LIDO is both a *trial orchard* and a production facility: this is where the highly disease-prone variety Rosy Glow Pink Lady® grows – on vertical fruit walls that give the engineers easier access.

Digital Revolution

The apple orchard of tomorrow: the *LIDO field lab* at the Laimburg Research Centre is a testing ground for agricultural scientists, engineers, and IT specialists. It sets worldwide standards in AI and digitalization in apple growing.

By Barbara Bachmann
Photography by Michael Pezzei

When agricultural scientist Elias Holzknecht wants to apply a plant protection product, all he needs to do is press a button. In front of him is a monitor displaying 19 numbers, each representing one of the 19 adjacent rows of around 40 Rosy Glow Pink Lady® apple trees. On a Tuesday in early April, they are in full bloom.

On the monitor, Holzknecht can select which rows he wants to spray, with what product, and for how long. Seconds after he presses the button, the sprinklers – a permanent fixture above the tree canopies – distribute the spray mist from above. "Timely application allows for effective and environmentally sound pest control," he says, explaining the main advantage of the fixed spraying system. Compared to the standard mobile application with tractors and sprayers, this method is unique in South Tyrol. In this apple-growing region, it is currently only being piloted here at LIDO, a field lab on a manageable 0.65-hectare site at the Laimburg Research Centre.

"In 2023, we started measuring soil moisture operationally," says Walter Guerra, pointing to a sensor that provides information about water availability for the plants. Watering is done automatically when required. Guerra has led the Pomology working group at the research center since 2005 and as such is also responsible for the LIDO project. "This year, we want to expand our research to look at sensors for measuring and counting fruit." The aim is to use them to determine how quickly the individual fruits are growing.

"With the new technologies, we will inspire young farmers for agriculture again."

Walter Guerra, *head of the Pomology working group at the Laimburg Research Centre and LIDO project lead*

Digitalization and smart technologies have been central themes at the Laimburg Research Centre for many years. In the early 2000s, for example, the center developed the dynamic controlled atmosphere (DCA) for apple production: a sustainable storage system in which sensors monitor the condition of the apples in storage and which adjusts the air composition to the apples' needs. Today, this system is used worldwide to store hundreds of thousands of tonnes of fruit.

AI has been used in sorting and storage for decades. "But in the storage room, you can't improve on what comes in from outside," Guerra points out. Therefore, most investments are increasingly being focused on field production, like at LIDO. The information here comes directly from the field. Testing, development, validation, and demonstrations are carried out on a small scale, underpinned by the search for added value for apple production worldwide.

Elias Holzknecht holds a clip with a sensor that he attaches to the underside of an apple leaf. The apple tree absorbs water from the soil through its roots, which is transported through the tree via the xylem (transport tissue). "The remaining liquid is transpired through the leaves," explains Holzknecht. This creates moisture, which the sensor detects. "In dry conditions, the plant's stomata close, so transpiration no longer correlates with the radiation from the sun. The system then sends the signal in time to turn on the drip irrigation."

The LIDO is a showcase garden for the future of apple growing. It's also a real commercial production facility. Since Rosy Glow Pink Lady® is particularly susceptible to diseases like scab or mildew, it is the perfect variety for testing technologies that detect pathologies early. Due to the late fall harvest, the trial period is particularly long. Unlike the standard three-dimensional cropping system, LIDO is planted up in a multi-axis system; only 100 of the 18,000 hectares of growing area in South Tyrol are currently structured this way. Guerra points to the vertically growing fruit walls. Easy to manage and two-dimensional, they simplify the work of engineers and IT specialists.

Guerra and his team are currently collaborating with over 20 different companies at LIDO. They are also helping to develop algorithms for, among other things, harvest forecasting. "The key to success is interdisciplinarity," says Walter Guerra. Agronomists with expertise in fruit growing, engineers who develop the applications, and IT professionals who

1 Agricultural scientist *Elias Holzknecht* can apply plant protection products in the LIDO orchard at the touch of a button: he keeps an eye on the 19 rows of trees on the monitor while fixed sprinklers spray the trees.

2+3 Precision *water management*: Elias Holzknecht attaches clips with sensors to the undersides of leaves. Trees normally transpire via their leaves; in drought conditions, this process stops. The system recognizes this and initiates drip irrigation.

4 The system currently "only" works with automation. Possibilities for the future include harvest forecasts by algorithms, *artificial intelligence* to identify diseases, and robotic arms to thin out fruits and prune trees.


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The human factor is central and should remain so.

transfer and process the massive amounts of data. Together, they brainstorm a wide variety of ideas.

One such idea is an image recognition system that provides information about each tree's individual needs, which should make thinning the blossoms much more precise in the future. Eventually, robotic arms linked to this system could handle the thinning directly. There could also be arms that can precision spray and prune the trees – or even take over the picking. At LIDO, power and broadband reach directly into the orchard. "In the future, this could be used to charge an electric mulching system for mowing the orchard or for under-vine maintenance," says Guerra.

Last year, 500 visitors from various continents came to LIDO to get a first-hand impression of these developments. Guerra and his team are at the forefront of research with other institutes worldwide, making a major contribution to the apple orchard of tomorrow (more examples on p. 24). In New Zealand, for instance, researchers are creating a virtual version of the apple orchard using "digital twins" to simulate various future scenarios.

And yet, Walter Guerra admits that he sometimes struggles with the term "artificial intelligence." "It has become a buzzword," he says. The fixed spraying system that Elias Holzknecht just used to demonstrate pesticide application currently still falls under automation. "If it is combined with detection of a possible outbreak of fungus X and we apply plant protection product Y at time Z based on this information, then we are increasingly moving towards the realms of AI," Guerra says.

The goal is the integrated digital orchard. This is also the meaning of the name LIDO: Laimburg Integrated Digital Orchard. A place where various pieces of information are combined to assist the farmer in decision-making. A place where information about each individual tree is available. A place where knowledge is securely stored – unlike before, or in addition to the farmer's memory. Achieving this goal will require perseverance.

"With the new agricultural technologies, we will inspire young farmers for agriculture again and create generational change," Guerra says with conviction. For this to happen, apple growing must be made more attractive and modernized. South Tyrol provides good conditions for this. The local fruit-growing area has full LoRaWAN (Long Range Wide Area Network) coverage, a network offering cheap and energy-efficient data transmission.

So are the developments exclusively positive? Or do they also pose risks? "We must not rely solely on them and keep our eyes glued to our phones or computers," warns Guerra. "The human factor is central and should remain so." Nobody is aiming for full automation. It's about maximizing the productivity and quality of the apple orchard while minimizing its environmental impact. And ultimately, significantly easing the work of fruit growers.

Elias Holzknecht nods. He is fascinated by the potential of the new technologies to save resources and costs in order to address future challenges: the shortage of specialized labor, climate change, resource scarcity, and better sustainability. "Thanks to digitalization, we will be able to keep agricultural enterprises economically viable," he says. Agriculture will become more cost-effective, more efficient, and more energy-saving. "But ultimately, it is the farmer who produces our food, with the help of nature," says Holzknecht. Not artificial intelligence. **BB**

Interdisciplinarity as a key to success. Walter Guerra (left) and Elias Holzknecht show **ipoma** reporter Barbara Bachmann around the LIDO trial orchard.

VIDEO TOUR

through the LIDO trial orchard: see the technologies in action here

Technology in the Orchard

Around the world, efforts are being made to develop the orchard of the future. Three experts from different regions share their progress.

Tree monitoring with 3D data

3D scanning of orchards with LiDAR (Light Detection and Ranging) systems not only provides data on the height and thickness of tree canopies but also on their porosity, leaf surface area, and space utilization. “We use these data to identify differences in growth and adapt our management measures accordingly,” explains **Alex Escolà**, coordinator of the AgroICT and Precision Agriculture Research Group at the University of Lleida and the CERCA Center for Research in Agrotechnology in Catalonia, Spain. Mobile terrestrial laser scanning provides farmers and their advisors with very precise information about the tree canopies in their orchards.

Smart yield and quality recognition

Research manager **Ian Goodwin** and his team at the Tatura SmartFarm in Victoria, Australia, have been collaborating with commercial companies to develop sensor systems to monitor fruit yield and quality. They have designed high-speed cameras that capture images of fruit trees to provide data on the number of fruits, their size, and color. “Fruit growers use these data to predict yields and quality parameters, such as thinning in certain areas or the targeted use of reflective mulch to improve fruit color,” Goodwin explains.

Shift towards two-dimensional systems

At the Center of Excellence for Fruit Production in the Lake Constance Region (KOB), head of Yield Physiology **Konni Biegert** and her team are developing models for predicting storage quality and the effectiveness of fruit thinning based on sensor data from the orchard. They are also investigating the suitability of 2D systems for fruit production. Two-dimensional systems with narrow fruit walls reduce the use of plant protection products and could increase water usage efficiency. They represent the future, “supported by new rootstocks that increase resistance to climate change and fill the stand space more quickly,” says Biegert. The quality is produced in the orchard, she adds. The combination of data from apple growing and storage will enable better management decisions to be made on production and storage in the future.


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