PLANTASTIC DISCOVERIES

Plants for the Future
European Technology Platform

PLANT BREEDING

FOR THE BIOECONOMY

PLANT BREEDING SERIES

WHAT IS THE BIOECONOMY?

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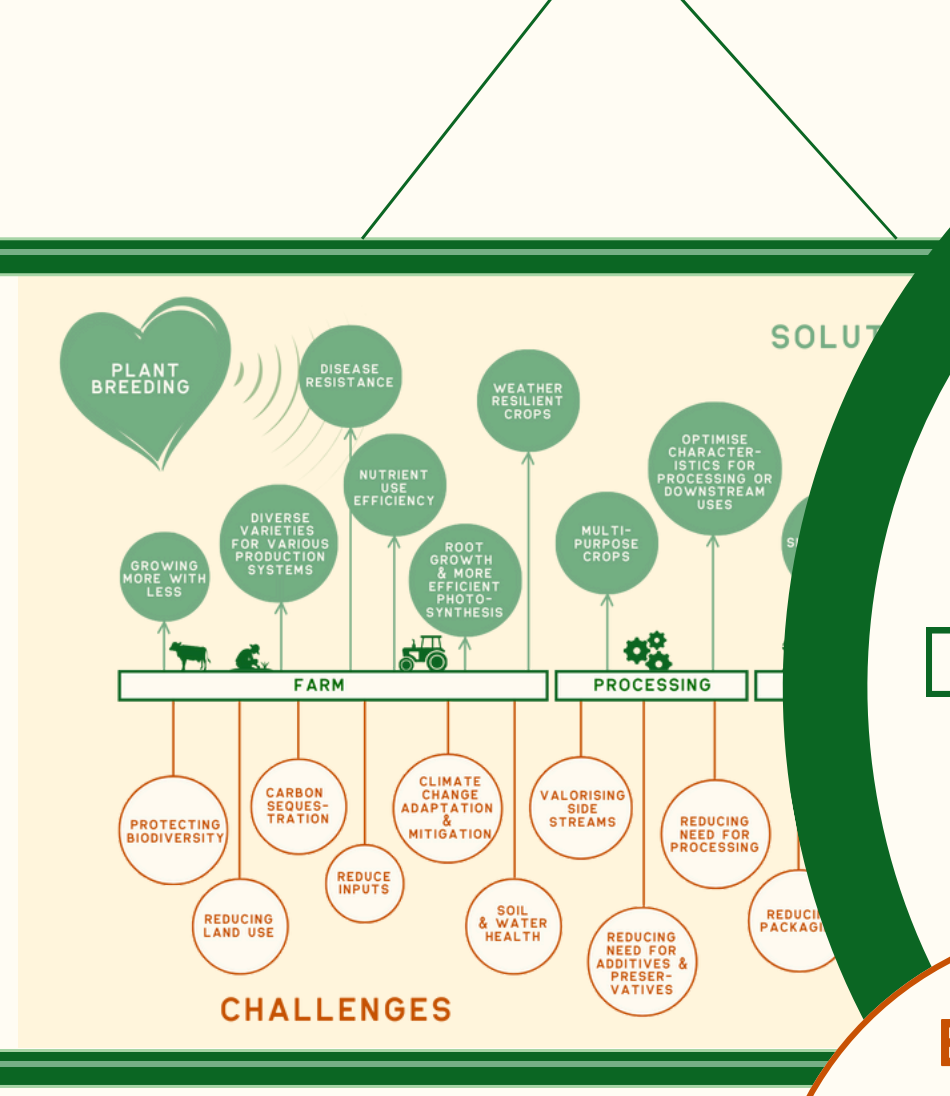
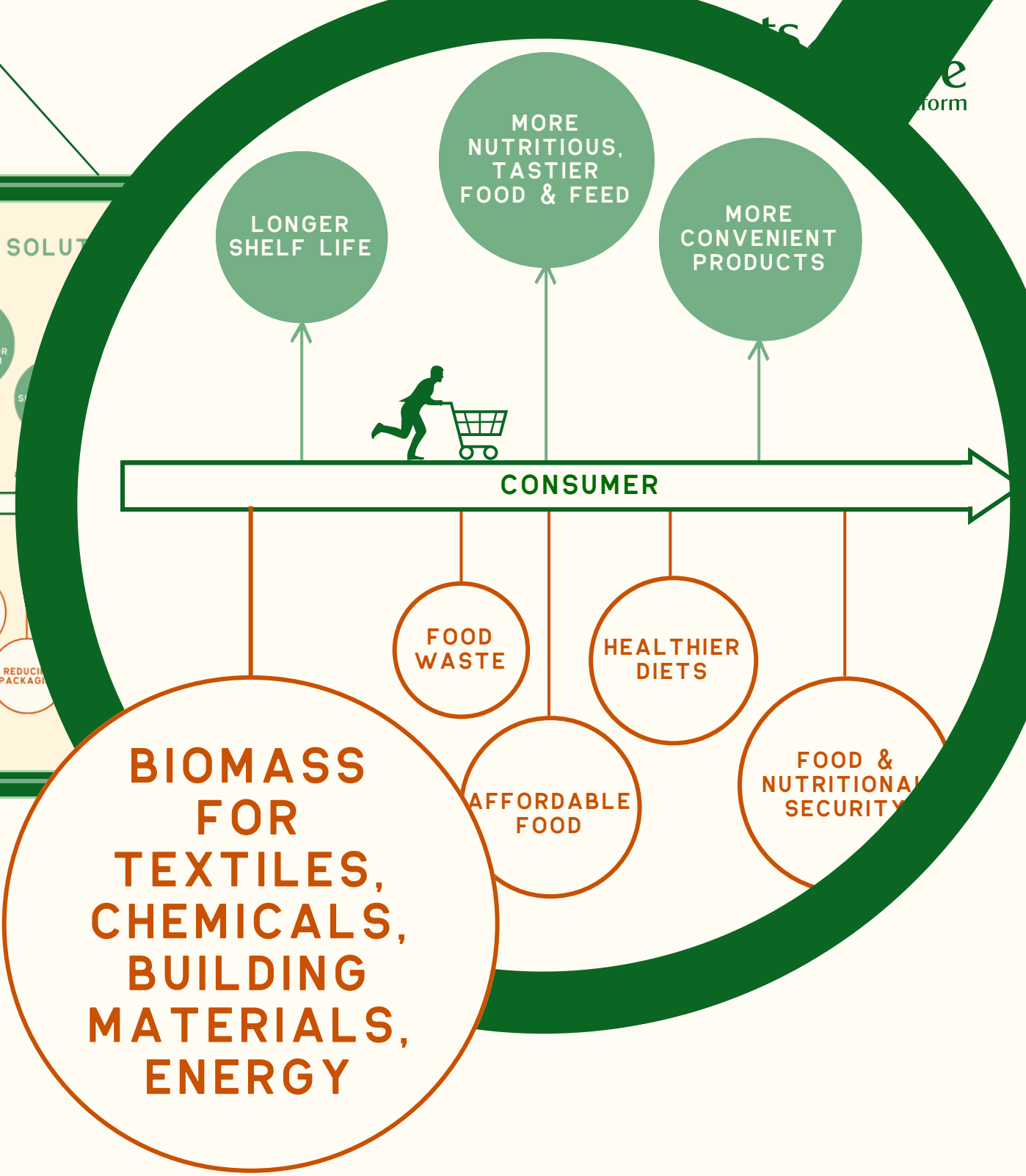
BIOECONOMY *(NOUN)*

/ˈbʌɪəʊɪˌkɒnəmi/

The bioeconomy is an economic system that uses renewable biological resources, such as plants, microorganisms, and organic waste, to produce food, feed, materials, energy, and other products. It aims to reduce reliance on fossil fuels, promote sustainability, and create value from biomass.

In this instance of the plant breeding series, we delve on how plant breeding can help build a future resilient circular bioeconomy!





In particular, on how plant breeding can supply the biomass we need for textile, chemicals, building materials and energy!

BIOMASS

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Biomass is the foundation of the bioeconomy. It provides raw materials for biofuels, bioplastics, biochemicals, and sustainable construction materials.

However, the global demand for biomass is rising - by 2050, supply may fall short by 40–70%. To ensure a stable and sustainable supply, we need to optimise how biomass is grown, processed, and utilised.

Without plant breeding, we face several challenges:

- **Limited land availability:** We cannot endlessly expand farmland without harming ecosystems.
- **Low efficiency:** Many crops do not naturally produce enough biomass for industrial use.
- **Climate stress:** Drought, heat, and poor soils limit how much biomass can be grown.
- **Processing difficulties:** Some plants are not suited for biofuel or bioplastic production due to their composition.

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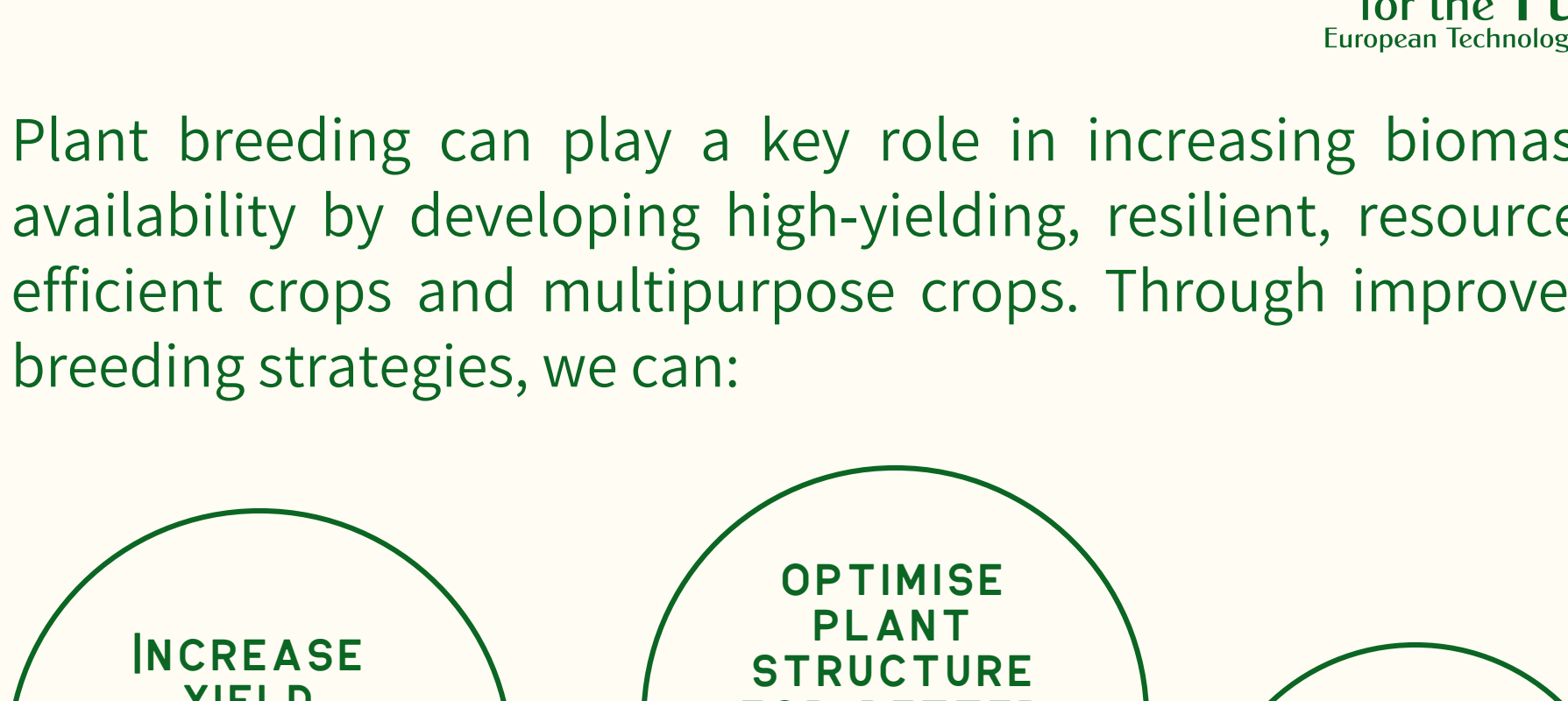
Plant breeding can play a key role in increasing biomass availability by developing high-yielding, resilient, resource-efficient crops and multipurpose crops. Through improved breeding strategies, we can:

INCREASE YIELD POTENTIAL WHILE USING FEWER RESOURCES

OPTIMISE PLANT STRUCTURE FOR BETTER PROCESSING AND CONVERSION

IMPROVE CROP RESILIENCE TO CLIMATE STRESS



The entire biomass supply chain can benefit!

BIOMASS VS. FOOD

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A big **challenge** around the production of biomass is **land availability**. The land needed to grow biomass competes with land needed for food and feed production.

In Europe, the push to reduce agricultural land to meet climate targets intensifies this competition.

A way to avoid this competition, is to have multipurpose crops!

MULTIPURPOSE CROP *(NOUN)*

/ˈbʌɪəʊˌkɒnəmi/

Plant cultivated for multiple uses, such as food, feed, fibre, fuel, or industrial applications. These crops maximise resource efficiency by providing both primary and secondary products, supporting sustainability and the bioeconomy.

Integrating multipurpose crops into agricultural systems can enhance resource efficiency. Here are some examples of how this is already done!

Potato: Primarily cultivated for human consumption, potatoes are versatile in culinary applications. Beyond direct consumption, they are processed to extract potato starch, which serves as a thickening agent in sauces, soups, and gluten-free baking, as well as for the production of biomaterials. Additionally, byproducts like potato peels and cull potatoes are used as animal feed, offering a high-energy supplement for livestock.

Sunflowers: They are cultivated mainly for oil production, which is used for both food and bioenergy. The leftover seed cake, rich in protein, is used as animal feed. Additionally, their deep root systems help maintain soil structure.

Plant breeding can enhance the multipurpose traits of multipurpose crops, making them more efficient and valuable across different uses. Here are some examples:

Rice: Rice varieties have been developed to increase yield and improve disease resistance, with breeding efforts also focusing on enhancing rice straw for biofuel production. The straw, rich in lignocellulose, is a promising feedstock for bioethanol. However, high lignocellulosic biomass often results in reduced grain yield, so breeding strategies aim to create dual-purpose varieties that balance high grain yield with enhanced biofuel potential.

Tomatoes: While comprehensive breeding programs specifically targeting tomatoes for bioplastic production are limited, research has explored utilising tomato processing byproducts, such as peels and seeds, for biodegradable plastic production. These byproducts are rich in starches and cellulose, making them suitable for developing eco-friendly materials.

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MARGINAL LANDS

Another way to avoid conflict with food and feed production, could be to grow dedicated crops for biomass on marginal lands!

These are areas with marginal agronomic and economic potential for cultivation of food crops and currently not used by agriculture. The issue here is that most existing crops don’t grow well on marginal lands. But once again, here is where plant breeding can help!

Breeding new varieties can help by making **crops more drought-resistant**, able to **grow in poor or salty soils**, and more **efficient** with water and nutrients.

An array of new crops tailored to marginal environments could therefore be developed!

INCREASING BIOMASS PRODUCTION

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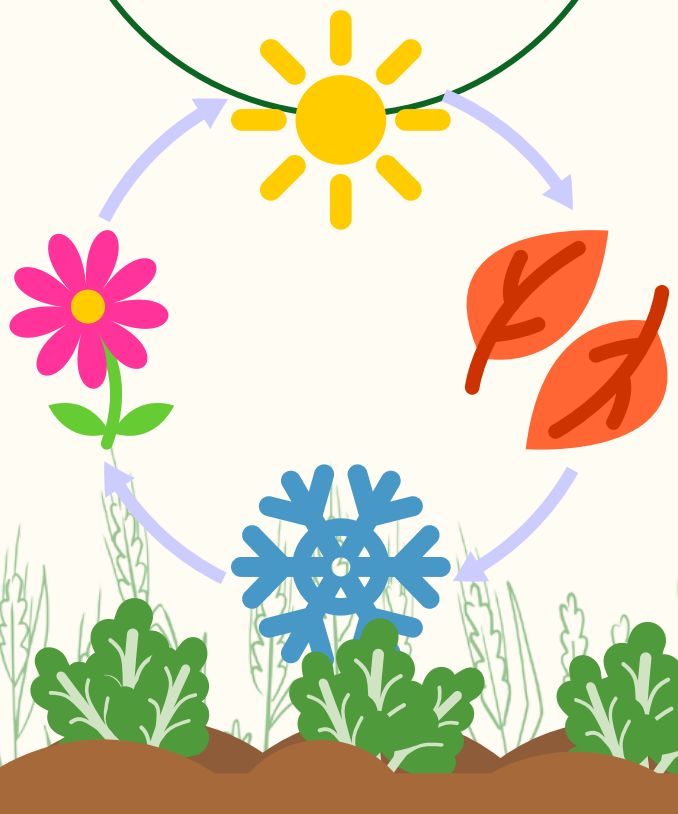
Multipurpose crops and marginal lands can contribute to the solution, but with our growing demand for biomass, we also need crops that yield more biomass per hectare.

How can breeding help?

DEVELOPING TALLER, DENSER CROPS WITH MORE LEAVES AND STEMS

EXTENDING THE GROWING SEASON SO PLANTS CAPTURE MORE SUNLIGHT

IMPROVING PHOTOSYNTHESIS EFFICIENCY TO CONVERT SUNLIGHT INTO BIOMASS MORE EFFECTIVELY



IMPROVING BIOMASS QUALITY FOR INDUSTRIAL USE

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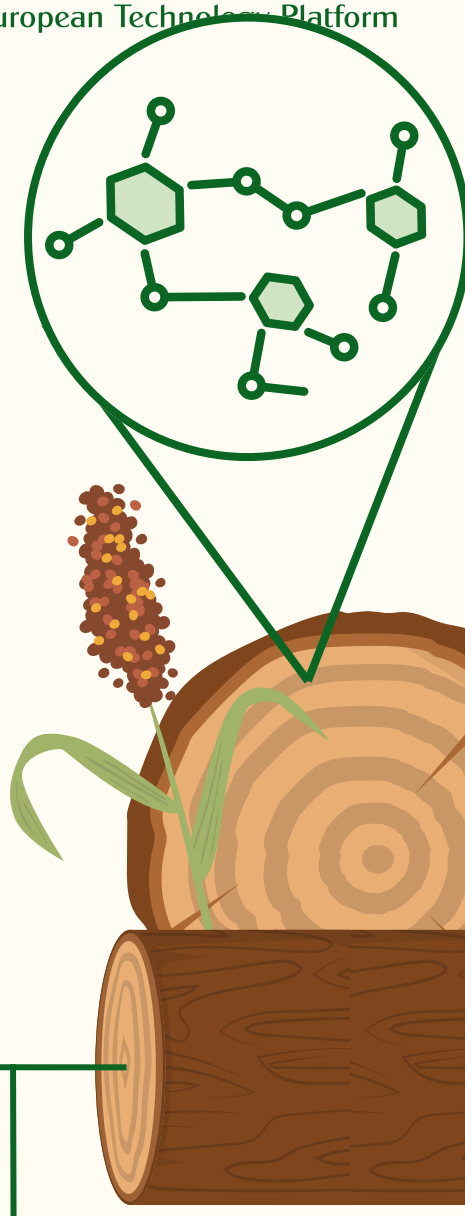

For biofuels, bioplastics, and other bio-based products, biomass must be processed efficiently. However, this can be challenging due to certain plant compounds that make conversion more difficult. One example is **lignin**, a tough, rigid substance in plant cell walls that provides strength and protects against pests.

While essential for plant structure, high lignin content and other complex materials can challenge processing, requiring more energy and increasing costs.

How can breeding help?

BY REDUCING LIGNIN CONTENT: KEEPING ENOUGH FOR PLANT STRENGTH, BUT MAKING IT EASIER TO BREAK DOWN.

BY CHANGING LIGNIN COMPOSITION: MODIFYING THE STRUCTURE TO MAKE LIGNIN MORE DIGESTIBLE FOR BIOFUEL PRODUCTION.

BY BALANCING LIGNIN WITH CELLULOSE AND HEMICELLULOSE: MAXIMISING THE USEFUL PARTS OF THE PLANT WHILE MAINTAINING DURABILITY.

CROPS UNDER DEVELOPMENT FOR BIOMASS ENHANCEMENT VIA PLANT BREEDING

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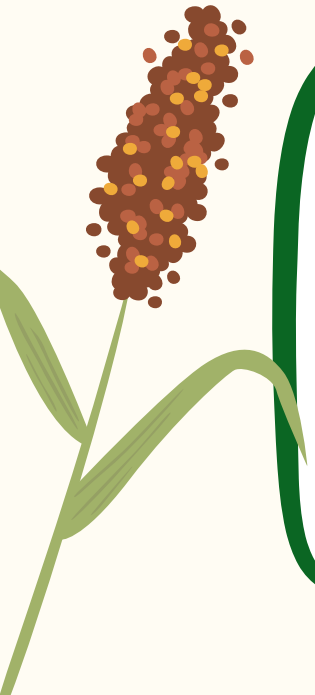

Sorghum is a versatile crop known for its drought tolerance and adaptability to various climates. Breeding programs have developed hybrids that extend the growing season, allowing the plants to accumulate more biomass before the first frost. These efforts aim to increase its potential as a biofuel source, especially in regions with shorter growing seasons.

Researchers are modifying **sugarcane** to boost cellulose production for biofuels. By introducing a cellulose synthase gene, they've increased cellulose content by 31% and improved biomass breakdown efficiency by 39%, making it a more efficient bioenergy crop.

Cactus pear is gaining attention as a sustainable crop for arid regions. Its biomass can be processed into various products, including bioplastics. In Italy's Puglia region, some startups are cultivating cactus pear to develop eco-friendly materials, capitalising on its resilience to drought and potential as a bioplastic feedstock.

ASK US

🌱 Got questions about plant science & breeding? We've got answers!
Join Plant ETP's campaign to feed your curiosity! 🌿
Ask your questions here:

tinyurl.com/bdzhepr9

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Breeding transforms sorghum’s potential as biofuel of the future for northern latitudes

Cactus pear is a crop with potential in Italy's parched south and beyond