



Photograph: Mats Cerenitz

Efficient production of bioethanol from cellulose

Plant biomass is the largest renewable source of organic raw materials on earth. But if we are to benefit from this enormous green resource, new biofuel manufacturing techniques must be developed.

Bioethanol is currently mainly made from cultivated crops such as sugar cane, sugar beet, wheat and corn. It is also pos-

sible to produce ethanol from high-cellulose plant biomass, such as straw and wood residues from agriculture and forestry. However, cellulosic plant biomass must be pre-treated before yeast fermentation in order to obtain economic quantities of ethanol. This can be done using strong acids or enzymes produced by various microor-

ganisms that degrade plants.

The MicroDrive research programme at SLU develops novel and sustainable biofuel production systems for both bioethanol and biogas processes. ■

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Rapid hormone production in shaded plants

Plants that are close together, e.g. in pot cultivations, nurseries or in unthinned forest, know they are in the shade. This is because they are exposed to a greater proportion of infrared light in relation to red light. The red light is absorbed by the uppermost leaves, and infrared rays are reflected from adjacent plants. When plants are exposed to shade, a number of physiological processes are triggered as a result of the change in light quality.

The plant quickly increases production of auxin, a growth hormone that increases stem growth and inhibits formation of lateral shoots. In a joint project with scientists in other countries SLU researchers have identified a gene responsible for converting the amino acid tryptofan into indole pyruvic acid, a precursor to auxin. It has long been known that this pathway of auxin synthesis exists in bacteria, but now it has been proved for the first time that it is also existing in higher plants. ■

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Monitoring methane from cows

Methane (CH_4) is a greenhouse gas formed when cows and other ruminants digest their food. 95 per cent of the gas is released when the cow belches; the rest is emitted anally. A Swedish dairy cow produces 100 – 130 kg of methane each year, depending on the size and nature of its diet. More feed increases methane production per cow and day, but means less methane per kilo of milk.

Earlier estimates suggest that a change in the balance between coarse feed and concentrated feed causes only fairly small changes. New SLU research is developing methods to more accurately monitor methane emissions associated with various kinds of cattle feed. A further aim is to be able to predict how much methane is emitted by cows eating a given type of feed. ■

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Plant cultivars fend off aphids

Plants engage in chemical warfare. When different species are grown together, they defend themselves against each other.

A side-effect of this chemical battle

between plants is that pests also find it more difficult to attack the plant. This means that the effect extends throughout the entire chain of plant/herbivore/natural enemy, a phenomenon known as allelobiosis.

Plants are thus better equipped to fend off aphid attacks when different varieties are grown in the same field.

Different barley cultivars grown together were tested. It was found that there are genetic differences between varieties capable of inducing other plants and varieties that are induced. These allelobiotic



Photograph: Valentin Ninkovic



characteristics are found in modern barley cultivars, but to an even greater extent in primitive varieties. This may be of use when developing future cultivars. ■

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Healthy fat from grazing heifers

We consume too much omega-6 fatty acids in relation to omega-3. In the modern diet the ratio between omega-6 and omega-3 is 10–20:1, although it would be better if the balance were 1–4:1 instead. Omega-6 are the main fatty acids stored in cereals. Most animal products come from production systems based on cereal and concentrate feeding, which increases the proportion of omega-6 in the meat.

A study of Charolais heifers grazing on grass has been made at SLU. Heifers that are slaughtered in the autumn immediately after the end of the grazing season, or that receive their final feed in the form of ley silage indoors, produce meat with a healthier fat composition than those fed on barley or whole-crop silage for four months after grazing.

Feeding systems based on grazing or silage thus yield healthier meat. ■

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Farmland birds still declining

Many Swedish farmland birds are becoming increasingly rare. The curlew (*Numenius aquata*) has been particularly hard hit and is now very rare in southern Sweden. The reason for bird declines is that landscapes have become more regionally uniform with more monoculture – cereals are mostly grown on the plains; farmland in forest areas is mostly used for ley grass or fallows.

Several species have declined most in the plains of intensive farming and the most extensively farmed forest regions. Increased production of cereals in forest regions and more cultivation of ley grass

and fallow land in the plains would therefore probably be good for birds. ■

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Agriculture in a changing climate

SLU researchers have carried out an inter-disciplinary futures analysis for Swedish agriculture. As carbon dioxide levels rise, production of most agricultural and horticultural crops increases. A warmer climate will also extend the growing season by 6–10 weeks. Crops such as hay, root vegetables, green vegetables, fruit and berries will all benefit. Autumn-sown crops such as wheat and oilseed rape will increase, and sunflowers may provide an additional source of vegetable oil. Vineyards may become commonplace in southern Sweden, and within 40–50 years it will be possible to cultivate corn to ripeness in central Sweden. New cultivars, adapted to cope with our long hours of summer daylight, will have to be developed.

Researchers believe that crops will be more susceptible to attack by insects, fungi and viruses. Changes in the weed flora and growing resistance problems will also increase the need for herbicides and pesticides. Erosion and leaching of nutrients owing to more abundant precipitation will necessitate more use of fertilisers. ■

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Late grazing good for flora

Species diversity in dry or mesic, nutrient poor grasslands in the pastoral landscape would increase if grazing animals were let out to pasture later in the season. If no grazing at all took place some years, this would further improve the prospects for survival of many endangered species, which would then be able to survive by self-sowing. This would reduce the cost of maintaining an open landscape, since

fewer grazing animals would be needed per unit area.

Flowering plants shed far more seed on land that is grazed late than on land where animals begin grazing in early spring. Later cultivation also accords with the way that most species-rich farming areas have been managed historically, i.e. with late hay cutting. ■

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Breeding for healthier dogs

Breeding programmes in which dogs are DNA tested for certain disorders makes it possible to produce healthier breeds of dog. Geneticists at SLU have succeeded in identifying exactly which mutation causes disorders linked to white spotting and reverse hair pattern along the spine.

White-spotted dogs have probably been actively selected by man through the ages, perhaps for aesthetic reasons or because white is more easily visible in the dark and when hunting. But there is a downside to this characteristic: it is associated with hearing problems in many breeds.

The Rhodesian Ridgeback is one of the breeds that sometimes suffer a genetic mutation leading to the characteristic reverse hair pattern along the spine. This in turn leads to a condition called *Dermoid sinus*, symptoms of which include rigidity, incontinence and behavioural abnormalities. Eight to ten per cent of Ridgeback puppies are born with this defect. ■

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Lack of nitrate in blooming lakes

Massive algal blooms occur in eutrophic lakes and the Baltic Sea during warm summers. The algae are often cyanobacteria, also known as blue-green algae. Cyanobacteria often multiply explosively, especially when the nutrient nitrate-nitrogen is depleted but the phosphorus con-

centrations remain high. Such intensive algal blooms comprise species that are able to fix nitrogen from the air, giving them a survival advantage over other species. Occurring in large numbers these species can be toxic to humans.

Researchers have monitored nitrate-nitrogen levels in a hundred European lakes. They could clearly see how spring nitrate concentrations impacted summer concentrations. In addition, spring nitrate concentrations displayed a sharply declining trend in northern European lakes. This trend has been attributed to an earlier nitrate uptake by flora and fauna in a warmer climate, and to a decrease in nitrogen deposition from air pollution. The number of occasions with very low concentrations has tripled in shallow lakes since 1988. The decline in nitrate concentration has been unexpectedly rapid.

This imbalance must be redressed and greater efforts must be made to reduce phosphorus concentrations in lake systems displaying high levels of phosphorus. ■

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Browner water with less acidification

As sulphur deposition decreases, our lakes and watercourses are becoming ever browner, an effect caused by humus from surrounding land. This has been confirmed by environmental monitoring of acidification in numerous countries in Europe and North America.

When acidic deposition decreases, there is also a decrease in the capacity of soil to retain acidic humic substances, which then dissolve in water. This results in a more natural concentration of organic matter in the water (brownness).

When acidification began to cause concern in the 1960s, it is likely that an opposite process occurred in parallel with acidification. Humic substances were then fixed to a greater extent in soil, and the water became less brown. ■

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Spider silk in bullet-proof vests

Spider silk is an extremely strong and elastic biomaterial that can be used for many purposes: from surgical sutures to bullet-proof vests. It is now possible to produce spider silk on a larger scale in an environmentally friendly way. This is done with the help of the intestinal bacteria *Escherichia coli*, to whose DNA has been

added a fragment of DNA from a South African spider. Anna Rising has induced these bacteria to form pieces of spider silk protein. The proteins join themselves together into metre-long threads that are stronger than tendons. It has been found that spider silk produced in this way is tolerated by human cells *in vitro*. Hence, there is a good chance that patients will also tolerate this material when used for medical applications. ■

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Children need secret places

It is important that cities have areas where children are able to create their own places, where it does not matter if it looks a little untidy. Maria Kylin at SLU has studied the private world of children. Throughout the world children play in dens, which, to varying degrees are kept secret from other friends or adults. Dens may also be more open and more social, places where many children can play.

Children describe their dens by saying what they do there and how it feels, whereas adults describe the design, function and appearance of the den. Thus, to find out how children perceive their environment, it is necessary to ask questions in the right way. ■

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Tax favours “clean” technology

The current technology used for heating and vehicle engines etc makes it very difficult to achieve sizeable reductions in carbon dioxide emissions. However, more widespread use of existing new and “clean” technology at the expense of the old “dirty” technology can be encouraged

by taxation of carbon dioxide emissions.

Rob Hart has shown that emission taxes favour the spread of new, clean technology, partly at the expense of new technology promoting economic growth. This suggests that the emission tax should normally correspond to the environmental damage caused. Departure from this principle may be justified in some situations, however, for example where the need for technical progress in the field of clean technology is particularly great. And it is precisely there that the gap between what the market offers and what society needs is greatest. ■

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Sesamine improves farmed fish

Farmed rainbow trout (*Oncorhynchus mykiss*) and salmon (*Salmo salar*) grow just as well when fed with food whose fat content comprises 75 per cent rape oil and only 25 per cent fish oil. Levels of the healthy marine omega-3 fatty acids DHA and EPA decrease in these fish, however.

SLU researchers have now tested various bioactive substances from the plant kingdom and their ability to influence fish fat profile so as to increase the quantity of the longest, most polyunsaturated fatty acids. In one experiment, a supplement of alfa-lipoic acid increased the proportion of EPA in muscle tissue; in another a sesamine supplement increased DHA. The latter effect was so great that a patent application has been made for the addition of sesame seeds to the feed to improve the fatty acid composition of farmed predatory fish. ■

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Photograph: Anna Rising



Fertilised spruce better at fixing carbon

The role of the forests as a carbon sink, acting as a brake on global warming can be enhanced by use of fertiliser. When spruce forest receives an optimum dose of all nutrients, the rate of growth can be three times higher than without fertiliser. This applies in northern Sweden, where nitrogen deposition is much lower than in the south. Increased growth means greater needle biomass, which in turn means increased photosynthesis and storage of carbon in the trees.

Findings also show that storage of carbon in the soil rises with increased fertiliser use. This is because both microbial degradation and root respiration decrease.

SLU scientists believe that use of fertilisers in the forest is also positive from a climate viewpoint in the sense that increased biomass production can replace some of the fossil fuels used for heating and transportations. ■

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Wood preservation using linseed oil

Refined linseed oil can be used for industrial pressure impregnation of spruce without causing any adverse environmental impacts. The process entails filling the pores in the wood with water-repelling oil. It was not formerly possible to impregnate spruce, but SLU researchers have now shown that the technique also works on this type of wood. ■

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Many species in young forests

Commercial forests contain broadleaf trees, dead trees and tree stumps left after felling. These have been found to serve as habitats for many species of lichen and moss, and are thus important for biodiversity. Jörgen Rudolphi has studied forests of varying ages bordering each other and found that the number of species per dead tree and broadleaf tree was the same whether the tree was standing in a young or an old forest. However, the diversity of both lichens and mosses in young forests was greatest in those areas that had had most old forest adjacent to them over the previous decades.

Forestry operators are increasingly making use of branches, tree tops and stumps left after felling for biofuel. Large tree trunks lying on the forest floor are also taken. This reduces the biological heritage in the form of old and dead trees from ancient forests. Jörgen Rudolphi also shows that there are more unusual species on the stumps of felled trees than had been expected. Account must also be taken of this factor when planning cutting and biofuel harvesting. ■

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Plant defences resemble those of animals

New knowledge about immune systems may ultimately increase our chances of curing plant and animal diseases. SLU geneticists have collated knowledge on development of the defence in plants and animals.

There are two protein building blocks (or domains) in the immune systems of both plants and animals. They are known as TIR and NOD and are linked to each other in various ways. Each domain is responsible for a certain function in all proteins possessing it.

Scientists have studied the way in which TIR and NOD are interconnected in lower plants and animals, e.g. mosses, brown algae, sponges and urchins in order to trace their evolutionary history. It was found that the two domains began to evolve separately even before plants and animals evolved in different directions. The plant domains remain fairly similar to those found in bacteria and have retained their form far more than have their animal counterparts.

Hence, immune systems stem from a common origin and certain functions remain similar. ■

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Early elms may avoid disease

Many elms in Europe and the US are still threatened by Dutch elm disease (DED). DED is caused by a fungus - *Ophiostoma novo-ulmi* - whose spores are carried by the elm bark beetle (*Scolytus* spp.). In Sweden, DED was discovered in the 1950s and is now spread to the Mälars valley in south-central Sweden.

Luisa Ghelardini found that elms with an early bud burst, generally of southern origin, were less susceptible to DED than late flushing elms from more northern sites and/or higher elevations. Early flushing elms exhibit an earlier transition from spring to late wood which, having more narrow and grouped vessels, hinders the spread of the fungus in the vascular system. An asynchrony between the time of maximum susceptibility of the tree and the peak of *Scolytus* flight may be a mechanism to escape DED which could be exploited in elm breeding.

Elm dormancy was weak and it was removed mainly by low temperature whereas light had no effect. Elms with a northern or highland origin required more chilling during winter to start growing than trees from southern or lowland sites. ■

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