Bioplastic substrates in horticulture and agriculture

Expanded PLA enables the production of sustainable substrates for agricultural produce, plants, trees and shrubs

Fig 1. A shrub grown in a pot with a soil mixture of peat and 40% BioFoam.

Fig 2. Shrubs grown in hydro culture covered with a 5 mm open BioFoam sheet preventing any weeds from growing.

Nursery and greenhouse potting soil is widely used as a medium for plant growth. This relates especially to pots for cultivation under glass, container-shrubs and tree cultivation. They mainly use peat as a substrate. Peat, like oil, is considered to be a non-renewable resource and its use is under pressure. Also certain markets (UK) are increasingly asking for more durable substrates, that have to be stable in use, offer acceptable end of life solutions, and preferably being biodegradable, renewable and sustainable.

The Synbra Group has a leading position in Europe regarding expandable polystyrene (EPS) for Sustainable Insulation Systems and Industrial Products & Solutions. Synbra Technology bv, based in Etten-Leur, the Netherlands, is the in-house polymerization and R&D facility of the Synbra Group that recently developed BioFoam®, a biobased and biodegradable alternative for EPS.

BioFoam, a polylactic acid foam (E-PLA) can be used as loose beads or as a moulded foam material and offers an alternative to materials currently available on the market. It has passed stringent stability test on e.g. mould resistance and attack by termites. It does not degrade at ambient temperature conditions, but it can be composted in industrial composting installations. BioFoam has a huge advantage over most commodity plastics with regard to CO_2 emissions. Comparing E-PLA and EPS a remarkable resemblance of mechanical properties is observed [1]. The development of BioFoam is steadily progressing and moulded parts for packaging applications, like the KelvinBox marketed by Cryostore, are produced by Synprodo for everyday use. IsoBouw has developed SlimFix®DecoBIO that can be used for interior (sloping) roof insulation and loose foamed beads can be used for cavity fill.

Synbra has together with the Sustainable Development Group of AkzoNobel conducted an ex-ante Life Cycle Assessment (LCA) of industrial scale BioFoam production (Borén and Synbra 2010) [2]. An LCA allows holistic and quantitative environmental impact evaluations of economic systems, and facilitates relating environmental impacts to a functional unit. An LCA can take into account many different environmental aspects of products, processes or services throughout their value chains (life cycles), from extraction of resources to end of life treatment. By conducting an LCA a holistic profile of a system's environmental impact is generated. There are ISO standards on LCA; ISO 14040 and 14044.

Research is now further widening to develop sustainable BioFoam applications for horticulture. Composting according to EN-13432 has been performed successfully with densities of up to 55 g/l.

The use of peat in horticulture is becoming controversial due to loss of natural habitats and the emission of carbon dioxide by extraction and

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degradation. Finding sustainable and renewable alternatives that can be industrially and locally produced is in the interest of growers, governments and compost producers. It is especially relevant for pot growers who deliver to countries where the proportion of peat used has to be shown on the label (like the UK). The government seeks to address biodiversity concerns and provides guidance to enforce self-regulation in the sector. The compost producers seek alternatives to replace relatively scarce fractions (black peat and brown peat) which can provide for products with less fluctuation in quality due to weathering.

A formal R&D project was initiated to address these issues. This development included the following components:

- Development of modified BioFoam suitable for substrates
- Development and production of substrates based on BioFoam
- Testing of the new substrate materials and products
- Technical and economic evaluation of production
- Communication of project results.

Biomaterials increasingly allow the agricultural and horticultural industry to develop new applications, particularly for the waste phase, allowing cost savings in the value chain (waste disposal and labour). For the substrate industry BioFoam can be used for the development of new products. Synbra's E-PLA is a material having similar properties to EPS, also called *styrofoam*, but is made from renewable resources and is biodegradable. A very promising avenue seems to be the use of BioFoam as a substitute for peat. The substrate must meet the high demands placed on a growth medium. Also for other applications such as transport filler and covers can also be suitable.

Within the project, various strategies were successfully investigated to produce modified BioFoam granules. This is covered by a pending patent. BioFoam was made in several variants that can absorb amounts of water and had adjustable densities and bead sizes, both in round and cubic shapes (see figs. 1 to 6). ▶

Fig 3. Hydroculture shrub growing with 20% BioFoam in the substrate

Fig 4. Eggplant (aubergines) grown on a water-permeable BioFoam cube shaped substrate replacing perlite, without any adverse effects to growth yield. It offers reduced value chain costs due to improved end of life options while preserving nutrients contained in the roots by composting.

Fig 5. Raspberries grown on 20, 40, 60 and 100% BioFoam substrates in a hydroculture application.

Fig 6. BioFoam greenhouse ground cover accelerates the growth of chrysanthemums due to better insulation and improved light reflection. After the growth BioFoam is mixed into the soil.

Important characteristics of BioFoam containing substrates were investigated. Research showed that the stability of BioFoam is comparable to that of fresh coconut and by adding a modified E-PLA with open cells the water retention (see infobox) can be adjusted. For pF curves see graph.

It was also established that BioFoam granules are suitable as a filler when transporting perennials and bulbs (lily and phlox) and gave a better product than the current packaging (fig. 7).

A test cultivation in a hydroculture gutter system with a variety of crops (pivots) and with BioFoam beads as a part of the substrate showed that the growth is fully comparable to a standard substrate. Up to 100% BioFoam was used as a substrate in a hydroculture application showing no loss of growth rate. At the end of life stage it offers the potential to retain the nutrients that are contained in the substrate (roots) by composting - nutrients that otherwise may become lost when using perlite or mineral wool.

These opportunities are now further explored and invitations are open to growers to be among the first users to participate in the industrialisation and scaling up.

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[1] J. Noordegraaf, J. de Jong, P.de Bruijn, R. Hartmann
BioFoam: PLA Particle Foam (further) expaning in Europa; Paper presented at the International Conference Particle Foam Conference Berlin, Germany, 28 and 29 November 2012

[2] J. Noordegraaf, A Comparative LCA on building materials. bioplastics MAGAZINE Vol. 6, issue 02/2011

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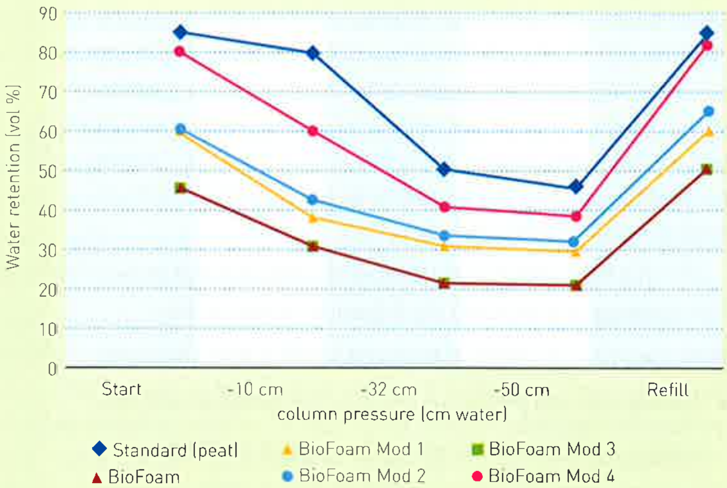
Fig 7. Phlox after transport with traditional transport protection (1) and with BioFoam (5) leads to a much improved preservation and quality of the bulbs.



Graph 1. Water retention curves comparing various BioFoam modifications under investigation, compared with traditional peat.

Info:

Waterretention curves are used to show how much water a given substrate can hold at various suction forces. The amount of water a given substrate can hold and the force a plant has to apply to take it up is very important for the growth. This amount is measured in volume% and the suction force (or how easy it is for a plant to take up water) is measured with a water column. -10 cm corresponds with 1 kPa suction pressure.

The graph clearly shows different water retention for the various substrates at the start of the experiment. By modifying BioFoam the water retention can be modified this way controlling the water uptake of the plants. The graph also shows that at the end of the experiment most substrates can be refilled to return to the starting amount of water.