replacing fossil white peat with renewable Sphagnum biomass as an environmentally friendly and high quality raw material for horticulture .Sphagnum farming on rewetted bogs is a profound & promising example of paludi culture, which allows agricultural use of wet peat lands while halting degradation of the peat layer(Bahram et al.,2013). In addition to biomass production, paludi culture garners a range of other ecosystem services including climate regulation, water purification/nutrient retention, regulation of the water cycle, and provision of habitats for specialized biodiversity (Barroetaveña et al.,2007) .

The first pilot field research on Sphagnum farming in Germany, installed in 2004, was inspired by the Canadian moss layer transfer technique for ecological restoration of cutover bogs. Sphagnum farming experiments on cut-over bogs have also been conducted since 2005in Canada (Alberton et al., 2014).

SPHAGNUM FARMING: a: site with infrastructure for water management (pump, ditches, and overflow) and dams used as causeways (maintenance, harvest, transport) b: Preparation of a Sphagnum farming synthesizing site; c: same site with established Sphagnum culture and irrigation system. Sphagnum (peat moss) biomass garners a GHG-neutral alternative to fossil peat in professional horticulture. So far however, it has only been collected in the wild. Small-scale land-based – Sphagnum farming is recently practiced on degraded peatlands.

Sphagnum farming has also been tested on specially constructed floating mats that guarantee a constant water supply. This water–based cultivation mainly allows bog waters to be used as reservoirs to irrigate cultivated areas in dry periods. It also creates additional Sphagnum farming areas. A mosaic of rewetted areas with land-and water-based cultivation may present the optimal combination for Sphagnum farming on degraded bogs. Experiments have also shown the suitability of growing media made of Sphagnumbiomass for cultivating a vast variety of crops from seedling to saleable plant (Agerer et al., 2012).

Sphagnum biomass is also suitable for other uses, including gardening design, terrariums, sanitary items, insulation of buildings, water filtering and pharmaceuticals(Bent et al.,2011).When Sphagnum is cultivated as a novel agricultural crop on rewetted peat lands, the high and stable water levels greatly reduce GHG emissions and the subsidence of the formerly drained peat soil(Burns et al.,2008). Sphagnum farming merges long-term land productivity with climate change mitigation and sustainable employment in rural areas. It also provides habitats for rare bog species and preserves the land's paleo-environmental archives (Agerer et al., 2004).

CONCLUSION

Sphagnum growth form is very sensitive to local environmental conditions, as mosses are unable to actively regulate carbon uptake and water loss because they lack stomata. This paper discusses the biomass production by sphagnum in peat land. The organic materials contained in sphagnum biomass were also discussed.

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