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OF SUGAR BEET RESEARCH

ABSTRACTS OF PAPERS

77TH IIRB CONGRESS

Maximising sugar beet performance in a changing climate

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ORAL PRESENTATIONS

1.1 CAROLYNE DÜRR

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WILL CLIMATE CHANGE AFFECT SUGAR BEET ESTABLISHMENT OF THE 21ST CENTURY? INSIGHTS FROM A SIMULATION STUDY

Crop models can help to evaluate the potential impact of climate change on many stages of the crop cycle. We performed a simulation study to pinpoint how future climate change will affect potential sowing dates, germination and emergence as well as bolting rates of sugar beet crop. Sugar beet emergence simulations were performed using the SIMPLE crop emergence model between 2020 and 2100 in Northern France, for five sowing dates from mid-February to mid-April, under the most pessimistic IPCC scenario (RCP 8.5). We also evaluated the probability of field access for the earlier sowings, based on the amount of cumulated rainfall during February and March, and we examined the changes in water balance during sugar beet growth in summer. The results showed a significant increase in seedbed temperatures by 2°C after 2060. Emergence rate was generally higher for 2081-2100, while time to reach the maximum emergence rate decreased by about one week. The rate of non-germinated seeds decreased, but the frequency of non-emergence due to water stress increased after 2060 for all sowing dates, including the mid-February sowing. Bolting remains a risk for sowings before mid-March but this risk markedly decreased after 2060. However, the field access will be a main limiting factor for earlier sowings, as no significant changes in cumulative rainfall, compared with the past, will occur under future climate change. When field access is not a constraint, an anticipation of the sowing date can contribute to limit negative impact of water stress that the crop will encounter during summer. This study demonstrates that knowledge integrated into climate and crop models allows precisely investigating changes in future growing conditions and contributing to anticipate required changes in cropping systems.

1.2 ELISABETH LACOSTE

CIBE, International Confederation of European Beet Growers, Boulevard Anspach 111, B – 1000 Bruxelles

INFLUENCE OF CHANGES IN THE AVAILABILITY OF PLANT PROTECTION PRODUCTS ON THE SUGAR BEET SECTOR

Through non-renewals of approval and/or severe restrictions on approval of numerous active substances, the plant protection products toolbox for beet growers is shrinking drastically. The recent ban on neonic active substances in seed treatments, the non-renewal of a key fungicide active substance, the disappearance of key herbicide active substances are mobilizing all beet growers across Europe and their technical beet institutes. The improvement of good practices and the reduction of the use of inputs - and in particular of plant protection products (PPP) – in sugar beet growing is not new. However, the rapid pace of the disappearence of plant protection tools, the lack of time granted to seek and find sustainable alternatives and some broad sweeping policy directives are of particular concern. To be able to cope with these challenges and to continue to grow beet sustainably, beet growers need to respond to major questions: do we have the technologies, do we have the right regulatory framework and do we have the money to develop these technologies? Their actions aim at responding to these questions and focus especially on:

- The close monitoring of the regulatory status of the remaining available active substances, the advocacy for science and risk-based assessments of these substances and – when and as far as possible – advocating their renewal;
- The definition of appropriate methodology and indicators to monitor the development of the use of PPPs;
- The continuous improvement in the monitoring of pests and for diseases spread by pests (e.g. virus yellows by aphids);
- The tailoring of the management/use of remaining PPP tools to avoid build-up of resistance to the remaining active substances;
- The continuing development and cost reduction of combinations of mechanical & chemical weed control strategies;
- The support in the development of low risk PPPs and biocontrol strategies, including with a right regulatory framework;
- The development of breeding of beet varieties resistant to key pests and diseases and the support in the development of new breeding techniques with an incentivisingright regulatory framework;
- The support of investment in innovation and R&D.

1.3 JAN SELS, JUAN VEGAS, MAARTEN VANDERSTUKKEN, OLIVIER AMAND, GLENDA WILLEMS, HUGO BAUWELEERS, HENDRIK TSCHOEP

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CLIMATE CHANGE DRIVES UPCOMING CHALLENGES FOR SUGAR BEET BREEDING – A PERSPECTIVE FROM SESVANDERHAVE

Challenging times in sugar beet breeding are again ahead of us. In addition to increased volatility of the sugar market and the associated value chain, the global climate change leads to increased uncertainties in many areas where beet is grown. More frequent extreme environmental conditions – for example disease severity, drought or heat periods – are observed during the growing seasons. As the result of current societal trends, more plant protection products are being banned or their use is subject to more constraints, putting an increased pressure on the development and discovery of genetic solutions which can improve existing variety characteristics and performance towards more frequent extreme climatic conditions or disease pressure.

These challenges have a major impact on the breeding strategy for developing the next generations of sugar beet varieties. Varieties showing consistent performance, with additional stacked genetic tolerances to various biotic and abiotic stresses, some being new emerging threats, will be more than ever needed. To address this, genetic diversity resources need to be optimally harnessed by a combination of traditional breeding techniques and the opportunities offered by novel techniques arising from plant breeding innovation. This requires that breeding companies increase their investment in developing know-how and innovative technologies in areas such as high throughput phenotyping indoor and outdoor, large-scale genotyping methodologies, discovery of new traits, robotisation and advanced big data analysis.

In this presentation SESVanderHave would like to outline its integrated breeding approach, complemented with some case studies illustrating how we approach these challenges in order to continue supplying competitive sugar beet varieties which are adapted to the local needs of farmers and the sugar industries for the coming decades.

1.4 KARIN FIEDLER-WIECHERS, KNUTH WEISSLEDER, ANDREAS LOOCK
KWS SAAT SE & Co. KGaA, Grimsehlstrasse 31, D – 37574 Einbeck

BREEDING FOR CHANGING ENVIRONMENTS: DROUGHT A CHALLENGE FOR SUGAR BEET

Abiotic stress is one of the major factors causing yield reduction of sugar beet. Extreme weather events like flooding, heat waves in combination with drought stress phases will occur more frequently in future due to the forecasted climate change. Drought stress phases vary in timepoint, strength and duration during the vegetation period dependent on the location and year. A broad range of test sites is necessary to cover many drought stress scenarios as well as the testing across several years leads to develop stable drought stress tolerant varieties. Field trials revealed that genetic variation for drought tolerance exists but the genotypic response during the critical yield formation phases is different. Since several years, KWS is working on the breeding of stable drought tolerant varieties. New methods as genomic selection, phenotyping, growth models and the usage of weather data will help to speed up the breeding process.

1.5 GEORGINA BARRATT[1], MARK STEVENS[2], ERIK MURCHIE[1], DEBBIE SPARKES[1]

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UNDERSTANDING SUGAR BEET WATER USE EFFICIENCY (WUE)

In the UK, sugar beet is not commonly irrigated and in the driest years yield losses of up to 25% are evident (Pidgeon and Jaggard, 1998). The selection of varieties which are inherently more water use efficient would therefore be beneficial to UK beet growers. Our work uses modern varieties to assess changes in water use efficiency (WUE) over the growing season, to understand whether there are varietal differences in WUE, and how WUE is affected by water availability.

Two sugar beet varieties with contrasting upright and prostrate canopies were grown in 610L boxes in a polytunnel and exposed to four different irrigation regimes. A fully irrigated control, a single drought period with no irrigation and re-watering, a double drought period with re-watering before another withdrawal of irrigation and a continually water limited treatment. Gas exchange measurements were taken at regular intervals over the season alongside relative water content (RWC), SPAD and canopy temperature. At harvest leaf and root biomass as well as sugar percentage was assessed and stomatal impressions taken.

In 2018 it was found that multiple drought stress followed by re watering was as detrimental to final sugar yield as continual water limitation, suggesting a limited but regular supply of water is better than dry periods followed by saturation. Analysis of physiological traits showed that the prostrate variety had fewer stomata and a higher RWC which are traits usually associated with more conservative phenotypes. Although these traits did not result in significant yield differences at harvest, varietal traits did lead to differences in how the varieties responded to the environment.

The experiment was repeated in 2019 and results will be compared with those from 2018 to further explore how sugar beet responds to water stress. We will examine whether the differences in traits identified in 2018 are evident in 2019 and whether these translate to differences in WUE between varieties.

1.6 BARBARA MANDERYCK, IIRB weed control group[2]
IRBAB-KBIVB, 45 Molenstraat, B – 3300 Tienen

WEED CONTROL IN A NEW CLIMATE

Weed control in sugar beet has been a complex and very difficult matter since the crop was first sown. If weeds are not controlled efficiently in the sugar beet crop, production losses of 10% up to 90% are possible. Hence weed control in the sugar beet crop is a key factor in achieving the highest yield in the crop. By the beginning of the 90's a refined chemical weed control system, the low dosage FAR system, was established and adopted by farmers. With this FAR system a synergistic mix of three herbicide components at low dosage is applied repeatedly (3 to 6 times) to each time newly emerged weeds at the cotyledon stage.The mix of the components is adapted to the flora on the field. Although there are variations on the system, the principles are the same for all the EU countries. Depending on the weather conditions, the FAR system is sometimes complemented with mechanical weed control in order to improve efficiency and/or to reduce the amount of herbicides used and/or as a weed resistance management tool. In recent years many efforts have been made to integrate mechanical weed control further into the sugar beet weed control system. Many advances have been made in improving the technology and making it more practical and reliable. However, remaining economical and practical limitations have meant a slow uptake of the integration of mechanical methods in practice. The current climate or context for the sugar beet weed control is now evolving fast. A combination of multiple factors play a role. First, the political climate is one in which there is a strong whish to reduce the reliance on chemical herbicides in combination with the implementation of IWM legislation. Secondly, many changes in authorisations of herbicides and their availability are occurring in the context of AIR renewals in frame of EC/1107/ 2009. Thirdly, new innovations like the Conviso ® Smart system are being introduced. Another factor is real climate change that influences the weed flora. And lastly, robotics are also under development for applications in future sugar beet weed control. The talk will focus on the factors influencing the evolutions in sugar beet weed control and the role of the IIRB weed control study group in this process.

1.7 PAUL TAUVEL, JEAN-CHARLES GERMAIN
Institut Technique de la Betterave ITB, 45 rue de Naples, F – 75008 Paris

CHANGING WAYS OF THINKING TO PRODUCE ORGANIC SUGAR BEET

Development of organic sugar beet production is a huge challenge, especially concerning weeds management. Innovations and a new way of thinking are essential to reach harvest in good conditions with controlled costs.

ITB carried out four experimental trials comparing three planting strategies: conventional seedling, square seedling (Kverneland's technology), and 4-leaves sugar beet planting. Square seedling is used to hoe in two directions. 4-leaves sugar beet planting enables to weed shortly after it.

Square seedling and sugar beet planting modalities show good weed management results combining with appropriate interventions. Even if manual weeding is needed, it is less mobilised than for conventional seedling modality.

The presentation will bring technical precisions to optimise chances of success for these strategies.

Experience acquired through these trials shows organic production forces to change practices. Later seeding seems necessary to start managing weeds before sugar beet seedling. A decrease of sugar beet population must be accepted to implement these strategies. And, first mechanical weeding must be done earlier than advised in conventional production.

2.1 ANNE-KATRIN MAHLEIN

Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

IIRB SEMINAR 2019 ON SENSORS AND DIGITAL TECHNOLOGIES IN SUGAR BEET PRODUCTION

Promising innovations in the field of sensors and digital technologies for agriculture are constantly developed. There are two main domains of application: (i) Precision Agriculture in terms of considering the heterogeneity within agricultural fields and adapting management practices precisely in time, space and amount, (ii) Plant Phenotyping for supporting decisions within the breeding process. New approaches like drones, robots or cameras find their way more and more into management practices.

On December 17th 2019 an IIRB Seminar titled 'Sensors and digital technologies in sugar beet production' was held at the Forschungszentrum Jülich, Germany. The interesting program with three sessions covered talks from international experts on Innovative technologies for breeding and cultivation, Crop management, and plant protection, and Precision harvesting and quality assessment. The diversity of the talks illustrated impressively the innovative potential of digital technologies, but it also demonstrated a high demand for future research, knowledge transfer and teaching. The workshop was further supported by a high number of exhibitors (start-ups and companies) providing solutions or developing first prototypes. There was a vivid discussion and exchange at the exhibition site. The following tour through the laboratories and facilities of the Forschungszentrum Jülich, Institute of Bio- and Geosciences, Plant Sciences (IBG-2) gave new insights and inspiration for future research aspects.

In terms of sugar beet cultivation multiple application scenarios are discussed and identified, starting with monitoring plant development over the vegetation period, assessing biotic and abiotic plant stress non-invasively or supporting the harvesting process by sensors for a more gentle treatment of the harvested beets. Now it is up to us to develop a network with partners from different disciplines to foster research and integration of digital technologies for sugar beet growing.

2.2 JAKE RICHARDS[1], SACHA MOONEY[1], MARK STEVENS[2], DEBBIE SPARKES[1]

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USING X-RAY COMPUTED TOMOGRAPHY, ELECTROMAGNETIC RESONANCE AND THERMAL IMAGERY TO UNDERSTAND THE EFFECTS OF COVER CROPS ON SOIL STRUCTURE AND SUGAR BEET GROWTH

The use of cover crops has increased dramatically over the last decade as a result of evidence supporting their use for preventing leaching of nitrate. It has also been proposed that using cover crops, in favour of bare soil, could improve soil structure and the growth of the following crop. Sugar beet are sensitive to the soil structure both during early growth, when soil conditions affect establishment, and during mature growth, when soil structure influences root growth and water uptake.

The project has investigated cover crop growth on a range of soil textures over a period of three years to understand their effects in the UK climate. We conducted replicated experiments and strip trials on commercial farms in Nottinghamshire, Norfolk and Suffolk. Traditional measurements of shear strength, penetration resistance, earthworm abundance and soil aggregate size distribution were conducted alongside X-ray Computed Tomography and electromagnetic resonance (EMI) to understand the effects of cover crops on soil structure. Measurements of sugar beet canopy expansion, thermal imagery, root morphology and yield were made during each season at each field site.

The overall effects of the cover crops on the sugar beet system were highly dependent on soil texture and weather conditions during cover crop and sugar beet growing seasons. Cover crops on loam soils resulted in a greater proportion of small soil aggregates however, this was affected by secondary tillage. There was evidence to suggest that multi-species cover crops are not more effective than single species in terms of root production. On a sandy loam soil, cover crops resulted in greater soil porosity which allowed sugar beet better access to water.

2.3 BRAM HANSE[1], ARJEN BUIJZE[2]

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INTEGRATED MANAGEMENT OF FOLIAR DISEASES IN SUGAR BEET

In Dutch sugar beet production, two foliar fungi are most damaging: *Cercospora beticola* and *Stemphylium beticola*. Both can cause epidemics in sugar beet fields causing sugar yield losses up to 40%. Whether an epidemic will take place depends on a number of requirements to be full filled on a field. The conditions in the crop like relative humidity and temperature play an important role. They determine which of the fungal species receives its optimal conditions for infection, sporulation and spread in the field. To guide farmers to have their applications with the proper fungicide on the right time in the crop, a network of relatively cheap temperature and air humidity sensors measuring the micro-climate in the crop was set up, using an automated ICT infrastructure to translate the conditions to Daily Infection Value's (DIV) specified for both *Cercospora beticola* and *Stemphylium beticola*. The use of this automated sensor network and the research behind it will be presented, as well as its value in the management of foliar diseases.

2.4 CELINE GOUWIE, ILIES GHEZAL, FLORENT LAVIGNE, REMY DUVAL, FABIENNE MAUPAS

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BETA'STAT: UNDERSTANDING FARMING PRACTICE FOR ACCURATE ADVICE

Since 1997, French sugar beet grower annual cultural practices are recorded and analyzed by ITB, setting up a factual sugar beet technical management observatory. The precise knowledge of their status and evolutions is a major tool for the sector to insure sugar beet competitiveness and sustainability.

As result of a multiple year development taking into consideration both farming and industrial interests, Beta'Stat, our new online collecting information tool now replaces ITB's former long term survey. Therefore, ITB launched a completely redesigned web-based participative tool in October 2019: sugar beet growers can now fill in their cultural practices securely in real-time without advisers' help. Farmers can then access individual indicators to position their farms within French sugar beet production. This farmer data real-time feedback strengthens the tool adoption. Moreover, new developments are scheduled for 2020 to make it gradually interoperable with the most popular crop recording programs. Cultural practices completion will be automated for longer questions.

This redesign resizes and adjusts the position of this observatory. Time gains allow ITB to improve data analysis and their valorisation: data management has been harmonised and automated. Recent outcomes have been synthesised to highlight the sugar beet practice including their evolutions. In parallel to the strong increase in productivity, many environmental improvements have been managed within 23 years of survey. However some future challenges can already be noted and open new prospects.

2.5 TOBY TOWNSEND[1,2], DEBBIE SPARKES[2], SIMON BOWEN[1], NEIL CROUT[2]

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BENCHMARKING FOR IMPROVED SUGAR BEET YIELDS

There is significant variability in sugar beet yields between farms in the UK, which is mainly attributed to crop management factors. This demonstrates a considerable opportunity to increase yield through improved crop management that is customised to the farm- and field-specific level. Key to this improvement is the better use of data. We present progress in developing benchmarking resources for growers that will help to identify areas where their crops are losing out on yield and provide them with targeted resources to help them manage their crops to overcome these challenges. Following from the creation of a digital tool for benchmarking yield performance in 2019, a digital platform is being developed that allows growers to compare observations of their own crop progress with data from multiple sources, including: 1) the sugar beet growth model; 2) tracked performance of other growers' crops grown in the same area and on a similar soil type; and 3) targets based on field trials. From this, growers can identify the stages in the season where yield is being lost and gain an understanding of the yield that they could achieve given improved crop management. The grower can then be provided with relevant resources, such as case studies and agronomic guides, that target the areas where they are losing out on yield. Alongside this, support will be provided to enable the grower to use the benchmarking data to make a detailed yield improvement plan that helps them to bridge their yield gap and reach their yield potential.

3.1 DIDIER DEMILLY[1], SYLVIE DUCOURNAU[1], MARIE-HELENE WAGNER[1], ANGELIQUE DELANOUE[1], AUDREY DUPONT[1], CAROLYNE DÜRR[2]

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PHENOTYPING OF SUGAR BEET GENETIC DIVERSITY FOR BETTER GERMINATION AND EARLY GROWTH IN COLD CONDITIONS

In the framework of the AKER project in France (http://www.aker-betterave.fr), 2744 genotypes were phenotyped to determine wether genetic diversity exists and could be exploited for cold tolerance at early stages. The equipment from PHENOTIC platform (https://www6.inrae.fr/phenotic/) designed for seeds and seedlings digital phenotyping was used: tables of Jacobsen equipped with cameras and regulated at several temperatures for germination; an automated tool called ElonCam to measure seedling heterotrophic growth under green lights. Germination was automatically measured every 4 hours on 25 seeds on each genotype at 5°C. According a sequential analysis a second replicate was tested for 419 genotypes to obtain a subset of 136 genotypes selected for their extreme values, high or low speed of germination at 5°C. This subset was more deeply phenotyped at 10 and 20°C and also with ElonCam, at 10°C on three replicates of 10 seedlings.

Results indicated that genetic diversity existed on germination speed and final rate at 5°C with a difference of about 2 days (relative to about 15 days) for T50 and of 50% on final germination rates. Moreover, the extreme genotypes that were more deeply phenotyped, showed that their germination was also in average better at 10 and 20°C. Importantly, germination traits were not strongly correlated with seedling heterotrophic growth at 10°C. Radicle elongation rate was either high or low for a genotype having a high germination speed at 5 or 10°C. This indicated that the two traits are at least for a part independantly determined at the genetic level.

The Aker program allowed to collect a large range of genotypes and organise their exploration at the genetic and phenotypic levels. Variability was revealed on a number of traits including germination and early growth. This will allow improvement of sugar beet cultivars facing new cultivation technics for adaptation to climate change and decrease of pesticide uses.

3.2 DEBBIE SPARKES[1], JENNIFER BUSSELL[1], STEPHEN ALDIS[2], MARTIN BROADLEY[1], SACHA MOONEY[1]

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IMPROVING ESTABLISHMENT IN SUGAR BEET

Rapid, uniform establishment is vital for sugar beet production. Early establishment allows the plants to get the most from the sun's energy, and uniform establishment allows them to make the best use of the space available, with the minimum amount of competition.

We have previously reported on our work to model soil physical properties at the point of drilling (Bussell *et al*., 2018), to identify the most important factors governing sugar beet establishment. Soil physical properties accounted for 60-70% of the variation in establishment although there were significant differences between seasons. Our work has now progressed to the consider the impact of cultivation strategy on soil physical properties of the seedbed. Using X-ray CT technology we can analyse soil pore space and connectivity to understand how this links to establishment, crop growth and yield. Our presentation will focus on data from two seasons, comparing a range of cultivation strategies on contrasting soil textures.

3.3 HEINZ-JOSEF KOCH
Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

SUGAR BEET YIELD RESPONSE TO INCREASING ROW DISTANCE

In Europe, sugar beets are traditionally grown with a row distance of 45 or 50 cm. Due to the crop´s slow canopy development in spring light interception during early growth is incomplete. It was hypothesised that lowering the row distance to 30 cm increases light interception during early growth and thus, increases yield. Field trials were conducted near Göttingen to quantify the effect of 30, 60 and 90 cm row distance compared to the 45 cm standard on canopy development, yield formation and light interception. The results will be discussed with regard to implications on weed control and harvest performance.

4.1 MARK STEVENS

British Beet Research Organisation, Innovation Centre, Colney Lane, UK – Norwich NR4 7GJ

SUMMARY OF NEONIC WORKSHOP LEUVEN 03/2019

An IIRB workshop 'Growing sugar beet without neonicotinoid seed treatments', chaired by Mark Stevens (BBRO), Elma Raaijmakers (IRS), and Mark Varrelmann (IfZ), was held in March 2019 to which 14 international speakers from different research institutions were invited. They gave an overview on current and future options for the control of soil pests, leaf miner and virus-carrying aphids.

The first session highlighted alternative control approaches with root-colonizing entomopathogenic fungi, and an attract & kill approach. Natural control of pests in arable crops may be supported by flower strips and landscape measures. For effective aphid control, monitoring of their populations becomes increasingly important. Several complementary aphid control strategies were presented that require further development.

The second session concentrated on breeding activities towards resistance of sugar beet to virus yellows, with the aim to reduce the dependence on insecticides for virus yellows control.

The third session on chemical alternatives reviewed active ingredients currently still available in Europe for use against insect pests in sugar beet and highlighted existing insecticide resistance against some of these plant protection products.

Overall, the workshop, attended by 85 participants, provided a valuable and broad overview on measures to be further developed for insect control without neonicotinoid seed treatments. The meeting also gave food for thought and provided opportunities for future collaboration.

4.2 ANNE LISBET HANSEN[1], ELMA RAAIJMAKERS[2], KATHLEEN ANTOONS[3], ANDRE WAUTERS[3], FRIEDRICH KEMPL[4], MARK STEVENS[5], FRÉDÉRIC BOYER[6], MARK VARRELMANN[7]

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EFFECT OF INSECTICIDES AND STRATEGIES OF INSECTICIDE APPLICATIONS ON THE CONTROL OF *ATOMARIA LINEARIS* AND OTHER SOIL BORNE PESTS

The EU ban of neonicotinoid seed treatments since 2019 gives new challenges for the control of soil borne pest from early germination to 4- to 6 leaves stage of sugar beet. Among the most frequently occuring soil borne pests is the pygmy mangold beetle, *Atomaria linearis*. Effects on symptoms, plant stand and sugar yield of a number of registered and new insecticides have been studied in field trials and results are presented.

4.3 FRÉDÉRIC BOYER[1], KATHLEEN ANTOONS[2], ANDRE WAUTERS[2], MARK STEVENS[3], LISBET HANSEN[4], ELMA RAAIJMAKERS[5], MARK VARRELMANN[6]

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OVERVIEW OF APHID AND VIRUS YELLOWS MONITORING ON SUGAR BEET IN WESTERN EUROPE

Since the ban of neonicotinoid class insecticides in seed treatments in most European countries, transmission of yellowing viruses by aphid vectors has become a major concern for sugar beet production. Indeed, without any control, these viruses can induce important yield losses, depending on the viral species involved and on the severity of infection. Currently, only foliar aphicides are available to control the aphids before they transmit the viruses, although authorised active substances and available commercial products strongly differ between European countries.

In order to give advice to beet growers regarding the timing of aphicide applications, it is necessary to have an understanding of aphid flights, of wingless aphids' colonisation in the fields and of the viral species involved. To do so, several methods are available, such as the capture of winged aphids in yellow water pans and suction traps, field scouting, sampling of infected leaves/aphids and virus detection in the laboratory. In addition, identifying virus reservoirs (such as crops or weeds) is valuable information in order to contain and minimise virus pressure in the surroundings of sugar beet fields.

This presentation will give an overview of host crops for the viruses and on the different methods and main results of aphid and virus yellows monitoring obtained by six European countries over the past few years.

4.4 ANDRE WAUTERS[1], KATHLEEN ANTOONS[1], MARK STEVENS[2], ELMA RAAIJMAKERS[3], LISBET HANSEN[4], FRÉDÉRIC BOYER[5], MARK VARRELMANN[6]

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TESTING FOR TOLERANCE AND RESISTANCE AGAINST YELLOWING VIRUSES IN SUGAR BEET VARIETIES

BMYV, BChV and BYV are important yellowing viruses that cause damage to the sugar beet crop in Europe. All three viruses are transmitted by *M. persicae* and can be found spread over the European countries. Since the ban on the neonicotinoids only a few efficent foliar insecticides can be used to avoid the transmission of these viruses by aphids. A genetic response seems therefore to be an essential complementary tool to prevent the yield losses due to these viruses.

This presentation gives an overview of the trials conducted by the different european institutes to evaluate the varieties for their tolerance and/or resistance to the individual virus types. Trial and inoculation techniques, including field experiments and greenhouse assays, and effect of viruses on the yield performance of the varieties are discussed.

4.5 ELMA RAAIJMAKERS[1], KATHLEEN ANTOONS[2], ANDRE WAUTERS[2], MARK STEVENS[3], LISBET HANSEN[4], FRÉDÉRIC BOYER[5], MARK VARRELMANN[6]

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THE EFFECT OF NEW INSECTICIDES AND STRATEGIES OF INSECTICIDE APPLICATIONS ON THE CONTROL OF APHIDS AND VIRUS YELLOWS

Since the ban on the neonics virus yellows has become a new problem again. BMYV, BChV and BYV are the most important yellowing viruses that cause damage to the sugar beet crop. All three viruses are transmitted by aphids, of which *M. persicae* is the most important one. In the different European countries only a few insecticides are authorised to control this vector of virus yellows. However, in many populations of this aphid resistances to several classes of insecticides (e.g. carbamates, pyrethroids and neonicotinoids) are reported. The aim of this study is to investigate the effect of new insecticides and strategies of insecticide applications on the control of aphids and virus yellows.

Therefore, new insecticides and strategies were tested in field trials with natural and artificial inoculation of aphids. The effect of the insecticides was measured by assessments on number of aphids, on virus yellows and on sugar yield.

In this presentation, the results will be presented and discussed to better control virus yellows in the future.

4.6 Ralf Nauen[1], Barbara Manderyck[2], Elma Raaijmakers[3], Mark Varrelmann[4], Anne Lisbet Hansen[5]

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A broad monitoring of *M. persicae* resistance status in Belgium, Netherlands, Denmark and Germany urgently calls for the implementation of resistance management strategies

Peach-potato aphid, *M. persicae* is the most important vector for the virus yellows complex in sugar beet. In the absence of efficacious control in combination with early infection, such virus infections facilitate crop losses and have a major economic impact. Before the introduction of neonicotinoid seed treatments, virus yellows were an important cause for yield loss in countries with a maritime climate such as the UK, B, F and NL and to a lesser extent in D and DK. In anticipation of the potential loss of the neonicotinoid seed treatments in sugar beet a broad monitoring of the resistance status of *M. persicae* was initiated in 2014. This was driven by the fact that only a limited number of modes of action, mainly pyrethroids and pirimicarb are available as foliar sprays to control *M. persicae*. A COBRI collaboration was set up to evaluate the resistance status of *M. persicae*, particularly by genotyping samples for target-site resistance. In contrast to the UK, no recent data was available on *M. persicae* resistance for the COBRI countries. Samples were collected in 2014, 2015 and 2016 in sugar beet, potato and winter oilseed rape fields, yellow water pans and suction traps in NL, B, D and DK. All samples (n > 300) collected over a 3-year period were analysed by pyrosequencing for the presence of target site resistance against pyrethroids (kdr or L1014F mutation, s-kdr or M918L and M918T mutation in voltage-gated sodium channels), pirimicarb (MACE or S431F mutation in acetylcholinesterase) and neonicotinoids (R81T mutation in the ß1-subunit of the nicotinic acetylcholine receptor). The collected data show an alarmingly high level of kdr and s-kdr resistance, an intermediate level of pirimicarb (MACE) and a lack of neonicotinoid (R81T) resistance, with a few individuals carrying the mutation. The results were validated using nine living *M. persicae* populations from NL, B and DK in a leaf disc bioassay using discriminating rates of deltamethrin, pirimicarb and imidacloprid. The results of the bio-assays correlated with the molecular genotyping data and revealed a total lack of pyrethroid efficacy in all tested strains, a limited efficacy for pirimicarb and a lack of resistance to imidacloprid. The obtained resistance monitoring results revealed an alarming level of resistance against established modes of action and suggest major limitations for the implementation of resistance management strategies to guarantee sustainable yields. This in conjunction with restrictions in regulatory approval of alternative insecticides jeopardises the effective future control of *M. persicae* in the countries investigated here. Implications of the presented findings in an integrated pest management context will be discussed.

4.7 HERBERT EIGNER, MARTINA MAYRHOFER, ANDREAS SENNINGER, STEFAN GEYER
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SUGAR BEET WEEVIL (*BOTHYNODERES PUNCTIVENTRIS*) A THREATENING PEST IN THE PANNONIAN SUGAR BEET GROWING AREA

An increasing number of periods with distinct dry and hot conditions are causing severe damage in agricultural crops by different pests. Due to favorable reproduction conditions during the last few years, an exponential progression in the occurrence of beet weevils (*Bothynoderes punctiventris*) in sugar beet fields has been observed.

While information on the reproduction cycle of the weevil is adequate, there is a lack of knowledge on the migration behaviour as well as on the possibilities to fight this periodically appearing pest. Additionally, legal restrictions reduce the number of available insecticides for protecting the sugar beet crop.

Beside the implementation of a monitoring and warning service, our investigation focuses on population control by different measures: Field trials on the effect of parasitic nematodes (*Heterorhapditis bacteriophora*) and entomopathogenic fungi (e.g. *Metharizium brunneum*) prohibiting larvae development were realised. The impact of soil tillage, the succeeding crop, trench lines and pheromone traps on weevil migration has been determined. Not at last, the efficacy of insecticide and repellent application was evaluated. Results show, that only a combination of most of the suggested measures allows a certain effect in population control.

5.1 REBECCA E. SPANNER, VIVIANA RIVERA-VARAS, LINDA L. YOUNG, GARY A. SECOR, MELVIN D. BOLTON

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GENOME-WIDE ASSOCIATION STUDIES IDENTIFY MUTATIONS ASSOCIATED WITH DMI RESISTANCE IN THE CERCOSPORA LEAF SPOT PATHOGEN

Cercospora leaf spot (CLS) caused by *Cercospora beticola* is one of the more destructive foliar diseases of sugar beet worldwide. In the United States, losses to CLS approached $200 million in the 2018 growing season alone. Management strategies for CLS rely on timely fungicide application. The CLS management fungicide repertoire often includes the application of fungicides in the sterol demethylation inhibitor (DMI) class. The reliance on DMIs has led to the emergence of resistance in many *C. beticola* populations. Previously, we showed that DMI-resistant strains of *C. beticola* have high expression levels of *Cyp51*, which are induced further upon DMI exposure. However, no mutations in the *Cyp51* coding or promoter regions appeared to correlate with DMI resistance. To identify mutations responsible for DMI resistance, a genome-wide association approach was undertaken using nearly 200 isolates from local sugar beet fields. Approximately half of the isolates were DMI-sensitive (EC50 value <1.0 µg mL^{-1}) while the other half were DMI-resistant (EC50 value ≥1.0 µg mL^{-1}). After whole genome resequencing, genome wide association identified one locus highly correlated with DMI-resistance. To confirm the association between mutations in this locus and DMI resistance, CRISPR-Cas9 mutants have been developed. The results of this study will be reported.

5.2 FRIEDRICH J. KOPISCH-OBUCH, CARSTEN STIBBE, WERNER BEYER, WOLFGANG MECHELKE

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KEEPING SUGAR BEET COMPETITIVE WITH NEW STRATEGIES FOR CERCOSPORA RESISTANCE

Increasing disease pressure of cercospora leaf spot (*Cercospora beticola* Sacc.) and decreasing efficacy of fungicides threaten sugar beet production in important growing areas around the world. In response to that, KWS has significantly invested in the successful development of sugar beet varieties with a high level of resistance towards the disease. A sustainable use and cultivation of highly resistant sugar beets, however, result in a number of requirements towards (i) the variety and (ii) the production system. Presenting a new generation of high performing CR resistant sugar beet varieties, we will outline strategies for improving an integrated management approach towards foliar diseases.

5.3 DANIEL LAUFER, CHRISTINE KENTER, ERWIN LADEWIG
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EFFECT OF FUNGICIDE STRATEGY AND VARIETY ON CERCOSPORA LEAF SPOT EPIDEMICS IN SUGAR BEET

Cercospora leaf spot disease is becoming increasingly important in Germany. At the same time, existing fungicides are losing efficacy. Therefore, efficient control strategies have to be developed to stabilise yields and reduce the further spread of resistance. In 2017 to 2019, 12 field trials were conducted to test the efficacy of four fungicide strategies against Cercospora in a susceptible and a tolerant sugar beet variety. All fungicide strategies reduced infestation in all environments. With moderate infestation, this reduction did not always affect yield, especially in the tolerant variety. Furthermore, the tolerant variety reached the threshold for the second or third fungicide application up to three weeks later than the susceptible one. In the case of strong to extreme infestation, the fungicide strategies including a contact fungicide in addition to triazoles and thiophanate-methyl had the greatest effect on infestation and white sugar yield. Tolerant varieties and also contact fungicides, which are only approved for emergency situations, can currently contribute to the resistance management of *Cercospora beticola*.

5.4 FREDERIKE IMBUSCH[1], TOBIAS ERVEN[2], MARK VARRELMANN[1]

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RELATION BETWEEN *CERCOSPORA BETICOLA* SPORE FLIGHT AND LEAF SPOT DEVELOPMENT AFTER FUNGICIDE APPLICATION ACCORDING TO DISEASE THRESHOLDS AND/OR SPORE FLIGHT

Cercospora leaf spot caused by *Cercospora beticola* is the most relevant leaf spot disease in sugar beet in Germany. The disease spreads by spores mainly by wind and splash water. However, current presence of air-borne inoculum of *C. beticola* is not implemented in disease prognosis models. A rapid and inexpensive detection of *C. beticola* spores might provide an alternative basis for a more specific and efficient fungicidal control of Cercospora leaf spot disease. Two fungicide trials with inoculated plots were conducted in different environments near to Göttingen during summer 2018. Spore flight was assessed on a two to three day basis as well as Cercospora leaf spot disease development once a week. For detection and quantification of *C. beticola* DNA from Rotorod spore traps DNA was extracted followed by a TaqMan qPCR. Plots were treated for a maximum of two times with fungicides according to time-specific thresholds, after *C. beticola* DNA detection and combinations of both criteria including an untreated control. To determine possible effects on spore flight and disease development weather data was recorded during sampling period. Preliminary analysis indicate that fungicide applications, besides causing less severe disease development, also reduced subsequent spore flight intensity. A combination of a threshold-based application timing followed by an application after first detection of spore flight earliest three weeks after the first application gave one of the best reductions in disease severity development.

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REDUCED TILLAGE IN SUGAR BEET CROP SYSTEMS: SYNTHESIS OF A 20 YEARS FIELD EXPERIMENT

Reduced tillage expanded in French field crop areas from mid-nineties aiming at lowering energy consumption, sparing time, lowering production costs, and improving crop systems economical performances. Reduced tillage was also promoted because it can support soils preservation need and reduce risks of erosion. Nowadays, reduced tillage is consistent with the issue of global warming, in so far as it will save energy through less traction time and is likely to enable carbon storage in soils.

Do simplified tillage techniques in sugar beet rotations meet productivity and economical targets? Which main soil parameters are modified in the long term?

An overview of Arvalis-Boigneville long term trial provides figures and observations to answer these questions. This trial compared different reduced tillage options in a 4 year rotation (wheat-sugar beet-peas-spring barley), in a calcareous loamy soil, from 1998 to 2017. A conventional ploughed modality was kept as control.

All reduced tillage techniques present more variability in population establishment, yields and external quality results between years, than ploughed modality. The trial confirms the difficulty to manage sugar beet in direct drilling or superficial reduced tillage, but the gap with conventional techniques shrank during trial time. Yield and economic performances give advantage to simplified tillage techniques when looking at the whole rotation results. In terms of carbon storage, Boigneville trial shows practically no increase in soil stored carbon in the long term, even with direct drilling system.

The experimentation shows a remarkable improvement in equipments and techniques, since the trial compared different tillage options that evolved with new equipment arrivals within these 20 years.

7.2 SILVIA MADRITSCH[1], SVENJA BOMERS[1], SANDRA OTTE[2], FLORIAN EMERSTORFER[3], REBEKKA BIRKE[3], HERBERT EIGNER[3], EVA M. SEHR[1]

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VARIETY-SPECIFIC MOLECULAR MECHANISMS IN SUGAR BEET DURING AN EXTENDED STORAGE TIME

Sugar beet (*Beta vulgaris* ssp. *vulgaris* L.) provides almost 30% of the world's sugar. Since the sugar beet processing is more and more centralised to a small number of companies, storage of harvested beet roots over months has become necessary. Sucrose loss during the post-harvest storage is a major concern of the sugar industry. It is mainly lost through respiration accompanied by the accumulation of invert sugar, the latter severely affecting sucrose processing. But also changes in the cell wall composition, changes in hormone levels as well as increased rot formation are noticed. The capacity for an extended storage is an essential economic factor but differs from cultivar to cultivar.

Aiming at uncovering mechanisms that underly variety-specific storage capabilities (estimated by invert sugar accumulation and sucrose loss) we applied comparative transcriptomics together with anatomical analyses on a core sample of sugar beet tap roots of six varieties reacting differently during a 13-week storage trial. Variety-specific differences could be pinpointed already before storage, whereby the well storable varieties were characterised by a higher number of parenchymatic cells, a smaller cell area, and a thinner periderm. This is supported by transcriptomics analysis, where 82 significantly differentially expressed genes were identified between well and badly storable varieties. Among them, genes related to cell division and cell expansion. After 13 weeks of storage, over 900 genes were detected that significantly discriminated between well and badly storable varieties. Interestingly, one gene that is directly associated to sucrose catabolism showed a significantly higher expression in the badly storable varieties. Besides that, differentially expressed genes were found in the categories of defence response, response to biotic/ external stimuli, to oxidation-reduction, to the biosynthesis of salicylic acid. These findings were further confirmed with gene co-expression network analysis and highly interconnected genes as specific marker genes will be identified.

Especially the further integration of metabolomics data will allow us to understand polygenic processes during storage and the functionality of the biological system, since anatomical, molecular and genetic factors influencing the storability are not yet fully understood.

7.3 GUNNAR KLEUKER[1], JOAKIM EKELÖF[2], MARTIJN LEIJDEKKERS[3], FRANÇOISE VANCUTSEM[4], CHRISTA M. HOFFMANN[1]

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IMPACT FACTORS ON THE TISSUE STRENGTH, DAMAGE SUSCEPTIBILITY AND STORABILITY OF SUGAR BEETS

Observations in the field showed different damage susceptibility of sugar beets depending on variety and growing site. A possible reason could be the tissue strength of sugar beet, which may also affect the storability.

The COBRI storage group investigated the influence of variety, site and agronomic factors on the tissue strength of the beet and their impact on damage susceptibility and storability. For that purpose, three varieties, which differed in yield formation, were grown at three sites in Belgium, the Netherlands and Sweden in six replications. Additionally, agronomical practices, such as N-fertilisation and irrigation were varied. Tissue strength was measured with a texture analyser using puncture and compression tests. Storage trials were con-ducted in climate containers with a constant temperature of 8.6 °C over 70 days.

With both texture analysing methods differences in tissue strength between varieties and site could be identified. Furthermore, it could be demonstrated that the impact of site and variety was larger than those of agronomical operations.

POSTER PRESENTATIONS

1.1 GIOVANNI CAMPAGNA[1], ROMANO GIOVANARDI[2], MARCO SANDONA[2]
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SUGAR BEET AND OTHER CROPS IN ROTATION SUSTAINABILITY CULTIVATION (CARBON FOOTPRINT) IN ITALY

The goal of the study was to evaluate the potential environmental impacts of the production of some crops throughout their life cycle. The analysis refers to the ISO14040 standard and assesses both the energy impact and the emissions (limited to those GHG expressed in kg of equivalent carbon dioxide). The study includes the production of raw materials up to the harvest. Technical means and packaging, including related transport, are included in the impact energy values. With regard to the analyzes, primary data were obtained from the flows of raw materials and energy (input/output) taken from the cultivation data sheets and others taken from mathematical models and Ecoinvent databases. The processing to define the impact categories was carried out with the SIMAPRO software, while using an original model for the energy balance. Direct air emissions (nitrogen oxide: N_2O - carbon dioxide: CO_2 - ammonia: NH_4 - nitrogen oxide: NO_x) and soil, correlated with the use of chemical substances used for cultivation, have been quantified referring to inventories of the life cycle of agricultural production systems and the IPPC guidelines for national inventories of greenhouse gases, as well as to the composition of crop protection products found in the product data sheets.

Evaluating the different species cultivated in terms of biomass produced (energy content) and efficiency of the input factors (Output/Input ratio) makes it possible to verify that sugar beet, according to the level of cultivation intensification adopted, has a high energy production per hectare and to highlight an Output/Input ratio between 9.4 and 14.4. Maize combines a lower O/I ratio (due to the significant contribution of fertilisers and fuel consumption for irrigation) to high production. Soya, like tomato, shows a lower energy content and an even lower O/I index. If we consider the quantities of carbon dioxide organicised and subtracted from the atmosphere by the different cultures compared over the course of a crop cycle, the best productions of beet roots equal the same area of cultivated forest (poplar grove), compared to lower quantities of other crops.

From an environmental point of view, it is possible to affirm that sugar beet shows a low impact both for the reduced carbon dioxide emissions (carbon footprint), and for the reduced needs of water supplies and nitrogen fertilisation. This is possible thanks to the considerable depth of the root systems reached by the crop. The relative advantages are the supply of precious humidity in the summer from the ground, as well as considerable quantities of leached nitrogen, otherwise destined to pollute the groundwater.

1.2 PHILIPP GÖTZE, HEINZ-JOSEF KOCH
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EFFECT OF CROP ROTATION AND REMOVAL OF BEET LEAVES AND TOPS ON SOIL ORGANIC CARBON STOCKS IN THE CROP ROTATION EXPERIMENT AT HARSTE

The crop rotation trial in Harste near Göttingen was set up in 2006. Different crop rotations with sugar beets (SB), silage maize (SM), winter rape seed (WR), grain pea (GP) and winter wheat (WW) are tested. In an additional treatment of the crop rotation SB-WW-WW, green manuring by beet leaves (without, single and double amount of beet leaf) is also varied. After a 12-year trial period, the effect of the crop rotation (SB-WW-WW-mustard, SB-WW-mustard-SM and SB-WW-WR-WW-WW-phacelia-GP-mustard) as well as the effect of green manuring by beet leaves on the soil organic carbon stock is analysed. In the spring of 2018 and 2019 soil samples were taken to determine the dry bulk density (undisturbed soil cores, n = 2 per depth, 250 cm^3, h = 5 cm) and the organic carbon content (dry combustion method) on four repeated measurements per field (3 field repetitions). Soil depths investigated were 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm and the soil organic carbon stock was calculated for the soil depths 0-10 cm, 0-20 cm and 0-30 cm on the basis of equal soil masses. Subsequently, outliers (values smaller / larger than mean +/- standard deviation) were eliminated on variant level. The poster presents the methodology used and first results.

1.3 Gernot Bodner[1], Herbert Eigner[2], Dietmar Horn[3], Stefan Geyer[2], Katharina Keiblinger[4]

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EUF SOIL EXTRACTION FOR THE DETERMINATION OF STRUCTURE-RELEVANT ORGANIC CARBON FRACTIONS

Stabile soil structure is a pre-requisite for optimal emergency conditions, rapid youth development and untroubled yield formation. Soil structure fundamentally depends on soil organic carbon fractions contributing to aggregation of soil mineral particles at different scales.

Soil analysis by the Electro-Ultrafiltration procedure and deriving fertiliser recommendations are a well-established tool optimizing nutrient supply in sugar beet. The objective of this study is to investigate possibilities to determine soil organic carbon fractions in EUF-extracts with relevance to soil aggregation. For this purpose soil samples from a long-term tillage trial (plough, chisel, disc harrow, no till; silt-loam chernozem soil) were taken and extracted with variable length and intensity (voltage, temperature) by the EUF-procedure. The EUF-extracts were then analysed by py-GCMS to determine organic carbon species extracted under the different conditions that allow inference on their function for soil structure.

1.4 ALEXANDER STRACKE, HEINZ-JOSEF KOCH
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ABOVE- AND BELOW-GROUND BIOMASS AND N UPTAKE OF CATCH CROPS AFFECTING SOIL N_{MIN} OVER WINTER

Agricultural crop production is increasingly focusing on topics such as climate protection and protection of groundwater from nitrate contamination (Kaye and Quemada 2017). Catch crops potentially reduce nitrate leaching to lower soil layers (Sieling 2019; Askegaard *et al.* 2005). Different types of catch crops can absorb different amounts of N, which can subsequently mineralise and influence the N supply, root growth and yield formation of following crops. Currently, such effects are difficult to calculate and thus, are hardly to be included in N fertiliser recommendations for succeeding crops. The aim of the study is to (i) quantify and optimise the positive effects of catch crop cultivation and (ii) provide farmers with improved methods for exploiting the potential N supply from temporarily stored nitrogen in catch crops by succeeding crops.

Field experiments were carried out in 2018 and 2019 with 4 different catch crops (oil radish, oat, spring vetch, winter rye) in comparison with a fallow.

First results confirm that catch crops were able to prevent nitrate from leaching, but effects differed according to the catch crop type. For instance, winter rye maintained a low soil N_{min} content over winter while N_{min} increased soon after freezing of spring catch crops.

1.5 DIETMAR HORN, GEBHARD MÜLLER
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CHALLENGES OF NITROGEN AND PHOSPHORUS FERTILISATION ADVICE FOR SUGAR BEETS WITH REGARD TO THE IMPLEMENTATION OF THE EU NITRATES DIRECTIVE

Soil analysis and fertiliser advice using the electro-ultrafiltration (EUF) system has been successfully used in Germany and other European countries for more than 35 years. Fertilisation with phosphate, nitrogen and other nutrients has been regulated by law since 1998, in particular by the Düngeverordnung (DüV) - German Fertilisation Ordinance for the EU Nitrate Directive. This was updated in 2017, particularly for phosphate and nitrogen, in order to reduce the leaching into surface water and groundwater. According to §3 (6) DüV, high phosphate contents are achieved if EUF-P is more than 3.6 mg/100 g soil. Then P fertilisation may be applied but not exceeding the expected phosphate removal from the field. The determination of the nitrogen fertiliser requirement is essentially regulated in §4 DüV and is based on the N-requirement value and yield level of the crop, the available and the mineralised nitrogen in the soil, precrop and catch crop and the application of organic or organic-mineral fertilisers. The calculation of the N fertiliser requirement by means of EUF system is based on binding specifications of the DüV. The EUF system is also used and recognised as a method of soil analysis in areas with high nitrate concentrations.

1.6 Massimo Zavanella, Massimiliano Cenacchi, Daniele Rosini, Giovanni Campagna

COPROB, Via Mora, 56, I – 40061 Minerbio (Bologna)

SURVEY ON SOIL FERTILITY IN THE COPROB BEET COMMUNITIES: SECOND CONTRIBUTION

The results of 3 years of soil sampling and analysis in the COPROB districts, mainly in the Po Valley area (Italy), are presented.

Compared to the first contribution, the analyzes of the soil have also been extended to the determination of the organic substance and the texture of the soils, carried out with NIR spectroscopy (Near InfraRed), a method that guarantees high reliability, combining it with low operating costs and rapid execution. The analyzes also include the determination of phosphorus, potassium and total soluble nitrogen obtained through traditional methods.

Overall, the soils of over 1,200 farms were analyzed, mostly located in Emilia Romagna and Veneto.

The processed data confirm the high diffusion of soils with low availability of phosphorus (P_2O_5 <30 ppm), which require adequate additions not only for sugar beet but also for other rotating crops.

The potassium endowments appear generally good except for some areas of the Veneto, characterised by a greater sand content in the soils.

Particular attention should be paid to the allocation of organic substances, with low values in over 50% of the sampled companies.

The analyzes were also extended to a group of biological companies engaged in the activity of organic sugar production started in 2019 by the COPROB group. These farms, despite having higher organic substance values than other companies, must however carefully treat this issue as they cannot use chemical fertilisers.

1.7 JOAKIM EKELÖF

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DECREASING SOIL P AND K RESERVES – A HIDDEN THREAT TO IMPROVEMENTS IN SUGAR BEET YIELDS

Most basic knowledge around soil P and K reserves in Swedish soils was developed in the beginning of the 20th century. In the following years up to the late 60s huge amounts of P and K were applied to improve soil fertility. However, in the 70s and 80s oil crisis, an increased environmental debate and a decreased profitability within agriculture occurred. This resulted in lower recommendations for P and K applications. Due to this and increased yields, many Swedish farms today have a negative P and K net balance over the crop rotation.

Between 2017-2019 Nordic Beet Research (NBR) has investigated areas within beet fields that did not grow as well as the rest of the field. A variety of analyses were made, such as plant nutrients, soil structure and nutrient analysis, soil borne diseases, etc. Analyses were taken both in a good and a bad area of the field with a maximum of 20 m distance from each other. The results show that the main cause of poor growth is related to soil fertility. In most cases P was involved but deficiencies of K are also often abundant. In addition, many of the bad areas also suffer from a low pH, which together with low nutrient status favors soil borne diseases such as Aphanomyces and Pythium. It seems like many years of negative P and K balance together with insufficient liming now has pushed soil fertility to the limit where it starts to influence sugar beet yields negatively.

1.8 ÅSA OLSSON NYSTRÖM[1], LARS PERSSON[1], JENS BLOMQUIST[2]

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STRUCTURE LIME AND GROUND LIME STONE IN SUGAR BEET ROTATIONS

Results from long term field trials started 2012 with ground limestone ($CaCO_3$) and structure lime ($Ca(OH)_2 + CaCO_3$) are presented. The results show increased sugar yields in treatments of both structure lime and ground limestone compared to the untreated control. There are several factors that contribute to the higher sugar yield. On some locations the increase in sugar yield was caused by a higher soil aggregate stability measured as lower turbidity. On other locations it was a reducing effect on Aphanomyces root rot that explained the higher sugar yield. In addition, on all locations, sugar yield in treatments with structure lime exceeded yields in treatments with ground limestone with a few percent. A possible explanation was significantly higher levels of potassium in the plots with structure lime.

The underlying soil factors that determine the effect on soil aggregate stability caused by structure lime are clay mineralogy, clay content and soil organic matter. The results from the study indicate that knowledge on these factors are important for the results when applying structure lime. In addition, to optimise the effect of structure lime, it needs to be applied at high soil temperatures to facilitate the chemical reactions. The incorporation into the soil needs to be done within 24 hours from application. Application under wet conditions may on the contrary result in soil compaction in the subsoil on some soils. Current investigations focus on describing these soil factors to optimise the use of structure lime both for the environment and the grower economy.

1.9 SAKARI MALMILEHTO
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STRUCTURAL LIMING IN FINLAND

To keep soil pH level optimal to sugar beet growing liming is essential to Finnish farmers. Besides pH rising some other soil properties can be improved at the same time with liming if correct lime material is chosen. Lately, structural liming (CaO or Ca(OH)2) has become popular in Finland among farmers that have clay soils. It is known that the benefits such as improved soil structure, erosion control, better nutrient availability and better water capacity can last many years. Sugar Beet Research Centre among other institutes in Finland has got a funding to further examine the effects of structural liming and its benefits to make a guide how to use structural liming in Finland.

1.10 SUSANNA MUURINEN
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SURVEY OF SULFUR STATUS OF SUGAR BEET IN FINLAND

During the growing season 2017-2018 Sucros Oyj, Yara and Sugar Beet Research Centre (SjT) collected 322 leaf samples from the farmers sugar beet fields for analyses of nutrient content of the beets.

The sulfur content of the leaves indicated that 69% of the samples had the sulfur deficiency (rate under 2.00 g/kg dm). Leaves were without the deficiency symptoms. There were small number of soil information of the sulfur content of the soils, however there was weak indication of correlation between soil sulfur content and leaf sulfur concentration. The average use of sulfur on the farms was 21 kg S/ha.

On 2018-2019 SjT has done sulfur step trials to see more closely the sulfur fertilisation impact to the yield formation.

1.11 JACEK PRZYBYŁ, NATALIA MIODUSZEWSKA, IRENEUSZ KOWALIK
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ANALYSIS OF SIMPLIFIED TILLAGE SYSTEMS IN SUGAR BEET PRODUCTION IN THE ASPECT OF YIELD QUANTITY AND QUALITY

Modifications in soil cultivation affect the quality and quantity of the yield of sugar beets. The crop density, yield and the external quality of sugar beet roots are highly dependent on the preparation of soil. The sugar beet production technology, which includes selection of the cultivation system, affects a wide range of yield characteristics, such as the internal root quality or the size and shape of the root system.

The aim of the study was to determine the dependence between the soil cultivation technology and the state of the plantation before harvesting crops as well as the yield quality and quantity. The research included three different technologies of sugar beet cultivation: plow tillage, conservation tillage with stubble mulch and strip-tillage. The systems were evaluated according to the crop density, yield quantity and external and internal quality of sugar beet roots.

Analysis of the results showed that the use of simplified cultivation systems does not reduce the sugar beet yield and the sugar yield in the roots. In the strip tillage system, also a tendency to decline in plant density and simultaneously growth of large roots was observed.

1.12 NATALIA MIODUSZEWSKA, JACEK PRZYBYŁ, KRZYSZTOF PILARSKI
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ANALYSIS OF SIMPLIFIED TILLAGE SYSTEMS IN SUGAR BEET PRODUCTION IN THE ASPECT OF SOIL PHYSICAL PROPERTIES

In Europe, simplified cultivation is increasingly replacing traditional cultivation (plowing). Its advantages include, among others, saving time or reducing costs, but also a beneficial effect on the soil environment. The tillage technology determines the physical characteristics of the soil, which in turn shapes the crop. The appropriate intensity and precision of fragmentation of superficial soil layer and the depth of soil tillage have to allow for the proper development of sugar beets roots.

The aim of the study was to determine the dependence between soil cultivation technology and the soil physical properties during the sugar beet growing season. The research included three different technologies of sugar beet cultivation: plow tillage, conservation tillage with stubble mulch and strip-tillage. Cultivation systems were analyzed for soil moisture and compaction. Changes in soil physical properties during the sugar beet growing season were evaluated in four terms: after sowing, in the inter-row covering phase, in the full maturity phase and before harvesting.

The analysis showed that the strip tillage system contributes to soil compaction increase. It has also been shown that crop residues have a positive effect on keeping water in the soil. Strip tillage caused an increase in soil moisture in the first stages of sugar beets development, compared to traditional cultivation.

1.13 REMY DUVAL[1], VINCENT TOMIS[2]

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SOIL COMPACTION IN NORTHERN FRANCE SUGAR BEET CROP SYSTEMS: A COLLABORATIVE STUDY TO GIVE A CLEAR PICTURE OF THE SITUATION AND IDENTIFY SOLUTIONS

SolD'Phy is a collaborative study lead by Agrotransfert in Hauts-de-Seine region and gathering ITB, regional agriculture chambers, public research (Inra) and production sectors technicians. It tackles with compaction risks in crop systems including productions concerned by machinery weight increase: sugar beet, potatoes, or industrial processed vegetables. Apart from scientific knowledge improvement, one of the main objectives was to sensitise farmers to the issue, by measuring compaction impacts on following crops productivity, with particular attention on deep soil compaction. The second objective was to gather diverse observations and results to build decisions rules for farmers in order to prevent compaction, particularly at sugar beet harvest.

The study combined a diagnosis in different plots, a technical survey, and field experimentations for better understanding compaction parameters in different soil and machinery situations. Project 1st phase was partly dedicated to compaction consequences on following crops development and yields, and to ease diagnosis methods for farmers.

The whole study, completed in 2018, gives an extensive overview of sugar beet parcels soil structure state, compacted parcels frequency and consequences for following crops. It also brings answers to sugar beet growers' practical questions. Compaction symptoms were observed in 1/3 of a series of 35 parcels. This first work enables to give accurate and precise advice in specific harvest situations, for different types of equipments, soil conditions, and cropping systems.

The future is now to build strategic and tactic decision-making tools from the data set and observations acquired during the SolD'phy project 1st phase.

1.14 SYLVIE DUCOURNAU[1], ANDRÉ WAUTERS[2]

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TESTING *BETA VULGARIS* SEED QUALITY IN LABORATORY TO PREDICT FIELD EMERGENCE

Beta vulgaris seeds are often grown in Northern Europe where sowing conditions are usually cold, wet, and sometimes done in crusty soils. The wide use of priming Beta seed treatment has decreased drastically the poor field emergence that could occurr in adverse environmental conditions.

Nevertheless, exceptional accidents still happened, and the need to predict those behaviours at an early stage in the laboratory, has re-emerged.

A 3-year study was initiated by the IIRB (International Institute of Sugar Beet Research) Seed Quality and Testing Study Group in order to analyse the potential of different laboratory testing methods to predict the field emergence of seed lots having varying germination quality, in different sowing conditions.

The interest of different germination methods, including ISTA (International Seed Testing Association) germination test in optimal laboratory conditions, IRS (Institute of Sugar Beet Research) test using a 10°C temperature regime and the IRBAB (Institut Royal Belge pour l'Amélioration de la Betterave, Département Recherche Variétale, Semences et Maladies du Sol) method using cold soil substrate, is presented and discussed over the 3 years of the study.

1.15 JORDAN LONG, RAFAL MARCINEK, JACK BROOKS
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IMPROVING YOUNG PLANT GROWTH WITH SEED TECHNOLOGIES

Sugar beet seeds are drilled in the spring as soon as conditions allow, research has shown there is an optimum window for drilling after which yield potential is progressively lost. Getting a crop established early also avoids a number of issues and gives you a longer growing season resulting in higher yields. However following drilling the temperature often remains cool and under these conditions the seedlings emerge and initially grow quite slowly. These small plants are more vunerable to biotic and abiotic stresses and some plants can be lost. Fertilisers are applied to the soils to drive plant growth, but until the plant extends its roots into the soil it is unable to exploit this resource fully. Many seedlots are primed, which helps by speeding up the germination stage, but plant growth at the emergence and early stages of development can also be improved through use of targeted nutrients and biostimulants on the seeds. This gets the plants away to an even faster start, helping to establish a healthy crop and maximising the amount of sunlight captured.

1.16 HENNING EBMEYER, CHRISTA HOFFMANN
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REASONS FOR THE STRONG EFFECT OF DROUGHT STRESS IN YOUNG SUGAR BEET PLANTS

Yield formation and quality of sugar beet is affected by drought stress. It is not known if there are differences in the extent of yield reduction, when drought stress occurs in different growing periods. The objectives of this study were to determine the growing period in which drought stress has the strongest growth reduction and to find reasons for the different extent.

For that purpose pot experiments in the greenhouse with 6 (2017) or 3 (2018) genotypes in 5 replications were conducted in 2017 and 2018. Drought stress was simulated by a reduction of water supply for a period of 4 weeks in May, Juli, or September (2017) or June, August or June and August (2018). The growth reduction was strongest, when drought stress occurred early in the growing season. In spite of differences in water consumption between the different drought stress treatments, dry matter was formed with a similar efficiency (transpiration coefficient/WUE). The strong effect of early drought stress in comparison to later stress could be explained with a higher growth rate early in the growing period.

1.17 LUCY TILLIER
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THE IMPACT OF CANOPY ARCHITECTURE ON RADIATION USE EFFICIENCY AND YIELD POTENTIAL OF SUGAR BEET

In recent years, breeders have released sugar beet varieties which differ widely in canopy architecture. Some have a very prostrate canopy whilst others have a much more upright growth habit, both of which have made the recommended lists for growers. A direct relationship exists between radiation interception in sugar beet and sugar yield, therefore initial canopy expansion and closure is vital to maximising yield, which would suggest that a more prostrate canopy would be beneficial. However, in other crops, such as rice and wheat more upright leaf angles are desirable due to better light distribution through the canopy which leads to higher radiation use efficiency (RUE).

This project is testing the theory that a more upright sugar beet canopy has higher RUE than a prostrate canopy. Differences in leaf angle and leaf area between varieties are being quantified using both a 3D modelling approach and manual measurements in field and glasshouse experiments. Regular assessments of canopy cover, alongside sequential biomass harvests in the field will be used to calculate the RUE of contrasting varieties.

1.18 CHRISTA HOFFMANN

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CAN YIELD OF SUGAR BEET VARIETIES BE ASSESSED BY THE LEAF CANOPY?

For phenotyping of sugar beet varieties and for harvest estimates via satellite a close correlation between leaf characteristics and final yield in autumn is required. The objective of the study was to analyze the importance of canopy cover for final sugar yield of sugar beet varieties. The general aim was to elucidate whether yield formation of sugar beet is source or sink limited.

Field trials with 2 sugar beet varieties (E-Type, Z-Type) were conducted with 3 sowing dates and 4 harvest dates in 4 replicates at 2 sites in 2 years (2012, 2014). Results show a linear increase of sugar yield with thermal time from September to November, while leaf yield decreased from August on. Although variety 2 reached canopy cover about 100 °Cd later than variety 1, had a lower LAI and leaf yield, it always obtained higher sugar yields. This could be attributed to a more beneficial assimilate partitioning towards sugar storage. Therefore, sugar yield seems to be determined more by assimilate partitioning and thus sink capacity than by the time-point of canopy closure or other leaf characteristics (source). Therefore, it seems to be difficult to estimate yield difference of sugar beet varieties through the analysis of leaf properties.

1.19 MASSIMO ZAVANELLA, GIOVANNI CAMPAGNA , ALESSANDRO VACCHI , ADRIANO FABBRI

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STUDY ON THE POSSIBILITY OF AUTUMN SOWING IN THE SUGAR BEET AREAS OF COPROB (NORTHERN ITALY)

The autumn sowing of sugar beet, widely adopted in the beet growing areas of southern Italy, was tested in the late 90's also in the northern areas by the agronomic services of Eridania, COPROB and other sugar companies. Other tests were carried out by BETA in the two-year period 2013-14 and then recently taken into consideration by COPROB with the availability of new low-bolting genetics.

There are at least 2 reasons for interest in this agronomic technique:

- The autumn-winter crop cycle occurs in a period of more abundant rainfall and allows you to arrive with crops already more resistant at the first stresses by high temperatures and droughts of late spring and summer, characterised above all by T max values increasing in recent years and persisting for several days
- Autumn sowing allows the harvest to be brought forward by several days, lightening the final part of the campaign, with positive potential effects also for organic crops, which provide for a very early harvest. On the other hand, there are some problems that must be taken into account when applying the technique:
  - The bolting and flowering which the crop undergoes with the induction of winter temperatures and photoperiod which, in addition to the variety tolerance, is also influenced by the time of sowing with a higher incidence in earlier sowing
  - The loss of plants due to winter frosts which is more important in the case of late sowing, with crops that pass through the coldest period at the most sensitive stage of 2-4 leaves.

The field test: In October 2018, 2 trials were set up in Minerbio (BO) with a comparison of about twenty varieties, mostly provided directly by the main seed companies. Both tests were identical and adjacent, with an experimental randomised block schema with 4 replications and a 6-row plot, but they differed in the time of sowing: a so-called "early" performed on 1 October 2018 and the second, so-called "late", carried out on 19 October 2018, for a difference of about twenty days between. The sowing distance adopted was 11 cm between the seeds and 45 cm between the rows. Immediately after the two sowing operations, was irrigated adding 20 mm to encourage a homogeneous emergence of the plants.

1.20 MASSIMILIANO CENACCHI, GIOVANNI CAMPAGNA, MASSIMO ZAVANELLA, DANIELE ROSINI
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ORGANIC SUGAR BEET CULTIVATION IN ITALY – FIRST EXPERIENCE ON FIELD

After a few years of experimentation, during the last week of July 2019, the harvest of about 1,300 hectares was carried out in Italy in 140 beet farmers for the production of organic sugar. The harvest also involved areas in which the crop was no longer present for several years. The results were very varied, but interesting from an economic point of view and crop differentiation. The weighted average gross income was around 2,500 €/ha (up to over 5,000 €/ha), with average costs for companies of around 1,500 €/ha (from 1,000 to 2,000 €/ha depending on the techniques applied). Early harvest allowed to simplify defense operations, reducing production costs and facilitating crop management in succession. One of the main critical issues is the weeds control, in fact in the post-seeding phase the harrow must be used with caution, after setting the machine and verifying the damage to the crop. Timeliness is decisive in weed control, combining tamping. Other critical issues emerged were the supply of phosphorus, but also of the organic substance, often below the threshold of sufficiency. In this regard, it is necessary to carry out preventive sampling and analysis, which are not mandatory in Italy, which are decisive in determining the right contribution during the basic preventive fertilisation phase. The organic substance represents the basis of soil fertility (structure, water retention, intake of elements, etc.), which can be pursued not only using manure, but also replenishing the crop residues and making greater use of interplant green manure, also useful for improving the structure and often the health status of the land itself.

1.21 ALICE LORRIAUX, BENNY JACOBS, MARCEL BRANDT, BRUNO DEQUIEDT, BRUNO VANDAMME
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CHALLENGES AND OPPORTUNITIES OF ORGANIC SUGAR BEET SEED PRODUCTION FOR SESVANDERHAVE

SESVanderHave is committed to serve all types of farming with the best possible plant reproductive material of new and improved varieties conforming to uniform European standards and requirements.

While the market for organic seed will remain a niche market for the vast majority of the field crops for the foreseeable future, plant breeders, and SESVanderHave in particular, are committed to serve the expectation of the organic farmers, in particular those who want to grow organic sugar beet.

Breeding being a complex process, producing organic sugar beet seed is a challenging task. It is unrealistic to set up a completely isolated system to breed and produce limited amounts of organic seed which would result in excessive costs for the breeder and the farmer. On the other hand, SESVanderHave is engaged in developing a number of dedicated processes to supply seed matching the specification of organic standards.

As was suggested by EUROSEEDS, this commitment to produce amounts of organic sugar beet seed should contribute to reduce the need for granting national derogations when there is a shortage of organic seed on the EU market.

This poster will present SESVanderHave's vision to address this new market segment.

1.22 OTTO NIELSEN

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THREE-YEAR EXPERIENCE WITH ORGANIC SUGAR BEETS

Cultivation of organic sugar beets was re-initiated in Denmark in 2017. Since then a lot of experience has been gained both in practice and in research. Main focuses have been on classical and new mechanical solutions for weed control including “seed-bank management”, false seed bed, precision harrowing, hoeing using finger-weeders or hilling and different types of robots. Satisfactory weed control has so far only been achieved when weed densities were very low or by including manual weed control. In addition, fertilisation strategies using banded organic fertilisers, have been tested. Experiences and progress during the years 2017-2019 will be presented.

1.23 CHRISTEL ROß, KERRIN TRIMPLER, NICOL STOCKFISCH
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COMMUNICATION OF DATA FROM A FARM SURVEY

Generally, communication of scientific results to a non-scientific audience calls for simplified results to make the message clear. On the other hand, some topics are not suitable for simplification or simplified messages may lead to misinterpretation of results if not integrated into the adequate background. We show results of a farm survey that provides data from more than 300 sugar beet cultivating farms per year. Data on yield performance and biodiversity activities in sugar beet cultivation are prepared for communication to non-scientific target groups in order to test the effect of different styles on the perception of contents. The quite popular way of emotional presentations may provoke unwanted reactions. A safer method to inform a distinct audience is via a mediator, who knows the audience well. We would like to discuss the potential effects of the different styles and formats.

1.24 NICOL STOCKFISCH, CHRISTEL ROß, ANNE-KATRIN MAHLEIN
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COMPARISON OF INDICATORS FOR PESTICIDE USE INTENSITY

Public debates concerning biodiversity and environmentally sound plant cultivation focus a lot on the intensity of pesticide use in agriculture. NGO’s and politicians support commitments to reduce the pesticide use intensity. Nevertheless, the more promising target seems to be reducing the risks associated with the application of pesticides in the field. For deriving risks associated with pesticide use, rather complex models are needed and results have to be interpreted carefully. It is difficult to communicate the model results in a simple and comprehensible way. Therefore, more simple indicators like the amount of pesticides, the amount of active ingredients or treatment indices are widely used to report the development of pesticide use intensity. In Germany, the use of pesticides for all main crops including sugar beet is being recorded for almost a decade through farm surveys. The various indicators and the ways of aggregating and displaying the results give room for different interpretation concerning the development of pesticide use intensity. Different view points, like more from the production side or more from the environmental point of view, can lead to different levels in argumentation and trigger lively debates.

1.25 François Joudelat[1], Dan Dutartre[2], Simon Madec[3], Etienne David[4]

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Measuring vegetative heterogeneity of sugar beet varieties with drone and deep learning phenotyping

Unmanned Aerial Vehicles are the quickest and cheapest vectors able to retrieve sub-centimetric images of a field plot. In the same time, phenotyping and remote sensing have benefited a lot from the rise of deep learning techniques in the mid 2010's. Those tools give us the opportunity to extract growth indicators at a more precise level than satellite while being more practical than manual measurements.

A joint work, inspired by wheat ears detection, led to the training and validation of a deep neural network (Faster R-CNN Inception ResNet v2) able to localise every beet with a 98% precision. Manual labeling of every plant on a few hundred images had to be done to train the weights of the network and to give a ground truth for its validation. Accuracy has been confirmed on three consecutive years (2017, 2018, 2019) with chalky and loamy soils under various light conditions. Furthermore, the processing pipeline has been improved for easier computation of derived traits.

Indeed, simpler algorithms were designed to use beets locations as an input and provide agronomical traits such as plant counting, in-row plant distance, and individual leaf cover. The former two concern mainly sowing trials and the vigor of varieties, whereas the latest gives a more precise snapshot of the varieties ability to cover the soil quickly and evenly. According to our intuition, a fast and uniform growing beet will compete better against weeds, accumulate photo-synthetic metabolites faster and grow more uniform roots. For instance, we made homogeneity rankings available to farmers, highlighting the varieties giving potentially uniform roots and consequently easier to extract with less breaks and less soil tare.

The images and their labels have been shared with UMT CAPTE, a consortium of several agricultural institutes and actors. This allows further discussions, improvements and transfers to other contexts. Moreover, a finer resolution or newer analysis methods would allow us to characterise beets more precisely, thus giving hints for a better production: more sugar with less inputs.

1.26 TOBIAS EKBLAD

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AUTOMATIC IMAGE ANALYSIS OF SUGAR BEET – A DEEP LEARNING APPROACH

Camera-equipped drones and other image generating devices could change how we do plant phenotyping in the future, but the true potential can only be realised if the new technology is combined with accurate and automatic image analysis methods. However, the natural variation in the appearance of plant material makes method development quite challenging. Over the last few years, there has been great progress in using so-called deep learning for creating robust image analysis systems. In this study, deep learning was compared with a traditional image analysis method for classification of sugar beet seed images (multigerms, monogerms, twins, etc.). The images were generated by X-ray CT scanning. A deep learning model was trained to recognise six classes of seed using ca. 350,000 images. The trained model was then used for classification of new seed images. The results indicate that the model could predict the correct class with high accuracy. Classification of individual seeds took about 20 ms on a standard desktop computer. The deep learning method outperformed the classical image analysis method in terms of accuracy, robustness, speed and development costs. The study proves that deep learning is a valuable tool that can potentially be applied to a range of classification and scoring tasks within sugar beet phenotyping.

1.27 ABEL BARRETO, STEFAN PAULUS, ANNE-KATRIN MAHLEIN
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PROOF OF CONCEPT FOR THE DIGITAL VISUAL RATING OF CERCOSPORA LEAF SPOTS USING MULTISPECTRAL UAV IMAGES

Visual rating of Cercospora leaf spot (CLS) is a time-consuming process that demands trained personel. Disease incidence (DI) and disease severity (DS) are the most reliable parameters and tools to identify resistant varieties in the plant breeding process. In 2019, a plot design sugar beet field trial inoculated with *Cercospora beticola* was monitored with a UAV multispectral camera system in time series. The field trial was performed within the context of the COBRI-Project 'Sensing of plant diseases by hyperspectral imaging and UAVs' and was located near Göttingen (Long = 9,896798195°; Lat = 51,55867619°; Alt = 195,52 m). Acquired images achieved a ground sample distance (GSD) of 0.35 cm allowing the detection of single leaf spots. In parallel, ground truth data on DI and DS were assessed.

Before data analysis and quantification of CLS-spots were performed, elemental pre-processing steps on the multispectral data like plant identification and leaf detection have to be performed. For the extraction of morphological parameters of object, a data processing pipeline for multispectral data of sugar beet plots has been established. Different morphological algorithms for plant segmentation were tested to delimit leaves: focusing on segmenting plant and soil, and to detect shadows and highlights. Furthermore, detected leaves were addressed to a virtual plant center. With this procedure, it was possible to locate CLS-spots in each virtual plant center allowing the calculation of a digital DI and DS. The established routine has to be evaluated in the future on data from different environments and different varieties.

The suitability of the procedure will permit a high throughput of CLS-scoring on a field scale.

1.28 GIOVANNI CAMPAGNA[1], ADRIANO FABBRI[1], MATTIA BASSI[1], ANDREA BRESOLIN[2]
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MONITORING WATER-NUTRITIONAL AND NDVI ON SUGAR BEET IN ITALY

In the year 2019, after the good results achieved during the last four years by the collaboration between AGQ Labs and COPROB, the activities of water-nutritional monitoring of sugar beet are continuing with suction probes starting from the early stages of development. This report shows, in particular, the results of the extensive activity accomplished in 2018 on a network of 48 stations. Leaf samples were useful to check the nutritional correspondence of the crop and its state of health. Since 2016, we have also verified the photosynthetic efficiency of beet fields through NDVI indexes obtained from satellite in two different times during the beet cultivation. On this basis, in 2018, a technical assistance activity aimed at optimizing the crop involved about 400 farms. After these important experiences, it is possible to affirm the validity of the system not only at farm level, with probes positioned at differentiated depths, but also to better understand the climate and soil dynamics of the whole area.

In particular, in 2018 some critical points were highlighted due to the climatic course:

- The reduction in the period of maximum photosynthesis activity did not allow to obtain good production results (low sugar content);
- The limited supply of phosphorus in the soil and the high nitrogen inputs to compensate the delays of the foliar coverage, have slowed the development of the crop, to the detriment of the accumulation of sugar;
- The arrival of high summer temperatures has reduced the useful development cycle, increasing the salinity levels in the soil, as evidenced in the circulating solution (tested using suction probes), with quantities of sodium toxic to beets.

In response to these nutritional imbalances, foliar fertilisation was carried out based on magnesium and later on potassium, as well as sulfur. The use of these solutions to support farms and technicians has significantly improved the nutritional status of the fields and consequently the production of the crop.

1.29 ULRIKE WILCZEK
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DEVELOPMENT OF A SENSOR SYSTEM FOR LOW-DAMAGE SUGAR BEET HARVEST – STATE AND PERSPECTIVES

The project aimed to develop a sensor system able to detect beet damages occurring in the harvester cleaning system. Sensor information should allow to design driver assistance systems safeguarding low-damage beets most suitable for long-term storage. Long-term storage trials in climate containers revealed that root tip breakage caused by turbine cleaning correlated sufficiently close with sugar losses, and thus can serve as an overall damage indicator. In a systematic drop test, heavier beets (> 700 g), beets impacting the ground with the root tip ahead and dropping from 2.5 m caused largest tip breakage. Field experiments were conducted with measuring bobs which were shaped like beets and equipped with accelerometers and surface pressure sensors. They showed that type and form of impacts affect damage severity in addition to impact intensity. Moreover, the turbines exerted less impact compared to the lifter, sieve conveyor and auger conveyor. Results imply that the beet throughput level through the cleaning section significantly affects the occurrence of damages. In addition, the structure-borne sound of the guide grades was measured. Single beet damage events were identified from videos taken by high speed cameras and synchronised with the associated frequency spectra. In future, time segments and synchronised Fast-Fourier-transformed frequency spectra will be used to derive specific trait variables in order to develop a Machine-Learning-Model.

1.30 AGNIESZKA ANDRUSIAK[1], ZDZISŁAW WYSZYŃSKI[2]

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EVALUATION OF SUGAR BEET YIELD DEPENDING ON THE METHOD AND HARVESTING DATE

Harvesting is the final, but also very important and difficult stage of growing sugar beet, affecting the quantity and quality of root yield. Made incorrectly causes large root losses. Topping (cutting the crown) leaves some of yield in the field. Defoliation is a method limiting the loss of root mass. There is lack of information which evaluates these two methods in Polish climate and growing conditions. The objective of the study was to determinate the impact of the sugar beet harvesting method by topping and defoliation and harvesting date on the quantity and quality of root yield and sugar yield. The studies were carried out in 2015-2017 in south-eastern Poland. The root yield of defoliated beets (regardless of the harvesting date) was higher in comparison with topped beets. On average in 2015-2017 was higher by 6.6%. Similar differences in the yield of defoliated and topped beets occurred in individual years of research. Regardless of the harvesting date (length of the growing season) topped beets were characterised by higher sugar content and lower α-amino N, Na^+, K^+ on average for the examined period and in individual years of research. A significantly higher yield of defoliated beets allows to obtain higher sugar yield, despite their weaker technological value (higher content of melassigenic nonsugar substances – α-amino N, Na^+ and K^+). Using defoliation instead of topping improves the profitability and productivity of sugar beet cultivation.

1.31 CHRISTINE KENTER, ERWIN LADEWIG

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STORABILITY AS A VARIETAL CHARACTERISTIC OF SUGAR BEET?

Genotypic differences in storability of sugar beet have been found in many studies, but most ot them focused on particular varieties or breeding material. The storage properties of commercial varieties grown in Germany have not been routinely assessed to date, as storage trials are very time-consuming and labour-intensive. Because of the increasing importance of beet storage and the demand to further improve storage management, information on the storability of current varieties seemed necessary. The aim of the present study was to test the storability of 13 sugar beet varieties with a method that could be established as a routine in variety testing.

In 2016-2019, nine storage trials were carried out. The corresponding field trials were part of the official variety trials in Germany. The methodology for storage was coordinated by the Coordination Board at the Institute of Sugar Beet Research, the breeding companies and the German Federal Plant Variety Office. Beets were stored in climate containers for approximately 480 °Cd. Root weight and the concentrations of sugar, invert sugar and marc were determined before and after storage. Invert sugar and marc are not included in standard beet analysis, but they were found to be correlated with beet storability in earlier studies.

During storage, the sugar content decreased in all varieties while the invert sugar content increased. The calculated sugar loss was highest in an environment where SBR (syndrome des basses richesses) had occurred. Varietal differences in sugar loss were significant in each environment, but not for the mean of the eight trials without diseases. No correlation was found between sugar loss and marc content or invert sugar. Variety recommendations concerning the storability of sugar beet are thus currently not possible.

1.32 MARTIJN LEIJDEKKERS
Institute of Sugar Beet Research (IRS), P.O. Box 20, NL – 4670 AA Dinteloord

EXPERIENCES WITH MECHANICAL VENTILATION OF SUGAR BEET STORAGE CLAMPS IN THE NETHERLANDS

To minimise sugar losses of sugar beet in a storage clamp it is important to keep the beet as cool as possible, but frost-free. Therefore, respiration heat that is produced inside the storage clamp must be able to escape from the clamp rapidly by means of ventilation. Natural ventilation can sometimes be insufficient due to the dimension of the storage clamp, presence of dirt tare and/or weather conditions. In these cases, mechanical ventilation might be helpful to reduce the average storage temperature inside the clamp.

From 2016-2018, the IRS has conducted several trials to test the use of mechanical ventilation in outdoor storage clamps. The poster will show the setup of the trials and the main results and conclusions.

1.33 SAKARI MALMILEHTO
Sugar Beet Research Centre Finland, Meltolantie 30, FIN – 21510 Paimio

FLEECE COVER FOR SUGAR BEETS. RISK OR POSSIBILITY?

Sugar Beet Research Centre has, already for several years, had trials considering fleece cover for sugar beets. The benefits have been clear but also the work load has increased so much that it can´t be guaranteed that the benefits out weights the risks. New Conviso system can bring help regarding the risk management. Problem has always been how to control weeds under the fleece. In Finland you usually have to spray against weeds three times per season. This means that the fleece has to be removed and installed multiple times annually. Now with the Conviso system spraying can be done once. This helps dramatically crowing sugar beets under fleece. That's why Sugar Beet Research Centre has launched trials regarding this method, in plot size, but also farm size. One farmer in Finland has big scale trial with fleece method and at the moment it seems promising.

1.34 NELIA NAUSE, CHRISTA HOFFMANN
Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

CAMBIUM RINGS AND CELL WALL COMPOSITION OF SUGAR BEET GENOTYPES DIFFERING IN ROOT STRENGTH

Storage losses of sugar beet genotypes are closely related to their susceptibility against damage during harvest, indicating that tissue properties of the root could be important to assess the storability of genotypes. The study aimed at analyzing tissue properties which are related to root strength of genotypes.

In 2018 field trials were conducted with 6 genotypes in 4 replicates at 2 sites. Penetration resistance and tissue strength of the beet increased from August to November, but differences among genotypes were similar (no interaction). Genotypes with a higher root strength had a higher level of cell wall components (AIR). However, the composition of the cell walls with regard to pectin, hemicellulose, cellulose, and lignin did not show great difference between genotypes. Differences in the number of cambium rings could not explain the differences in strength. Genotypic effects for all parameters turned out to be very stable during the growing season. Microscopic analysis of root tissue should indicate whether cell size or cell wall thickness are related to root strength.

1.35 WILLIAM ENGLISH[1], JOAKIM EKELÖF[1], MARTIJN LEIDEKKERS[2], FRANÇOISE VANCUTSEM[3], GUNNAR KLEUKER[4], CHRISTA HOFFMANN[4]

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IN SEASON TEXTURE ANALYSIS OF SUGAR BEETS USING A HANDHELD PENETROMETER

Texture analysis in the laboratory is used to quantify sugar beet mechanical properties, including the tensile strength of the beet surface and the compressive strength of the beet's inner structures. It has been shown to be a reliable method. It also has the potential to be used in decisions at harvest and storage time, such as in the selection of which fields can tolerate more handling or should store better.

The next stage in the development of the method is to test if a handheld penetrometer can also provide data that is reliable and in line with expectations. While the handheld penetrometer cannot provide the range of tests of the laboratory equipment, it has the advantage that it can be used pre-harvest and is much more farmer accessible.

As part of an ongoing COBRI trial into sugar beet mechanical properties, field testing of a hand-held penetrometer was undertaken in 2019. The trial includes three sugar beet varieties known to have different mechanical properties, grown in Sweden, the Netherlands, and Belgium. The handheld penetrometer was used to conduct puncture tests to a depth of 5 mm on the beets in-situ. The tests were conducted at all sites, approximately 60, 30 and 1 day/s prior to the scheduled harvest dates. Results from Sweden for 2019 will be presented.

1.36 MADELEINE NILSSON[1], WILLIAM ENGLISH[2], EVGENIJ TELEZHENKO[1]
[1] Swedish University of Agricultural Sciences (SLU), Box 52, S – 23053 Alnarp
[2] NBR Nordic Beet Research foundation, Borgeby Slottsväg 11, S – 237 91 Bjärred

PRESSURE MAPPING OF SUGAR BEETS

Wounding from impacts is a major detrimental factor during the harvest, storage, and transport of sugar beets, resulting only in the loss of quality and value. Wounding can include lost fragments of healthy beet material, ruptured internal cells (bruising), or the opening of the beets' surface that in turn permits easier pathogen incursions. The potential for loss in value from wounding is particularly important when beets are stored. The size and site of impact, the size of the beet, and the mechanical properties of the beets, have all been suggested as potential key factors in the rate of wounding.

This project investigates the size and effect of the impact stresses that sugar beets may be exposed to during harvest and transport. It also provides the basis for the development of a method for the conversion of dynamic impact events to equivalent static loads. The data was collected during the campaign of 2019/20, in late October and mid-January. Sugar beets from three varieties with known and different mechanical properties were exposed to both a static load and a dynamic impact force at a fixed location on the beet. For the static tests, three different loads were applied – 500, 1000, and 2000 Newtons. A high precision pressure mapping system (I- Scan 7.70, Tekscan, Inc., Boston, MA) captured data on the contact area and pressure distruibution at every load using ultrathin pressure sensors (spatial resolution of 15.5 sensels per cm^2). For the dynamic tests, contact time and area was captured using a high-speed camera and contact sensitive film, respectively. After 650 degree-days in storage, bruising and root rots were assessed. The key findings of this research will be presented.

1.37 ELKE HILSCHER, HEIKO NARTEN, STEFAN MELDAU
KWS SAAT SE & Co. KGaA, Grimsehlstraße 31, D – 37574 Einbeck

IMPROVING SUGAR BEET QUALITY LAB SAMPLE MEASUREMENT AND ANALYSIS QUALITY USING THE KWS BEETROMETER®

Sugar content not only varies within one beet, but also between beets. In this poster we show results for variation of sugar content and impurities within beets, and between beets.

The current method for measuring the quality of farmer-delivered samples in the sugar beet quality lab is based upon the need to create brei. This is a procedure that dates back over 40 years. The process is mainly based upon manual inputs which requires trained staff and specialised analytical equipment to operate correctly for reliable results, starting with equipment calibration through sample preparation and analysis.

The KWS BEETROMETER® system instead uses a developed automated method of sample preparation and designed method in sample presentation. The new method in sample preparation consists of a chopper, which chops 20-100 kg of sugar beets in a few seconds in small, uniform pieces. A conveyor belt, equipped with a pressure roll, produces a homogenised and uniform stream of chopped beets. A process spectrometer records a single spectrum every 40 ms, leading to a total of 400 spectra (measurements) per 40 kg sample. Using this approach, the whole heterogeneity of a beet sample is captured.

More than ten years of calibration development have yielded a high accuracy for measuring quality parameters for example as sugar content, content of recoverable sugar, and marc content via NIRS on freshly chopped beets.

This technology combines innovative sample preparation and analysis via a diode array-NIRS-spectrometer. The system called KWS BEETROMETER® works fully automatically, is mobile and can be implemented with less effort.

2.1 LARS PERSSON, ÅSA OLSSON NYSTRÖM
NBR Nordic Beet Research foundation, Borgeby Slottsväg 11, S – 237 91 Bjärred

MEASUREMENT OF APHANOMYCES ROOT ROT POTENTIAL IN SOIL

Damping off and root rot in sugar beet is primarily caused by a complex of pathogens. Most often *Aphanomyces cochlioides*, *Pythium* spp., and *Rhizoctonia solani*. In Sweden and to some extent also Denmark, *A. cochlioides* is the most devastating pathogen. Efforts have been made to find methods for avoiding crop losses, by using tolerant varieties and cultural practices such as liming and plant nutrition. It is of importance to have knowledge on the root rot potential of soils to be able to make the right decision in cultivation. An easy and reliable method has been to use a soil bioassay which is done by growing sugar beets in a soil sample from the field in a green house. Questions have however been raised about the impact of time of sampling on the outcome of the bioassay. In this study, 10 soils in Sweden with a crop rotation including sugar beet were sampled repeatedly in the same spot during one year, and were tested using the bioassay. The soils varied in the infestation of *A. cochlioides* including both high and low levels. There were variations in the outcome for different sampling time of the year. The results indicate that sampling during warm and dry conditions, in Sweden May-September, should be avoided since the infection in the bioassay is lower for these samples compared to sampling during October-April. The mechanisms for these effects could be related to both seasonal variations in chemical elements and populations of other organisms increasing or decreasing the infection. Further studies will be done to evaluate if any of these mechanisms can be used for controlling Aphanomyces root rot in sugar beet in the future.

2.2 JUAN VEGAS, ERIC DE BRUYNE, I. ADETUNJI, OLIVIER AMAND
SESVanderHave N.V./S.A., Soldatenplein 15, B – 3300 Tienen

GENETIC STUDY OF CHARCOAL ROT (*MACROPHOMINA PHASEOLINA*) RESISTANCE IN SUGAR BEET USING A DIVERSE PANEL OF COMMERCIAL AND NON-COMMERCIAL HYBRIDS

During the summer of 2009 in the Vojvodina region in Northern Serbia, sugar beet (*Beta vulgaris* L.) roots with severe rot symptoms were observed in many farmer fields. Initially, the plants wilted, and leaves soon turned brown and died. Diseased plants appeared in patches in the field. Brown-black lesions were observed in the external part of the root crown while yellow-mustard colored lesions occurred internally. *Macrophomina phaseolina* (Tassi) Goid. (1) was isolated and correctly identified by ribosomal DNA sequencing from 30 rotted roots collected in different fields. Severe economic losses due to charcoal rot have been repeatedly reported in the Krasonadar (Russia) and Konya (Turkey) regions (2009), and in big parts of Serbia, Rumania and Hungary in 2011, 2015 and 2018. Root rot in 216 hybrids was studied in observation trials in Serbia and Hungary during 2016-2018. SESVanderHave has intensively tested a wide range of commercial and non-commercial hybrids in order to identify tolerance and/or resistance. Our results showed a significant difference among breeding lines in their tolerance to charcoal rot. Several breeding lines were found to be considerably resistant to Macrophomina.

2.3 VERA STOJŠIN[1], DRAGANA BUDAKOV[1], ŽIVKO ĆURČIĆ[2], ALEKSANDRA STANKOV[1], TATJANA DUDAŠ[1], FERENC BAGI[1], NEVENA NAGL[2]

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[2] Institute of Field and Vegetable Crops, Biotechnology, RS – 21000 Novi Sad

INFLUENCE OF NPK MINERAL NUTRITION AND CULTIVAR ON SUGAR BEET ROOT ROT

Sugar beet is susceptible to a number of root rot diseases, and they are regularly occurring in Serbia. Economically most important pathogens are *Macrophomina phaseolina* and *Fusarium* spp.. *Macrophomina phaseolina* is predominantly found in isolates from sugar beet, especially during dry and hot summers. For more than thirty years already, our team of researchers follows the occurrence and etiology of sugar beet root rot in Serbia. The aim of this experiment was to evaluate the effect of mineral nutrition on root rot in commercial sugar beet cultivars. The trial was set up in 4 replications of 20 NPK nutritions (N_2, P_2, K_2, N_2P_2, N_2K_2, P_2K_2, $N_1P_1K_1$, $N_1P_2K_1$, $N_1P_2K_2$, $N_2P_1K_1$, $N_2P_2K_1$, $N_2P_2K_2$, $N_2P_3K_1$, $N_2P_3K_3$, $N_3P_1K_1$, $N_3P_2K_1$, $N_3P_2K_1$, $N_3P_3K_2$, $N_3P_3K_3$) and 8 commercial sugar beet cultivars (G1-G8). Mineral nutritions were presented in scale from lowest to the highest dose (1. 50 kg/ha; 2. 100kg/ha and 3. 150 kg/ha). Weather conditions in 2019 were favorable for the development of sugar beet and incidence of the root rot was lower than in previous years. Statistically significant differences were not observed among root rot incidence in different cultivars. The highest intensity of plant decay and root rot was observed on plots with unbalanced NPK nutrition, especially where potassium levels were minimal. Balanced mineral nutrition led by the proper amount of potassium plays a key role in raising plant immunity and preventing root rot disease in sugar beet.

2.4 ALEKSANDRA STANKOV[1], NEVENA NAGL[2], VERA STOJŠIN[1], DRAGANA BUDAKOV[1], FERENC BAGI[1], TATJANA DUDAŠ[1], ŽIVKO ĆURČIĆ[2], MILADA ISAKOV[2]

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[2] Institute of Field and Vegetable Crops, Maksima Gorkog 30, RS – 21000 Novi Sad

CHARACTERISATION OF *TRICHODERMA* SPP. FOR ANTAGONISTIC ACTIVITY AGAINST CHARCOAL ROOT ROT *MACROPHOMINA PHASEOLINA* FROM SUGAR BEET

Charcoal rot of sugar beet, caused by *Macrophomina phaseolina* in recent years has become a main concern for farmers in Serbia. Since control measures are mostly preventive with only partial effect, introduction of alternative measures, such as biological control based on augmentation of mycoparasites, represents the most promising approach. ITS region and tef gene sequence analysis of ten *Trichoderma* spp. isolates from sugar beet and soybean rhizosphere was done to confirm species identity. All isolates were confirmed to be *Trichoderma harzianum*. Their effect was tested in vitro using dual culture test, using mycelial growth of *M. phaseolina* isolate SR55(3)/9 pathogenic to sugar beet as tested parameter. All *T. harzianum* isolates significantly reduced mycelial growth and microsclerotia formation. Five days after inoculation, mycelial growth inhibition ranged from 54.1 to 64.4% in dual culture test. Isolate T2 showed maximum antifungal activity in dual culture test inhibiting growth of *M. phaseolina* up to 64.4%. In eight isolates, the antibiosis phenomenon was observed through the formation of an intermediate band without growth between colonies. Isolates T11 and T12 grew rapidly and when they came into contact with the *M. phaseolina* colony, they continued to grow and sporulate until the entire Petri dish was covered. As the result of confrontation between the T13 isolate and *M. phaseolina*, there was a zone of growth inhibition between mycelia, where the culture medium changed color, probably due to secondary metabolite excretion.

2.5 Dragana Budakov[1], Vera Stojsin[1], Zivko Curcic[2], Tatjana Dudas[1], Aleksandra Stankov[1], Ferenc Bagi[1], Mila Grahovac[1]

[1] University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovica 8, RS – 21000 Novi Sad

[2] Institute for Field and Vegetable Crops, Maksima Gorkog 30, RS – 21000 Novi Sad

Influence of sugar beet cultivar and NKP nutrition on Cercospora leaf spot

Cercospora beticola is economically the most important sugar beet leaf disease primarily controlled by fungicide applications. However, other factors influence its incidence as well, some of which are the choice of cultivar and plant nutrition. These factors have been put together in field trial, which tested reaction of eight sugar beet genotypes (G1-G8) and 20 variants of NPK nutrition (N_2, P_2, K_2, N_2P_2, N_2K_2, P_2K_2, $N_1P_1K_1$, $N_1P_2K_1$, $N_1P_2K_2$, $N_2P_1K_1$, $N_2P_2K_1$, $N_2P_2K_2$, $N_2P_3K_1$, $N_2P_3K_3$, $N_3P_1K_1$, $N_3P_2K_1$, $N_3P_2K_1$, $N_3P_3K_2$, $N_3P_3K_3$). Mineral nutrition is presented in scale from lowest to the highest dose (1. 50 kg/ha; 2. 100kg/ha and 3. 150 kg/ha). Significant differences occurred both in reaction between tested genotypes and variants of plant nutrition.

2.6 Živko Ćurčić[1], Dragana Budakov[2], Aleksandra Stankov[2], Ksenija Taški-Ajduković[1], Nevena Nagl[1], Vera Stojšin[2]

[1] Institute of Field and Vegetable Crops, Maksim Gorki st. 30, RS – 21000 Novi Sad
[2] Faculty of Agriculture, University of Novi Sad, Dositej Obradović square 8, RS – 21000 Novi Sad

Effect of different sowing dates on *Cercospora beticola* infection level

Cercospora leaf spot caused by the fungus *Cercospora beticola* is the most significant foliar disease of sugar beet in Serbia. Measures to reduce damage of this disease are based on the use of tolerant varieties, crop rotation and fungicide application. Climate changes and the resistance of *Cercospora beticola* strains to fungicides from the strobilurin group further complicate the fight against this disease. In extremely favourable years for the development of disease with high temperatures and precipitation during the summer months, growers in Serbia perform 4-8 fungicide treatments. Unfortunately, despite so many treatments, they fail to keep the disease under control. In order to overcome this challenge in sugar beet production, it is necessary to review the entire technology of sugar beet cultivation in Serbia. Primarily, measures that directly affect the microclimate in the sugar beet crop and the canopy size of the crop during the summer months: different sowing dates, mineral fertilisation and sowing density. Adjusting the sowing date is by far the most frequently investigated climate change adaptation option that determines the length of the growing season and influence on the crops yield. Earlier observations have shown that in later sowing periods, the infection of sugar beet with cercospora is lower than in the first sowing dates, and that later sowing could reduce the number of treatments against cercospora. Favourable conditions during the spring of 2019 made it possible to set up a trial with sowing dates from the beginning of March to the end of April. The trial included 9 different varieties of sugar beet. Assessment of cercospora infection was done in early August. The results showed significant differences in the level of cercospora infection between the examined sowing dates and between the tested varieties in the trial.

2.7 MAARTEN VANDERSTUKKEN, JAN SELS, OLIVIER AMAND, DAVID BOEHM, HENDRIK TSCHOEP

SESVanderHave, Industriepark Soldatenplein Z2 nr 15, B – 3300 Tienen

AN INTEGRATED BREEDING APPROACH TOWARDS CERCOSPORA RESISTANT VARIETIES – A PERSPECTIVE FROM SESVANDERHAVE

Cercospora beticola is an aggressive fungal disease, causing significant financial losses. In recent years, the disease has substantially expanded its area of occurrence and aggressiveness. Moreover, effectiveness of fungicides is decreasing due to increasing fungicide resistance. Additionally, the public acceptance of using fungicides as well as their availability is decreasing.

Cercospora resistance is a main trait focus for SESVanderHave breeding. In our breeding efforts we make extensive use of existing genetic variability by applying state-of-the-art genotyping and phenotyping methodologies. These efforts already brought varieties to the market that combine performance with strong Cercospora tolerance and are continued.

In this poster, SESVanderHave would like to outline this breeding strategy for the development of competitive Cercospora resistant varieties as part of an integrated pest management to create durable resistance.

2.8 MOHAMMED KHAN, GIOVANNI CAMPAGNA

North Dakota State University & University of Minnesota, Plant Pathology,
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STRATEGIC MANAGEMENT OF *C. BETICOLA* USING IMPROVED RESISTANT CULTIVARS OF SUGAR BEET

Cercospora beticola causes Cercospora leaf spot (CLS), one of the most damaging foliar diseases of sugar beet grown in warm and humid regions. Growers use a combination of resistant varieties, crop rotation, incorporation of infected residue, and fungicides to manage CLS. Since the 1970s, growers have become more dependent on fungicides for effective control of CLS. Growers have used fentin acetate and triphenyltin hydroxide, benzimidazoles, demethylation inhibitors (DMIs), and quinone outside inhibitors (QoIs) with varying levels of success at controlling *C. beticola*. Over time, the pathogen, which has the ability to produce large numbers of conidia and multiple generations during a growing season, has developed resistance to most of the fungicides used for its control. In 2016, growers in the USA lost over $200 million because of QoI resistance and a CLS epidemic. Currently, there are few fungicides that provide effective control of *C. beticola* when used alone and very few effective alternating partners. There is no new chemistry identified for CLS control in the near future. Sugar beet seed companies have been working at developing cultivars with improved resistance to *C. beticola*. Current field trials in the USA and Italy indicate that new cultivars have better resistance to *C. beticola* compared to the best older resistant cultivars. Fungicides were applied on a calendar basis, and on an only when needed based on the presence of symptoms and favorable environmental conditions. Trials will be harvested in August in Italy and September in the USA. The recoverable sucrose from the different treatments and the economics of using improved *C. beticola* resistant cultivars will be discussed.

2.9 MAXIMILIAN MÜLLENDER[1], MARK VARRELMANN[1], GERD STAMMLER[2]
[1] Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen
[2] BASF SE

POSSIBLE CAUSES AND MECHANISMS FOR ALTERATIONS IN THE SENSITIVITY OF *CERCOSPORA BETICOLA* TOWARDS DMI FUNGICIDES

Cercospora leaf spot caused by *Cercospora beticola* is the most relevant leaf spot disease in sugar beet in Germany. In respect of a decreasing efficacy of *Cercospora beticola* against different fungicides used to control this disease in field, the most important basis in fungicide management and resistance monitoring of diverse fungal diseases in field is the identification of resistance mechanisms and development of methods for their detection. Different mechanisms, mediating a reduced sensitivity towards demethylation inhibitors (DMI), were identified in different plant pathogens so far, but none of them were found to be responsible for the shifting in DMI sensitivity towards this group of fungicides in *C. beticola*. A detailed investigation of the cytochrome P450-dependent sterol 14α demethylase gene sequence (*cyp51*) of diverse *C. beticola* strains collected in different European countries with reduced DMI sensitivity was performed in order to find possible correlations of mutations with low EC_{50} values. The amino acid alterations Y464S, L144F and I306T together with L144F were found to be associated with a reduced sensitivity. Additionally, constitutive and fungicide triggered expression of *cyp51* was assayed by RT-qPCR. A very strong induction of *cyp51* in sensitive strains led to the conclusion that the fungal cells upregulates expression to maintain ergosterol biosynthesis in DMI presence. The less intensive cyp51 induction in isolates with higher EC_{50} values underlines the possible correlation of the found target-site mutations with reduced sensitivity. More isolates with different genotypes in the cyp51 gene sequence need to be analyzed to confirm and validate the conclusions.

2.10 THIES MARTEN HEICK[1], ANNEMARIE FEJER JUSTESEN[1], LISE NISTRUP JØRGENSEN[1], ANNE LISBET HANSEN[2]

[1] Aarhus University, Department of Agroecology, Research Center Flakkebjerg, Forsøgsvej 1, DK – 4200 Slagelse

[2] NBR Nordic Beet Research, Højbygaardvej 14, DK – 4960 Holeby

DISEASE CONTROL AND MANAGEMENT OF QOI RESISTANCE OF SUGAR BEET POWDERY MILDEW (*ERYSIPHE BETAE*) IN SCANDINAVIA

Powdery mildew on sugar beet, caused by *Erysiphe betae*, is one of the most predominate diseases of sugar beet in northern Europe and occurs in most seasons. The disease reduced sugar yield by several hkg if not adequately controlled. QoI fungicides in mixtures with azoles have provided reasonable control of powdery mildew and usually are applied two to three times per season at ¼ to ½ of the registered label rate. The detection of the first QoI-resistant powdery mildew in 2018 in Denmark and Sweden gives rise to concerns that disease control might be compromised if resistance spreads further (Heick *et al*. 2019). QoI resistance is conferred by the G143A mutation in the cytochrome b gene (Bolton and Neher 2014). In the season 2019, powdery mildew samples from farmers' fields were screened for the presence of the G143A mutation. The efficacy of Opera (epoxiconazole + pyraclostrobin), Comet Pro (solo pyraclostrobin) and Serenade ASO (*Bacillus amyloliquefaciens*) was tested under semi-protected conditions. In addition, in two field trials located in the Danish sugar beet growing area, the control of different fungicide strategies against powdery mildew was assessed. Treatments compared current strategies to new chemistry and sulfur and *B. amyloliquefaciens*.

2.11 HÉLÈNE YVANNE[1], KUMAR GAURAV[2] , SANU ARORA[2] , ISABELLE DE CAUWER[3], NEIL HALL[1] , BRANDE WULFF[2], MARK MCMULLAN[2]

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[3] Université de Lille, 42 rue Paul Duez, F – 59000 Lille

CAN WE HARNESS DISEASE RESISTANCE BY ASSOCIATION DIRECTLY IN WILD SEA BEET?

Plant host and pathogen co-evolution can maintain genetic polymorphism at resistance genes and effectors, respectively. However, crop domestication has reduced genetic variation and this is believed to be important for their ability to resist pathogens that freely evolve. Until now, modern agricultural practices have introduced novel resistance genes by crossing crop lines. More recently, our attention has turned toward exploring the genetic diversity of wild crop relatives. My PhD project aims to identify and study resistance genes in wild populations with a goal to improve crops resistance. I will use the beet system to identify associations between resistance gene polymorphism and fungal pathogens resistance. Direct wild associations are difficult for a number of reasons, not least because many wild hosts, crop progenitors, may not share their pathogens with crops. I will use the sugar beet (*Beta vulgaris*) system, because its recent domestication from sea beet (*Beta vulgaris* subsp. *maritima*) means that numerous pathogens infect both wild and agricultural plants. Moreover, these plants can still be crossed. To do this, I will use an association genetics method combined with genome sequencing, allowing the identification of specific sequences (k-mers) present in sea beet genes resistant to rust. The association genetics method will rely on an understanding of the population genetics of European sea beet. Moreover, I will explore genetic diversity and divergence, of associated resistance genes, across populations. This project includes a collaboration with the KWS company, which aims to clone the identified genes in the sugar beet crop.

2.12 GIOVANNI CAMPAGNA, ALESSANDRO VACCHI
COPROB, Via Mora, 56, I – 40061 Minerbio (Bologna)

LIXUS JUNCI AND *CONORRHINCHUS MENDICUS* DIFFUSION ON SUGAR BEET IN PO VALLEY AND CONTROL STRATEGY

In the last 10 years *Conorrhynchus mendicus* has been considerably reduced to almost disappear with beet seed tanned with neonicotinoids. On the other hand, in recent years, *Lixus junci* had been spreading to become particularly harmful during the 2019 campaign (first year without seed tanned with neonicotinoids). Therefore in these last two years alternative control means have been tested in some areas with beets stressed by extremely high summer temperatures, where the damage of this insect can cause showy rottenness. Insecticides and other methods of struggle were evaluated in both conventional and organic cultivation. An important aspect to set up the defense strategies is the monitoring of the insect to identify the most suitable period to contain the adult, after which the larvae in the collar cannot be devitalised. Studies are also in progress to investigate the development cycle and natural enemies able to control it.

Waiting to deepen the studies and knowledge related to monitoring, natural parasites, development of the biological cycle of *Lixus junci*, etc., it is possible to implement valid containment strategies. The use of the most active insecticides allows to obtain good results through the applications in the moments of maximum presence of adults during the mating phase, which in the Po Valley corresponds from the end of April to the end of May. The best time to check the presence of adults is in the morning on the leafy beets. In the absence of chlorpyriphos-methile (recently revoked) and dimethoate (imminent release), it is necessary to anticipate the use of the other more active phosphorganic, the phosmet.

Pyrethroids do not perform a sufficient activity, with the exception of alpha-cypermethrin, which can be used in contexts of low environmental impact practices (integrated measures). Alternatively and in organic cultivation it will be possible to use garlic extracts for their repellent activities and the ability to control adults.

The damage threshold of the lisso up to about 10 larvae in the leaf-stalks for each beets is tolerable and the production reductions are negligible. The greatest damage is found if the larvae penetrate up to the upper part of the root, concurrently with high temperatures, promoting a state of rotting, as well as a reduction of technological quality.

2.13 MARTINA MAYRHOFER[1], FRIEDRICH KEMPL[2], HERBERT EIGNER[1]

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SUGAR BEET WEEVIL (*BOTHYNODERES PUNCTIVENTRIS*) – INVESTIGATIONS ON THE EFFICACY OF INSECTICIDES IN MODEL TRIALS

During the last few years, an exponential increase in the occurrence of sugar beet weevils (*Bothynoderes punctiventris*) has been recorded in Middle and Eastern Europe. Control of this pest is based on the use of registered ingredients, e.g. Chlorpyrifos, Lambda-Cyhalothrin, Alpha-Cypermethrin, Pyre-thrine, Deltamethrin and Thiacloprid.

In field trials as well as in practical application insecticides based in these ingredients are missing many times the expected efficacy. To clear the reason for this observation model trials were set up in 2018 and 2019. Compared to an untreated standard, five active ingredients – in direct and indirect application – were included in the investigation. In six replications per treatment, 20 weevils were placed per box (60 x 40 x 20 cm), whose bottom was covered with sand. Insecticides were applied according to the registered amount of active ingredient. Counting for weevils dead, retarded and still alive was carried out in 2018 after 24 and 48 hours, in 2019 starting already two respectively five hours after spraying.

In 2018, 24 hours after application, Karate Zeon (Lambda-Cyhalothrin) and combinations with Agritox (Chlorpyrifos), Biscaya (Thiacloprid), Fyfanon (Malathion) and Sumi Alpha (Pyrethroid) showed a rapid and high efficacy. More than 90% of the weevils were dead or motionless. The other 10% of the weevils were mobile. There was no difference between weevils, whether hit by the pesticide directly or coming into contact with the contaminated sand. In 2019 the results five hours after application, Karate Zeon, Sumi Alpha, Trebon, Fastac Forst and Sumicid Top showed high efficacy. The mortality was higher than 95%. Mospilan didn’t work well.

Applications differ in their efficacy, most of them meeting the expected mortal rate. The outcome confirms the assumption that unsatisfying results are caused by the difficulty to hit the weevil in the field by spraying. Another important aspect, which has to be taken into account, is a migration rate of up to 300 m a day.

2.14 ZDZISŁAW KLUKOWSKI[1], JACEK PISZCZEK[2]

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BIOLOGICAL ASPECTS OF SUGAR BEET WEEVIL CONTROL – POLISH EXPERIENCE OF 2014-2019 OUTBREAK

In the past five years, a growing threat of plantations has been recorded in the east and southeast part of country by the numerous migrations of sugar beet weevil (*Asproparthenis punctiventris* Germar). The economically significant damage has been recorded in Poland annually since 2016 – slightly later than in Hungary, Croatia and Austria. Currently SBW randomly inhabits the sugar beet fields from the Ukrainian border to the south-central part of the country.

Our previous studies covered field observation and rearing of weevils under controlled conditions. Analysis of soil opencasts showed that most beetles end the pupa stage in the last decade of September. In 89% of cases wintering imagos settled the soil profile to a depth of 20 cm. The places most densely populated by beetles had 11-16% soil moisture (at the depth of wintering) and less compactness than the average in the field. Isolated from larvae and imago were entomopathogenic fungi of the genera *Acremonium* sp., *Isaria* sp., *Metharizium anisopliae* (?).

Also reproductive biology and behavior of populations from eastern Poland were studied under laboratory conditions. Studies have been undertaken on climate requirements conducive to the development of larvae and weevils wintering. Initially, a new type of "groove" trap was developed to increase the attractiveness of pheromones

Further study topics are:

- Determination the moment of pest appearance and the peak of threat on the basis of pest culture and field data from previous years. Ultimately, the model of first spring activity and migration to sugar beet plantations,
- Optimisation of insecticides applications,
- Designation of the most vulnerable areas,
- Optimisation of sugar beet beetle capture system at the field edges using attractants,
- Indication of agrotechnical activities that enable an effective reduction of the pest's numbers.

There is a need for international research cooperations in the field of sugar beet weevil control.

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INCREASE OF THE WEEVIL POPULATION IN FRANCE

Lixus juncii is a well-known pest affecting sugar beet seed-producing plants in the south of France. It was spotted near Clermont-Ferrand 5 years ago and has been moving up north over the past 2 years. In spring, adults settle on sugar beet leaves, females lay their eggs inside the petioles and larvae then dig galleries towards the root crown. Yield losses can reach 5 to 7%. Galleries are also gateways for *Rhizopus* infections. Once the egg is laid, it is impossible to fight against Lixus. It is therefore necessary to set up preventive pest management methods, and in case of colonisation of the beets, to identify peaks of flights via field traps in order to control the adults. However, experiments showed limited effectiveness of insecticide applications.

2.16 Åsa Olsson Nyström[1], Lars Persson[1], Mariann wikström[2]
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FREE LIVING NEMATODES AND ROOT GALL NEMATODES IN SUGAR BEET

Free living nematodes and root gall nematodes in sugar beet cause substantial yield losses due to reduced growth, increased fanginess and infections by secondary fungi in the root lesions caused by the nematodes.

In a research project during 2016-2019 we have studied damage thresholds especially for sugar beet and investigated options for control using different varieties. The results indicated that the stubby root nematodes *Trichodorus* spp. and *Paratrichodorus* spp. should be treated separately with separate damage thresholds. *Paratrichodorus* has a lower damage threshold than *Trichodorus*. Root lesion nematodes, e.g. predominantly the genus *Pratylenchus* in Sweden, cause extreme fanginess in sugar beet and the number of individuals should be kept lower than 250 ind/250 g soil for most of the species. A trial with *Meloidogyne hapla* showed that this nematode caused severe yield reduction, around 50%, at densities above 10 individuals/250 g soil. The damage threshold for sugar beet is therefore proposed to be kept very low with only one or two individuals/250 g soil. Keeping densities of plant parasitic nematodes low in the crop rotation requires a well-planned crop sequence with resistant or tolerant varieties that minimise multiplication.

Trials in green house and field were conducted to study if sugar beet varieties differ in susceptibility to various nematodes. Symptoms were studied in both field and green house trials and impact on yield was studied in the field. In the green house, symptoms on roots were evaluated by counting galls, assessment of percentage of stubby roots or extraction of larvae from roots in a mist chamber. The results indicate significant differences in susceptibility between the varieties. The research project continues with new trials for three years on how to sanitate soils for nematodes using inter crops.

2.17 CEDRIC ROYER, CELINE GOUWIE, FREDERIC BOYER, FABIENNE MAUPAS
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THE AFTERMATH OF THE NEONICOTINOID BAN IN FRANCE: FIRST LESSONS AND NEW PERSPECTIVES

2019 has been the first agricultural campaign in 25 years that did not rely on neonicotinoid class insecticides to protect sugar beet against virus yellows and soil pests. Now that the campaign has ended, it is time to discuss what lessons 2019 taught us in that matter and what perspectives we can expect in the coming years.

If soils pests are still mostly under tefluthrin (a pyrethroid) control, some uncertainty remained on its actual efficacy without the neonicotinoid partner in the seed pellet. To answer this question, field trials were conducted comparing standard seeds with Force 20CS seed treatment and Force 1,5G application on several soil pests.

Concerning virus yellows, two new aphicides were available to French farmers last spring in order to control the multiplication of aphid vectors. If those products happened to be efficient notably against apterous green aphids, precise monitoring of aphid flights and virus incidence as well as regular field scouting to monitor the presence of wingless aphids were necessary before releasing any spraying advice. Field scouting data were also released in real-time on a new online platform to facilitate farmers' access to information and encourage simultaneous sprayings on a local scale.

New solutions to control virus yellows, which do not rely on phytosanitary applications, are currently under study at ITB within collaborative research projects associating INRA research teams and arable crops technical institutes. These projects encompass the evaluation of biocontrol products and new tolerant varieties to virus yellows.

2.18 FRIEDRICH KEMPL[1], KATHARINA WECHSELBERGER[2]

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EFFICACY OF SEED TREATMENTS WITH AND WITHOUT NEONICOTINOIDS

The ban of neonicotinoids in the dressing of sugar beet seeds eliminated a considerable part of the insecticidal plant protection. Only the active ingredient Tefluthrin, which, however, has no systemic effect, remained.

In Austria, a derogation for the use of neonicotinoids as seed treatment was achieved in 2019 for a part of the beet area. Nevertheless, it will be necessary in future to protect the sugar beet against pests even without these active ingredients. The aim is to develop guidelines for beet growers to control pests within the framework of integrated pest management.

For this reason, field trials with differently treated seeds were established in several sites, and infestation rate by pests as well as resulting plant losses were recorded. In addition, surveys from experiments that were created for other purposes – but led to distinct differences in the final plant density due to different seed dressing – were included into the assessment.

The results show clear differences: These were mainly caused by *Bothynoderes punctiventris* and *Chaetocnema tibialis*. The infestation by aphids in 2019 was only of minor importance.

2.19 NIELS WYNANT, IAN MUNNERY, JAN SELS, HEIDI LIESSE, GLENDA WILLEMS, JUAN VEGAS, ERIK DE BRUYNE, OLIVIER AMAND,HENDRIK TSCHOEP
SESVanderHave, Industriepark 15, 3300 Industriepark 15, B – 3300 Tienen

BREEDING FOR INSECT TOLERANT VARIETIES AT SESVANDERHAVE

Coping with insect pests is one of the major future challenges for the cultivation of sugar beets. Insect pests are usually controlled by insecticides, but the political and socio-economical context, as well as the occurrence of insecticide resistances, argues against the sole use of these chemicals. Plant resistance breeding is a proven cornerstone in integrated pest management.

Breeding for insect tolerance varieties is a major focus for SESVanderHave. Our objective is to select competitive varieties with high tolerance and/or resistance to economically important insects, such as aphids, hoppers, moths and beetles that attack sugar beets at various stages of development. SESVanderHave equally targets the pathogens that are spread by vector insects, such as yellowing viruses, the curly top virus and the proteobacteria and phytoplasma, which cause the Syndrome Basse Richesse.

In this poster presentation, SESVanderHave will outline its breeding strategy for the development of competitive insect tolerant varieties, which will be elaborated by means of four case studies.

2.20 LINDA FRIJTERS, ELMA RAAIJMAKERS, LEVINE DE ZINGER
Institute of Sugar Beet Research (IRS), P.O. Box 20, NL – 4670 AA Dinteloord

TESTING ALTERNATIVE PESTICIDES AND MONITORING SYSTEMS FOR THE CONTROL OF PYGMY MANGOLD BEETLES (*ATOMARIA LINEARIS*) UNDER FIELD CONDITIONS

Since the ban on seeds coated with neonicotinoid insecticides, pygmy mangold beetles (*Atomaria linearis*) are more difficult to control. Especially on fields where beet or spinach was grown in the previous year, or fields that border to it, pygmy mangold beetles can cause significant yield losses. In the Netherlands, tefluthrin can be applied as seed coating, but is proven to be less effective than neonicotinoids on belowground damage and does not have any effect on above-ground damage. In the Netherlands, pyrethroid foliar insecticide applications are the only chemical alternative to control this pest aboveground. However, due to the negative side effects on beneficials and risk of pesticide resistance, pyrethroid application can result in higher population densities of other pests, such as aphids.

Therefore, two field trials were conducted to test the efficacy of alternative pesticides to control pygmy mangold beetle damage below- and aboveground. Plots were treated with insecticides and plants were scored for damage during early plant development. Also, various insect traps were placed around the trial fields to monitor flights of the pygmy mangold beetles. Results of these trials and traps will be presented.

2.21 KATHLEEN ANTOONS, FRANCOISE VANCUSTEM, ANDRÉ WAUTERS, JOHAN KELEMAN
IRBAB-KBIVB, 45 Molenstraat, B – 3300 Tienen

OPTIMIZING OF PEST MANAGEMENT IN BELGIUM THANKS TO THE OBSERVATION AND WARNING NETWORK

The European ban of three neonicotinoids gives new challenges for the control of soil borne pest and foliar insects in sugar beet crops. Therefore, IRBAB-KBIVB reactivated his observation and warning network for insect pest in 2019.

Weekly observations are performed in about 100 fields spread over all the beet growing region from early germination until row closure. The observations are done by IRBAB-KBIVB, agronomists of the Belgian sugar factories and external observers (farmers,…). Thanks to these observations, messages are posted weekly on the website and sent for free by email to inform farmers about the pressure level of pest insects and to provide recommendations for the use of available products.

To help sugar beet growers to control green aphids, vectors of yellowing viruses, a map is published on the IRBAB-KBIVB website. Each monitored field is represented by a coloured square on the map. The colour is related to the number of green wingless aphids present in the field. The aim of the online publication of this map is to assist farmers to choose judiciously the date of the insecticide treatment.

2.22 Roland H.M. Wouters[1], Roberto Biello[1], Sam T. Mugford[1], Erik de Bruyne[2], Fokke-Jan Bulthuis[2], Ian Munnery[3], Richard Robinson[3], Niels Wynant[2], Glenda Willems[2], Diane G.O. Saunders[1], Saskia A. Hogenhout[1], Thomas C. Mathers[1]

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[2] SESVanderHave, Industriepark 1, B – Tienen 3300
[3] SESVanderHave UK limited, Grantham road, UK – LN5 0HH, Wellingore, Lincoln

Global diversity of the sugar beet aphid pest *M. persicae*

The green peach aphid *M. persicae* has a broad plant host range of over 400 species from over 40 families and is a significant insect pest of sugar beet and many other crops. Furthermore, *M. persicae* transmits about 100 plant viruses and has developed resistance to more than 70 insecticides. So far, knowledge of crop resistance mechanisms to aphids is limited and to achieve durable resistance more information is needed about genome sequence diversity, particularly of virulence genes, within and between aphid populations. Given that sugar beet production yields are challenged by insect-vectored viruses, particularly those transmitted by *M. persicae*, we investigated genome-wide patterns of genetic diversity and global population structure of *M. persicae* using whole genome sequnces of 36 individuals collected from field populations on sugar beet and other crops throughout the world. *M. persicae* population structure analyses revealed an absence of clustering by region or by plant host. This suggests migration of genotypes around the world without regional barriers and/or recent global population expansion. It remains to be established if this is via natural migration or is mediated by human activity. Despite the predominant clonal reproduction of *M. persicae*, we observed a decay of linkage disequilibrium over genetic distance indicative of recombination between genotypes. As such, sexual reproduction likely plays a significant role in shaping patterns of *M. persicae* genetic diversity. Given these data, the diversity of *M. persicae* genotypes will have to be considerd in the development of strategies to achieve durable resistance in sugar beet and other crops to these insects.

2.23 Elma Raaijmakers[1], Fokke-Jan Bulthuis[2], Niels Wynant[2], Erik De Bruyne[2], Jan Luimes[3]

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[3] The Dutch General Inspection Service (NAK), Randweg 14, NL – 8304 AS Emmeloord

Monitoring of aphids in sugar beet fields and trial fields, a basic tool to understand virus yellow epidemics in the post-neonic era

A basic understanding of the sugar beet yellows epidemics has become a crucial know how tool to allow good disease management for farmers and breeding companies/sugar beet institutes in the current frame of the neonics ban. The monitoring of aphid visits in trial plots in particular has regained interest to redefine new quality criteria to set up yield trials for breeding purposes and variety testing. In this project, the standard aphid collection protocol developed by the Dutch General Inspection Service (NAK) for the aphid and virus management in seed potato fields was applied to a large number of sugar beet trials and fields in Europe as a collaborative project between SESVanderHave, the Dutch Institute of Sugar Beet Research and the Dutch General Inspection Service.

A large number of yellow water pans to trap aphids was set up next to sugar beet yield trial fields and seed production fields. Moreover, yellow water pans were set up inside commercial sugar beet fields, close to commercial seed potato fields with yellow water pans and suctions traps to compare numbers of aphids in the different trap systems. Winged aphids were regularly collected between April and August 2019 and morphologically identified.

In this poster presentation, the application of the water trap system will be further discussed in the context of virus yellow control in sugar beet trials and commercial sugar beet fields.

2.24 ROXANA HOSSAIN[1], WULF MENZEL[2], MARK VARRELMANN[1]

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VIRUS YELLOWS IN SUGAR BEET – BIOLOGY, OCCURRENCE AND INFLUENCE ON YIELD PARAMETERS

Sugar beet production is challenged by pests and diseases, restricting the genomic yield potential. The virus yellows disease which is caused by a complex of different virus species, is mainly transmitted by the aphid *M. persicae*. In Europe, *Beet yellows virus* (BYV), *Beet mild yellowing virus* (BMYV) and *Beet chlorosis virus* (BChV) are economically most important, while *Beet mosaic virus* (BtMV) occurs only rarely. Symptoms are highly variable and are characterised by chlorosis and necrosis as well as mosaic-like yellowing of older leaves. Infestation risk depends on natural fluctuation of the aphid population and is influenced by climatic conditions mainly in the winter months and infection time point during plant vegetation. In the past, virus yellows in sugar beet has been efficiently controlled by neonicotinoid seed treatment. However, these substances have been banned in Germany since 2019. The widespread and frequent use of remaining insecticides will increase the selection pressure on aphid populations leading to enhanced risk of insecticide resistance and spread of virus yellows disease. Representative data on the current natural occurrence of the different virus species in Europe and especially Germany as well as yield losses caused by the disease under natural infection are lacking. Within the framework of a recent study, a current situation of the occurrence of different virus species was determined by means of a European-wide monitoring. The monitoring which was done in the years 2017 and 2018 in different European countries showed that even the decades-long use of neonicotinoids has not led to a complete extinction of the virus species. BYV, that was thought to be mainly limited to Southern Europe, has now also been found in Northern and Central Europe. Symptom severity was investigated by artificial aphid inoculation of sugar beet plants in field trials. Although only 10% of the plants per plot were inoculated by virus loaded to *M. persicae*, infection rates of 100% were obtained in September. Yield effects will be additionally presented. The experiments will provide new insights into current yield and quality losses in sugar beet during virus yellows disease.

2.25 Dragana Budakov[1], Vera Stojsin[1], Zivko Curcic[2], Tatjana Dudas[1], Nevena Nagl[2], Ferenc Bagi[1], Mila Grahovac[1]

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[2] Institute for Field and Vegetable Crops, Maksima Gorkog 30, RS – 21000 Novi Sad

Sugar beet virus diseases in Serbia

During 2017, yellowing of sugar beet leaves occurred in sugar beet fields in Serbia. Disease was visible on individual plants which had symptoms of intercostal yellowing, leaves were upright and brittle and in time this yellowing turned into necrosis. For the purpose of this research leaves with these symptoms were collected from 40 fields and analyzed using ELISA on the presence of *Turnip Yellows Virus* (*Beet mild yellowing virus*), *Beet Mosaic Virus*, *Beet Necrotic Yellow Vein Virus* and *Beet yellows virus*. Results proved occurrence of these viruses and were commented in regard to meteorological data which were favorable for vector activity.

2.26 ŽIVKO ĆURČIĆ[1], ŽELJKO MILOVAC[1], KSENIJA TAŠKI-AJDUKOVIĆ[1], ALEKSANDRA STANKOV[2], ANĐA RADONJIĆ[3], OLIVERA PETROVIĆ-OBRADOVIĆ[3], BRITT-LOUISE LENNEFORS[4]

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[4] MariboHilleshög Research AB, Säbyholmsvägen 24, S – 261 62 Landskrona

BEET YELLOW VIRUS A POSSIBLE THREAT TO SUGAR BEET PRODUCTION IN SERBIA?

There are three main yellowing viruses that damage the beet crop in Europe: *Beet yellows virus* (BYV), *Beet mild yellowing virus* (BMYV) and *Beet chlorosis virus* (BChV). Although not a true yellowing virus, *Beet mosaic virus* (BtMV) is found in sugar beet in Europe and can cause damage. The yellowing viruses are transmitted by aphids. The recent ban of neonicotinoids in the EU endangered sugar beet production in terms of crop protection against aphids. Since, Republic of Serbia agenda is to become member state of the EU, in order to do that it is necessary to completely synchronise legislation with the EU in all domains, including agriculture and crop protection. That is why it is expected that this ban of neonicotinoids will be implemented in the near future in Serbia also in sugar beet growing. Although earlier research classified Serbia as a country where damage might occur occasionally without significant yield loss, in the last two years (2018 and 2019), BYV presence was confirmed in the fields of the Institute of Field and Vegetable Crops, Novi Sad. During mid of May 2019, the presence of BtMV was confirmed, also transmitted by aphids. First BYV symptoms in 2019 occurred mid of June and the presence of BYV was confirmed by ELISA. Aphids monitoring during the 2019 vegetation period showed existence of over 50 different aphid species. The most dominant species were *Aphis fabae* and *Aphis spiraecola*. The presence of *M. persicae*, the most significant vector of yellowing viruses in Western Europe, was very low. Further studies will be done to examine possible vectors of viruses and to assess effect of yellowing viruses on sugar yield.

2.27 LUCY JAMES[1], RICHARD ROBINSON[2], JEROME DE PESSEMIER[3], NIELS WYNANT[3], IAN MUNNERY[2], GLENDA WILLEMS[3], HENDIRK TSCHOEP[3], NEIL PAVELEY[1], BRITT-LOUISE LENNEFORS[4], THOMAS KRAFT[4], ULRIKA AKESSON[4], CAROLINA NILSSON[4], SUZANNAH COBB[5], KEVIN SAWFORD[5], MARK STEVENS[5]

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A NOVEL PRE-BREEDING STRATEGY TO REDUCE DEPENDENCE ON INSECTICIDES FOR VIRUS YELLOWS CONTROL IN SUGAR BEET – A FINAL UPDATE

In 2018, the European Commission enforced a ban on the three main neo-nicotinoids (clothianidin, imidacloprid and thiamethoxam) for all outdoor uses. For the first time since the 1990’s, sugar beet crops across Europe have been grown during the 2019 season without neonicotinoid seed treatments, leaving the industry vulnerable to highly damaging viruses, such as the Virus Yellows complex and their aphid vectors. If uncontrolled, Virus yellows can cause up to 50% annual yield losses and represents a particularly significant threat to the UK beet industry because the maritime climate favours the overwinter survival of aphid vectors. A vital component of future control strategies without neonicotinoids, is the development of virus yellows resistant or tolerant sugar beet varieties. During a successful five year pre-breeding project our research team (BBRO, ADAS, SESVanderHave, and Maribo Hilleshög) have identified several wild beet genotypes that show resistance or tolerance to the effects of virus yellows, significantly enhancing the resistance/tolerance gene pool. The project has further developed these heritable resistance and tolerance traits, by crossing selected wild beet with modern commercial breeding lines. Over the five year period new lines have been rigorously tested in the field for virus yellows resistance or tolerance, plant vigour and yield. Genetic testing has also been completed to develop molecular markers for marker-assisted selection of virus yellows resistance/ tolerance and to identify genes controlling these traits.

This five year pre-breeding project is partly funded by Innovate UK, the UK’s innovation agency and has significantly accelerated production of new sugar beet varieties that provide host protection against the virus yellows disease complex.

2.28 ALISTAIR WRIGHT[1,2], MARK STEVENS[2], ERIK MURCHIE[1], DEBBIE SPARKES[1]

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PHENOTYPING VARIETAL RESPONSES OF SUGAR BEET TO VIRUS YELLOWS, BEET CYST NEMATODE AND FOLIAR DISEASES

With the future of many major agrochemicals uncertain, and the recent withdrawal of neonicotinoid seed treatments, unlocking the genetic potential of current and future varieties of sugar beet is more important than ever to protect against pest and disease threats. This new project is looking at phenotyping sugar beet varieties, both current and those close to market, for their potential resilience against three major threats: virus yellows (*Beet yellows virus* and *Beet mild yellowing virus*), beet cyst nematode (*Heterodera schachtii*) and major foliar diseases such as rust and powdery mildew.

A range of trials have been established to understand more about the varieties under investigation. All have been subjected to pressures from the afore-mentioned pests and diseases through artificial or natural inoculation. Regular assessments of the phenotypes of the varieties with and without disease or pest pressure were made, such as canopy growth and performance, using multi-spectral and colour imaging. Measurements were taken throughout the growing season of the sugar beet to help elucidate yield responses seen at harvest.

It is hoped that the findings of this project will develop new understanding of varietal resilience to pest and disease threats and gain valuable knowledge for growers when selecting varieties. This poster will detail our latest findings and outline future aims of the project.

This is a Knowledge Transfer Partnership (No. 11116) project jointly funded by BBRO and the UK government through Innovate UK.

2.29 CAROLINA NILSSON, THOMAS KRAFT, BRITT-LOUISE LENNEFORS
MariboHilleshög Research AB, Säbyholmsvägen 24, S – 261 91 Landskrona

SUCCESSFUL BREEDING FOR RESISTANCE/TOLERANCE TO VIRUS YELLOWS AT MARIBOHILLESHÖG

Virus yellows in sugar beet is caused by one or more viral agents including *Beet mild yellowing virus* (BMYV), *Beet chlorosis virus* (BChV) and *Beet yellows virus* (BYV). In infected sugar beet fields the yield losses can be considerable. *M. persicae* (Sulzer) is an efficient aphid vector for all three viruses. As the possibilities to control the aphid vectors by insecticides have decreased, it has become more important to have genetic virus and/or insect tolerance/resistance in sugar beet varieties.

MariboHilleshög breeds for resistance/tolerance to all three viruses causing virus yellows. Through different kinds of screening and selection methods such as greenhouse and lab tests, semifield- and field trials, it has been possible to successfully select sugar beet materials with different levels of resistance/ tolerance.

In one category of sugar beet genotypes the viruses multiply, but the plants develop less symptoms than the control material. Plants from other origins appear to be highly resistant to more than one of the yellowing viruses. The viruses have low multiplication rate and the plants stay green. We have identified QTLs for tolerance/resistance in several different sources.

It is challenging to work with resistance/tolerance to virus yellows and therefore different research and external collaboration projects are ongoing e.g. with the aim to identify key genes involved in the interaction between the viruses and sugar beet.

These activities support further breeding at MariboHilleshög in order to produce varieties giving high yield even under pressure of virus yellows.

2.30 KAZUYUKI OKAZAKI, YOSUKE KURODA, KENJI TAKASHINO, HIROAKI MATSUHIRA, SHIGENORI UEDA

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RESISTANCE BREEDING TO YIRUS YELLOWS IN JAPAN

Virus yellows (VY), which causes yellowing in adult leaves, is an important disease of sugar beet. Since the 1950's, yield loss due to VY have been frequently reported in Hokkaido, Japan. In recent years, sever outbreaks of VY occurred from 2008 to 2014. Previously, it was thought that VY in Japan were mainly caused by *Beet western yellows virus* (BWYV), but recent studies have revealed that *Beet leaf yellowing virus* (BLYV), closely related to BWYV, is a pathogenic virus. Since BLYV is transmitted by aphids and has wide host range, it is difficult to completely control BLYV. Therefore, we consider that resistant varieties are promising control of BLYV and started resistant breeding program in 2016. At beginning of the breeding, USDA-ARS has been conducting VY-resistant breeding since the 1950s, so we introduced their VY resistant lines and evaluate their resistance to BLYV by inoculation using aphids. In the inoculation test, we evaluate BLYV resistance based on the degree of yellowing symptoms in adult leaves. As a result of inoculation test, we selected the two USDA lines as resistant materials because these lines showed less yellowing symptom than the other lines. Using segregating population(F2) derived from the cross between resistant USDA lines and susceptible our breeding parent line, we investigated the effect of selection based on yellowing symptom and found that yellowing symptom is a selectable genetic trait. Regarding the inheritance pattern of BLYV resistance in F1, we performed an inoculation test of F1s derived from the crossing between resistance and susceptibility lines, and considered that BLYV resistance was additive inheritance.

This research was supported by grants from the Project of the Bio-oriented Technology Research Advancement Institution, NARO (the special scheme project on advanced research and development for next-generation technology).

2.31 Nina Behnke, Werner Beyer
KWS SAAT SE & Co. KGaA, Grimsehlst. 31, D – 37574 Einbeck

Breeding for Virus yellows resistance – a new success story?

Yellowing viruses affect the sugar beet crop all over the world. The virus yellows complex comprises a combination of several viruses. Most prominent are the closterovirus *Beet yellows virus* (BYV) and the poleroviruses *Beet mild yellowing virus* (BMYV) as well as *Beet chlorosis virus* (BChV). Genetic resistance against yellowing viruses and breeding efforts have not been strongly demanded during the last two decades due to the broad utilisation of insecticides protecting sugar beet against the aphid virus vectors. After the recent political decisions and the ban of neonicotinoids for the cultivation of sugar beet in many European countries, the situation for sugar beet growers and the whole industry has changed dramatically and requires quick and prudent decisions of farmers, plant protection and seed companies. KWS has strongly strengthened its breeding efforts in the last years and developed first tolerant varieties which have been entered official trials in UK, France and Germany. They provide good level of tolerance against yellowing viruses, but so far do not reach highest sugar yields without yellowing disease. Second generation experimental hybrids are currently in the testing phase and KWS is combining yellowing virus resistance with other resistance traits which are required in different markets. Results of most recent infection trials with different viruses will be presented, commenting on the observed resistance levels, but also on field performance with and without virus infection.

2.32 YOSUKE KURODA, KAZUYUKI OKAZAKI, KENJI TAKASHINO

Hokkaido Agricultural Research Center, National Agriculture and Food Research Organisation, 9-4 Shinsei Minami, Memuro, Kasai, J – 082-0081 Hokkaido

QTL ANALYSIS OF RESISTANCE TO BEET LEAF YELLOWING VIRUS (BLYV)

Beet leaf yellowing virus (BLYV), a species of Polerovirus closely related to *Beet western yellows virus* (BWYV), has recently been identified as a new virus species that occurs in many parts of Hokkaido. The infection causes yellowing symptom at adult leaves and serious damage to sugar beet production. Breeding of resistant varieties is a method to mitigate the damage. As preliminary studies, we have evaluated an artificial inoculation assay that can evaluate by either index (0-3) or yellowing area ratio (%) calculated from digital camera images. In addition, we have confirmed that variation among strains from sensitivity to resistance in the symptoms. The objective of this study is to identify genomic regions controlling resistance to the virus. Using genetically segregating F2:3 progenies developed by crossing a susceptible parent and a resistant parent, phenotypic data was acquired by an artificial inoculation assay, and genotype data was acquired by GRASS-Di, which is one of the analyses using next-generation sequencing. QTL analysis was performed from phenotype and genotype data, and several QTLs associated with resistance to BLYV were detected. It was confirmed that genotypic data of loci closely linked at some QTLs generally agreed with patterns of the phenotypic data. Molecular markers of those QTLs may be applicable to efficient breeding selection for BLYV resistance.

This research was supported by grants from the Project of the Bio-oriented Technology Research Advancement Institution, NARO (the special scheme project on advanced research and development for next-generation technology).

2.33 MARGARET REKOSKE, HENNING FRIEHE, JAY MILLER
Betaseed Inc., 1325 Valley View Rd., USA – 55379 Shakopee

BETASEED: 50 YEARS OF INNOVATION – A COMPANY LOOKING TO THE FUTURE

Betaseed Incorporated was founded in 1970 to supply triploid hybrids to North America (NA). Early breeding objectives were established for resistance to Cercospora leaf spot (CLS) and *Beet curly top virus* (BCTV), each affecting distinct geographic areas of approximately 60% and 40% of the NA sugar beet acreage respectively. The development of field, greenhouse, lab and molecular tools was essential to improve resistance to *Aphanomyces cochliodes*, *Cercospora beticola* (CLS), *Fusarium* spp., *Heterodera schachtii* (SBCN), rhizomania (RZ), *Rhizoctonia solani*, BCTV, *Erypsiphe polygonia*, *Pemphigus betae* (SBRA) and *Tetanops myopaeformis* (SBRM). Genetic resources including USDA releases were utilised for germplasm enhancement. Diverse, challenging market conditions required multiple resistances be combined with improved yield and quality for economic competitiveness to other crops. A commitment was made to routinely incorporate Fusarium tolerance, SBRA resistance and multiple rhizomania resistances due to minimal impact on performance in the absence of pests and potential benefit of relative 20% or more on productivity and storage in the presence of pests. Betaseed, the leading supplier of glyphosate tolerant sugar beet seed, led the rapid and complete market change to glyphosate resistant sugar beet in NA. The ability to combine up to 9 resistance factors in a single high performing hybrid allows Betaseed to meet the increasing demand for disease and pest resistance throughout the world. Upcoming GM traits for multiple virus resistance and next generation herbicide tolerance will be available in the next decade. Advanced breeding tools provide a means to fulfill the future global industry needs for greater agronomic productivity and improved tolerance to abiotic stresses and diseases and pests including CLS, SBRM and other insects, virus yellows and rhizomania.

2.34 CHRISTINE KENTER, PHILIPP GÖTZE, ERWIN LADEWIG
Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

EFFECTS OF SAMPLE SIZE AND HEAD ROWS ON THE PRECISION OF VARIETY TRIALS WITH SUGAR BEET

In Germany, all agricultural variety trials and registration trials have to be set up and managed according to the official guidelines of the German Federal Plant Variety Office. For sugar beet, these guidelines require plots with 80-100 beets for a representative estimation of root yield. They also say that, if possible, one or two head rows shall be planted at right angle to the plots to avoid border effects at open alleys. The necessary sample size was derived from trials in the 1970s and the effect of head rows in variety trials with sugar beet has not been systematically studied to date. The aim of the present study was thus to quantify the effects of sample size and head rows on the precision of yield and quality data of sugar beet in two trial series carried out in Germany in 2016-2017.

In the series “sample size”, samples of 30, 60, 90 and 120 beets were compared for four varieties grown at nine environments. With increasing number of beets, coefficient of variation (CV) and least significant difference (LSD, multiple t-test) for root yield, sucrose content and the concentrations K, Na, amino-N decreased, especially between 30 and 60 beets. The precision of samples with 60 beets was close to the current standard of 90 beets for sugar content and the melassigenic substances, but lower for root yield.

In the series “head rows”, ten trials with 24 varieties were conducted without and with head rows. With head rows, all varieties yielded lower and were higher in sugar content than without head rows. The effect on white sugar yield was not uniform across varieties and environments. Head rows increased the homogeneity of beet size (i.e. no bigger beets at the plot ends), but this had no uniform effect on white sugar yield or LSD across varieties and environments.

2.35 ANDRE WAUTERS, KATHLEEN ANTOONS
IRBAB-KBIVB, Molenstraat 45, B – 3300 Tienen

FIELD TESTING FOR BMYV TOLERANCE IN SUGAR BEET WITH DIFFERENT INOCULATION TECHNIQUES

BMYV is an important yellowing viruse that causes damage to the sugar beet crop in Belgium. The virus is transmitted by *M. persicae*. To avoid the virus transmission, after the ban on the neonicotinoids, beets must be protected by foliar insecticides. Genetic resistance for BMYV is here a complementary tool for protecting the infection and/or losses due to the virus.

This poster describes the investigations around inoculations techniques and inoculation density with BMYV carrying aphids in field trials in Belgium. An inoculation density of 15% of the plants was compared to an inoculation density of 2.5% according to the EPPO proposed protocol (6 infested plants). We discuss the inoculation technique on the yellowing, distribution and effect of the inoculation density on the tolerance (yield penalty) of 10 different varieties.

2.36 LÁSZLÓ POTYONDI
Beta Research Institute Nonprofit Ltd., Fo út 70, HU – 9463 Sopronhorpács

CHALLENGES OF NON-RENEWAL OF APPROVAL OF PESTICIDES IN HUNGARIAN SUGAR BEET PRODUCTION

Every year newer pesticides disappear from the toolbars of sugar beet growers. According to the 2019 September situation, thiram and propiconazole are banned, and in 2020 farmers are able to use chloridazon and desmedifam as herbicides, fenpropimorph as fungicide, and dimetoat as insecticide for the last time. Some other pesticides are waiting for renewal of their approval, and many of them probably will be banned.

The possible technological changes to substitute these pesticides are continuously investigated. The challenges and the potential solutions under the Hungarian conditions are detailed in this study.

2.37 LOUISE HOLMQUIST[1], STEFAN MITTLER[2], JOSE FERNANDO GIL[3], RICKARD JOHNSSON[1]

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[3] Swedish University of Agricultural Sciences (SLU), Department of Plant Biology, Linnean Centre for Plant Biology, Box 7080, S – 756 54 Uppsala

SYNDROME BASSES RICHESSES (SBR) IN SUGAR BEET – CROP ROBUSTNESS AS A POTENTIAL ELEMENT FOR CONTROL

SBR – Syndrome Basses Richesses was first seen in Eastern France in 1991 where for several years it affected sugar beet crops with severe sugar losses. First symptoms in Germany were described in 2008 and since then outbreaks have been fluctuating by year and in 2017 severe symptoms were seen. The disease has been described in at least France, Germany, Switzerland and Hungary. SBR is restricted to the phloem, causing yellowing of both young and older leaves and brownish discoloration of the taproot vascular tissue. These symptoms often appear late in the season, shortly before harvest. As a result, dramatical losses are registered for growers and the local sugar beet industry due to the critical reduction of sugar content in the taproot. The disease is associated with two unculturable phloem-restricted plant pathogens, *Candidatus Arsenophonus phytopathogenicus* (SBRp) and *Candidatus Phytoplasma solani*. Both organisms are transmitted by planthoppers belonging to the family *Cixiidae* and have been detected in SBR infected plants.

Since there is no chemical way to treat this disease the most effective control is growth of resistant/tolerant varieties. The variety Rhinema with its four trait combinations (RT, NT, CE, RZ) has shown good tolerance against the disease and field trials have shown that the sugar content of Rhinema was up to 3% higher in locations with natural SBR infection compared to other varieties. MariboHilleshög has developed, together with the Swedish University of Agricultural Sciences, a qPCR method for detection and quantification of SBRp. Additionally, a quantitative method for the phytoplasma is under development. It is now possible to compare the infection levels between different varieties, which will enable a quicker breeding progress.

2.38 ANDRÉ WAUTERS
IRBAB-KBIVB, Molenstraat 45, B – 3300 Tienen

SILVERING DISEASE IN SUGAR BEET CAUSED BY *CURTOBACTERIUM FLACCUMFACIENS* PV. *BETAE* IN BELGIAN SUGAR BEET TRIAL SITE

During the past 8 years, beets presenting silvering disease were recorded in the Belgian variety trials. The bacteria *Curtobacterium flaccumfaciens* pv. *betae* has been identified as causal agent and was isolated from root and leaf tissue in 2017. This seedborne disease has also been isolated from sugar beet seeds.

Infected plants present typical symptoms as stunted growth, leaves having a silver-grey matt color, presenting cracking tissue and veins are more visible. Early and severe infection can lead to plant death. Yield of infected plants is reduced (mean) by 50%.

This poster gives an overview of the observations in the variety trials, symptom description, isolation methods and effects on plant growth.

2.39 Claudia Chiodi[1], Chiara Broccanello[1], Piergiorgio Stevanato[1], Giovanni Campagna[2], Laura Treu[3], Matteo Moro[1], Giovanni Bertoldo[1], Maria Cristina Della Lucia[1], Samathmika Ravi[1], Laura Maretto[1], Stefano Campanaro[3], Giuseppe Concheri[1], Andrea Squartini[1]

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BACTERIAL COMMUNITY COMPOSITION IN A SOIL CARRYING A RESISTANCE-BREAKING STRAIN OF THE RHIZOMANIA VIRUS BNYVV IN COMPARISON TO STANDARD SOILS

One of the most impactful diseases of cropped sugar beet is rhizomania, caused by the *Beet Necrotic Yellow Vein Virus* (BNYVV), transmitted by the plasmodiophorid *Polymyxa betae*. The use of genetically resistant sugar beet cultivars is currently the sole defense strategy but in some soils a resistance-breaking virus variant of the virus has been reported which can bypass host resistance and infect even hitherto resistant varieties. Searching for clues on overall biotic structure of these soils, we sequenced 16S rDNA bacterial amplicons from a resistance-breaking soil and compared it to the corresponding communities from two control soils featuring standard rhizomania virus. A comparison of the conserved microbiome and of the specific differences occurring in each soil is presented suggesting the possible roles of specific biota in the overall community boundary and the possible indicators that appear to associate with the resistance breaking condition. Besides the strictly taxonomic and functional considerations data are likewise discussed in terms of ecological indexes, including species richness, alpha and beta diversities, and details on species mostly contributing to community differentiation in cluster ordination analysis. The possible implications in terms of indicators that could be foretelling of environmental imbalance, and thereby of crop pathology outcomes in relation to rhizomania, are discussed.

2.40 SEBASTIAN LIEBE[1#], EDGAR MAISS[2], MARK VARRELMANN[1]

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[2] Leibniz University Hannover, Institute of Horticultural Production Systems, Dept. Phytomedicine, Herrenhäuser Str. 2, D – 30419 Hannover

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APPLICATION OF A REVERSE GENETIC SYSTEM FOR *BEET NECROTIC YELLOW VEIN VIRUS* TO STUDY *RZ1* RESISTANCE BREAKING IN SUGAR BEET

Beet Necrotic Yellow Vein Virus (BNYVV) is a member of the genus *Benyvirus* in the family *Benyviridae*. BNYVV causes Rhizomania disease in sugar beet, which is characterised by the abnormal proliferation of lateral roots leading to a significant decrease in sugar content and massive yield losses. Therefore, all sugar beet cultivars carry the *Rz1* resistance gene preventing infection with BNYVV. However, there are several reports describing the occurrence of *Rz1* resistance breaking strains. The high selection pressure has led to the occurrence of several mutations in the pathogenicity factor P25 at amino acid positions 67-70 (AS67-70). Furthermore, an additional RNA component from the P-type (RNA5) has been associated with *Rz1* resistance breaking. Experimental studies confirming the resistance breaking effect of the mutations and reassortments are missing. Therefore, we developed a reverse genetic system for sugar beet using a cDNA clone of BNYVV A-type. First we confirmed that our cDNA clone carrying the amino acids ALHG at AS67-70 in P25 is not able to overcome *Rz1* resistance. Replacing ALHG by previously reported mutations (VLHG, VCHG, AYPR) led to resistance breaking. The same effect was observed when RNA5 of the P-type was supplied. Additionally, a new mutation (deletion) at AS179 in P25 mediating resistance breaking occurred after one host passage of the non-resistance breaking cDNA clone that was identified by deep sequencing and back-exchange into the cDNA clone. The results demonstrate the genome plasticity of BNYVV that allows the virus to overcome *Rz1* resistance.

2.41 VERONIKA WETZEL, MARK VARRELMANN

Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

RZ2 – A PLANT ANTI *BEET NECROTIC YELLOW VEIN VIRUS* RESISTANCE PROTEIN DERIVED FROM *BETA VULGARIS* TARGETS THE VIRAL MOVEMENT-PROTEIN TGB1 AS AVIRULENCE GENE

Sugar beets infected with *Beet Necrotic Yellow Vein Virus* (BNYVV) display a massive proliferation of rootlets, leaf vein yellowing and necrosis which can lead up to 70% sugar yield loss. Transmitted by the protist *Polymyxa betae* control of rhizomania is mainly achieved by using two dominant resistance genes, *Rz1* and *Rz2*. Recent studies identified *Rz2* as a classical R-gene, encoding a CC-NB-ARC-LRR protein (Capistrano-Gossmann *et al*. 2017). In artificially infected *Rz2* sugar beet breeding lines, no virus accumulation could be detected in comparison to susceptible plants. Expression analysis indicate a constitutively expression of *Rz2* in sugar beet roots. For further studies towards identification of the resistance response and viral gene targeted as avirulence protein, the model plant *N. benthamiana*, an experimental host for BNYVV, was used to perform *Agrobacterium tumefaciens*-mediated co-expression analysis. Leaf patch infiltration and transient co-expression of *Rz2* and BNYVV led to local cell death. Co-expression of all individual BNYVV encoded proteins in presence of *Rz2* led to cell-death only in case of the RNA2 encoded triple gene block protein 1 (TGB1). Furthermore, the TGB1 from *Beet soil borne mosaic virus*, a related *Benyvirus* only occurring in the USA, and *Beet soil borne virus*, a sugar beet infecting virus occurring in almost all sugar beet cultivation areas, were tested positive for elucidating a hypersensitive reaction.

2.42 DANIEL LAUFER, ERWIN LADEWIG
Institute of Sugar Beet Research (IfZ), Holtenser Landstraße 77, D – 37079 Göttingen

WEED CONTROL IN SUGAR BEET WITHOUT THE ACTIVE SUBSTANCES DESMEDIPHAM AND PHENMEDIPHAM

In Germany, chemical weed control in sugar beet is mostly applied at the cotyledon stage of the weeds. For a very long time, soil-active products containing the active substance metamitron have been used in combination with more leaf-active products containing the active substances desmedipham and phenmedipham on more than 95% of the beet growing area. In 2018, the re-registration of desmedipham and phenmedipham was communicated to be problematic. Meanwhile, desmedipham was not renewed in the EU (June 2019). Phenmedipham is currently being re-evaluated at EU level. The result is open at the present time. Thus, the previous herbicide strategies in sugar beet cultivation had to be newly evaluated to ensure high efficacy in weed control. In ten field trials in Germany, we tested the efficacy of herbicide applications without desmedipham and phenmedipham towards naturally occurring weed species in sugar beet.

2.43 STEFAN GEYER[1], FRIEDRICH KEMPL[2], HERBERT EIGNER[1]

[1] AGRANA Research & Innovation Center GmbH, Josef-Reither-Str. 21-23, A – 3430 Tulln

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WEED CONTROL MISSING DES- AND PHENMEDIPHAM

The decision by the European Commission not to renew the approval of Desmedipham forces sugar beet farmers to change their herbicide strategy. An aggravation of the situation might possibly be caused in near future by a similar judgement, excluding phenmedipham from practical use as well.

For this reason, field trials had been set up on different sites, evaluating twelve different herbicide strategies in four replications each. Compared to the actual standard – based on a tank mixture of des- and phenmedipham, metamitron, ethofumesat and lenacil – an untreated control as well as four strategies without desmedipham, another four without des- and phenmedipham and one with an ALS-tolerant variety with associated herbicide were included in the study.

Plots threated by a mixture with a high content of phenmedipham, metamitron, ethofumesat and triflusulfuronmethyl showed an effect of 98% against *Galium aparine* and 100% against *Chenopodium album*. With up to 100%, quite good results can be expected in case of a phenmedipham-ban, by adding dimethenamid-P effect against different weeds instead of phenmedipham. The aggressivity of this component should be kept in mind. In addition, the system with ALS-tolerant varieties showed results with up to 100% efficacy. Harvest results showed no significant difference in root yield, sugar content and sugar yield.

Weed control without desmedipham seems possible, taking into account, that the period for an effective application will be shorter than before. In addition, the system with ALS-tolerant varieties can be an option, but needs a strict resistance management throughout the whole crop rotation. Regardless of the achieved results, expenditure for sugar beet growing will most probably rise.

2.44 Sjef van der Heijden, Elma Raaijmakers, Iris Wijgergangs
Institute of Sugar Beet Research (IRS), P.O. Box 20, NL – 4670 AA Dinteloord

Effectiveness of ALS-herbicides registered for cereals to control ALS-tolerant and ALS-non-tolerant weed beets

In 2019, for the first time in the Netherlands the Conviso® Smart system was used. In this system sugar beet hybrids (e.g. variety Smart Blanca KWS) carry the specific tolerance to the ALS-inhibitor based herbicide Conviso® One (a.i.: foramsulfuron/thiencarbazone-methyl). The use of Conviso® One in a non-tolerant sugar beet variety will generally control all sugar beet plants.

From 2019 the use of neonicotinoids on seeds was banned in the Netherlands. Therefore the control of green peach aphids (*M. persicae*) and virus yellows is a real challenge and becomes a serious threat for the cultivation of sugar beets in the Netherlands. The control of weed beet (from part of sugar beet) in succeeding crops is important to minimise the survival of aphids and viruses. Control of weed beet to exclude seed production is also crucial for the lifetime of the Conviso® Smart system. One of the possible successive crops sown after sugar beets are cereals.

Since many herbicides in cereals are ALS-inhibitors, it is interesting to know if these herbicides are effective against ALS-tolerant weed beets. Therefore sugar beet plants were sown and after two weeks transferred to pots. For this an ALS-tolerant and an ALS-non-tolerant variety were used. One week before application, the plants (4^{th} leaf stage) were placed outside on a sheltered spot. The following (combination of) actives from commercial products were tested in their registered dose: foramsulfuron/thiencarbazone-methyl, mesosulfuron/iodosulfuron/thiencarbazone-methyl, florasulam/pyroxsulam, florasulam, metsulfuron-methyl, iodosulfuron, metsulfuron-methyl/tribenuron, metsulfuron-methyl/bensulfuron-methyl, tritosulfuron/florasulam and thifensulfuron-methyl.

Conclusion is that the effectiveness of the tested ALS herbicides on the ALS-tolerant variety is zero, which means that other chemical classes of actives have to be used to control these weed beets in the succeeding cereal crop.

2.45 Carsten Stibbe, Maik Klie, Wolfgang Wegener, Julia Wiessner
KWS SAAT SE & Co. KGaA, Grimsehlstrasse 31, D – 37574 Einbeck

CONVISO® SMART – TWO YEARS FARM SCALE EXPERIENCES

In 2018 and 2019 the innovative weed control system CONVISO® SMART has been successfully established in most European countries with a few more to come in 2020. An overview about the registration situation of the system in Europe is given.

Farm scale performance of the CONVISO® SMART system was convincing. SMART varieties allowed for full selectivity. The overall performance of the system is shown on examples. Variety portfolios include the relevant combinations of resistance traits, further yield progress is to be expected.

The herbicide CONVISO® ONE proved in large scale very high efficacy levels and a broad range of weed control including many weeds that used to be hard to fight. Adapted strategies proved their relevance in specific weed control situations.

Approaches for Integrated Weed Management include combining of additional mode of actions and adjuvants. KWS and Bayer's intense training of growers on use and resistance management as well as the stewardship program supported a very successful agronomic introduction of the new weed control system.

2.46 DIRK HYNDRIKX
SESVanderHave, Industriepark 15, B – 3300 Tienen

PERFORMANCE OF VARIOUS CONVISO® SMART SUGAR BEET VARIETIES UNDER DIFFERENT WEED CONTROL STRATEGIES

CONVISO® SMART is an innovative weed control system in sugar beet, proprietary of BAYER AG and KWS SAAT SE, based on 2 components: CONVISO® ONE herbicide (ALS-inhibitors) and SMART sugar beet hybrids (ALS-tolerant). The CONVISO® SMART system allows effective weed control on both broadleaf and grass weeds and enables growers to cut back significantly the number of herbicide sprays. Furthermore, CONVISO® ONE demonstrates excellent crop selectivity, therefore keeping the beet crop vigorous and preserving its full yield potential. Today's SMART hybrids fitting the CONVISO® SMART system still present a yield gap when compared to classic varieties. However, the use of CONVISO® ONE instead of classic herbicides can bring SMART hybrids close to the yield level of classic varieties as a result of optimal crop selectivity and excellent weed control. Sugar beet breeder SESVanderHave has bred his own SMART hybrids fitting the CONVISO® SMART system. To measure yield performance against local recommended standard herbicide programmes, a series of 6 selectivity trials have been set up in 3 different countries. In each location, the yield response of four SMART sugar beet hybrids with 2 different genetic origins was investigated under four different weed control strategies: one based on classic herbicides and three based on CONVISO® ONE. The trials were carried out in a split-plot trial design with 3 replicates. Observations during the growing season revealed no significant visual impact of both herbicide systems. All 6 selectivity trials were successfully harvested. Root yield over the locations varied from 69.6 up to 98.1 t/ha with sugar content varying between 16.5% and 18.5%. CONVISO® ONE, applied as split application as recommended by Bayer, out yielded the classic herbicide program for sugar yield on average by 2.4%. Adding classic sugar beet herbicides as partner in tank-mix to CONVISO® ONE resulted in a 1.9% sugar yield benefit. For the individual hybrids, the sugar yield upside varied from 0.5% up to 5.3%. Despite good consistency over the different locations, none of the detected differences were statistically significant. Results of these trials do confirm however the excellent crop safety of CONVISO® ONE herbicide programs. To detect statistical differences, more locations are most likely needed.

2.47 JÁNOS KIMMEL
Beta-Kutató Kft., Fö út 70, HU – 9463 Sopronhorpács

EXPERIENCES WITH CONVISO® SMART TECHNOLOGY IN FIELD TRIALS IN HUNGARY

Since 2016 small plot field trials are conducted near Sopronhorpács in BETA Research Institute. On the bases of four years experiences the main conclusions are the followings:

This system has many advantages compared to the current weed control practice in sugar beet: no phytotoxicity, the number of treatments reduced, the hard-to-control weeds can become controlled, less use of the active ingredients and gas oil. In general, the weed control can become more easier and economical.

The system may encounter difficulties especially during the period of introduction, and on field with ALS tolerant weeds. Should be avoided to get the chemical to the traditional variety, because eradicate it. To find the exact date of application is difficult, mostly the splitting application were better. The supplementation of CONVISO® ONE with advjuvant (Mero), or fertiliser, or other herbicide, etc. helped the weed control effects. In the case of ALS tolerant weeds these mixtures were more effective, too.

2.48 MARJA PALOMÄKI
Sugar Beet Research Center, Meltolantie 30, FIN – 21510 Hevonpää

FARMERS' OPINIONS ABOUT THE CONVISO® SMART SYSTEM IN FINLAND

Farmers have tested CONVISO® SMART system for three years. Last year, 200 ha and this year 2000 ha of CONVISO® SMART beet are grown in Finland. The cultivated varieties are Smart Johanna KWS and Smart Renja KWS. Farmers' opinion is that the use of CONVISO® SMART system saves time and costs. It gives the farmer more flexibility in the time of weed sprayings. In addition, the system is environmentally friendly with low herbicide application rates. Farmers have been pleased with the efficacy of CONVISO® ONE, and that it does not damage sugar beet. The two applications of 0.5 l/ha CONVISO® ONE with oil result in a clear field which means that the efficacy on the most common annual weeds and on the multiannuals as couch grass is excellent. In wild beet fields CONVISO® SMART system enables beet cultivation. One farmer's opinion is that there is no return to past any more in sugar beet cultivation. Other farmer's opinion is that CONVISO® SMART system has improved the quality of life.

2.49 MARJA PALOMÄKI

Sugar Beet Research Center, Meltolantie 30, FIN – 21510 Hevonpää

TIPS OF THE USE OF CONVISO® SMART IN FINLAND

The CONVISO® SMART system has been tested in Finland for seven years by Sugar Beet Research Centre. SjT has carried out both selectivity and efficacy trials during those years. The varieties have been tested in the official variety trials. In Finland there are two commercial varieties of sugar beet, Smart Johanna KWS and Smart Renja KWS. The best efficacy of CONVISO® ONE herbicide has been obtained with the split application of 0.5 l/ha CONVISO® ONE with 0.5 l/ha oil, when fat-hen (*Chenopodium album*) has two true leaves. In addition, 0.5 l/ha Betanal SE is added to the tank mixture to prevent the development of resistance. The spraying interval is normally 10-14 days but it could be longer depending on the weather condition. CONVISO® ONE has excellent efficacy on most common weeds as well as on couch grass (*Elymus repens*) and on wild beets, except on *Veronica* sp. If some weed species is suspected to have developed ALS resistance, the CONVISO® SMART system is not recommended for the field. Use of other than ALS-herbicides is necessary on cereals in the rotation. CONVISO® ONE is not allowed to use on fields located in groundwater areas.

2.50 MOHAMMED KHAN

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EXPERIENCES AND LESSONS LEARNED FROM A DECADE OF USING HERBICIDE TOLERANT SUGAR BEET IN THE USA

Herbicide tolerant sugar beet was first used commercially in the USA in 2007 and was rapidly adopted on nearly 100% of the acreage to manage weeds that was considered as the major problem for all growing regions in the USA. Growers typically used two to three timely applications of glyphosate which resulted in excellent weed control. The practice of using manual labor and mechanical tillage for weed control were discontinued in most areas. Yield of herbicide tolerant and conventional sugar beet were similar in several states planted with 50% each of conventional and herbicide tolerant beet. Seed companies rapidly incorporated resistance to major diseases in herbicide tolerant beets. Sugar beet growers were quick to incorporate the use of conventional herbicides for maize and wheat, and different modes of action herbicide (glufosinate) for soybean to manage herbicide resistance issues. More recently, US growers were able to incorporate the use of Dicamba and 2,4-D for weed management of rotational crops to help manage glyphosate tolerant weeds that were present in some sugar beet production areas. The availability of dicamba and glufosinate tolerant sugar beet will be a significant benefit in areas with glyphosate resistant weed species. Growers in western states such as Nebraska and Colorado have been successful in incorporating strip-till and no-till because of herbicide tolerant sugar beet, especially in areas with overhead sprinkler irrigation. Most growers are using a system of incorporating conventional herbicides in rotational crops, and where possible, in sugar beet. One limiting factor, since conventional sugar beet is not widely grown in the US, is the unavailability or limited availability of conventional herbicides for use on herbicide tolerant sugar beet.

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WEEDS RESISTANT TO CHEMICAL HERBICIDE

Each year, an investigation is done by ITB on the quality of weeding in France. The technical staff of ITB notes about 5000 fields in August/September. Grass weeds are in third position behind CHEAL and CIRAR. Year after year, the number of fields with percentage of grass weeds increases in sugar beet crop.

This trend is similar for other crops. Grass weeds must be managed in the rotation, but the same active substances are used on all crops within the rotation, so the resistant weeds are more and more numerous. It concerns mainly LOLMU and ALOMY.

At ITB, we test and advise farmers to reduce the number of resistant weeds:

- Using different means of action for chemical herbicide.
- Using agronomical solutions: mechanical weeding, ploughing and have winter crop and spring crop,…

The goal is to have sustainable products and prevent the generalisation of situations of weed resistance.

In France, ITB and other partners (ACTA, ARVALIS–Institut-du-végétal, INRA, FNAMS, TERRES INOVIA and AGROSOLUTIONS) have written a multi crop document about the management of weeds resistant to herbicides. The goal of this joint note is to remind the mechanisms of selection for resistant weeds but also to advise farmers in order to have a sustainable crop management system.

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HOW TO USE DRIFT REDUCING SPRAY NOZZLES AND MAINTAINING GOOD WEED CONTROL

Belgian legislation obliges sugar beet growers to use drift reducing spray nozzles to prevent drift outside the field. Only nozzles that are catalogued as 50% drift reducing or more are allowed. The government publishes a list with all the nozzles that can be used. Drift reducing nozzles create larger droplets which are less sensitive to drift. This could pose problems for certain herbicides that are used in the sugar beet FAR system. Especially the systemic herbicides that are taken up by the leaves, require a good coverage of the cotyledon leaves of the weed. Small droplets guarantee a good coverage and uptake of important herbicides like phenmedipham, ethofumesate and to a lesser extent metamitron.

A field trial was carried out to test different drift-reducing nozzles, that produce bigger droplets than flat fan standard nozzles. We used six different types of nozzles (Drift reducing flat spray tip, Air injector, Twin…) from different constructors varying from 0% (reference) to 90% drift reducing. Not only the nozzle type can influence the result of an application. Spraying pressure or water volume per hectare also have an influence. We used the selected nozzles in combination with two water volumes (180 l/ha and 250 l/ha) to determine if a higher water volume gives a better result for certain nozzles. The air injector nozzles were used at two pressures: 2 bar and 5 bar. Nozzels at a higher pressure produce smaller droplets (but still larger than the standard flat spray nozzles) and thus the efficacy of the herbicides could be higher. Efficacy was determined by weed counting at three different moments (during weed control, after final treatment and late summer) and compared with the number of weeds in a non-treated zone. The trial was repeated in three succeeding growing seasons (2017, 2018 and 2019) to test the drift-reducing nozzles in different weather conditions. The results showed interesting differences between drift reducing nozzle types especially in dry (2019) and cold and dry (2017) conditions. Also water volume and spraying pressure seemed to be important factors to keep in mind. All trials were carried out on a silty soil and with *Chenopodium album* as most present weed.