SWISS FUTURE FARM

Annual Report 2020

AGCO Your Agriculture Company

arenenberg

GVS Agrar

About the farm

Farm size and structure

81 ha agricultural area

- 55 ha arable farming
- 20 ha grassland
- 6 ha biodiversity area

Dairy barn

Cattle in Tänikon:

98 dairy cows in total

2/3 Brown Swiss, 1/3 Red Holstein and Holstein

Cow husbandry:

The farm provides the barns required for the various trials conducted by Agroscope and the Swiss Future Farm.

- Two sites with dairy barns: Emissions trial barn Waldegg & dairy barn Tänikon
- Cows are milked twice a day using a 2x5 herringbone milking parlour
- Free-stall barn with high and low cubicles with straw mattress and permanent access to exercise yard

Calf rearing:

- Single housing in igloos with access to exercise
- Milk freely available
- Breeding calves leave the farm after 3 weeks and spend the period until 4 weeks before the first calving on two partner farms and on the alpine pasture

Pig barn

Number of animals:

60 breeding pigs

1 boar

Number of spaces:

120 fattening pens

200 breeding pens

18 farrowing pens

Sheep and goat barn

Sheep:

24 Lacaune

4 East Friesian

Goats:

11 Chamois Coloured

13 Saanen

3 hybrids

Objectives

The Swiss Future Farm makes modern precision farming technologies visible, tangible and understandable for sustainable and competitive agriculture:

- Practice-oriented field trials are carried out on site and presented to the public
- Digital farm management is implemented in an exemplary and practice-oriented way in an agricultural environment
- Research and development results are applied in agricultural practice
- Innovative cooperation between private agricultural enterprises and public education and consulting
- Tänikon as a meeting point for agriculture

Partners

AGCO
Your Agriculture Company

AGCO International GmbH

Leading manufacturer of high-tech solutions for farmers.
Brands: Fendt, Challenger, GSI, Massey Ferguson, Valtra.

arenenberg

Arenenberg

Agricultural education and advisory center of the Canton of Thurgau with three research and pilot farms.

GVS Agrar

GVS Agrar AG

Market-leading importer of agricultural machinery in Switzerland.
Import, sales and service for all AGCO brands.

Foreword

The impact of the Covid-19 restrictions placed on public relations and events in 2020 has also hit us here at the Swiss Future Farm. Therefore, we are even more proud to present you in the following report the activities, successfully completed by our dedicated SFF operating team (Vivienne Oggier, Florian Abt, Raphael Bernet, Dr. Nils Zehner) and their colleagues.

Assisting our farmers in questions of research and sustainable farming, to ensure an efficient and resource-saving supply of food is and always will be at the heart of our mission. To guarantee this goal, we employ cutting-edge machinery and technology, and conduct trials on current agricultural issues, such as fertilizer efficiency, pesticide reduction and soil conservation management. We also offer animal husbandry training for young farmers and are actively involved in digital farm management.

For instance, the practical field trials undertaken, serve to investigate measures for mechanical weed control in corn, Variable Rate nitrogen fertilizer application in winter wheat, and the use of innovative planting technology for sugar beets, just to name a few here. More to be discovered in the field trial section of this report.

Whenever possible, the 2020 training courses took place at our training facilities on the SFF premises. After restrictions regarding personal attendance due to Covid-19, we decided and worked diligently to introduce virtual training sessions, which were tailored to specific target groups and were very much appreciated by the audience.

In summary, 2020 was, despite the additional challenges, another very successful year, and we thank the entire SFF team for these achievements.

We wish you many interesting and inspiring moments when reviewing the activities and results in this report. They were conducted in the name and on behalf of the SFF shareholders and associated partners to guarantee the research and educational mission of our partnership.

Dr. Bernhard Schmitz	Martin Huber	Nicolas Helmstetter
AGCO	Arenenberg	GVS Agrar AG

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1 Field trials

1.1 Swiss Future Farm – Sugar Beets 2019-2020 – Two-Year Planting Depth Study

Objective

The objective of this study was to evaluate yield in sugar beets planted at different planting depths using a Precision Planting test planter with a DeltaForce™ down force control system.

Study Design:

The study was carried out on the Swiss Future Farm with a side-by-side strip trial design. The following planting depths were tested:

- 2.5 cm (standard)
- 3.8 cm (slightly deeper)
- 6.4 cm (deep)

In order to ensure consistent planting depth, all treatments were planted with DeltaForce automatic down force control set to a target down force of 45 kg and with a plant population of 100,000 seeds per hectare. Planting date was 28th March 2019 and 6th April 2020. In 2019, the trial plot was located in a field with very heterogeneous soil conditions, whereas in 2020 in a field with homogeneous soil conditions.

The Crop Tour trial plot for sugar beets on the Swiss Future Farm in 2020 was planted under challenging conditions, as we were experiencing a spring period with extraordinarily low precipitation during the planting period for sugar beets between the middle of March and the middle of April. In comparison to previous years, the precipitation sum did not even amount to one-fifth of the amount we received in the past couple of years in our location in Northeastern Switzerland with 10 mm in 2020 vs. 55 mm in 2019 and 64 mm in 2018, respectively (Figure 1).

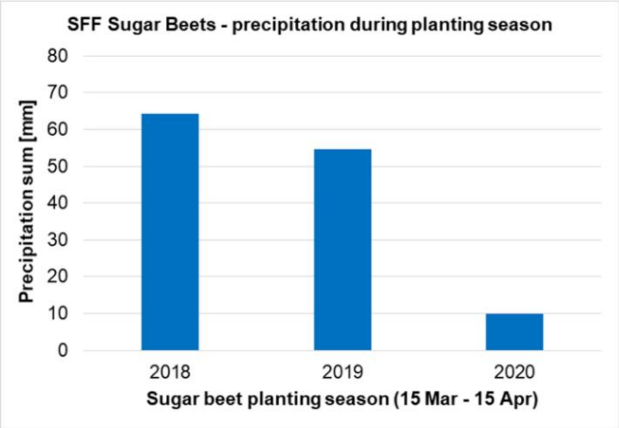

Figure 1: Precipitation during sugar beet planting season on Swiss Future Farm 2018-2020 (left) and planting sugar beets under very dry conditions with a planter equipped with Precision Planting FurrowForce in April 2020 (right).

Results

The trials were harvested on 1st October 2019 (188 days after planting) and on 9th October 2020 (187 days after planting), respectively. In our study, the fresh mass yield increase in sugar beets that can be generated amounts to 5.6% (2019) and 11.8% (2020) when planting at 3.8 cm instead of 2.5 cm planting depth (Figure 2).

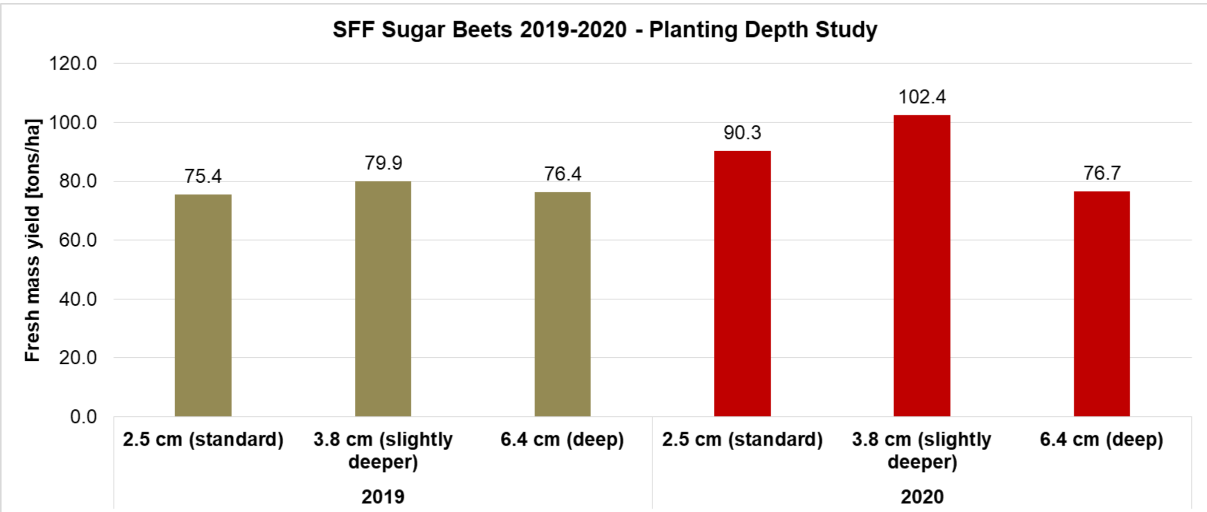

Figure 2: Fresh mass yield results of the SFF 2019-2020 Planting Depth Study in sugar beets.

The general difference in sugar content between the study years (Figure 3) is due to the sugar beet variety, as we planted a hybrid with generally confirmed high sugar content (Strube Strauss) in 2019, whereas in 2020 a hybrid with generally lower sugar contents was planted (KWS Smart Belamia).

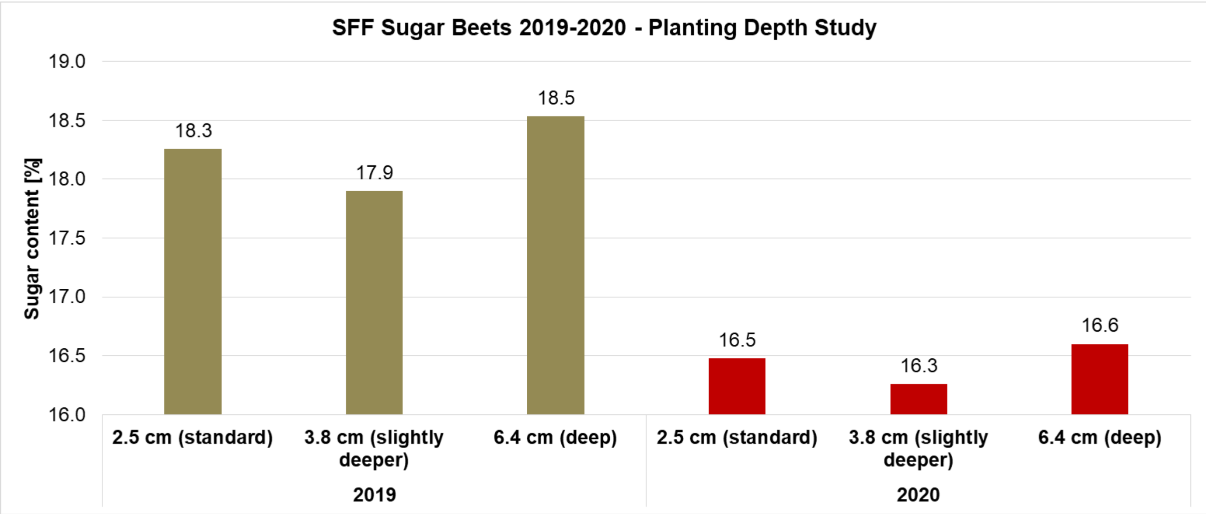

Figure 3: Sugar content results of the SFF 2019-2020 Planting Depth Study in sugar beets.

In our study, the increase in sugar yield (Figure 4) that can be generated by planting at 3.8 cm instead of 2.5 cm planting depth amounts to 3.9% (2019) and 9.6% (2020).

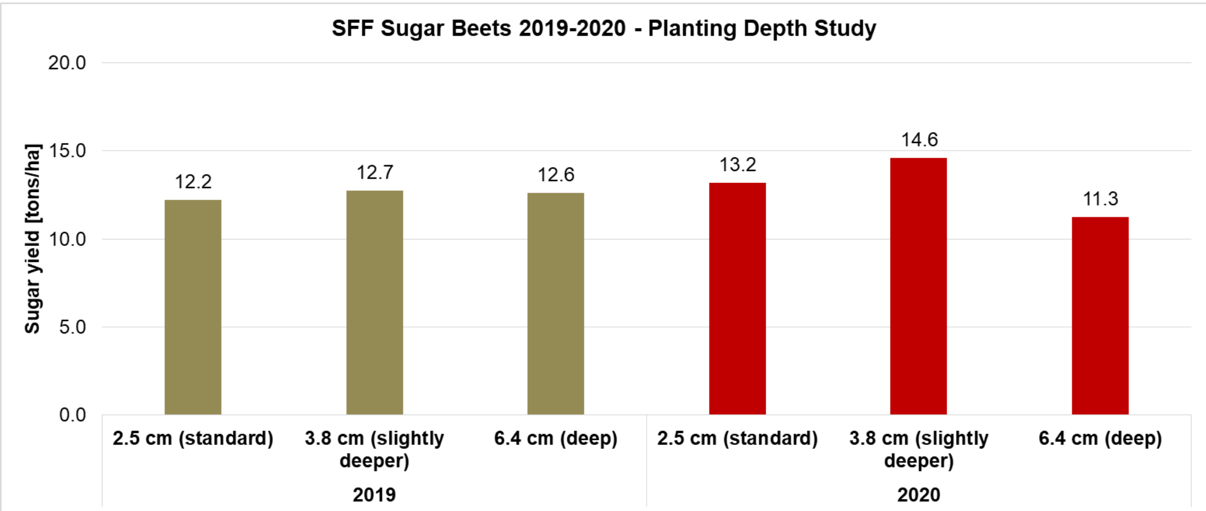

Figure 4: Sugar yield results of the SFF 2019-2020 Planting Depth Study in sugar beets.

Data from the two study years show that slightly lower placement depths (3.8 cm vs. 2.5 cm) may offer advantages in connection with mechanical weed control (blind harrow in pre-emergence), but investigation of the effect on yield must be consolidated in further trials. Another potential limitation that requires further examination is that some seed dressing products against pests for sugar beets may have a reduced effectiveness in connection to deeper placement of the seed.

Figure 5: Precision Planting SmartFirmer for measurement of soil moisture in the furrow (left) and Precision Planting SmartDepth for real-time adaption of planting depth according to soil moisture content (right).

Payback

Based on the 2020 total revenue data of our study, for sugar beets planted at slightly deeper planting depth of 3.8 cm, an additional revenue of CHF 490.00/ha could be generated in comparison to planting with the standard planting depth of 2.5 cm, whereas a deep planting depth of 6.4 cm resulted in revenue losses of CHF 1069.00/ha and CHF 579.00/ha in comparison the 3.8 cm and 2.5 cm planting depth, respectively (Figure 6).

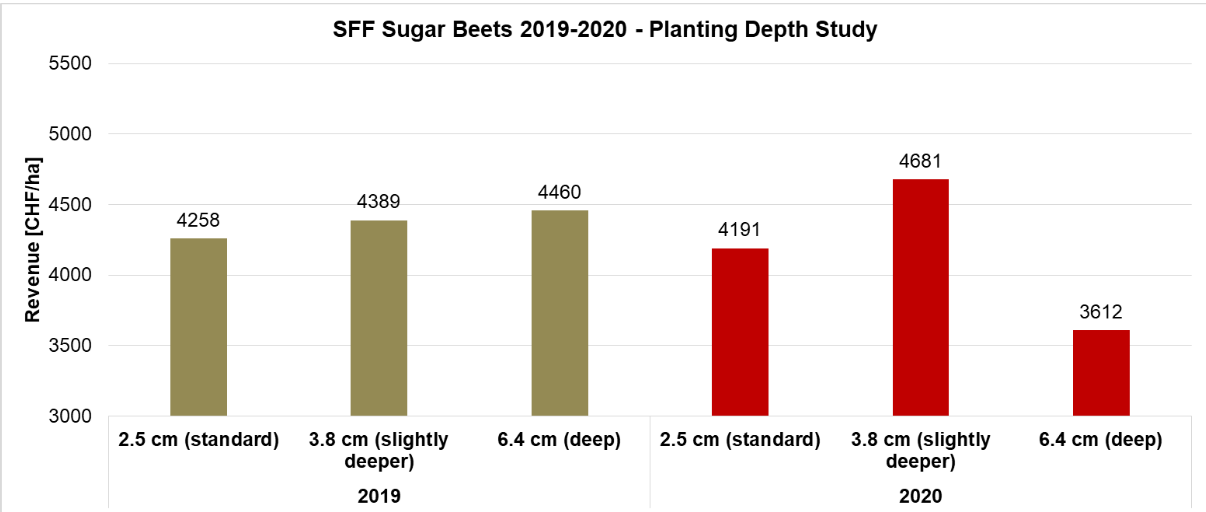

Figure 6: Revenue obtained from the SFF 2019-2020 Planting Depth Study trial strips in sugar beets.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact:

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.2 Swiss Future Farm – Sugar Beets 2019-2020 – Two Year Liquid Fertilizer Study

Objective

The objective of this study was to compare crop development and yield of sugar beets planted with two different liquid starter fertilizer types using Precision Planting FurrowJet™ and FlowSense™, and sugar beets planted without liquid starter fertilizer.

Study Design

This study was carried out on the Swiss Future Farm in a side-by-side strip trial in 2019 and 2020. The following treatments were compared:

- Kristalon 12-12-36 liquid fertilizer (applied with total 1.8 kg N/ha, 1.8 kg P_2O_5/ha, 5.4 kg K_2O/ha)
- Hasorgan 0-0-5 liquid fertilizer (applied with total 1.16 kg K_2O/ha)
- No liquid starter fertilizer (control)

In the first year of the study, the trial was planted in a field with very heterogeneous soil conditions in texture, moisture, and organic matter on 28th March 2019. In the second year of the study, the trial was planted in a field with homogeneous soil conditions on 6th April 2020. Both planting dates are within the usual timeframe for sugar beet planting in the region. All plants were planted at 3.8 cm planting depth, population rate of 100,000 seeds per hectare, and with DeltaForce automatic down force control set to a target down force of 45 kg. The liquid starter fertilizers were applied during planting using Precision Planting's FurrowJet™ and FlowSense™ liquid fertilizer system.

Results

The trials were harvested on 1st October 2019 (188 days after planting) and on 9th October 2020 (187 days after planting), respectively. Fresh mass yield increase in sugar beets that could be achieved due to the application of liquid starter fertilizer compared to no liquid fertilizer in an average of the study years was 1.0% (Figure 7).

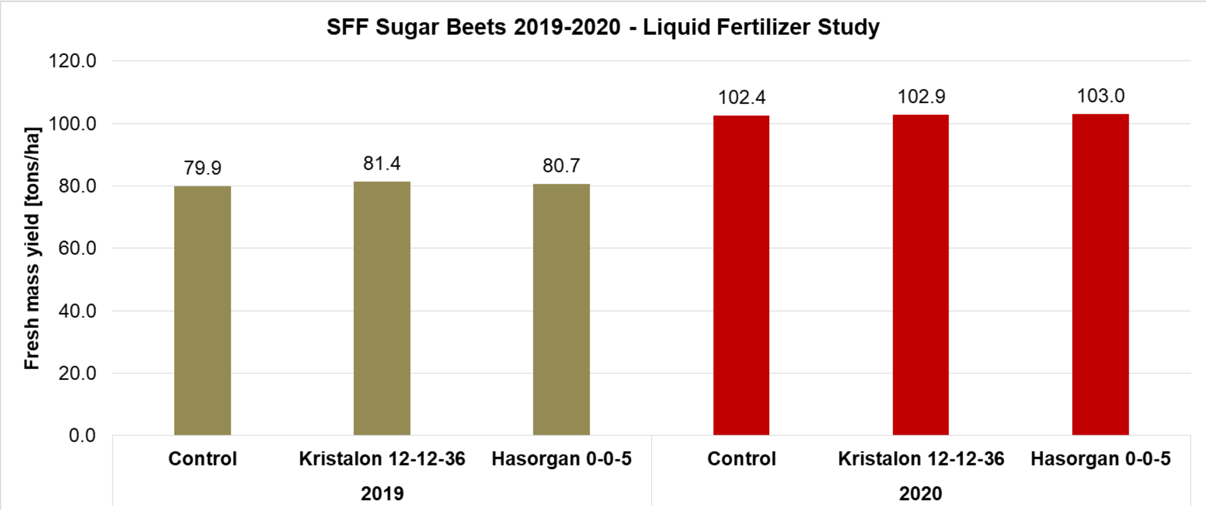

Figure 7: Fresh mass yield results of the SFF 2019-2020 Liquid Fertilizer Study in sugar beets.

In both study years, sugar beets planted with liquid starter fertilizer had 0.3% higher sugar content than beets without liquid starter fertilizer (Figure 8). The general difference in sugar content between the study years is due to the sugar beet variety, as we planted a hybrid with generally confirmed high sugar content (Strube Strauss) in 2019, whereas in 2020 a hybrid with generally lower sugar contents was planted (KWS Smart Belamia).

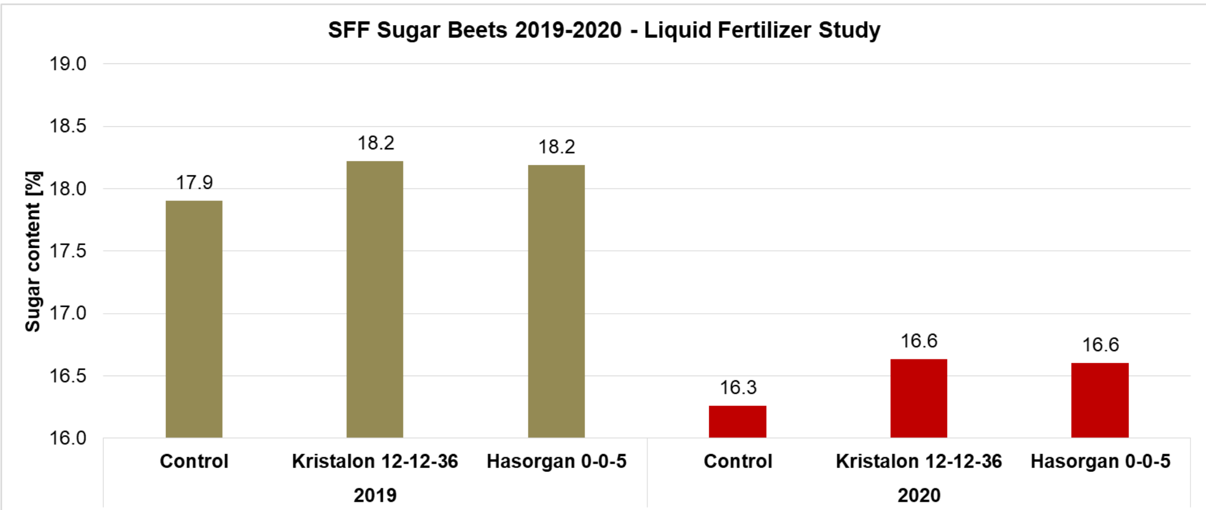

Figure 8: Sugar content results of the SFF 2019-2020 Liquid Fertilizer Study in sugar beets.

Sugar yield increase that could be achieved due to the application of liquid starter fertilizer compared to no liquid fertilizer in an average of the study years was 3.2% (Figure 9).

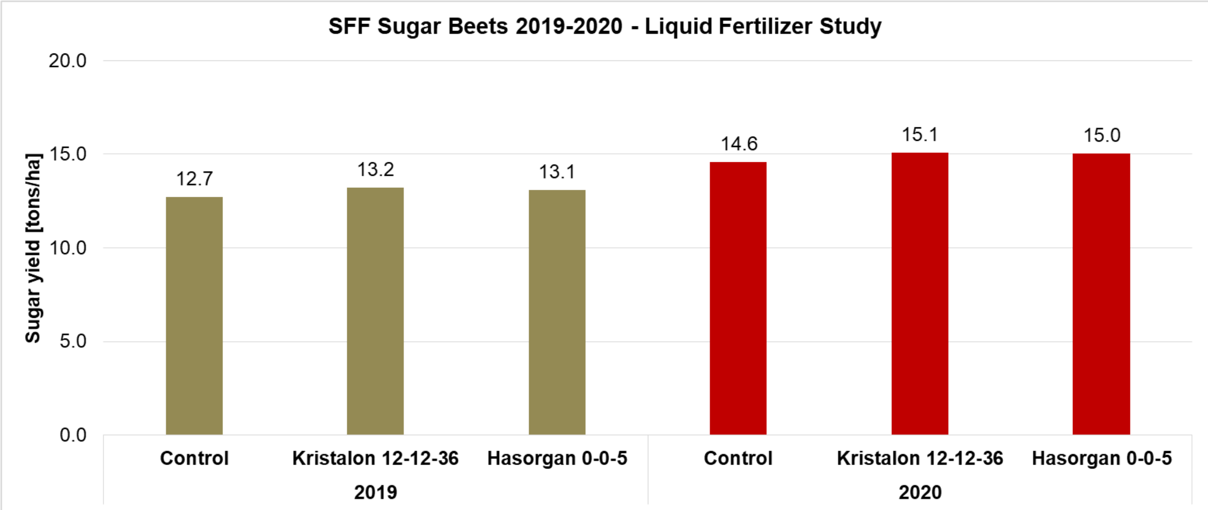

Figure 9: Sugar yield results of the SFF 2019-2020 Liquid Fertilizer Study in sugar beets.

Figure 10: Precision Planting test planter equipped with FurrowJet liquid fertilizer system used for planting the trial plots.

Payback

In an overall consideration of the study years, the additional total revenue due to application of liquid starter fertilizer using the Precision Planting FurrowJet und FlowSense system in sugar beets is ranging between CHF 164.00 and CHF 207.00 per hectare (Figure 11).

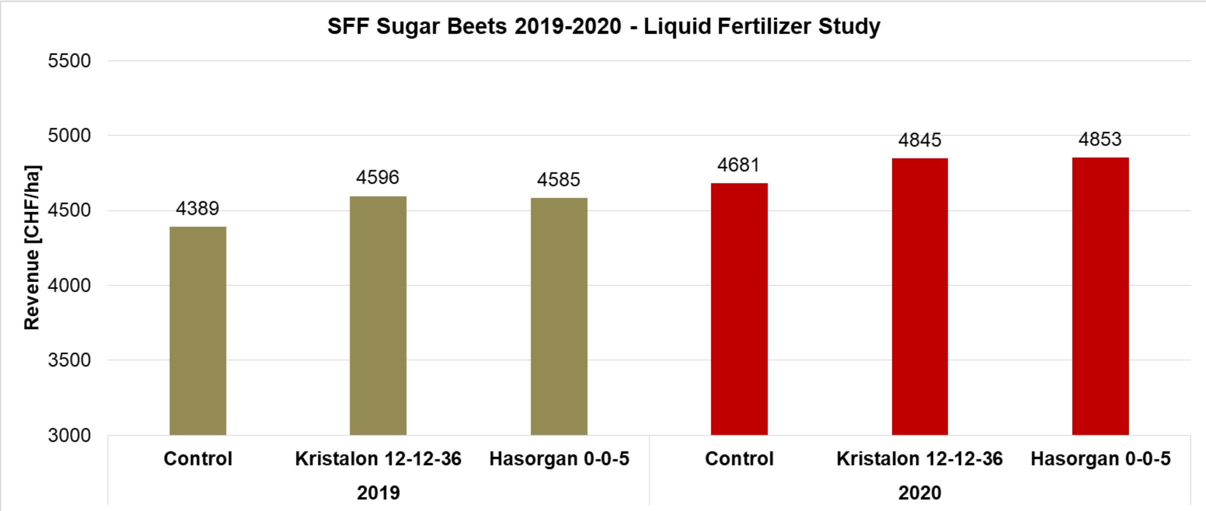

Figure 11: Total revenue obtained from the SFF 2019-2020 Liquid Fertilizer Study trial strips in sugar beets.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.3 Swiss Future Farm – Sugar Beets 2019-2020 – Two-Year Down Force Study

Objective

The objective of this study was to apply different planter down force using the automatic down force control system DeltaForce™ and to evaluate the resulting yield in sugar beets.

Study Design

The study was carried out on the Swiss Future Farm as a side-by-side strip trial with the following down force (DF) settings:

- Automatic Down Force Light (Auto DF Light 23 kg)
- Automatic Down Force Standard (Auto DF Standard 45 kg)
- Automatic Down Force Heavy (Auto DF Heavy 68 kg)
- Fixed Down Force (Fixed DF 45 kg)

Planting dates were 28th March 2019 and 6th April 2020. In 2019, the trial plot was located in a field with heterogeneous soil conditions, and in 2020 in a field with homogeneous soil conditions. All trial strips were planted at 3.8 cm planting depth and with a planting rate of 100,000 seeds per hectare, whereas down force applied by the Precision Planting DeltaForce system was changed between the settings described above.

Results

The trials were harvested on 1st October 2019 (188 days after planting) and on 9th October 2020 (187 days after planting), respectively. These results indicate that the use of DeltaForce automatic down force control can improve yield by applying optimal down force and considering the varying soil conditions in the field. In our study, the maximum fresh mass yield increase in sugar beets amounts to 4.4% to 5.5% when planting with automatic down force applied by DeltaForce instead of conventional fixed down force (Figure 12).

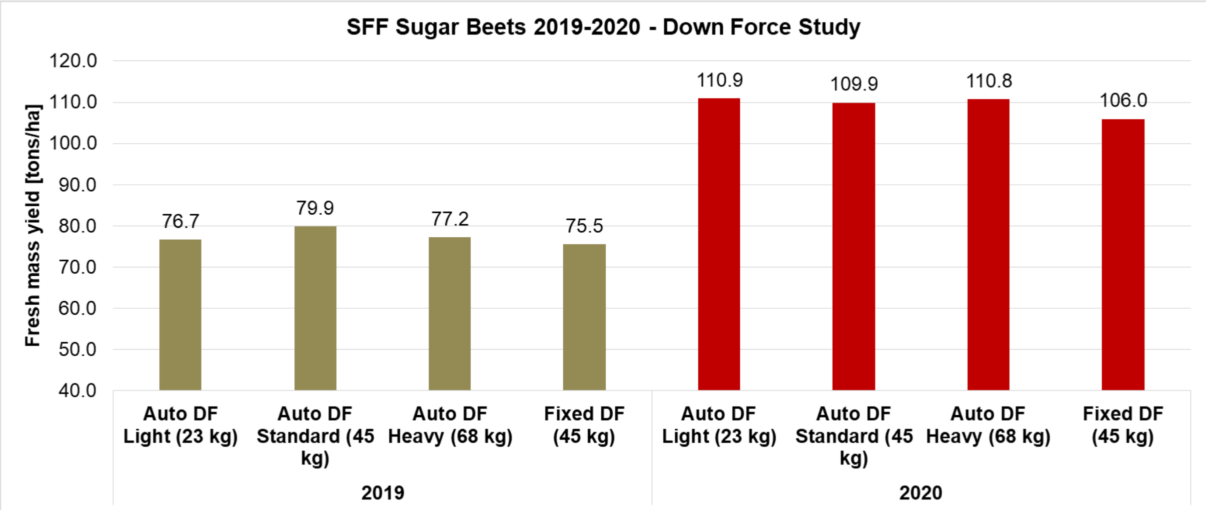

Figure 12: Fresh mass yield results of the SFF 2019-2020 Down Force Study in sugar beets.

The general difference in sugar content between the study years (Figure 13) is due to the sugar beet variety, as we planted a hybrid with generally confirmed high sugar content (Strube Strauss) in 2019, whereas in 2020 a hybrid with generally lower sugar contents was planted (KWS Smart Belamia).

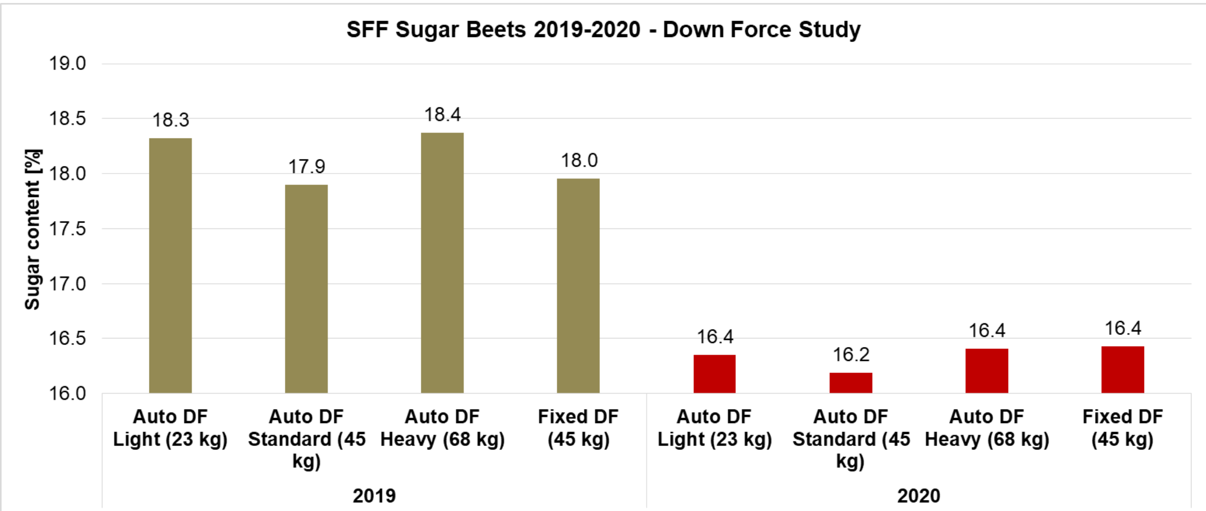

Figure 13: Sugar content results of the SFF 2019-2020 Down Force Study in sugar beets.

Based on the results from two study years, the maximum increase in sugar yield that can be generated by planting with automatic down force applied with DeltaForce instead of conventional fixed down force amounts to 4.7-5.0% (Figure 14).

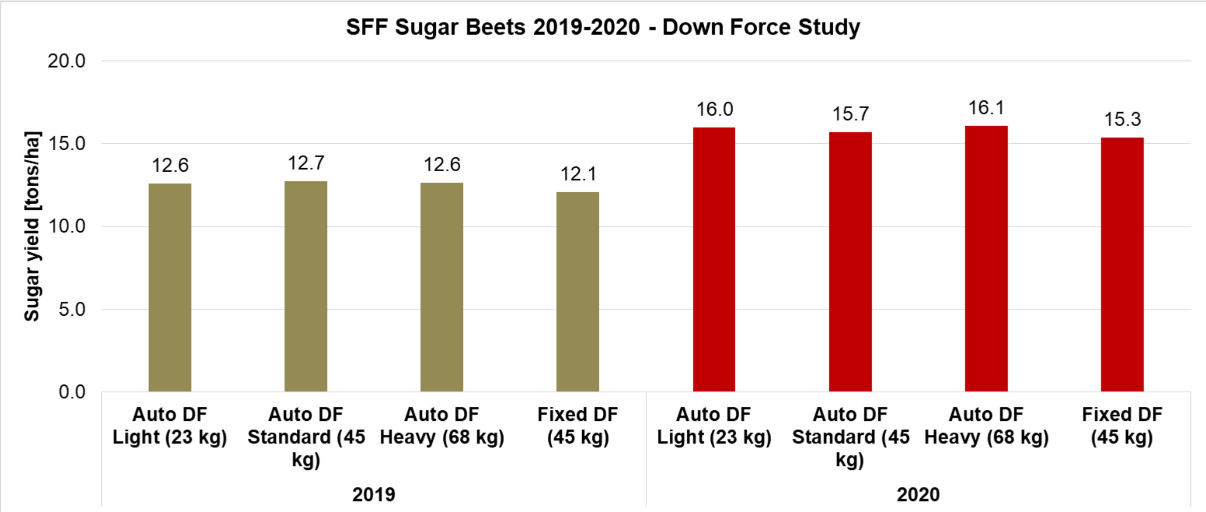

Figure 14: Sugar yield results of the SFF 2019-2020 Down Force Study in sugar beets.

Figure 15: Precision Planting 20/20 Gen3 monitor for adjustment and control of DeltaForce down force settings during planting.

Payback

Based on the 2020 data of our study, for the trial strips planted with the automatic down force control of Precision Planting DeltaForce, an additional revenue between CHF 68.00/ha (Auto DF Standard) and CHF 226.00/ha (Auto DF Light) could be generated in comparison to planting with fixed standard down force (Figure 16). The same trend can be found in 2019 data.

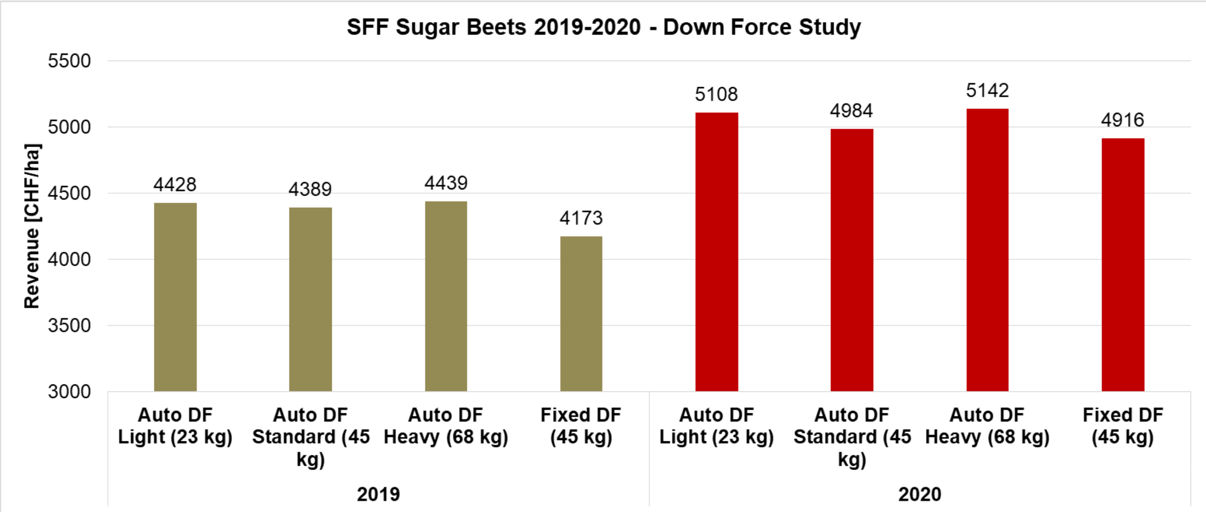

Figure 16: Revenue obtained from the SFF 2019-2020 Down Force Study trial strips in sugar beets.

Overall, automatic down force control with Precision Planting DeltaForce in sugar beets has proven generally advantageous over conventional fixed down force (beets and sugar yield increase approx. 5%, revenue increase up to CHF 226.00 per hectare), but automatic down force mode (Heavy, Standard, Light) should always be selected and adjusted depending on soil conditions of the respective field to achieve full potential in yield and revenue increase.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.4 Swiss Future Farm – Sugar Beets 2020 – Closing Study

Objective

The objective of this study was to evaluate field emergence and juvenile development in sugar beets planted at different closing pressure using a Precision Planting test planter with a FurrowForce™ closing pressure control system.

Study Design

The study was carried out on the Swiss Future Farm with a side-by-side strip trial design. A Precision Planting planter with 3 meters working width, 6 rows and 50 cm row spacing, equipped with Precision Planting's vSet, vDrive, DeltaForce, SpeedTube, and SmartFirmer technologies was used to plant the trial plot with a Fendt 516 with VarioGuide and RTK. As a new feature, the planter was equipped with Precision Planting's latest innovation, the FurrowForce pneumatic closing system. The following closing pressure settings were tested:

- FurrowForce 7 kg (light)
- FurrowForce 10 kg (standard)
- FurrowForce 20 kg (heavy)

The trial plot was located in a field with homogeneous soil conditions. All treatments were planted at 3.8 cm planting depth with DeltaForce automatic down force control set to a target down force of 45 kg and with a plant population of 100,000 seeds per hectare. Planting date was 6th April 2020.

The Crop Tour trial plot for sugar beets on the Swiss Future Farm in 2020 was planted under challenging conditions, as we were experiencing a spring period with extraordinarily low precipitation during the planting period for sugar beets between the middle of March and the middle of April.

Figure 17: The pneumatic closing system Precision Planting FurrowForce enables to preserve soil moisture and to ensure yields under challenging climatic conditions.

Results

Field emergence and juvenile development of beets on the trial plot was measured 22 and 37 days after planting by the Cantonal Crop Consultancy Service of BBZ Arenenberg. Results of the different closing pressure applied with the FurrowForce system in sugar beets planted at 3.8 cm depth show that field emergence improved, when higher closing pressure was applied (Figure 18). This can be explained by the extraordinary dry planting conditions, where furrows closed with high closing pressure had the best ability to preserve moisture and were not prone to be compacted.

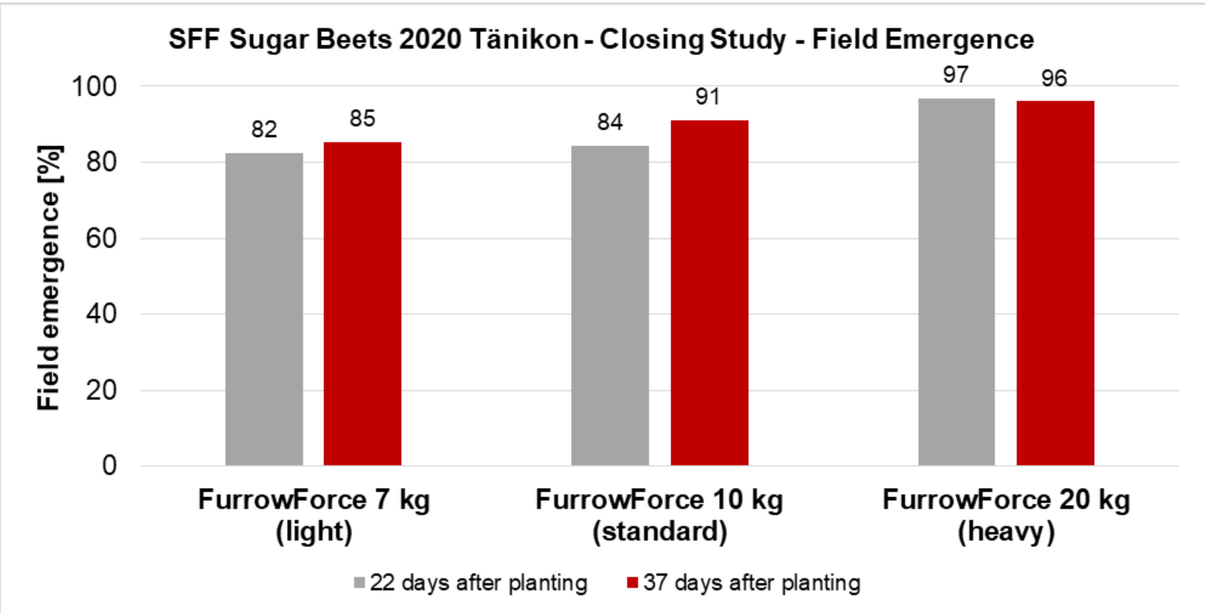

Figure 18: Field emergence results of the SFF 2020 Closing Study in sugar beets.

The proportion of late emergers was low for closing pressure of 7 kg and 10 kg (4-7%), whereas for a closing pressure of 20 kg a marginally reduced crop stand (- 1%) was found (Figure 19).

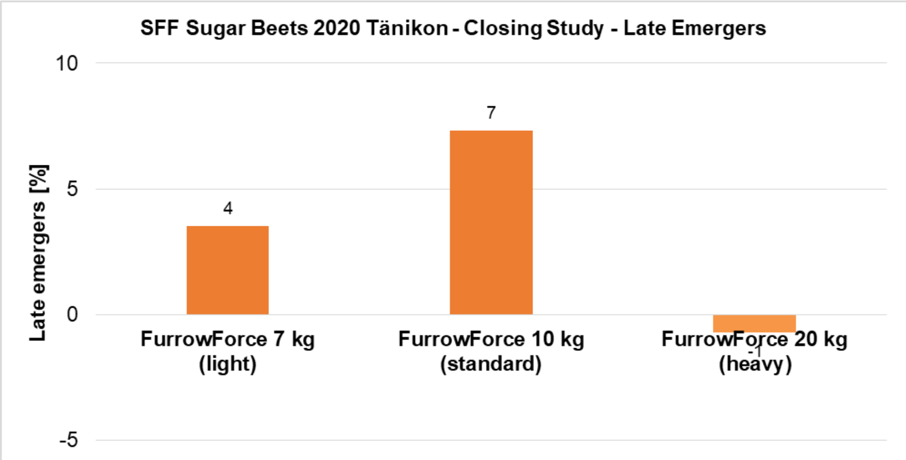

Figure 19: Quantification of late emergers in the SFF 2020 Closing Study in sugar beets.

Looking at juvenile development, the trial strip planted with a closing pressure of 20 kg exerted by FurrowForce had the highest share of further developed beets in the 6-leaves stadium, whereas beets planted with 7 kg closing pressure were least developed, as indicated by the higher share of plants in 2-leaves and cotyledon stage (Figure 20).

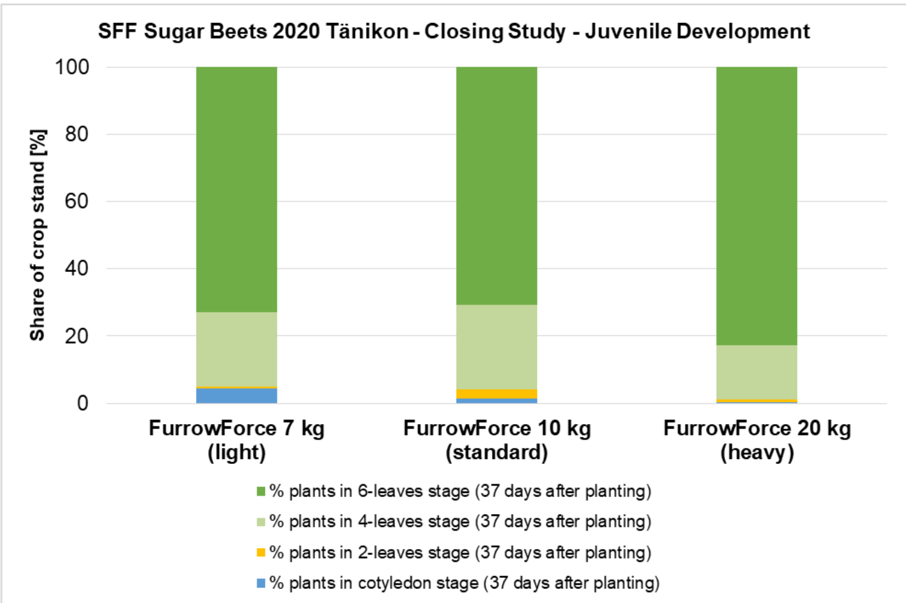

Figure 20: Assessment of juvenile development in the SFF 2020 Closing Study in sugar beets.

Payback

Insufficient soil moisture during the crop establishment in sugar beets results in approx. 10% yield losses. Assuming an average sugar beet yield of 90 tons/ha in Switzerland, avoided yield losses amount up to CHF 405.00 per hectare when using Precision Planting FurrowForce to preserve soil moisture in dry spring planting periods.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: CHF 45.00/ton.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.5 Swiss Future Farm – Silage Corn 2020 – Variable Rate Study

Objective

The objective of this study was to evaluate yield in silage corn planted at two different variable planting rates based on Precision Planting SmartFirmer™ soil sensor readings and the unique Precision Planting Organic Matter Control mode in comparison to a conventional flat rate planting.

Study Design

The study was carried out on the Swiss Future Farm as a side-by-side strip trial. The following planting rates were tested:

- Flat rate: 90 KS/ha (90,000 seeds per hectare, regional standard planting rate for silage corn)
- Variable Rate Organic Matter (OM) Control with 4 increments: 70 – 80 – 85 – 90 KS/ha
    - OM% <2.5 = 70 KS/ha
    - OM% 2.5-2.8 = 80 KS/ha
    - OM% 2.8-3.0 = 85 KS/ha
    - OM% >3.0 = 90 KS/ha (base population)
- Variable Rate OM Control with 5 increments: 70 – 80 – 90 – 95 – 100 KS/ha
    - OM% <2.5 = 70 KS/ha
    - OM% 2.5-3.0 = 80 KS/ha
    - OM% 3.0-3.8= 90 KS/ha (base population)
    - OM% 3.8-4.0 = 95 KS/ha
    - OM% >4.0 = 100 KS/ha

The Precision Planting Variable Rate OM Control mode adjusts the planted population as a deviation of the base population according to the organic matter content measured by the SmartFirmer soil sensors. For this study, the base population was set to 90 KS/ha for both Variable Rate treatments, which was according to population defined for the flat rate planting in this comparison.

The trial was planted in a field with heterogeneous soil conditions in texture, moisture, and organic matter (Figure 21).

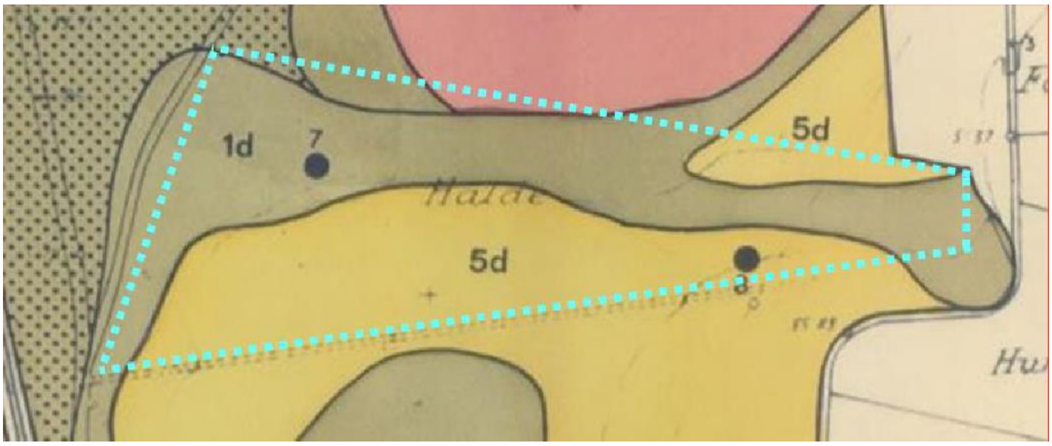

Figure 21: Soil zones in the trial field according to soil survey of 1977.

Properties of the soil zones are described in Table 1.

Table 1: Soil properties of the trial plot for the SFF 2020 Variable Rate Study in silage corn

Soil zone	Soil type and properties
1d	Partially decarbonated, stagnogleyic brown earth, skeletal, slightly clayey loam and slightly sandy loam, damming moisture, good water storage, flat slope 16-20%
5d	Regosolian calcareous brown earth, skeleton-rich, slightly sandy loam and slightly clayey loam, fairly low water retention, flat slope 15-20%

Planting date was 9th May 2020. Trial strips for each planting rate were planted across the different soil zones to enable full exposure to the heterogeneous soil properties. All seeds were planted at 6.4 cm (2.5 inch) planting depth and with DeltaForce automatic down force control set to a target down force of 45 kg. Planting rates were adjusted by Precision Planting vSet™ seed meters and vDrive™ electric drives.

Results

The field map of measurement of organic matter content by the SmartFirmer soil sensors during planting (Figure 22, top) shows field zones of different organic matter levels that partially correlate to the soil types found in the soil survey of this field. The as-applied map of the planted population (Figure 22, bottom) shows that the planting rate was adapted according to the readings of the SmartFirmer soil sensors and the increments defined for the Organic Matter Control mode of the planter in the respective Variable Rate trial strips.

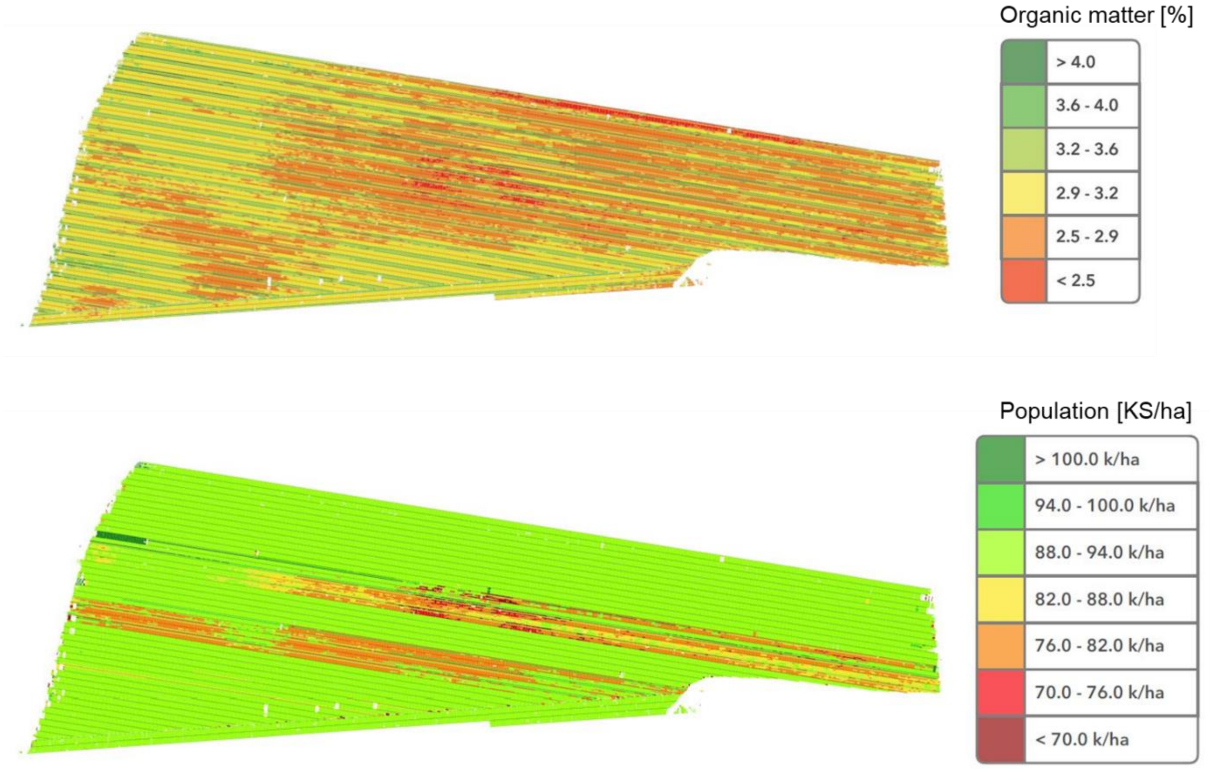

Figure 22: Organic matter content (top) and planted population (bottom) on the trial field of the SFF 2020 Variable Rate Study in silage corn.

The trial was harvested on 1st October 2020 (146 days after planting). Highest dry matter yield was obtained in the treatment planted with a variable planting rate with 4 increments (20.5 tons/ha), whereas the variable planting rate with 5 increments resulted in slightly lower dry matter yield (19.7 tons/ha). Planting with a planting rate of 90 KS/ha flat rate, resulted in the significantly lowest yield (15.6 tons/ha) in this comparison (Figure 23).

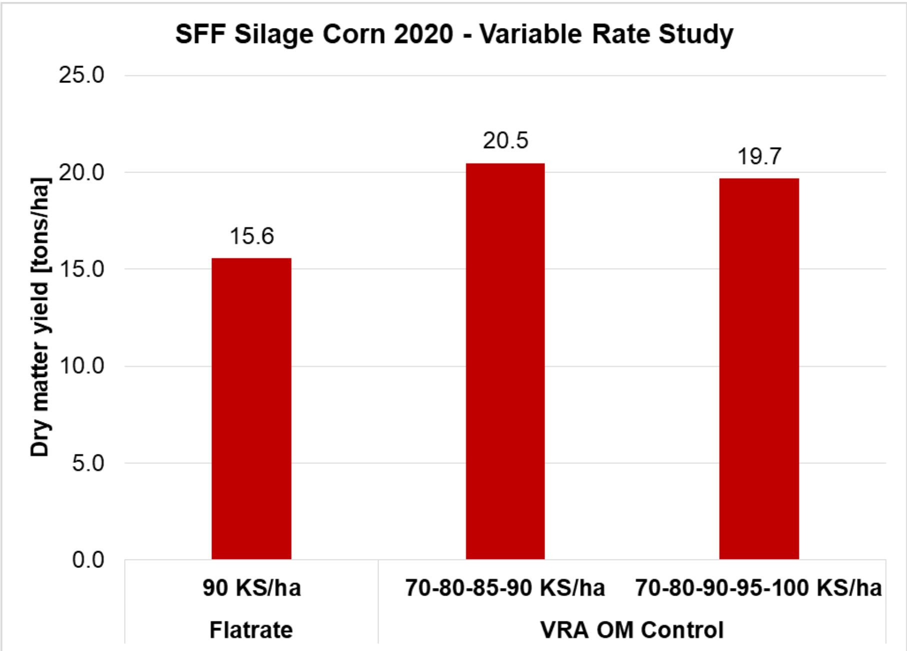

Figure 23: Dry matter yield results of the SFF 2020 Variable Rate Study in silage corn.

In our study, the yield increase that could be achieved due to the application of Variable Rate OM Control planting amounted to 24.0% (VRA OM Control 4 increments) and 20.9% (VRA OM Control 5 increments) compared to flat rate planting with 90 KS/ha. These results indicate that decreasing the planted population in field zones with lower organic matter content appeared as a suitable approach to site-specifically consider the soil's delivering capability and to ensure very good yield levels.

Additional Observations

Measurements of furrow moisture by the SmartFirmer soil sensors during planting show that there were different moisture levels across the field (Figure 24), however, these differences were less distinct than for organic matter.

Figure 24: Furrow moisture measurement values of the SmartFirmer soil sensors during planting on the trial field of the SFF 2020 Variable Rate Study in silage corn.

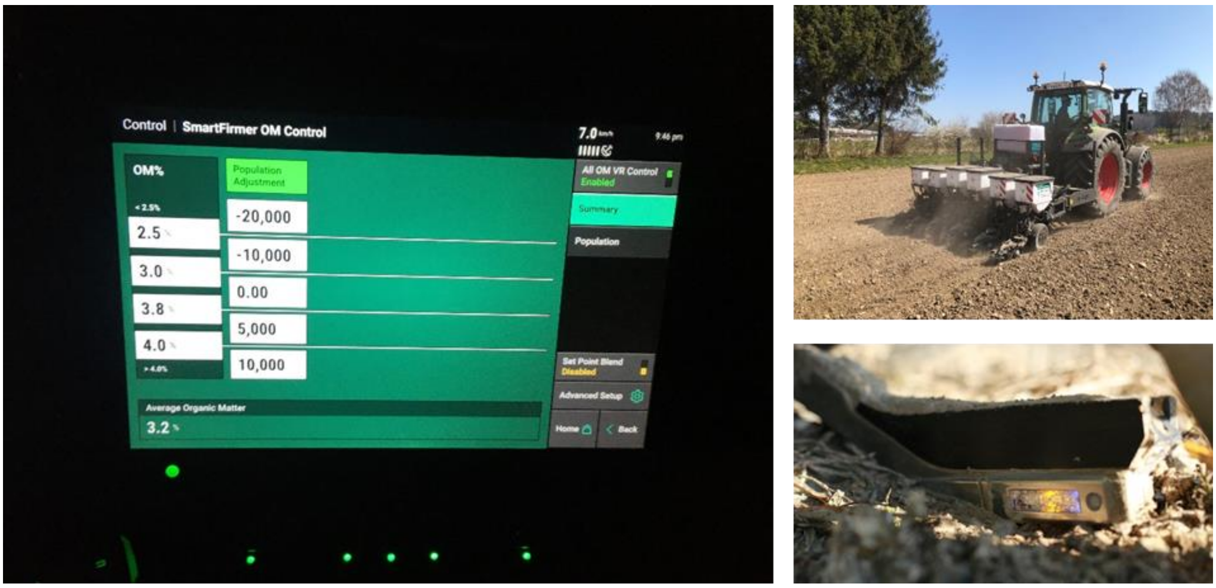

Figure 25: Variable Rate OM Control mode in the Precision Planting 20/20 Gen3 monitor (left), planter used for planting the trial plot (top right), and SmartFirmer soil sensor (bottom right).

Payback

For silage corn planted with Variable Rate OM Control based on Precision Planting SmartFirmer readings, an additional revenue of CHF 944.00/ha or CHF 653.00/ha could be generated in comparison to planting with conventional flat rate population of 90 KS/ha (Figure 26). Planted populations in the different trial strips were 89'933 seeds/ha for Flatrate 90 KS/ha, 86'913 seeds/ha for 70-80-85-90 KS/ha Variable Rate OM Control, and 85'739 seeds/ha for 70-80-90-95-100 KS/ha Variable Rate OM Control. Savings in seed costs amounted to CHF 9.00/ha for 70-80-85-90 KS/ha and CHF 12.00/ha for 70-80-90-95-100 KS/ha Variable Rate OM Control, compared to planting with Flatrate 90 KS/ha.

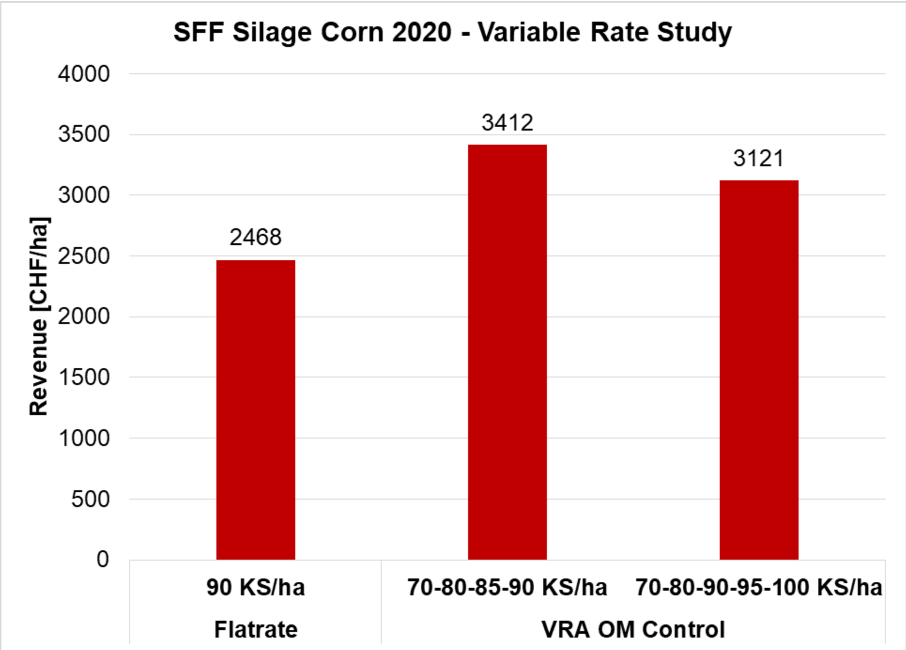

Figure 26: Revenue obtained from the SFF 2020 Variable Rate Study trial strips in silage corn.

Assumptions for payback

Price calculations for silage corn based on the guidelines of the Swiss Farmers Association (SBV).

Silage corn price after harvest by seller: CHF 65.00/ton fresh mass

Seed costs: CHF 140.00 per 50'000 seeds (standard pack)

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.6 Swiss Crop Tour – Sugar Beets 2019-2020 – Two-Year Planting Depth Study

Objective

The objective of this study was to evaluate yield in sugar beets planted at different planting depths using a Precision Planting test planter with a DeltaForce™ down force control system.

Study Design

The study was carried out on a commercial farm in Northeastern Switzerland (Tägerwilen, Canton of Thurgau) as a side-by-side strip trial. The following planting depths were tested:

- 2.5 cm (standard)
- 3.8 cm (slightly deeper)
- 6.4 cm (deep)

In order to ensure consistent planting depth, all treatments were planted with DeltaForce automatic down force control set to a target down force of 45 kg and with a plant population of 100,000 seeds per hectare. Planting dates were 25th March 2019 and 27th March 2020. The trial plots were located in fields with homogeneous soil conditions. The Crop Tour plots for sugar beets were planted under challenging conditions, as we were experiencing a spring period with extraordinarily low precipitation during the planting period for sugar beets in March and April compared to the long-term average at this site (Figure 27).

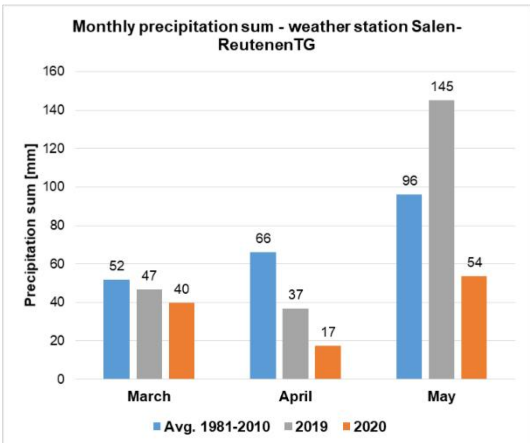

Figure 27: Precipitation during spring season at the trial location in Northeastern Switzerland in 2019-2020 compared to long-term average (left) and planting sugar beets under dry conditions with a Precision Planting test planter on the trial plot in March 2019 (right)

Results

The trials were harvested on 23rd November 2019 (243 days after planting) and on 14th November 2020 (232 days after planting), respectively. For study year 2019, we obtained the highest sugar beet yield at 2.5 cm standard planting depth (85.5 t/ha), whereas 3.8 cm planting depth had 6.2% and 6.4 cm planting depth had 8.0% lower yield, respectively. In 2020, the highest yield of 124.7 t/ha was achieved at a planting depth of 3.8 cm, which is 1.3 cm deeper than a standard planting depth of 2.5 cm for sugar beets. At a planting depth of 6.4 cm, the yield decreases by 1.4%, while the lowest yield is obtained at the standard planting depth with a minus of 4.7% (Figure 28).

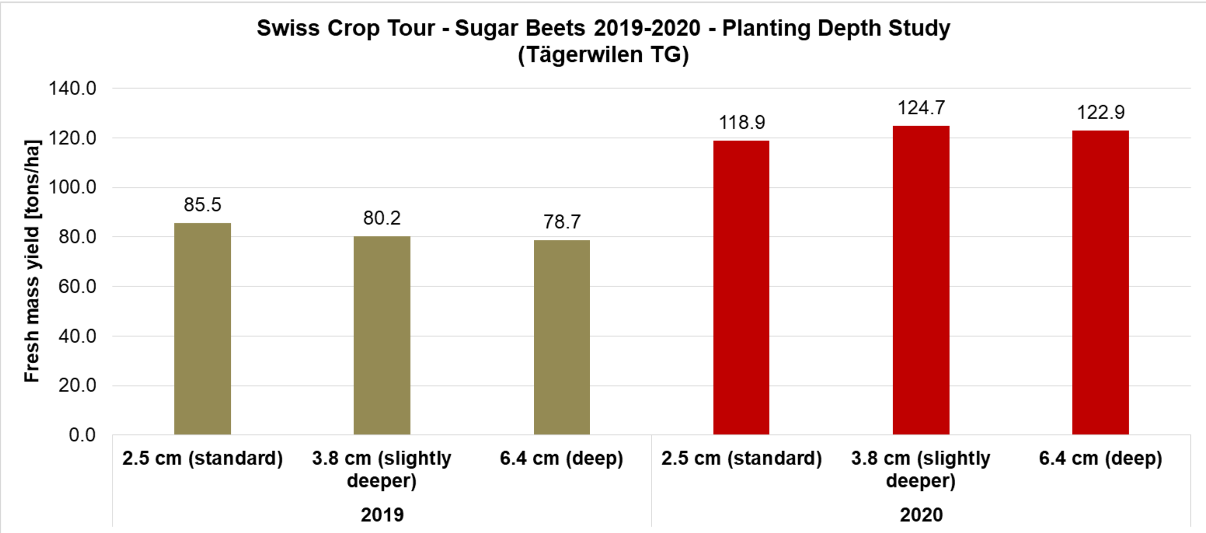

Figure 28: Fresh mass yield results of the Swiss Crop Tour 2019-2020 Planting Depth Study in sugar beets.

Highest sugar content in 2019 was obtained from sugar beets planted at deep planting depth of 6.4 cm (17.4%), whereas slightly deeper and standard planting depth had lower sugar content of 17.1%. In 2020, the highest sugar content (17.6%) was obtained at a planting depth of 3.8 cm, while the other two planting depths reached a sugar content of 17.5% (Figure 29).

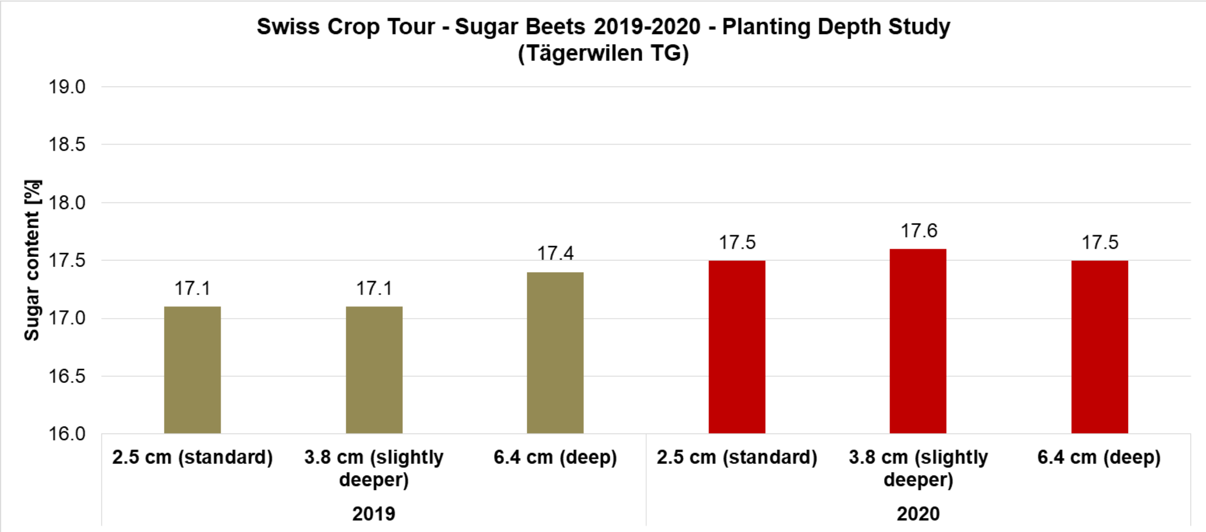

Figure 29: Sugar content results of the Swiss Crop Tour 2019-2020 Planting Depth Study in sugar beets.

In accordance with fresh mass yield, the highest sugar yield in 2019 was obtained from the trial strips with 2.5 cm standard planting depth, whereas we found 6.1% less sugar yield for 3.8 cm planting depth and 12.1% less sugar yield from 6.4 cm planting depth. Since there was little difference in sugar content, the highest sugar yield in 2020 (19.4 t/ha) was obtained at a planting depth of 3.8 cm, while the lowest sugar yield (18.4 t/ha) was obtained at standard planting depth (Figure 30). In our study, the increase in sugar yield that can be generated by planting at 3.8 cm instead of 2.5 cm planting depth amounts to 5.2% (2020).

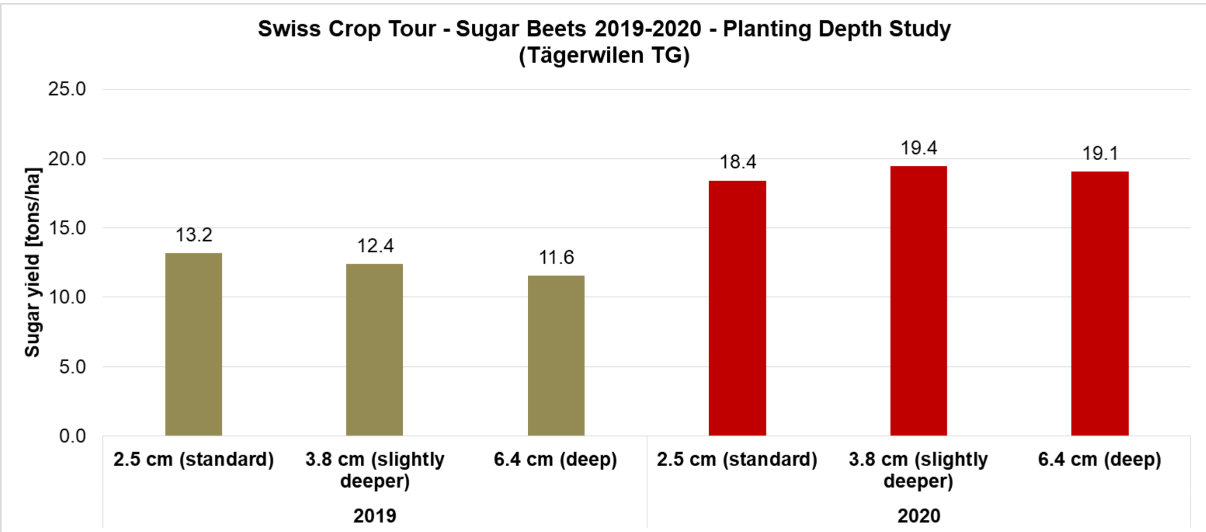

Figure 30: Sugar yield results of the Swiss Crop Tour 2019-2020 Planting Depth Study in sugar beets.

Payback

In 2019, the highest revenue was obtained from sugar beets planted at standard planting depth of 2.5 cm (4463 CHF/ha), which is 271 CHF/ha and 656 CHF/ha more revenue than at 3.8 cm and 6.4 cm planting depth, respectively (Figure 31). Due to less soil residue in the delivered beets, the highest revenue of 6712 CHF/ha in 2020 was achieved at a planting depth of 6.4 cm. The planting depth of 3.8 cm achieved a 2.3% lower revenue (6555 CHF/ha) while the placement depth of 2.5 cm reduced the revenue by 3.8% (6712 CHF/ha).

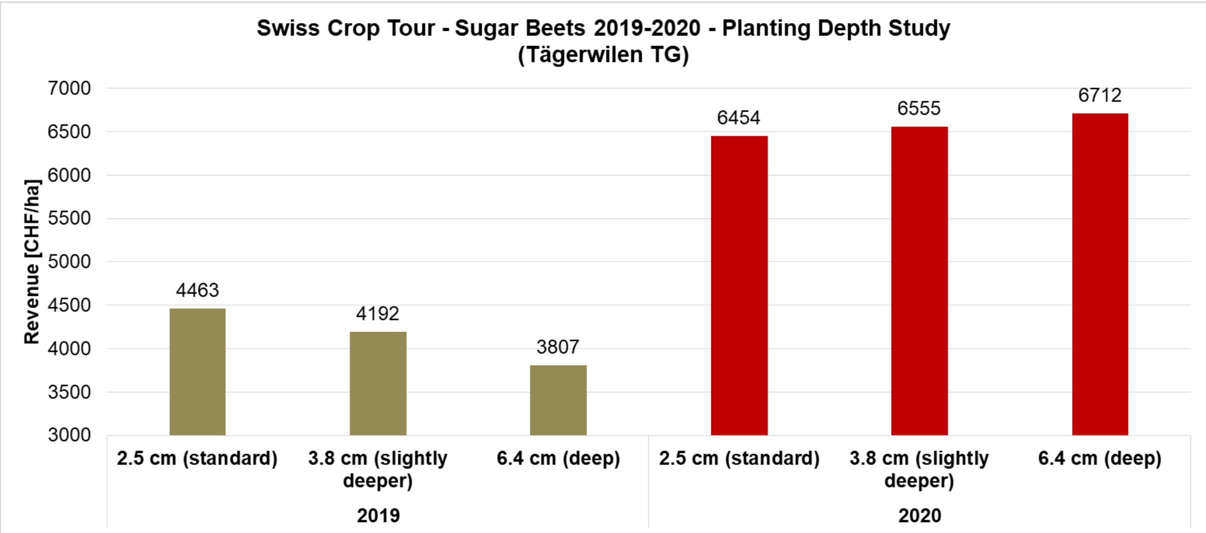

Figure 31: Revenue obtained from the Swiss Crop Tour 2019-2020 Planting Depth Study trial strips in sugar beets.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.7 Swiss Crop Tour – Sugar Beets 2019-2020 – Two Year Liquid Fertilizer Study

Objective

The objective of this study was to compare crop development and yield of sugar beets planted with two different liquid starter fertilizer types using Precision Planting FurrowJet™ and FlowSense™, and sugar beets planted without liquid starter fertilizer.

Study Design

The study was carried out on a commercial farm in Northeastern Switzerland (Tägerwilen, Canton of Thurgau) as a side-by-side strip trial in 2019 and 2020. The following treatments were compared:

- Kristalon 12-12-36 liquid fertilizer (applied with total 1.8 kg N/ha, 1.8 kg P_2O_5/ha, 5.4 kg K_2O/ha)
- Hasorgan 0-0-5 liquid fertilizer (applied with total 1.16 kg K_2O/ha)
- No liquid starter fertilizer (control)

Planting dates were 25th March 2019 and 27th March 2020. The trial plots were located in fields with homogeneous soil conditions. All trial strips were planted at 3.8 cm planting depth and with a planting rate of 100,000 seeds per hectare, and with DeltaForce automatic down force control set to a target down force of 45 kg. The liquid starter fertilizers were applied during planting using Precision Planting's FurrowJet™ and FlowSense™ liquid fertilizer system.

Results

The trials were harvested on 23rd November 2019 (243 days after planting) and on 14th November 2020 (232 days after planting), respectively. The treatment with Kristalon 12-12-36 as liquid starter fertilizer provided the highest sugar beet yield in 2019 (83.5 t/ha), whereas the control treatment and Hasorgan 0-0-5 liquid starter fertilizer had equivalently lower yield of 80.2 t7ha and 80.3 t/ha, respectively. In 2020, the highest yield was obtained with Hasorgan 0-0-5 (130.5 t/ha), closely followed by Kristalon 12-12-36 (128.5 t/ha). The control also achieved high yields of 124.7 t/ha (Figure 32). Fresh mass yield increase in sugar beets that could be achieved due to the application of liquid starter fertilizer compared to no liquid fertilizer in an average of the study years was 2.5%.

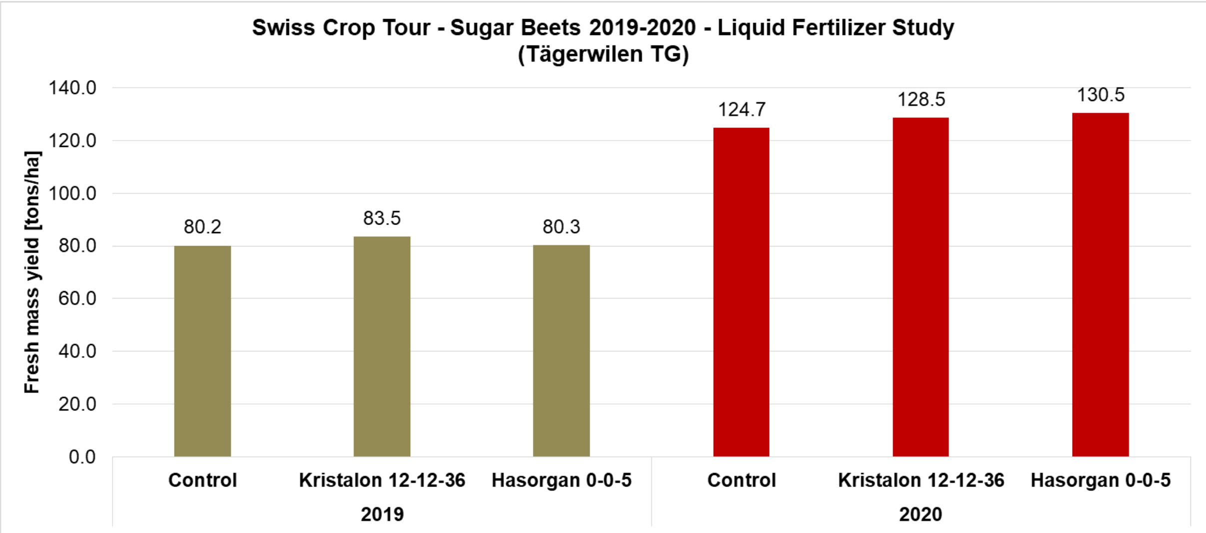

Figure 32: Fresh mass yield results of the Swiss Crop Tour 2019-2020 Liquid Fertilizer Study in sugar beets.

Sugar content in study year 2019 was 17.1% for the unfertilized control treatment and slightly higher with 17.3% for the two trial strips with liquid starter fertilizer treatment. In 2020, sugar content varied slightly among the variants from 17.3-17.6%, the highest content was obtained by the unfertilized control treatment, while the lowest content was obtained by the treatment with Kristalon 12-12-36 (Figure 33).

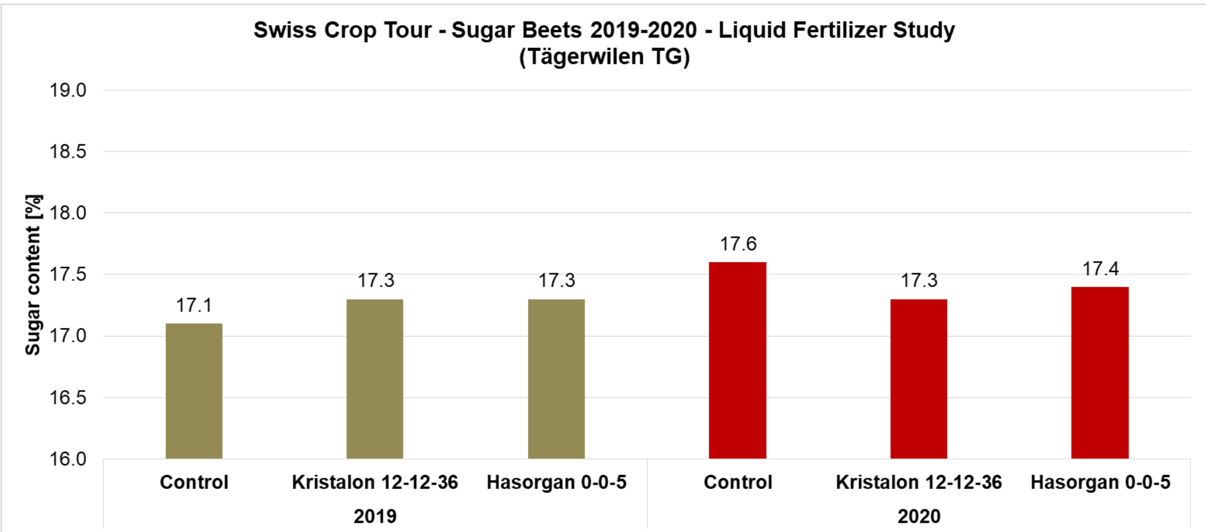

Figure 33: Sugar content results of the Swiss Crop Tour 2019-2020 Liquid Fertilizer Study in sugar beets.

Sugar yield compared to the unfertilized control treatment (12.4 t/ha) was only higher for Kristalon 12-12-36 liquid fertilizer in 2019 (12.5 t/ha), whereas the trial strip with Hasorgan 0-0-5 had slightly lower sugar yield (11.9 t/ha). In 2020, the treatment with the highest fresh mass yield (Hasorgan 0-0-5) also obtained the highest sugar yield of 20.1 t/ha, while the lowest sugar yield of 19.4 t/ha was obtained with the unfertilized control treatment (Figure 34). Sugar yield increase that could be achieved due to the application of liquid starter fertilizer compared to no liquid fertilizer in an average of the study years was 1.9%.

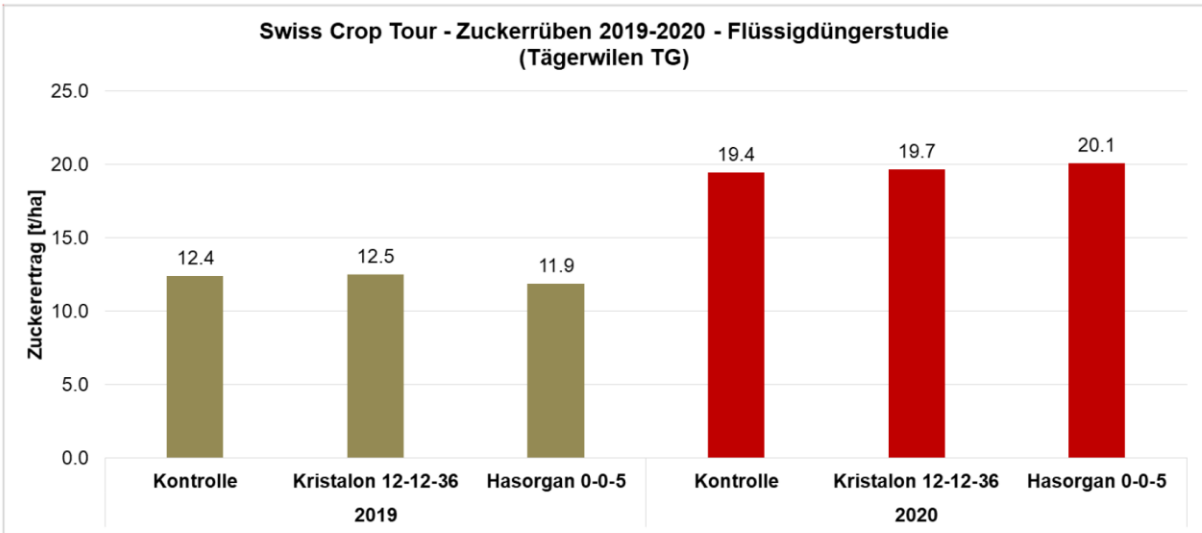

Figure 34: Sugar yield results of the Swiss Crop Tour 2019-2020 Liquid Fertilizer Study in sugar beets.

Figure 35: Precision Planting row unit equipped with FurrowJet liquid fertilizer system used for planting the trial plots.

Payback

For results of the 2019 study year, highest revenue was obtained from sugar beets with Kristalon 12-12-36 liquid fertilizer treatment (4226 CHF/ha), which is 34 CHF/ha more than the unfertilized control treatment (4192 CHF/ha), whereas the liquid fertilizer treatment with Hasorgan 0-0-5 provided the lowest revenue in the comparison with 3909 CHF/ha. Due to the high sugar content as well as yield, the highest revenue of 7020 CHF/ha in 2020 was obtained for the treatment with Hasorgan 0-0-5, an intermediate result with 6810 CHF/ha for Kristalon 12-12-36, while the lowest revenue of 6555 CHF/ha was obtained with the unfertilized control treatment. This shows that an additional revenue of 255 CHF/ha and 465 CHF/ha, respectively, can be achieved due to the application of liquid starter fertilizer (Figure 36). In an overall consideration of the study years, the additional total revenue due to application of liquid starter fertilizer using the Precision Planting FurrowJet und FlowSense system in sugar beets is ranging between 34 and 465 CHF/ha.

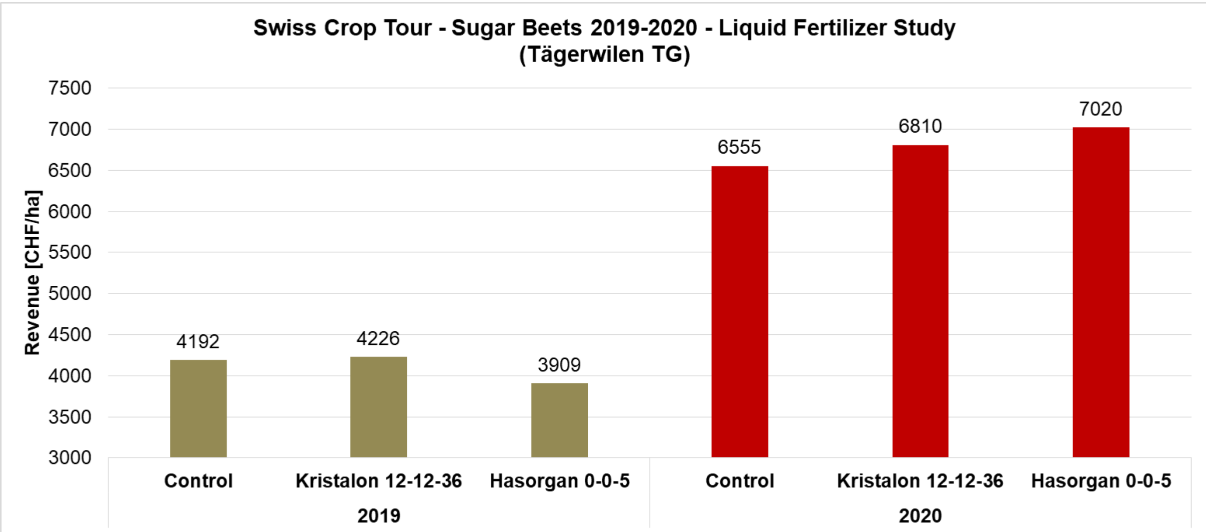

Figure 36: Total revenue obtained from the Swiss Crop Tour 2019-2020 Liquid Fertilizer Study trial strips in sugar beets.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.8 Swiss Crop Tour – Sugar Beets 2019-2020 – Two-Year Down Force Study

Objective

The objective of this study was to apply different planter down force using the automatic down force control system DeltaForce™ and to evaluate the resulting yield in sugar beets.

Study Design

The study was carried out on a commercial farm in Northeastern Switzerland (Tägerwilen, Canton of Thurgau) as a side-by-side strip trial with the following down force (DF) settings:

- Automatic Down Force Light (Auto DF Light, 23 kg)
- Automatic Down Force Standard (Auto DF Standard, 45 kg)
- Automatic Down Force Heavy (Auto DF Heavy, 68 kg)

Planting dates were 25th March 2019 and 27th March 2020. The trial plots were located in fields with homogeneous soil conditions. All trial strips were planted at 3.8 cm planting depth and with a planting rate of 100,000 seeds per hectare, whereas down force applied by the Precision Planting DeltaForce system was changed between the settings described above.

Results

The trials were harvested on 23rd November 2019 (243 days after planting) and on 14th November 2020 (232 days after planting), respectively. In the 2019 study year, automatic standard down force with 80.2 t/ha had a slight yield advantage of 1.0% and 2.6% over automatic light and heavy down force, respectively. In 2020, the highest sugar beet yield of 124.7 t/ha was obtained automatic standard down force at 45 kg, while the automatic light down force (23 kg) resulted in a decrease in yield of 3.0% and the automatic heavy down force (68 kg) in 4.7% less fresh mass yield (Figure 37).

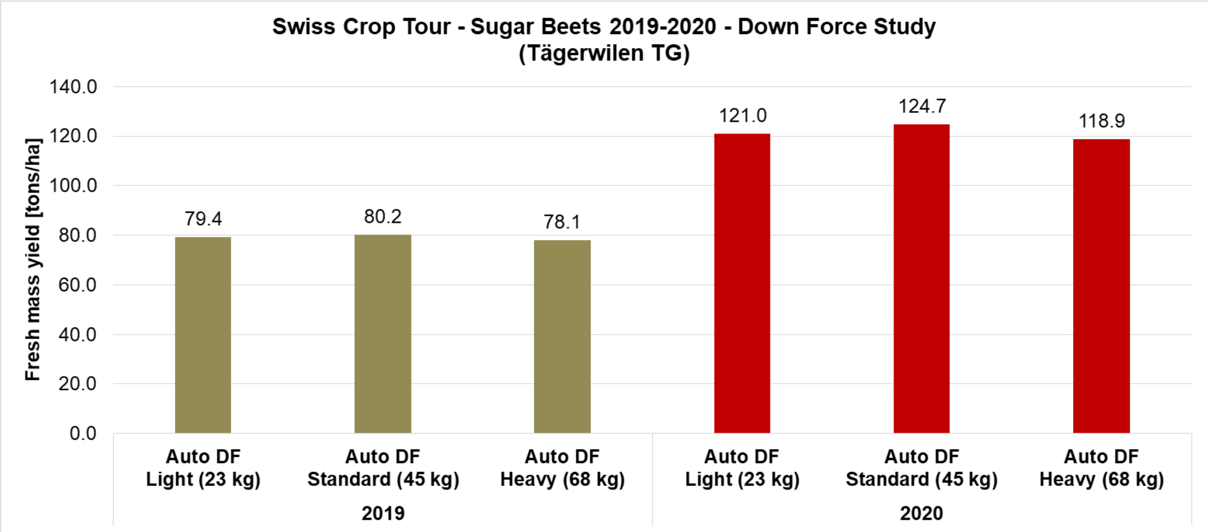

Figure 37: Fresh mass yield results of the Swiss Crop Tour 2019-2020 Down Force Study in sugar beets.

In 2019, the highest sugar content of 17.5% was obtained with automatic heavy and light down force settings, whereas standard down force had lower sugar content. Contrary, for the 2020 study year, the highest sugar yield of 17.6% was obtained with automatic standard down force, but the other down force settings showed little difference with a sugar content of 17.5% (Figure 38).

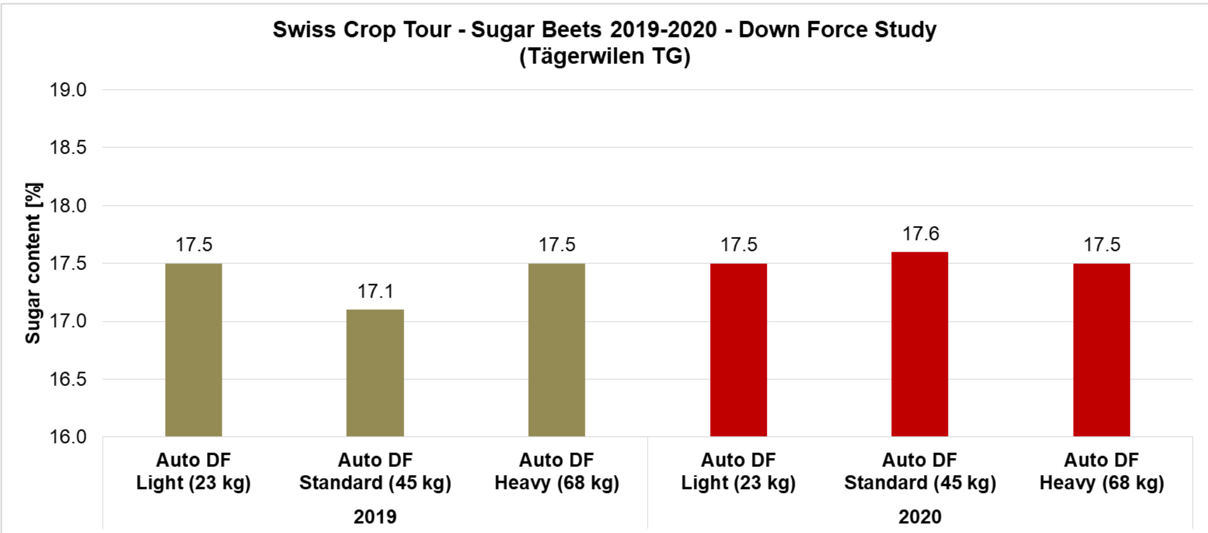

Figure 38: Sugar content results of the Swiss Crop Tour 2019-2020 Down Force Study in sugar beets.

In both study years, the highest sugar yield of 12.4 t/ha and 19.4 t/ha, respectively, was obtained for the automatic standard down force (Figure 39).

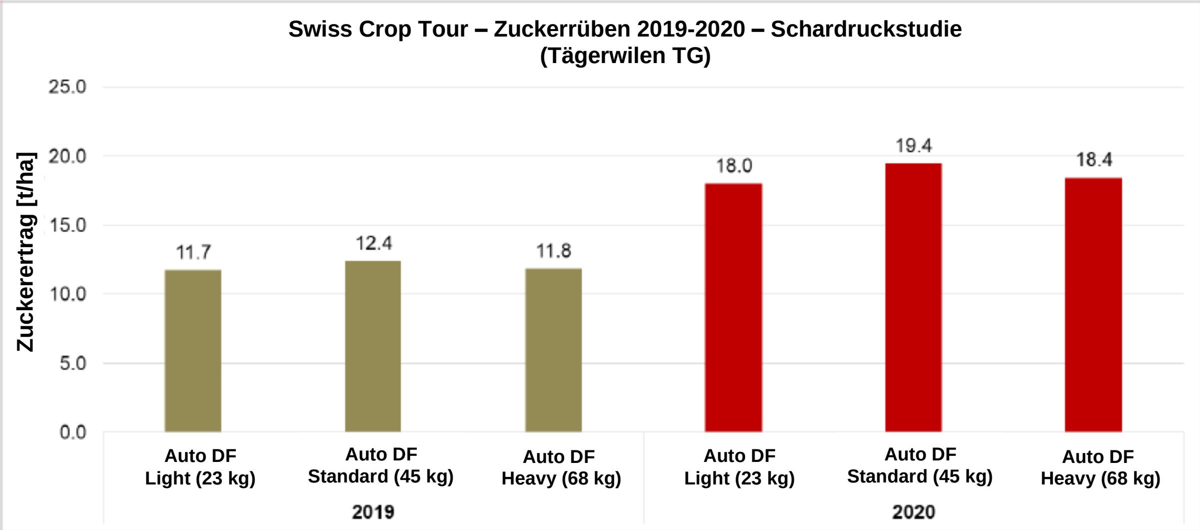

Figure 39: Sugar yield results of the Swiss Crop Tour 2019-2020 Down Force Study in sugar beets.

Figure 40: Precision Planting test planter equipped with DeltaForce down force control system on the trial plot.

Payback

Results from 2019 show that the highest revenue (4192 CHF/ha) was obtained from beets planted with automatic standard down force (45 kg), whereas automatic light down force (23 kg) provided 7.4% less and automatic heavy down force (68 kg) enabled 5.4% less revenue, respectively. Since other aspects are included in the calculation of the revenue, such as soil residue in delivered beets to factory, the highest revenue in trial year 2020 (6569 CHF/ha) was obtained for planting with light down force, and with standard down force of 45 kg the yield decreased by 0.2%, with heavy down force of 68 kg the yield decreased by 1.8% (Figure 41). The influence of down force on yield and revenue is thus only slight, but the highest yield and sugar content can be achieved at automatic standard down force of 45 kg.

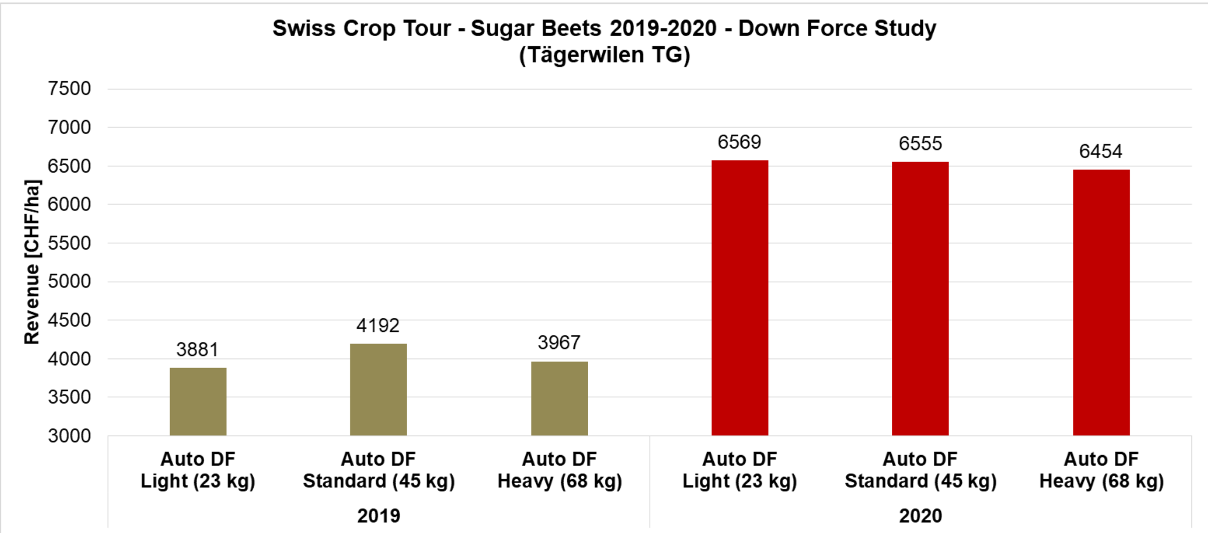

Figure 41: Revenue obtained from the Swiss Crop Tour 2019-2020 Down Force Study trial strips in sugar beets.

Assumptions for payback

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2021 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Study Contact

Nils Zehner, AGCO Agronomist, Swiss Future Farm, nils.zehner@agcocorp.com

1.9 Site-specific nitrogen fertilizer application in winter wheat using drone and soil data

Trial objectives

The objective of this multi-year trial (2018-2020) is to improve the efficiency of nitrogen use in winter wheat using drone, satellite and soil data. These additional data sources lead to a more accurate estimation of the spatial and temporal availability of nitrogen to better meet the needs of the wheat.

Methodology

The trial was conducted as part of the doctoral thesis of Francesco Argento (Agroscope Tänikon, ETH Zurich) on a total of seven fields at the Swiss Future Farm between 2018 and 2020. A description of the detailed scientific methodology can be found in Argento et al. 2020 (see link at the end of this sub-section). In the following, the focus is mainly on the technical implementation of the trials. In 2020, three fields, Altkloster F5 (4.6 ha), Rüedimoos F6 (3.3 ha) and Rütteli F7 (3.5 ha), were available.

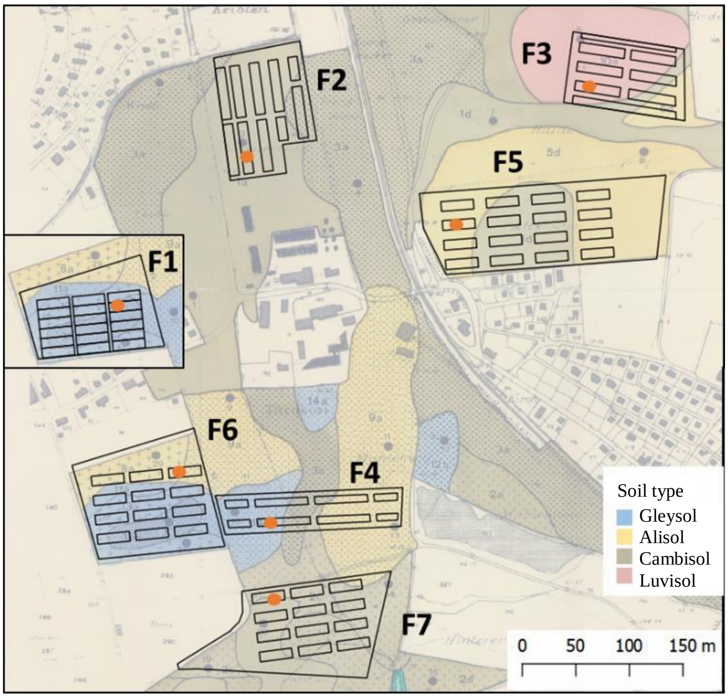

Figure 42: Overview of the 7 trial plots (2018-2020). The soil map in the background provides information on the heterogeneity of the plots. The orange dots indicate the positions of the soil probes.

Four different fertilization treatments were compared over a three-year period as part of the trial. The standard bands (ST) were fertilized with a constant amount of fertilizer as is common practice. In the bands with Variable Rate fertilizer application (VR), initial application was based on the N_{min} samples per soil zone. In the case of increased N_{min} contents, the amount of fertilizer was reduced during initial application, while it was increased in the case of low contents. The second and third application were based on aerial images shot by a drone. The indices identified from the multispectral images provide information about the amount of nitrogen already taken up by the plant. The NF (no fertilizer during the whole season) and NR bands (increased first and second application without third application) were used for inspection purposes. The trial plots measure 30m x 90m; and a 15m band between two tramlines was taken into account for the evaluation.

Figure 43: Last fertilizer application in winter wheat on 22.5.2020. The control plots (no fertilizer application)are clearly visible in the field.

Equipment and technology applied

Table 2: Technology and equipment used for the fertilizer trial

Measure	Machine	Brand	Model
Seeding	Tractor	Fendt	516 with RTK, incl. Rabe front-mounted press
	Planter	Horsch	Express 3 KR
Fertilizing	Fertilizer spreader	Sulky	Econov X40 (incl. SC and TC GEO)
	Tractor	Massey Ferguson	5713S with RTK and TC GEO External terminal CCI 1200
Controlling weeds	Tractor	Massey Ferguson	5713S with RTK and TC GEO
	Field sprayer	Favaro	Compact, 15m
Harvesting	Combine	Fendt	5275 C PLI with RDS Ceres 8000i yield monitor
Transferring data	QGIS	Shape file	Transfer via USB flash drive
Aerial imaging	Drone	DJI	Phantom 4 Pro with Parrot Sequoia multispectral camera

Crop care and fertilizer applications

Table 3 lists the dates for the 2020 trial plots. In the standard bands, a total nitrogen quantity of 155 kg N/ha was applied; in the NR band, 160 kg N/ha were fertilized. In 2020, the amount of fertilizer applied in the bands with Variable Rate fertilizer application ranged between 95-149 kg N/ha.

Table 3: Field calendar for the 2020 trial plots F5-7

	Altkloster (F5)	Rüedimoos (F6)	Rütteli (F7)
Tillage	23.10.2019 Ploughing 24.10.2019 Disc harrow	24.10.2019 Cultivator	13.11.2019 Cultivator
Planting	24.10.2019 Drill seed	26.10.2019 Drill seed	14.11.2019 Drill seed (lower section) 05.12.2019 Drill seed (upper section)
Fertilizing	16.03.2020 1. N application 24.04.2020 2. N application 22.05.2020 3. N application	16.03.2020 1. N application 24.04.2020 2. N application 22.05.2020 3. N application	16.03.2020 1. N application 24.04.2020 2. N application 22.05.2020 3. N application
Cultivating	18.03.2020 0.4 kg/ha Pacifica Plus 1.0 l/ha Mero 0.5 l CCC 25.05.2020 0.1 l/ha Audienz (damage threshold exceeded)	18.03.2020 0.4 kg/ha Pacifica Plus 1.0 l/ha Mero 0.5 l CCC 25.05.2020 0.1 l/ha Audienz (damage threshold exceeded)	06.04.2020 0.4 kg/ha Pacifica Plus 1.0 l/ha Mero 25.05.2020 0.1 l/ha Audienz (damage threshold exceeded)
Harvesting	27.07.2020 Combine harvest	28.07.2020 Combine harvest	10.08.2020 Combine harvest

A drone (DJI Phantom 4 Pro with an on-board multispectral sensor (Parrot Sequoia)) flew over the fields each week and shortly before the upcoming N fertilization to determine the spectral information on the N content in the wheat. The doctoral researcher Francesco Argento compiled a prescription map in shape format from the data obtained. This data could then be used without prior ISO-XML conversion thanks to the CCI 1200 terminal, which was used for the first time in 2020. This avoided the grid being automatically aligned to north as otherwise specified in the ISO-XML format.

Figure 44: Prescription map for the second N application on F6 in shape format before loading onto the terminal. The prescription map is aligned to the tramlines.

Figure 45: Universal Terminal CCi 1200 with fertilizer prescription map and ISOBUS operating mask for the fertilizer spreader.

Results

With the exception of plot F4 in 2019, the average yields in all seven fields were between 65 and 70 dt/ha. The reason for low yields on F4 was the late planting date in the autumn of 2018, which was not as successful as hoped. On that plot, there were also no major differences between non-fertilized and fertilized areas.

The actual yields and amount of fertilizer applied over the three-year trial period are shown in Figure 46. It indicates that the yields in treatments with Variable Rate fertilizer application do not differ significantly from the yields in standard treatments, but the amount of fertilizer could be reduced markedly. A comparison between the nitrogen-rich treatments (NR) and the standard bands shows that there were fields where additional fertilizer application was also reflected in higher yields (F2, F3 and F5). This effect was however the opposite on field 6. Yet another interesting factor is the differences in yield between the non-fertilized and the standard bands as well as between the non-fertilized zones within a field. On average and across all fields, the non-fertilized subplots offer a yield range of 25 dt/ha – 75 dt/ha. This shows the significant impact of soil and seasonal climatic conditions on plant-available nitrogen. Overall, an average 13% rise in nitrogen use efficiency was observed at all seven trial plots.

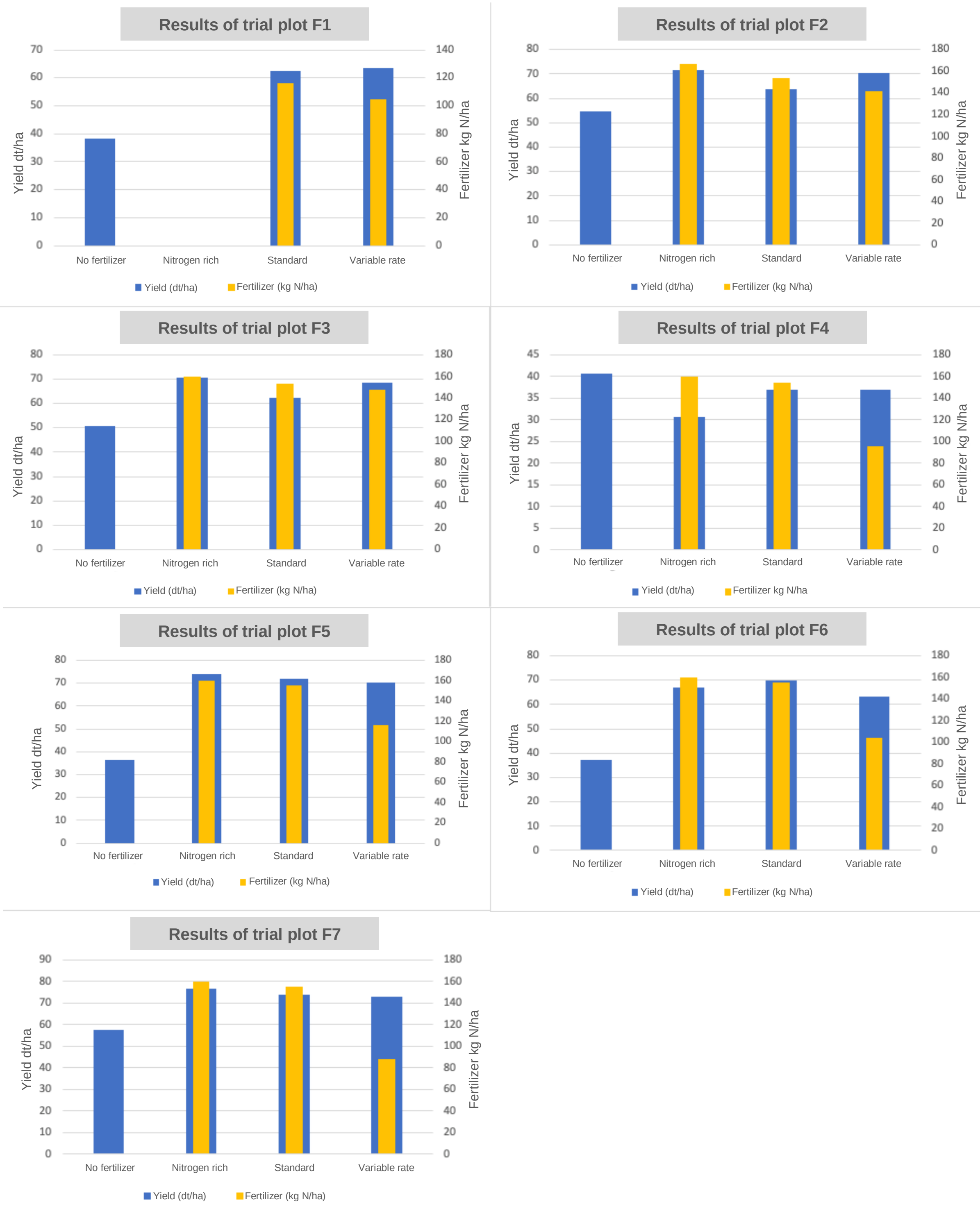

Figure 46: Yields (dt/ha) and amounts of applied fertilizer (kg/ha) per trial plot and treatment

These results and discussion points are to be included in the ongoing trials. During the next few years of the trial, the focus will be firmly on soil zoning and mineralization processes in the soil.

Knowledge transfer

The results of the trial on Variable Rate nitrogen fertilizer application were presented to a wide range of interested parties from agricultural practice, education and consulting as part of the public relations work of the Swiss Future Farm during visitor tours, workshops and external events.

Outlook

The trials will continue on four SFF plots in 2021. The spotlight here will be on two topics. On the one hand, the scientific methodology will be further developed with a focus on calibrating the spectral images and the mineralization processes in the soil and, on the other hand, the methodology will be implemented on a plot using the technologies available on the market. The aim is to validate whether the results of the trial can also be reproduced in real-life conditions.

Trial team

Trial design: Francesco Argento, Frank Liebisch, Thomas Anken (Agroscope Tänikon, ETH Zürich)
Drone flights and sampling: Francesco Argento (ETH Zürich)
Coordination and practical implementation: Operating team Swiss Future Farm

Further information

Scientific publication in Journal Precision Agriculture:

Argento, Francesco & Anken, Thomas & Abt, F. & Vogelsanger, E. & Walter, A. & Liebisch, Frank. (2020). Site-specific nitrogen management in winter wheat supported by low-altitude remote sensing and soil data. Precision Agriculture.
https://link.springer.com/article/10.1007/s11119-020-09733-3

1.10 Overview of weed control strategies in silage corn: Herbicide reduced, herbicide free and conventional chemical

Trial objectives

The objective of the trial is to conduct a detailed comparison of mechanical, herbicide-reduced and chemical weed control measures in silage corn with realistic 15m wide trial bands. The trial shall act as key demonstration tool for farms that already employ an herbicide-reduced method of weed control in silage corn or want to obtain information on this topic. Besides the observable effects of the measures in the field, the costs of the individual treatments are also compared to one another.

Trial set-up

The trial was conducted on the Grosswiese plot, which features medium to heavy soil types with low heterogeneity. The plot was previously used as grassland for two years. LG 30.205 with a planting rate of 90,000 plants/ha was sown as the silage corn.

Figure 47 shows the arrangement of the treatments on the plot, including the visitor walkway and a test plot that was used for harrowing crops transverse to the direction of travel. All the trial bands are 15m wide.

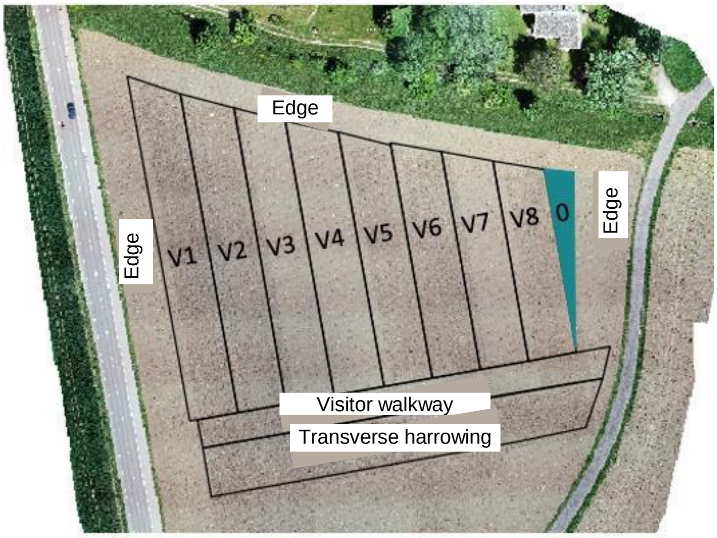

Figure 47: Arrangement of the treatments on the Grosswiese plot

Table 4: Weed control measures per treatment

Treatment	Rolling	Blind harrowing	Harrowing	Hoeing	Herbicide	Band spraying	Under-sown crops
Edge					1x		
V1		1x	1x	1x			
V2	1x	1x	1x	1x			
V3					1x		
V4			1x	1x			
V5	1x	1x	2x	1x			
V6	1x	1x	2x				
V7				1x		1x	
V8		1x	1x				1x
0 plot							
Transverse		1x	1x				

Table 4 lists the weed control measures per trial plot.

Table 5: Dates of weed control measures

Date	Measure and comment	Images
8 May 2020	**Ploughing**	

9 May 2020	**Harrowing and sowing** **Comment:** • Power harrow was not adjusted correctly. This led to unevenness in the field.	
9 May 2020	**Rolling (only three trial bands)** **Comment:** • Good effect in terms of levelling uneven soil • In general, however, the effects of the harrow were very good on both rolled and unrolled soil	
18 May 2020 (in the morning)	**Blind harrowing (V1, V2, V5, V6, V8)** **Comment:** • Nine days after planting, with harrow thickness 3.5/9 • Very few weeds, good effect • Best conditions after rainfall and well-dried soil	

26 May 2020 (in the afternoon)	**Harrowing (V1, V2, V4, V5, V6, V8)** **Comment:** • Harrowing was carried out at low speed so as not to damage the corn plants in BBCH13 • The conditions were very good and dry.	
2 June 2020 (in the afternoon)	**Undersowing crops (V8)** **Comment:** • Seeding with pneumatic fertilizer spreader (15m), followed by one harrow pass, UFA Maisfix 20kg/ha (white clover, ryegrass, orchard grass) • Dry conditions with rain in the following days	
2 June 2020 (in the afternoon)	**Harrowing (V5, V6, V8)** **Comment:** • Harrows set to a thickness of 5/9 • The conditions in the field were very good and dry	

20 June 2020	**Herbicide application (V3 and band spraying V7)** **Comment:** • Application rate 0.5l/ha Banvel 4S and 1.5l/ha Equip Power	 Image is of a different plot!
24 June 2020	**Hoeing (V1, V2, V4, V5, V7)** **Comment:** • Camera-controlled hoeing machine and finger hoes • Corn plants were already 80cm high	

Overview of the measures

<u>Blind harrowing</u>

In treatments 1, 2, 5, 6, 8, blind harrowing was carried out nine days after planting with hardly any visible weed pressure. The blind-harrowed treatments emerged equally well as the non-blind-harrowed trial bands, and the difference in weed pressure was insignificant (see Figure 5).

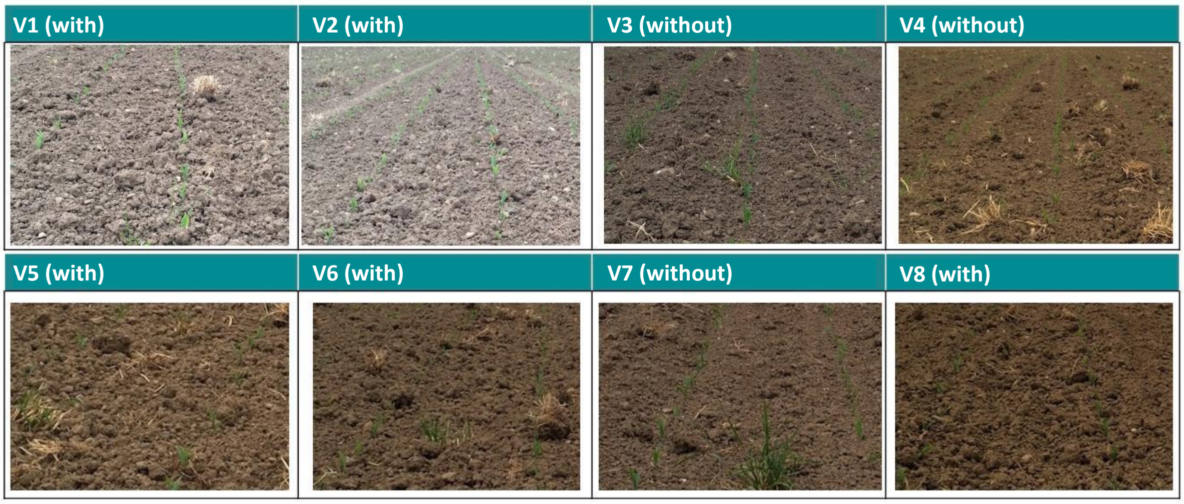

Figure 48: Differing treatments with and without blind harrowing on 22 May 2020

Harrowing

The conditions for using the harrow were very good thanks to the dry spring/summer. Following the initial blind-harrow pass, harrowing was performed on 26 May and 2 June. The predominant weeds, from germination up to 4 leaf stage, were simply removed with the harrow. However, the harrow had no impact on individual tufts of grassland that had grown. Corn plants were damaged, particularly during the harrow pass on 2 June, due to an initially over-aggressive harrow setting.

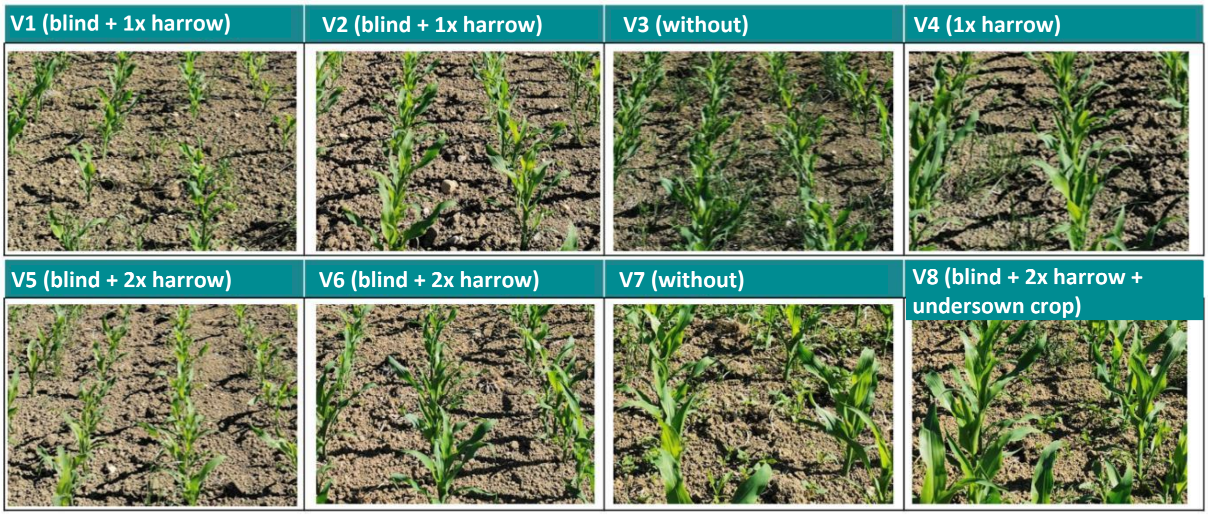

Figure 49: Overview of treatments on 12 June 2020

Hoeing

Initial hoeing took place on 24 June and thus quite late. The hoeing points cut the weeds cleanly beneath the surface. The tufts of grassland that had grown were cut to 75% by the inter-row hoe, but the finger hoes in the row had little impact in this regard (see Figure 50).

Figure 50: Finger hoes being used to remove tufts of grass in the row

In treatment 7, weed control measures were not carried out between crop rows after planting until 24 June 2020. A band sprayer was used to apply herbicide to the row on 20 June 2020. Figure 51 shows the effects of hoeing.

Figure 51: The left and right images show the crop before and after hoeing, respectively.

<u>Summary of all treatments</u>

Figure 52 shows the treatment bands after completing the treatment. The subsequent assessment, carried out with students from BBZ (Education and Consultation Centre) Arenenberg showed that weed infestation of between 1-3% was present in the trial bands. It is interesting to compare this result with the 0 plot, in which no weed control measures were carried out and which showed significant weed infestation (Figure 53). This shows the impact and effectiveness of all the treatments that proved to be well timed this year. On the one hand, the high temperatures ensured rapid corn growth and, on the other hand, the longer dry phases allowed optimal scheduling of the measures. In fact, hoeing was the only thing delayed due to a rainy spell in the first weeks of June.

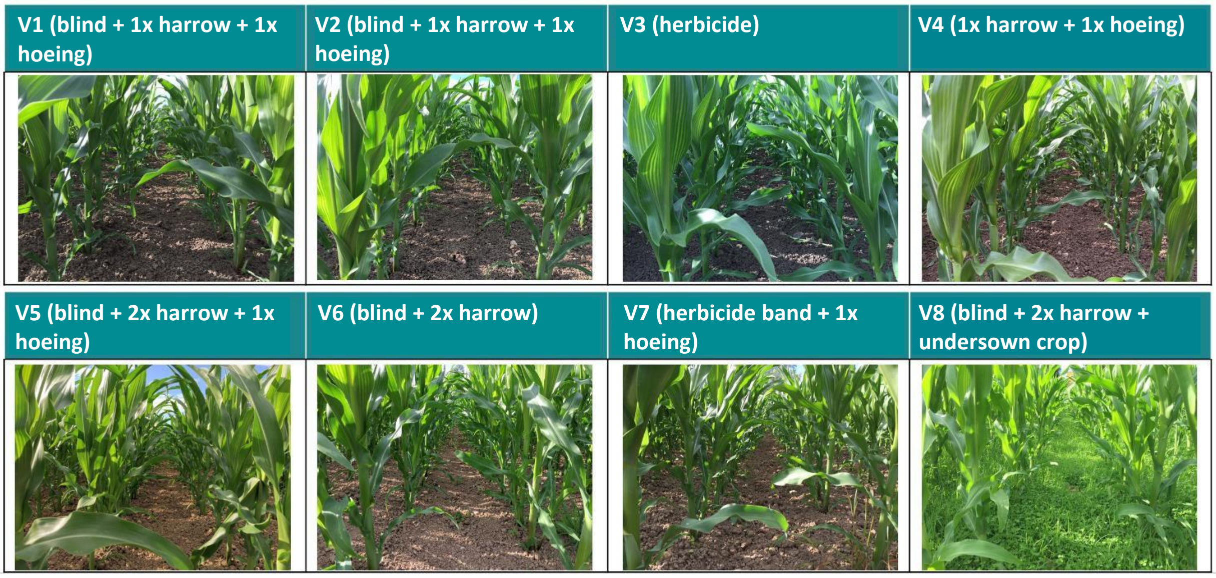

Figure 52: Treatment after completion of all weed control measures on 24 June 2020

Figure 53: The 0 plots in the field show the weed pressure in the absence of weed control measures.

Results

The average yield at the Grosswiese plot was 20.3 t/ha dry matter and ranged from 18.3 t/ha (V8) to 21.5 t/ha (V3) between the various subplots and treatments. The highest yield was achieved with the herbicide treatment.

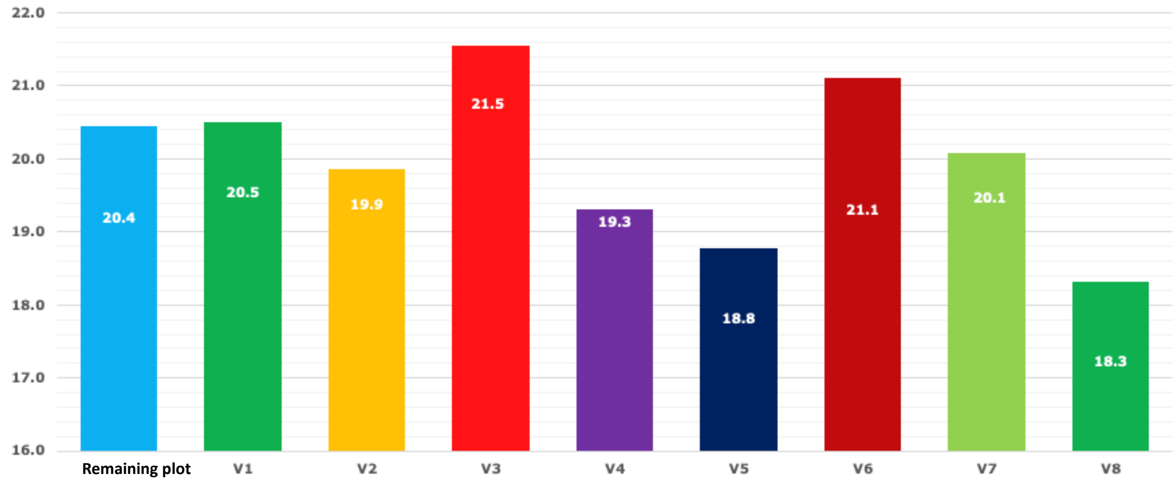

Figure 54: Yield t/ha TS in the individual treatments

The weed control treatment costs ranged between CHF156 /ha (V4) and CHF352/ha (V8). One of the biggest issues of under-sowing was the actual cost of the seeds. With just one hoeing and harrow pass, V4 was characterized by its low pass frequency and good soil penetration (harrow). Despite the high area performance when harrowing, the actual harrowing treatment (V6) proved to be only the second cheapest treatment due to the three passes.

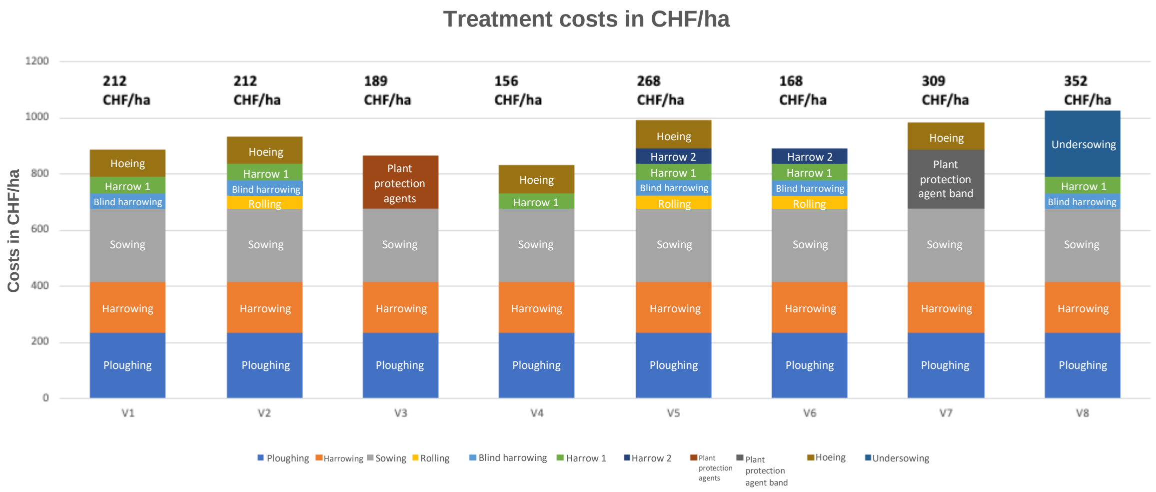

Figure 55: Overview of treatment costs. The costs for weed control are shown separately

Figure 56 shows the contribution margins MR2, including the costs for machinery, labour and operating resources for all the treatments. Harrowing treatment resulted in the highest contribution margin of CHF1190/ha. This is mainly due to the highest dry matter yield and the low costs for weed control measures with this treatment. Broad-spectrum herbicide treatment resulted in the second highest contribution margin of CHF1053.50/ha. The lowest contribution margin was achieved with under-sown crop treatment. This is also due to the fact that the under-sown crop cannot be used further after the corn harvest and the soil-improving effect cannot be valued in terms of monetary worth.

	V1	V2	V3	V4	V5	V6	V7	V8
Yield wet mt/ha with approx. 40% dry	47.60	45.10	48.90	45.90	45.70	51.40	46.70	44.60
Dry matter yield (mt/ha)	20.50	19.90	21.50	19.30	18.80	21.10	20.10	18.30
Revenue (CHF/mt) recommended	CHF 65.00	CHF 65.00	CHF 65.00	CHF 65.00	CHF 65.00	CHF 65.00	CHF 65.00	CHF 65.00
Performance								
Revenue per ha	CHF 3'094.00	CHF 2'931.50	CHF 3'178.50	CHF 2'983.50	CHF 2'970.50	CHF 3'341.00	CHF 3'035.50	CHF 2'899.00
Costs								
Controlling weeds	CHF 212.00	CHF 212.00	CHF 189.00	CHF 156.00	CHF 268.00	CHF 168.00	CHF 309.00	CHF 352.00
Tillage	CHF 414.00	CHF 461.00	CHF 414.00	CHF 414.00	CHF 461.00	CHF 461.00	CHF 414.00	CHF 414.00
Seeding	CHF 262.00	CHF 262.00	CHF 262.00	CHF 262.00	CHF 262.00	CHF 262.00	CHF 262.00	CHF 262.00
Harvesting	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00	CHF 1'260.00
MR 2 (incl. machinery, labour, operating resources)	**CHF 946.00**	**CHF 773.50**	**CHF 1'053.50**	**CHF 891.50**	**CHF 720.50**	**CHF 1'190.00**	**CHF 790.50**	**CHF 611.00**

Figure 56: Overview of contribution margins

Summary and next steps

The dry and warm spring and summer of 2020 ensured ideal conditions for mechanical weed control in silage corn. The weeds were controlled effectively in all the treatments and the under-sown crops developed very well. The highest contribution margins were achieved with the harrowing treatment. In principle, it can be said that corn as a successor crop to grassland offers farms an ideal opportunity to discover the effectiveness of mechanical weed control, since the weed pressure after grassland use is comparatively low. The trial will be repeated in 2021 on the Mühlewiese plot.

Knowledge transfer

The trial results were presented to a wide audience of experts and agricultural enthusiasts at the SFF Holiday Program, the SFF Field Day and the SFF/Arenenberg Student Days at the SFF. The various weed control strategies were demonstrated in a practical and tangible way thanks to the easy-to-access visitor walkway and excellent trial signposting.

Involved partners

The contribution margins were assessed and calculated with the help of second and third-year students as part of the SFF/Arenenberg Student Days.

1.11 Cover crop banding with high guidance system accuracy: Clever preparation for the direct seeding of corn

Trial objectives

The objective of the trial is to make clever use of existing mechanization by incorporating the repeatable accuracy of the RTK correction signal. To do so, banded application of cover crops took place in the autumn of 2020. The corn will then be sown directly and precisely into the created rows in the spring of 2021. In addition to appropriate soil protection, this method of cultivation aims to avoid chemical and mechanical weed control.

What are the advantages of cover crop banding?

Cover crop banding allows the existing mechanization, such as seed drill and cultivator, to be used in combination with a guidance system with RTK accuracy for an alternative method of cultivation. Compared to the discontinued strip-till treatment, cover crop banding saves one pass by eliminating the partial loosening of the soil in the spring. In contrast, cover crop banding involves intensive loosening of the entire soil surface in the autumn. Cover crop banding provides a high degree of soil cover in the winter, which reduces the risk of erosion, promotes biological soil activity and organically binds nutrients, thereby ensuring they are more readily available to the plants. It is desirable for cover crops to emerge as quickly as possible in the autumn to guarantee unseeded rows are covered and emerging seed-propagated weeds are suppressed. In the spring, the use of knife rollers stops the growth of the cover crops. Use of the knife roller for seeding eliminates the need for a separate pass-over. As a result the cover crop does not compete directly with the corn for water and nutrients. The upright non-wintering cover crops freeze out in the winter and are not planted in the autumn as usual. This prevents a layer of non-decomposed mulch forming, which would otherwise slow down the drying of the soil in the spring. The cover crops planted in the spring should cover the entire surface of the soil (also in the row) and contribute to weed suppression, thus making herbicide application unnecessary.

Trial set-up and equipment and technology applied

The trial is conducted in the lower section of the Rütteli plot (Figure). After harvesting the preceding crop, winter wheat, two cultivator passes were performed. The objective of the first cultivator pass was to mix in the crop residues of the winter wheat. In contrast, the second cultivator pass was intended to achieve deep loosening of the soil (30cm). Deep tillage can thus be carried out in the summer under optimal moisture conditions. Note that deep tillage in the spring is often disadvantageous, as the subsoil quite often has an excessive moisture content and the unloosened soil in the winter is less likely to freeze through.

Subsequently, four different cover crops were sown with 30cm-wide seed-free bands at regular intervals of 75cm. Band planting was performed thanks to a clever and easy-to-implement modification to the planter (row spacing of 15cm). The four closable outlets of the distribution head, which are intended for the tramline mechanism, were assigned to other seeding coulters and thus remained constantly closed. As a result, no seeds were sown at four seeding coulters over a working width of three metres. In the spring of 2021, grain corn will be sown precisely and directly into the 30cm wide gaps thanks to the used guidance system. The track guidance system employs an RTK (real time kinematic) correction signal that is characterized by its high static accuracy. This means that corn seeds can be sown precisely to the nearest centimetre in the 30cm wide bands without cover crops. When seeding, the front-mounted knife roller ensures that the overwintering cover crops are rendered incapable of growing again. At the planter, star-shaped scrapers clear the seeding rows of any remaining cover crops.

Figure 57: Arrangement of the trial bands.

***Table 6** Implemented measures and equipment and technology applied.*

	Measure	Date	Equipment and technology applied
Tillage	Cultivators (Horsch Terrano 3m) 15cm deep with MulchMix points	10 September 2020	Track guidance with RTK correction signal
	Loosening (30cm deep) with point shares	10 September 2020	Track guidance with RTK correction signal, section control
Seeding	Cover crop seeds with modified power harrow and drill combination (Horsch Express 3KR)	11 September 2020	Track guidance with RTK correction signal, section control

The four cover crops (Table 7) are divided into tender, half-hardy and hardy cover crops.

Table 7 *Compared cover crops mixtures.*

Cover crop	Composition of mixture	Cold hardiness	Quantity of seeds
UFA Maisfix	Small-leaf white clover, ryegrass, early orchard grass	Hardy	20 kg/ha
UFA Inka	Berseem clover, phacelia, common vetch, crimson clover	Half-hardy (only crimson clover is hardy)	31 kg/ha
White mustard	Pure seeds	Tender	20 kg/ha
Chinese white cabbage	Pure seeds	Hardy	15 kg/ha

Figure 58: Horsch Express 3KR drill combination with modified arrangement of the seeding hoses from the distribution head to the seeding coulters.

Figure 59: Seeding of cover crops in mid-September with the drill combination.

Results and discussion

Figure 60: The bands of sown Chinese white cabbage in mid-October.

Two hardy and two tender cover crops were sown to determine the differences between tender and wintering cover crops. Despite the rather late planting date, the cover crops UFA Inka, Chinese white cabbage and white mustard showed a satisfactory rate of emergence. Only the emergence of the UFA Maisfix mixture as a cover crop was deemed unsatisfactory. The basic reason for this is the temperature requirements of the individual varieties in the mixture, which are actually optimized for planting in the warmer spring months as under-sown corn. Drone images showed that, unfortunately, none of the cover crops were able to completely fill out the gaps created during seeding. As such, the future corn rows (30cm wide) did not remain completely weed free.

Knowledge transfer

This trial aims to show how smart farming technologies can advance arable farming systems and how standard machinery can be used even more efficiently. The experiences can be used to enhance consulting and training services. Progress of the trial will be shared on various social media channels.

Conclusions

This autumn's results show that accurate seeding can be implemented without any problems thanks to the dynamic RTK accuracy of the track guidance system. It also means that nothing stands in the way of precise corn sowing in the spring of 2021 in the designated rows, thanks to the static accuracy of the RTK correction signal and the reference lines stored in the tractor. Moreover, as expected, there were rather large differences between the various cover crops. The grass-free cover crops were impressive due to their faster emergence and they suppressed the weeds more effectively due to their lush growth. We are curious to see how the cover crops develop in the spring for corn sowing and how successful the direct seeding of corn is.

Involved partners

We would like to take this opportunity to thank Hanskasper Kübler from UFA Samen for his guidance and support in selecting the cover crops. The planning, implementation and communication of the trial was carried out by GVS Agrar AG (Marco Meier, Nicolas Helmstetter, Vivienne Oggier) and the Arenenberg (Florian Abt, Raphael Bernet).

1.12 Deep fertilization for rapeseed

Trial objectives and background

In the future, arable farming will face challenging climatic conditions that demand skilful crop management. The targeted placement of mineral fertilizer is intended to direct the roots of rapeseed. In particular, the targeted placement of ammonium and phosphorus should have an attracting effect on the roots. Targeted deep fertilization should, therefore, provide growth incentives for the root and promote deep rooting. Furthermore, nutrient-poor, deeper soil layers should thus also be fertilized. As a result, the treatment is likely to be particularly relevant for farms without livestock that specialize in no-till farming. Since deep fertilization aims to apply the fertilizer at a depth of approx. 20cm, which is approx. 10cm deeper than when mineral fertilizer is incorporated into the soil by a cultivator. Targeted deep fertilization thus ensures concentrated fertilizer application at a depth of approx. 20cm. The soil layers at this depth are less likely to dry out than higher soil layers. Therefore, the nutrient uptake of less mobile, stable nutrients is better ensured. This applies to the nutrients phosphorus and potassium, which reach the plant due to differences in concentration (diffusion) that requires the spatial proximity of fertilizer and root and, in addition, sufficiently high soil moisture. The deep loosening that goes hand in hand with deep fertilization is an additional key element to ensuring healthy and strong rapeseed plant roots. Deep loosening allows for unobstructed growth of the tap root. The narrow Horsch LD (low disturbance) points are designed to loosen the soil and thus remove physical obstacles to root growth. Due to the narrow width of the LD points, the working pass can also be carried out with little tractive force and consequently reduced fuel consumption. If deep loosening allows deep rooting, the addition of organic matter into the soil can have a positive impact on soil life.

Technically speaking, the objective of the trial is to test fertilizer application with the fertilizer unit on the Horsch Terrano cultivator in combination with the front tank. From an agronomic perspective, the question arises whether deep fertilization and simultaneous targeted loosening for rapeseed plants can lead to changes in nutrient availability, root phenology and drought tolerance compared to the treatment with targeted loosening but without deep fertilization. Furthermore, possible differences in yield between the two treatments are to be determined.

Trial set-up and equipment and technology applied

The cultivator was equipped with a 40mm-wide Horsch LD (low disturbance) pointer to achieve a targeted loosening effect and a low tractive force. A fertilizer distribution system was mounted on the Horrsch Terrano cultivator to guarantee direct application of the fertilizer. The fertilizer distribution system consists of a distribution head with hoses connected to the fertilizer inserts. The fertilizer inserts can be adjusted to allow the fertilizer to be deposited deep or superficial, or half of it deep and half of it superficial. On the cultivator, the fertilizer guide plates are attached to the rear of the Horsch LD cultivator points. The cultivator and fertilizer unit must be combined in this configuration together with a front-mounted fertilizer tank.

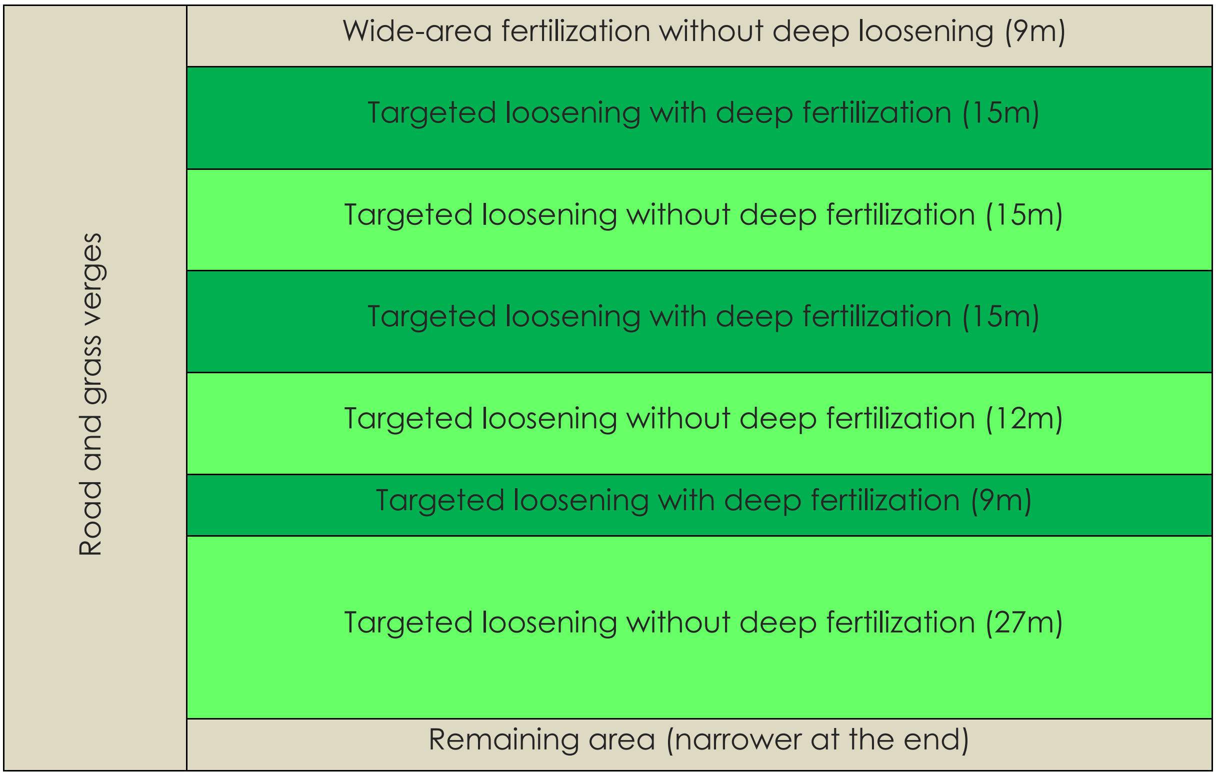

Figure 61: Arrangement of the trial bands.

Figure 62: Distribution head of the cultivator.

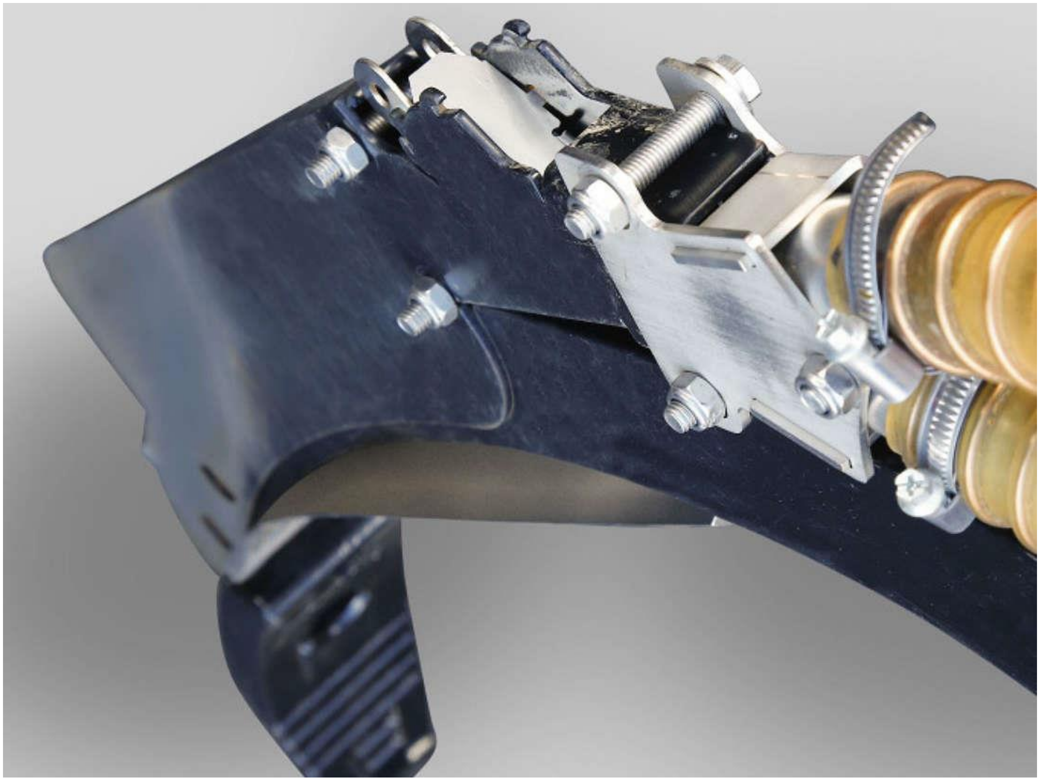

Figure 63: Fertilizer guide plate.[1]

[1] https://www.horsch.com/produkte/bodenbearbeitung/grubber/terrano/terrano-fx

The trial is being conducted in the western third of the Altkloster field in Tänikon (Figure 61). Winter wheat was the preceding crop of the sown rapeseed. The trial was set up as a banded trial. A 3m-wide border band without deep fertilization and deep loosening was created at the eastern edge of the trial field to act as a physical boundary to adjacent trials. This is followed by six west-facing trial bands, all of which have been subjected to deep loosening. Alternately, deep fertilization was applied directly to three of these six bands along with deep loosening. The fertilizer point of the cultivator ran exactly between two rows of seeds. Facing westwards, the plot terminates with a small area featuring the same cultivation as the eastern edge (without deep fertilization and without deep loosening). Triple Super with a fertilizer rate of 46 kg P2O5/ha was used for deep fertilization. The fertilizer pointer was adjusted to ensure 50% of the fertilizer was deposited 10cm deep and the remaining 50% of the fertilizer 20cm deep. Distribution of the fertilizer depends on the successor crop and the root geometry. Moreover, depending on the actual planting date, a decision must be taken on whether to apply a starter dose or whether the focus should be on root attraction deep in the soil. The rapeseed was sown one day after conventional tillage. Tempo, a variety of rapeseed, was sown using the seed drill method (row distance 15cm). The actual quantity of seeds was 50 plants/m_2 and the seeds were planted at a depth of 1-2cm.

Table 8 Implemented measures and applied mechanization.

	Measure	Date	Applied technologies
Tillage and basic fertilization	Cultivators (Horsch Terrano 3m) 15cm deep with MulchMix points	25 August 2020	Guidance system with RTK correction signal
	Basic fertilization in combination with 20cm deep loosening (Horsch Terrano 3m with fertilizer spreader and LD points combined with Monosem front-mounted fertilizer tank)	25 August 2020	• Guidance system with RTK correction signal • ISOBUS at the front-mounted fertilizer tank
Seeding	Tempo variety of seeds with modified power harrow and drill combination (Horsch Express 3KR)	26 August 2020	• Guidance system with RTK correction signal • ISOBUS at the planter
Fertilizing	Application of ammonium nitrate Mg S (24%)	22 September 2020	• Guidance system with RTK correction signal • Section control
Plant protection	Application of VA Basan Trio with Favaro plant protection sprayer	27 August 2020	• Guidance system with RTK correction signal • Section control
	Slug pellets at the edge	1 September 2020	
	Application of Cypermethrin (0.25 l/ha, insecticide) and Fusilade Max (1.5 l/ha, herbicide) with Favaro plant protection sprayer	21 September 2020	• Guidance system with RTK correction signal • Section control

Results and discussion

Soil samples were taken to prove the decreasing phosphorus content with increasing depth at this plot. Soil samples were taken using an auger on 2 November 2020. Ten composite samples were taken in two bands with deep loosening but without deep fertilization, distinguishing in each case between samples taken at 0-20cm and at 20-40cm. The analysis was carried out in the soil lab Arenenberg. The P extraction method used in the analysis was the CO2 method in which the plant-available P was measured.[2] The AAE method can only provide a meaningful result in lime-free soils (negative lime sample) and up to pH values below 6.8 and was not used for these samples due to the relatively high pH values.[3] We expected to see the phosphorus content decreasing with increasing depth in the bands without P deep fertilization. This assumption was confirmed by the soil samples taken (Table 9). Both in band 3 and band 5, where there was no deep fertilization, the 20-40cm composite sample had a lower P content than the 0-20cm composite sample. Thus, when the fertilizer is divided in half, the P gradient does not increase and, despite the deep fertilization, the P concentration at the surface remains higher. How the roots will react to the higher P concentration deep in the soil despite the constant gradient still needs to be investigated in more detail.

Table 9 Results of the soil samples.

Plot_band	Depth	Test figure	mg P/kg soil extracted	pH	Plant-available nutrients
Altkloster_band 3	0-20cm	22.1	3.4	7.5	Enriched
Altkloster_band 3	20-40cm	11.2	1.7	7.6	Provision
Altkloster_band 5	0-20cm	12.6	2.0	7.7	Provision
Altkloster_band 5	20-40cm	7.7	1.2	7.6	Sufficient

The impacts of deep loosening and deep fertilization on root phenology were quantitatively assessed using a conventional manual sample. The manual samples were taken in the middle of the field. This helped to avoid boundary effects and ensured that the optimum speed for primary soil tillage had already been reached at the sampling point.

[2] Richner, W., et al. "Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017)." Agrarforschung Schweiz 8.6 (2017): 47-66.

[3] Richner, W., et al. "Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017)." Agrarforschung Schweiz 8.6 (2017): 47-66.

Figure 64: Rapeseed roots and soil structure from the deeply loosened soil.

Figure 64 shows two manual samples of rapeseed plants from bands with deep loosening. Both plants from bands with deep loosening showed an unobstructed root, with one of the two roots kinked and not demonstrating straight downward growth. In the image on the left, a crumb structure can be identified up to the cultivation depth of the power harrow. In contrast, the large aggregates with a smooth surface deeper than 10cm indicate that the soil structure there is not ideal despite deep loosening. For the time being, no clear differences were found between roots in the band with and without deep fertilization. However, this manual sample was not a qualitative assessment and answers cannot be obtained conclusively using this method.

A further manual sample was taken in the area without deep loosening. Figure 64 shows a branched root from an area without deep loosening. The root of this plant was clearly shorter and more branched. Branching of the root starts at approx. 8-10cm, i.e. where the root leaves the power harrow horizon and meets the unloosened layer of soil.

Figure 65: Branched rapeseed root from area of the field without deep loosening.

Knowledge transfer

This trial aims to show how smart farming technologies can advance arable farming systems and how standard machinery can be used even more efficiently when extended. In addition, an alternative fertilizer strategy to conventional fertilization is to be tested under Swiss arable farming conditions. The experiences can be used to enhance consulting and training services. The background to the trial, its structure and the technology applied were presented by Nicolas Helmstetter at the Swiss Future Farm Day on 25 September 2020.

Conclusions

Deep loosening enabled the development of a strong tap root in rapeseed plants growing in this soil with severe structural damage. The extent to which deep loosening and deep fertilization impact yield and how the crops are faring in the spring of 2021 will be shown by the evaluation of the entire trial data after the 2021 harvest. The results of the completed trial will be published in the Annual Report 2021.

Involved partners

This trial was conducted by GVS Agrar AG at the Swiss Future Farm. Special thanks go to Raphael Bernet for his uncomplicated cooperation during the implementation of the trial and for procurement of the fertilizer and seeds. Many thanks also to the soil lab Arenenberg for analysing the soil samples.

2 Digital farm data management

2.1 Livestock operations

Establishing the barn network

The focus of farm data management at the Swiss Future Farm in 2020 was to renew the existing network infrastructure for livestock operations, thereby ensuring the systems for pig and dairy farming can be integrated into a common barn network.

This modification of the network infrastructure formed the basis for combining animal and milking data from the two barns "Tänikon Dairy Barn (MVS)" and "Waldegg Emission Trial Barn (EVS)" into one single program. Both barns are equipped with milking parlours from two milking technology companies, namely Lemmer-Fullwood (EVS) and GEA (MVS).

In the software provider Uniform Agri we have a partner who is able to ensure seamless integration between both systems. This integration should be completed by the end of Q1 2021 and will be a real advantage for the farm due to the fact that both animal and milk data can be managed from a central point for dairy farming. Further, the researchers at Agroscope Tänikon have direct access to the data from both barns.

Barto Active boxes

Barto ActiveDoc has been tested for livestock operations to gain an initial insight into how the feeding process in the dairy barn could be automated. ActiveDoc is a system designed for automated documentation. When using the app, a tractor or farm worker can be linked to an attachment (e.g. slurry tanker) via a Bluetooth-enabled beacon. As a result, the system automatically records which measure is being carried out. The system is currently optimized for documenting crop measures.

A simple initial test helped to clarify the following questions for the SFF:

- Is movement of the machine recorded correctly? Are the attachments (feed mixer) recognized?
- Can the barn be set up as a field and is it recognized accordingly when passing through it?

Figure 66: Recorded route of the MF5711 when travelling to and from the emission trial barn.

For the actual test, we installed a smartphone with the Barto ActiveApp on the MF5711 feeding tractor and powered it via USB charger. The attachments beacon was installed on the feed mixer (see Figure 67).

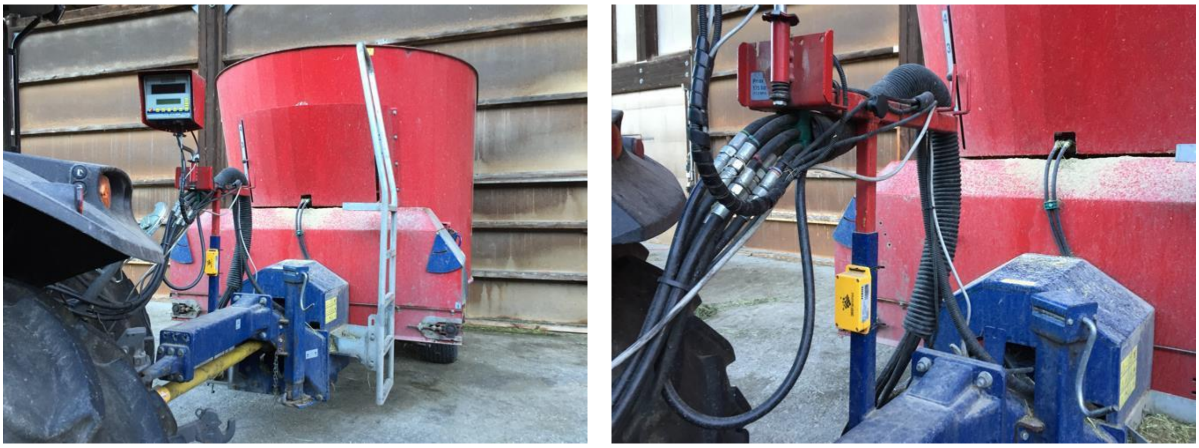

Figure 67: The attachments beacon also works perfectly in dusty environments.

The feed mixer was recognized by the smartphone in each case and the machine movement can also be correctly recorded by the system (see Figure 66). Moreover, movements were also recorded within the barns (Figure 68).

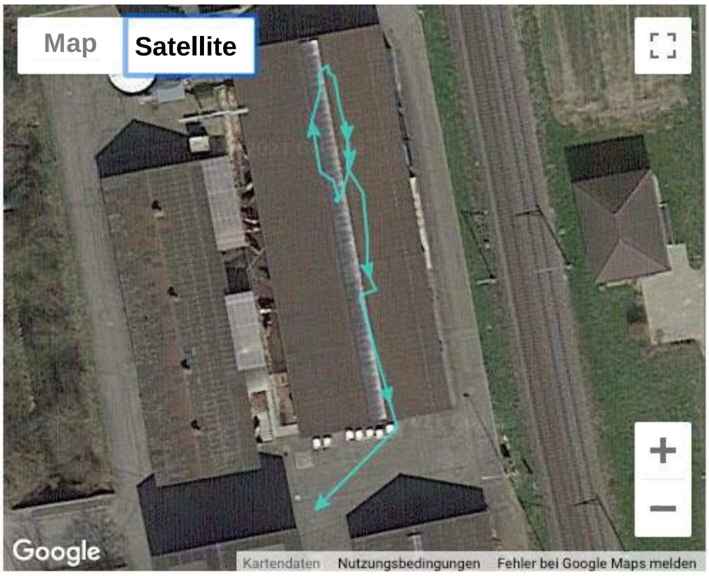

Figure 68: Movements of the feed mixer in the dairy barn.

For documentation purposes, the recorded values can be posted to different fields and barns (Figure 69).

12.08.	Siloking feed mixer	Dairy barn	08:40 - 08:56	00:05	00:11
12.08.	Siloking feed mixer	Yard	08:32 - 08:40	00:08	00:00

Figure 69: Field layout with working and idle periods.

2.2 Crop operations – Initial automation tests

For crop operations, initial tests were carried out for the automated collection of crop data using products of the German start-up Exatrek. Exatrek offers a telemetry box that retrieves telemetry data from tractors via the InCab socket and is linked to attachments via Bluetooth beacons. By combining these two data sets with the measured field boundaries stored in the Exatrek web app, measures carried out in the field can be automatically recorded and assigned to the respective plots. At the SFF, the tests were conducted with Exatrek for slurry spreading.

Figure 70: Automatically recorded slurry spreading on the Exatrek platform.

On the platform, the telemetry data is used to divide the working hours into various categories: working time, road travel, turning time and waiting time (see Figure 70). This also enables interesting automated calculations for farms regarding their utilization of tractors and attachments (see Figure 71).

Figure 71: Evaluation of slurry tank use during the test at SFF.

3 Public relations

3.1 Visitor program

Despite the Covid-related restrictions and imponderables, the 2020 public relations work at the SFF continued as much as possible. In the first few months of the year, before the outbreak of the pandemic, we welcomed participants to the AGM of **Swiss Beef Region East** and presented the results from trials at the SFF. We informed the **Seed Producers of Eastern Switzerland** about arable farming topics during their AGM at the SFF in Tänikon. Further, we welcomed pupils and student groups from **Plantahof** and the **Zurich University of Applied Sciences (ZHAW)**, as well as the **Laveba Cooperative**.

For the general public, we organized a **holiday program** at the SFF during two weeks of the summer in the cantons of Thurgau and Zurich, where, in a Covid-compliant and safe manner. Visitors could explore the Swiss Future Farm on their own and with the help of an exciting app-based rally. At various stations, the visitors were able to find out about roughage composition or Variable ate fertilizer application and solve tasks. The program attracted a broad, largely non-farming audience as well as numerous media representatives to the Swiss Future Farm.

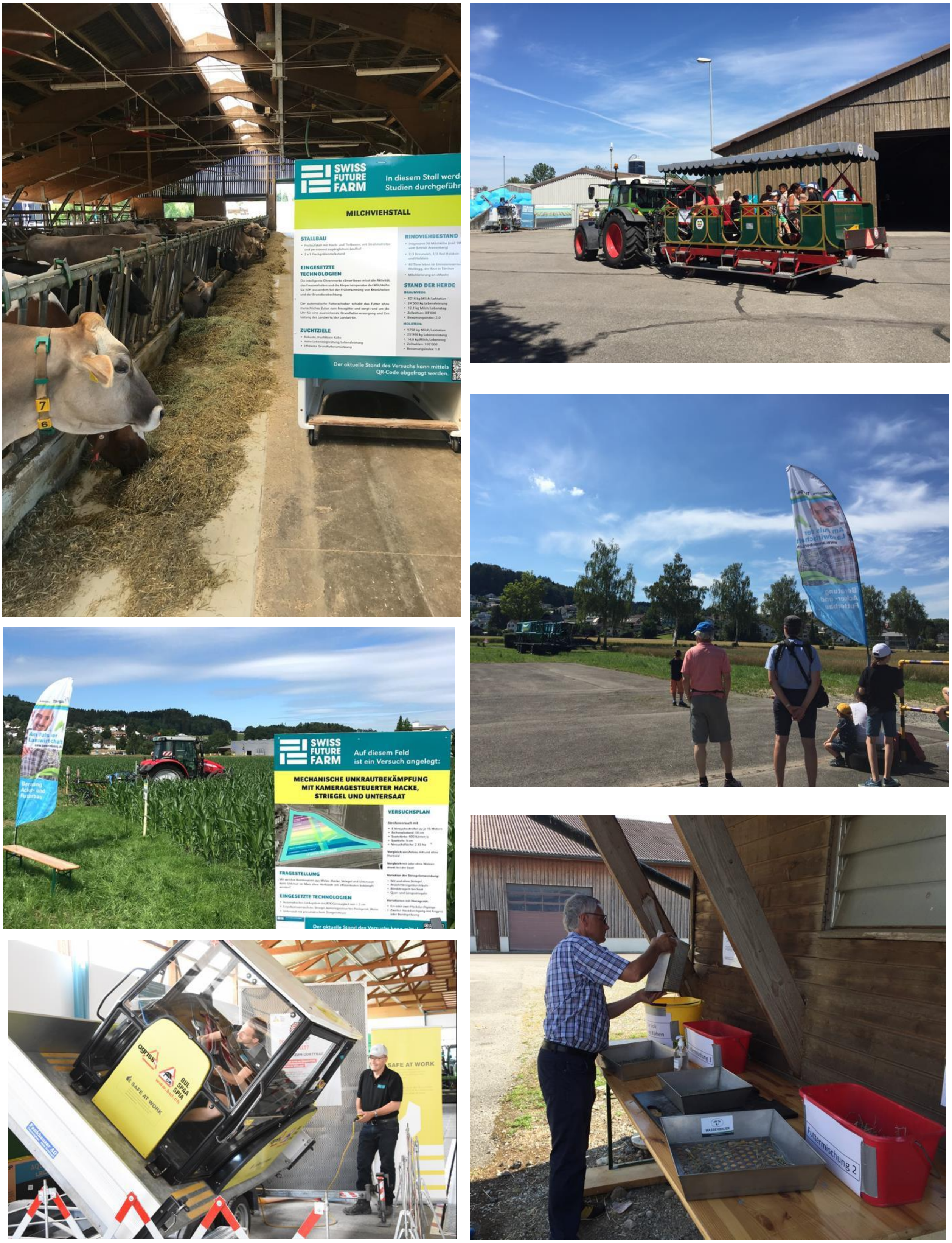

Figure 72: Images of the holiday program at SFF.

3.2 Swiss Future Farm Day 2020

The second Swiss Future Farm Day took place on September 20, 2020 and focused on arable farming. The 90 participants were introduced to the field trials set up at the SFF and the approach to working with a farm management information system (FMIS) at various field stations. The following arable farming and administrative topics were dealt with during the field trials and presentations:

- Various treatments for mechanical weed control in corn fields presented by Nils Zehner and Marco Meier
- Deep fertilization for rapeseed presented by Nicolas Helmstetter
- Comparison of varying plant protection treatments and new seed dressings for rapeseed plants as well as mechanical weed control for rapeseed plants presented by Raphael Bernet
- Working with farm management information systems presented by Florian Abt

The fascinating tour of the field trials concluded with lively discussions and a delicious lunch at the SFF premises. We would like to take this opportunity to again thank all of those who participated for their interest.

Figure 73: Images of the Swiss Future Farm Day 2020.

3.3 Innovation Forum Food Industry

The first edition of the Tänikon Innovation Forum Food Industry was held as a virtual event on November 27, 2020. Roughly one hundred participants discussed and shared their experiences of agri-food automation.

The Innovation Forum is organized by the Innovation Board Tänikon, which is made up of representatives from the Office for Secondary and Higher Education of the Canton of Thurgau, Agroscope Tänikon, OST – Eastern Switzerland University of Applied Sciences, the Swiss Future Farm, the Association of Thurgau Agriculture, the Thurgau Trade Association, the Thurgau Chamber of Industry and Commerce and the Food Industry Competence Network.

The objective of the annual innovation forum is to network researchers, entrepreneurs and agricultural producers along the entire value chain.

The next event is planned for Friday, 3 December 2021 as an attendance-based event in Tänikon.

Find more information on the following page:
https://innovationsforum-ernaehrungswirtschaft.tg.ch

3.4 External presentations by representatives of the Swiss Future Farm

The digitalization of agriculture and the related activities at the SFF continue to be a prominent driver of developments. Therefore, the members of the Swiss Future Farm operating team were also invited to speak at various events in 2020. The presentations at **Agrartag (Agriculture Day) in Donaueschingen** as well as at **Klimatagung (Climate Conference) Ebenrain**, at **Tänikoner Melktechniktagung (Tänikon Milking Technology Conference)**, at **Arbeitschwissenschaftlichen Kolloqium (Farm Work Science Colloquium, AKAL)** and at **Agrarökonomietagung (Agricultural Economics Conference)** took place in person. All other talks, for example at **Demeter-Klausur 2020**, at **SwissRe Life and Health Forum** or at **Digitalisierungstagung der Landwirtschaftskammer Niederösterreich (Digitalisation Conference of the Chamber of Agriculture of Lower Austria)**, were held online.

3.5 Swiss Crop Tour

The Swiss Crop Tour is an initiative of Swiss Future Farm to determine the benefits of Precision Farming technologies. Here, the possibilities for yield increase, potentials for savings and additional revenues through the application of new technologies in agriculture are investigated through field trials at the Swiss Future Farm and on commercial farms in the cantons of Schaffhausen and Thurgau.

The trials are carried out under local conditions and focus on agronomic benefits and on investigating the influence of machine settings on crop development and yield. The results are determined with the help of crop and yield measurements in order to be able to provide empirical values from practice for customer benefit determination under local conditions.

At the 2020 trial sites, the Swiss Future Farm and 7 commercial farms in the cantons of Schaffhausen and Thurgau, new planting technology solutions from Precision Planting were used to plant sugar beet and corn in order to determine the added value of this technology for crop production. The field trials, based on the concept of the international AGCO Crop Tour, were conducted in partnership with Arenenberg, GVS Agrar and interested farmers from the Schaffhausen/Thurgau region.

The procedure for conducting the Swiss Crop Tour is shown in Figure 74. The results of the field trials are made available to the interested public through field days and publications in the agricultural press.

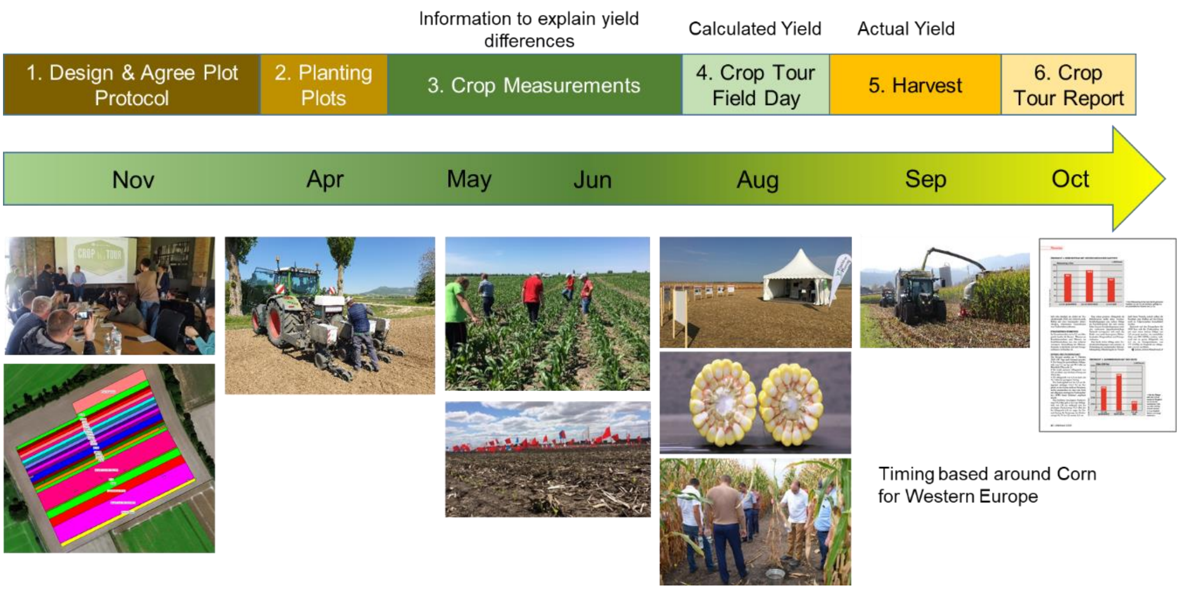

Figure 74: Procedure for the Swiss Crop Tour field trials.

4 Training and education

4.1 Knowledge transfer activities at Arenenberg

Field lessons with second and third-year students

The lessons for 104 second and third-year students were held outdoors at the Swiss Future Farm in Tänikon on September 22 and 24, 2020. At four teaching stations, the students were able to gain valuable insights into sustainable rapeseed cultivation, mechanical weed control for silage corn, how to calculate fertilizer applications and practical forage production. The practical lessons enabled the students to improve their skills in plant identification and field assessment, yield estimation and contribution margin calculation as well as rapeseed assessment and fertilizer management.

Figure 75: Images of the field lessons.

Smart Farming Module BF30 from 2021

The foundations were laid in 2020 for the first Smart Farming Module at the Swiss Farm Management School. In cooperation with the Strickhof farm and the Agricultural Centre in St. Gallen, a comprehensive module program has been developed, which will be taught for the first time in February 2021.

Intensive course of Gifted and Talented Education (BBF) of the canton of Thurgau

During the intensive course of BBF of the canton of Thurgau at the SFF in Tänikon, the participating 5th, 6th and 7th grade students were able to spend one afternoon discovering all there is to know about smart farming. The afternoon kicked off with a theoretical overview of «Digitalization in crop cultivation». This was followed by the students capturing field data using field survey equipment and a drone before analysing it in GIS. The recorded data was used by the students to generate a map, which they were then allowed to import at the tractor. The children were particularly enthralled by the tractor's automatic guidance system, which follows a predefined track exactly.

Figure 76: Activities during the intensive course of Gifted and Talented Education (BBF) of the canton of Thurgau.

Course on digital recording aids

We held a course on digital recording aids in agriculture at Arenenberg on February 06, 2020. The well-attended course saw participants learn how to export plot data from LAGIS and use it to get started in an FMIS. In addition to being provided with an overview of the possibilities, limits, opportunities and dangers of digital recording, the participants were able to gain initial experience in a selected FMIS under the watchful lead of the course instructor.

Digital technologies in agriculture (DiTeLa)

In order to integrate the topic of digital technologies in agriculture into the agricultural education system, the eBook «Digital Technologies in Agriculture – DiTeLa)» has been created as a modern, well-structured teaching aid featuring a multitude of images, short videos, illustrations and animated graphics. The teaching aid was developed with the participation of the SFF in 2020 and will be published in 2021 by the educational publisher for the vocational training of agriculture, dairy farming and horticulture students (edition-lmz AG).

Figure 77: View of the teaching aid «Digital Technologies in Agriculture».

5 Links

5.1 Websites

www.swissfuturefarm.ch

https://www.agcocorp.com

https://arenenberg.tg.ch

http://www.gvs-agrar.ch

https://www.fusesmartfarming.com/de

http://www.agrar-landtechnik.ch

https://www.precisionplanting.com

https://eu.precisionplanting.com

https://www.agroscope.admin.ch/agroscope/de/home/themen/wirtschaft-technik/smart-farming/swiss-future-farm.html

5.2 Social Media

https://www.facebook.com/swissfuturefarm

https://www.instagram.com/swissfuturefarm

https://www.youtube.com/channel/UCzsEm9mMLs0X_IT3MoaCJXQ

6 Credits

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