SWISS FUTURE FARM

Annual Review 2018

Thurgau
BBZ Arenenberg

AGCO
Your Agriculture Company

GVS Agrar

The Farm

The **Swiss Future Farm** is located south of Aadorf in the Canton of Thurgau and can be reached by car in 40 minutes from Zurich or St.Gallen.

Farm size and structure:
81 ha agricultural land
55 ha arable farming
20 ha grassland farming
6 ha biodiversity area

Livestock:
65 dairy cows
55 sows

The 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 on an agricultural enterprise
- Research and development results are applied in practical application
- Innovative cooperation between private agricultural enterprises and public education and consulting
- Tänikon as a meeting point for agriculture

The Partners

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

BBZ Arenenberg
Agricultural education and advisory centre of the Canton of Thurgau with three research and pilot farms.

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

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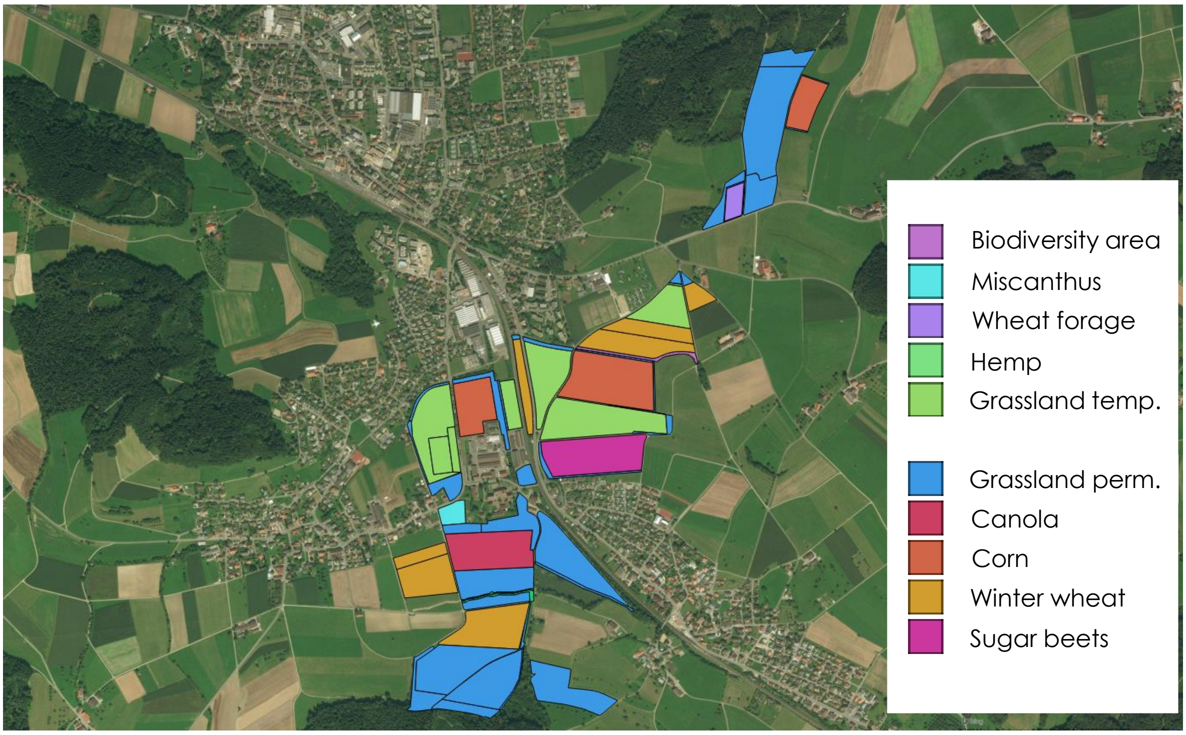
1. Harvest year 2018

1.1 Cropping plan



1.2 Overview of the year

2018 was the first full crop cycle season for Swiss Future Farm since the project was launched in autumn 2017. The year was characterised by extreme drought in the summer months, which was not devastating thanks to the heavy clay soils in Tänikon. The focus this year was on introduction and deployment of new agricultural technology. The complete machine park at the SFF was rebuilt. Tractors with guidance systems, camera-controlled hoeing equipment, application euipment with Section Control and Variable Rate Control as well as a modern grassland and harvesting fleet were introduced. In the field of planting technology, a prototype of the American company Precision Planting was put into operation. A further objective was to carry out first field trials to demonstrate the benefits of Precision Farming technologies. The first findings were already passed on in training courses in 2018. By September 2018, guided tours for more than 1000 people had already been conducted. The highlight of 2018 was the grand opening ceremony of the Swiss Future Farm with over 10,000 visitors from Switzerland and abroad.

2. Field trials

2.1 Investigation of the benefits of Precision Farming technologies

Objectives

In this field trial, the benefits of Precision Farming technologies (Auto Guidance and Section Control) with a focus on accuracy and crop development in winter wheat were investigated.

Trial design

The experimental setup in the Löhre Bach trial plot is shown in Figure 1. The plot covers a total area of 3.53 ha for the experiment. The southern part of the field with 1.97 ha was sown with Auto Guidance and Section Control, the northern part of the field with 1.56 ha was conventionally sown with track markers. For weed control, a chemical and a mechanical method were additionally compared in both subplots.

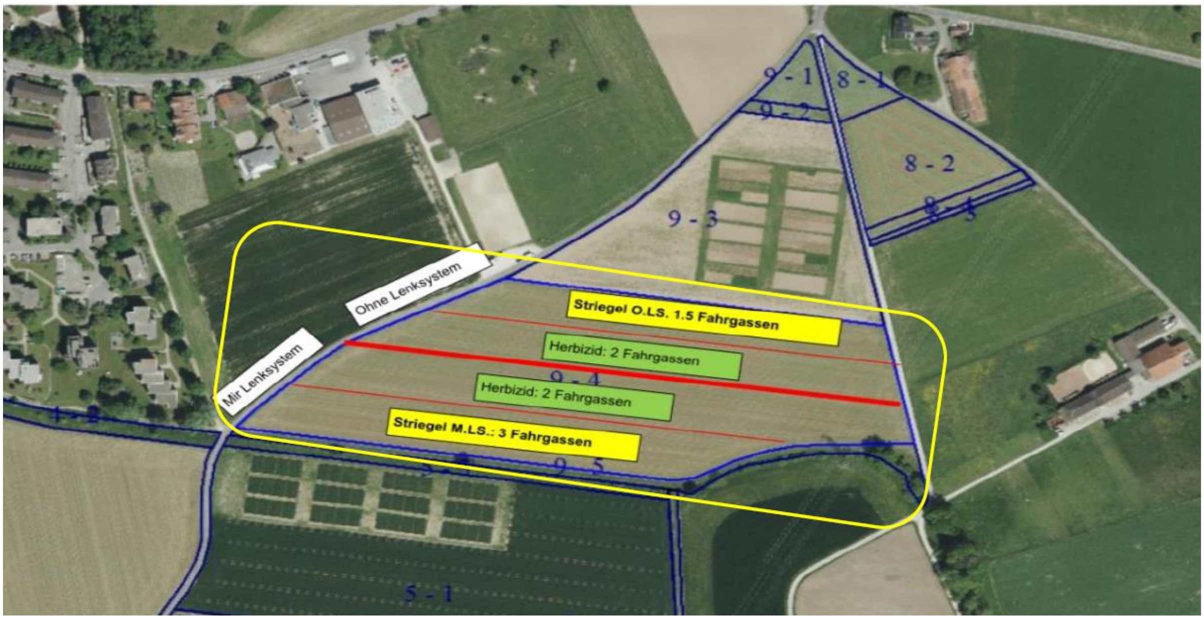


Figure 1. The trial plot Löhre Bach was divided. On the north side, field operations were conducted without Precision Farming technology. On the south side, Auto Guidance and Section Control were used.

Applied technology

Field operation	Machine	Brand	Model
Tillage	Tractor	Fendt	516 with RTK incl. front weight
	Cultivator	Horsch	Terrano 3 FX
Seeding	Tractor	Fendt	516 with RTK incl. front packer Rabe
	Seeder	Horsch	Express 3 KR
Fertilization	Fertilizer spreader	Sulky	Econov X40 (incl. Section Control)
Weed control	Sprayer	Fischer	Agri 3000, 15m
	Tractor	Fendt	313 with RTK
	Tine harrow	Treffler	TS 1520/H, 15m

Results

The tramline distances in the trial subplots that were worked with and without auto guidance were measured manually in the field and optically via drone image (cf. Figure 2). It can be seen that the target width of 12.45 m is achieved with an average deviation of 2.1 cm in the subplot operated with auto guidance. This accuracy is achieved due to seeding with RTK correction signal. On the subplot sown without auto guidance, the average deviation from the target width is around 62 cm. With the auto guidance system, it was thus possible to achieve a significantly higher precision in seeding.

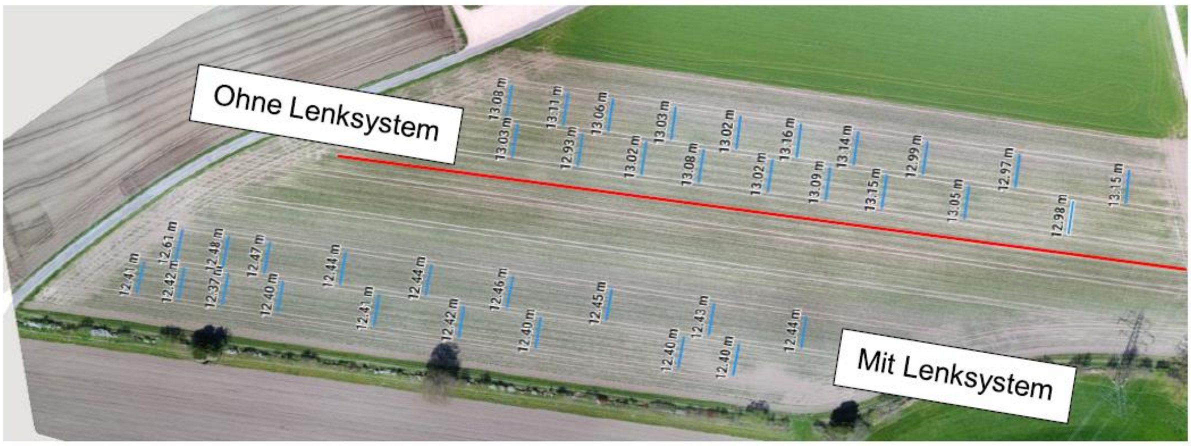


Figure 2. Measurement of the tramline distances on the field Löhre Bach via drone imagery. Date of recording: 19 April 2018.

No differences could be observed between the trial subplots in terms of stand density. Although the trial plot was not sown until the end of November, the target population density of 450-550 ears per m^2 could still be achieved (Table 1).

Table 1. Stand density (stalks per m^2 / ears per m^2) in the trial plot Löhre Bach

Trial subplot	Treatment	Ø-Stalks/m^2 1st Bonitation	Ø-Ears/m^2 2nd Bonitation
1-3	Tine harrow MS 1.5 tramlines	694	447
4-6	Herbicide MS 2 tramlines	607	449
7-9	Herbicide AG 2 tramlines	611	464
10-12	Tine harrow AG	603	486
	Ø-Tine harrow MS & AG	649	467
	Ø-Herbicide MS & AG	609	456
	Ø-MS Herbicide & Tine harrow	651	475
	Ø-AG Herbicide & Tine harrow	607	448

MS = manual steering, AG = auto guidance

Knowledge transfer

The results of the field trial to demonstrate the benefits of Precision Farming technologies were presented to a wide range of interested parties from agricultural practice, education and consulting during guided tours and workshops as part of the Swiss Future Farm's public relations work.

Outlook and next steps

This experiment will be continued in the coming years and future investigations will be carried out in particular with regard to economic efficiency.

Trial team

The pilot trial for the demonstration of benefits of Precision Farming technologies was planned and carried out by the Operating Team of the Swiss Future Farm.

2.2 Sugar beet planting with Precision Planting

Objectives of the 2018 sugar beet trial at the Swiss Future Farm

In the 2018 harvest year at the Swiss Future Farm, it was investigated how different down force settings for planting can affect the yield in sugar beets. In addition, the effects on the yield at different planting depths and planted populations were analyzed. A Precision Planting prototype planter with 3 m working width, 6 rows and 50 cm row spacing, equipped with DeltaForce, SpeedTube and SmartFirmer from Precision Planting, was used for this test field of the AGCO Crop Tour with sugar beets (Figure 3).

Figure 3. Precision Planting prototype planter during sugar beet planting at the Swiss Future Farm on 12 April 2018.

This planter uses a sensor unit which allows the down force to be adjusted to the current soil conditions during planting in order to ensure a consistent planting depth during each pass. On heavy or compacted soils, the down force is automatically increased individually for each row by the Precision Planting DeltaForce system, while the down force is reduced as soon as the planter is working in lighter soils. This ensures a consistent planting depth and results in an even field emergence without the risk of a compacted seed furrow due to excessive down force. At the Swiss Future Farm, this technology was tested under normal cultivation conditions and a strip trial (Table 2) was carried out on an experimental area of 0.7 hectares on the field Altkloster (sugar beet variety: Strube Strauss) to demonstrate the effects of different machine settings on sugar beet yield.

Table 2. AGCO Crop Tour sugar beet trial plot 2018 at the Swiss Future Farm - 1: automatic down force, 2: heavy down force, 3: light down force, 4: planting depth 1 cm, 5: planting depth 4 cm, 6: planting depth 6.5 cm, 7: planted population 150'000 seeds/ha. Planting date 12 April 2019.

		Down Force			Planting Depth			Population
Trail Plot ID		1	2	3	4	5	6	7
Machine		PP	PP	PP	PP	PP	PP	PP
Parcel Width	cm	300	300	300	300	300	300	550
Rows	n	6	6	6	6	6	6	11
Down Force	Setting	**Auto**	**Heavy**	**Light**	Auto	Auto	Auto	Auto
Down Force	KPa	Auto	2750	0	Auto	Auto	Auto	Auto
Planting Depth	cm	2.5	2.5	2.5	**1 cm**	**4 cm**	**6.5 cm**	2.5
Planting Depth	inch	1	1	1	0.5	1.5	2.5	1
Population	KS/ha	100	100	100	100	100	100	**150 KS/ha**
Driving Speed	km/h	8.5	8.5	8.5	8.5	8.5	8.5	**8.5**

Applied technology

Precision Planting technology has so far been used primarily in the USA, where large working widths are common. In 2018, Swiss Future Farm brought the individual components to Switzerland and adapted them to local requirements. A prototype planter with a working width of 3 meters was assembled exclusively for Swiss Future Farm at Agrar Landtechnik AG in Balterswil.

The following components represent the special features of Precision Planting technology:

- With the hydraulic "DeltaForce" down force control, the down force is automatically and individually adapted to the soil conditions for each row.
- With the "SpeedTube" seed placement system, this is not done in free fall, but directly into the seed furrow via a conveyor belt to enable precise seed spacing even at higher driving speeds.
- The "SmartFirmer" soil sensors measure soil moisture, soil temperature and organic matter in each row during planting.
- In the "20/20" monitor the machine settings can be adjusted and monitored during planting and documented in high resolution.

Timely planting and adequate planter settings for the respective soil conditions are a prerequisite for optimum yield. Working time, soil and resources are thus optimally used and the seed is precisely placed, with documentation via the monitor and an app being guaranteed.

Even field emergence with higher down force

Crop care was conducted uniformly for all 7 trial strips. The total amount of fertilizer was 86.4 kg N/ha. The planted population was 100,000 plants/ha for 6 trial strips. In addition, the planted population was increased to 150,000 plants/ha in an experimental approach for one trial strip. The experimental area is characterized by heavy soils with a high clay content. In the dry year 2018, rainfall was comparatively low at 793 mm/year, compared to the long-term average of 1184 mm/year.

Figure 4 shows the trial strip planted with a standard planting depth of 2.5 cm. In this trial strip, the down force was continuously measured and automatically adjusted by the DeltaForce system to ensure a consistent planting depth during the entire pass. It is clearly visible that very homogeneous beets have emerged here (field emergence 80.5%, measured with Precision Planting PogoStick).

Figure 5 shows the trial strip with 2.5 cm planting depth, but with heavy dow force. Here the down force was set to the maximum value of constant 2750 kPa. This trial strip also showed a very uniform emergence of the sugar beets (field emergence 88.5%, measured with Precision Planting PogoStick).

Figure 6 shows the third trial strip planted with minimum down force at a planting depth of 2.5 cm. The beets on this trial strip emerged strongly delayed and extremely sparse (field emergence 2.3%, measured with Precision Planting PogoStick), so that this trial strip was replanted at a later point in time with standard machine settings.

Figure 4.

Trial strip 1:

Automatic down force and 2.5 cm planting depth.

Figure 5.

Trial strip 2:

Maximum down force (2750 kPa) and 2.5 cm planting depth.

Figure 6.

Trial strip 3:

Strongly delayed and extremely sparse field emergence of sugar beets with minimum down force and 2.5 cm planting depth.

Effects of down force on yield

The yield measurements of the sugar beet trial plot were carried out separately for each trial strip. Each trial strip was harvested with a 6-row sugar beet harvester, loaded onto a trailer and weighed on a weighbridge. At the same time, 20 beets per trial strip were collected for analysis of the sugar content and sent to the laboratory (Figure 7). Beet contamination was generally low, but 7% soil residue was deducted from the measured fresh mass yield.

Figure 7. The trial strips are harvested and weighed separately. In this process, 20 beets per test strip are collected for laboratory analysis of the sugar content.

Figure 8 shows that the highest yield was obtained from the trial strip planted with maximum down force of 2750 kPa. Interestingly, no significant differences were found for field emergence in comparison to automatic down force. The exceptionally low rainfall in spring 2018 and a comparatively coarse seedbed favoured this down force setting. Consequently, the trial strip with maximum down force showed a higher yield compared to the trial strip with automatic down force setting, which was adjusted according to sensor measurements. This result is to be interpreted with caution, as too heavy down force under normal planting conditions with a crumby seedbed leads to compaction in the seed furrow and strongly impairs root development, which can lead to a significant drop in yield. We will therefore repeatedly evaluate this comparison of down force settings in the coming harvest years.

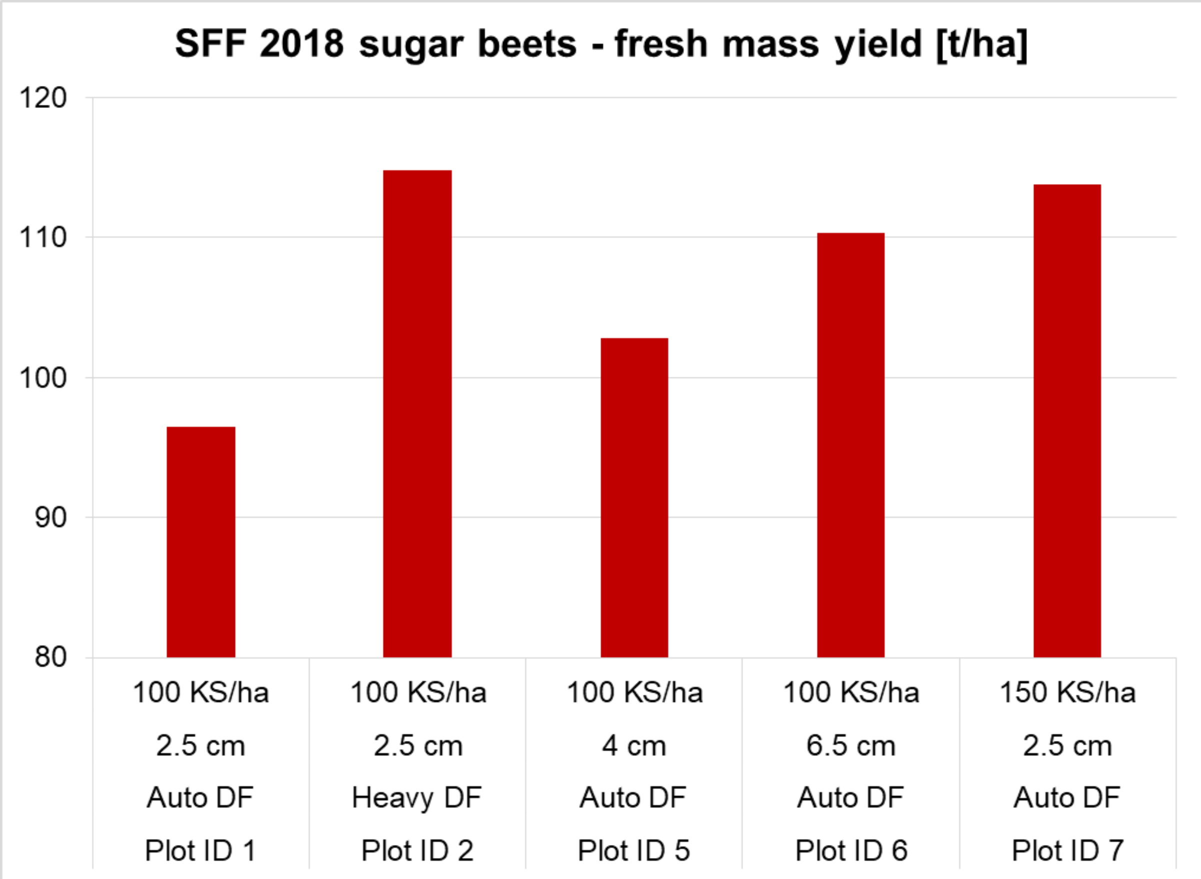


Figure 8. Fresh mass yield (t/ha) for the sugar beet trial strips on the Swiss Future Farm.

For the trial strips that were planted with minimum down force at 0 bar and a planting depth of 1 cm, due to insufficient field emergence, yield measurements were not possible. After strongly delayed and extremely sparse emergence, these trial strips were replanted later in the season with standard machine settings, so that the results are not comparable with the original trial strips and were excluded from further evaluation. Overall, despite the difficult growing conditions in 2018, good to very good yields were achieved on the sugar beet trial area of the Swiss Future Farm.

In the very dry year of 2018, the depper placement of sugar beet seed proved to be advantageous. When comparing the trial strips planted with automatic down force, higher yields were measured for both 4 cm and 6.5 cm planting depths than for the usual 2.5 cm planting depth.

Figure 9 shows hand-harvested sugar beets from the sugar beet trial plot 2018 at the Swiss Future Farm.

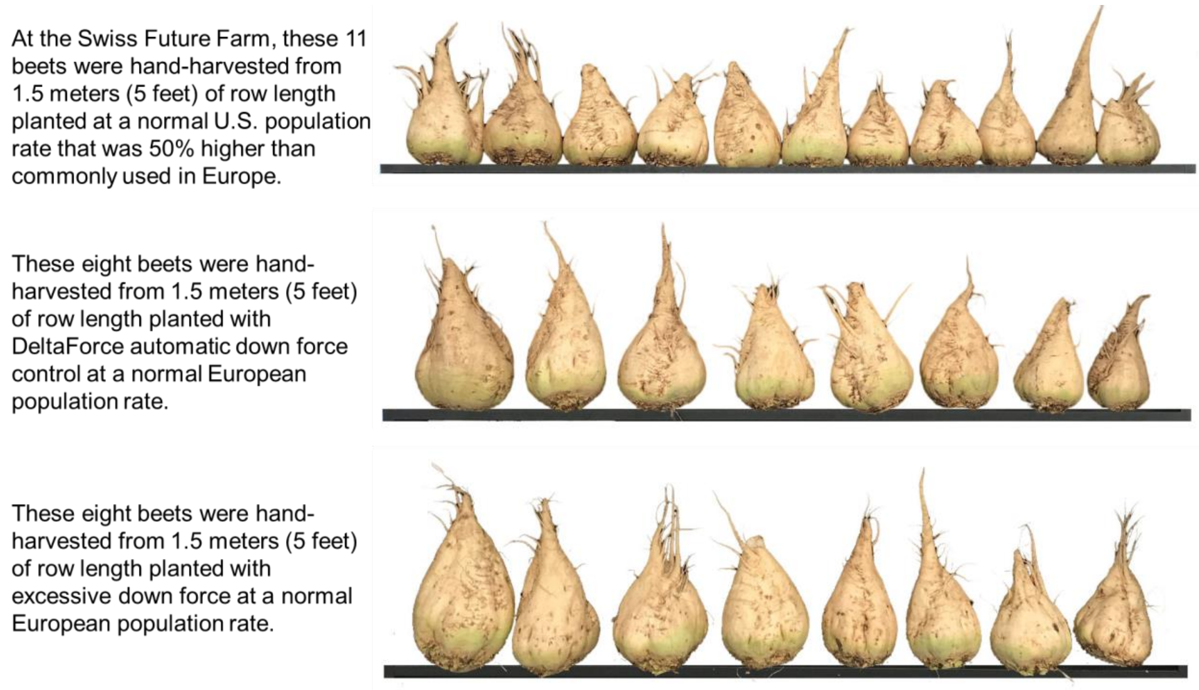


Figure 9. Hand-harvested sugar beets from three different trial strips at the Swiss Future Farm. Top – planted population 150,000 plants/ha, middle - automatic down force, bottom - maximum down force.

Analysis of sugar content

For the analysis of the sugar content, 20 beets were collected per trial strip at harvest time. The results for the sugar content of the beets from the various trial strips are shown in Figure 10. The highest sugar content was determined in beets planted at a planting depth of 4 cm, while the lowest sugar content was determined in beets from the trial strip with a planted population of 150,000 plants per hectare.

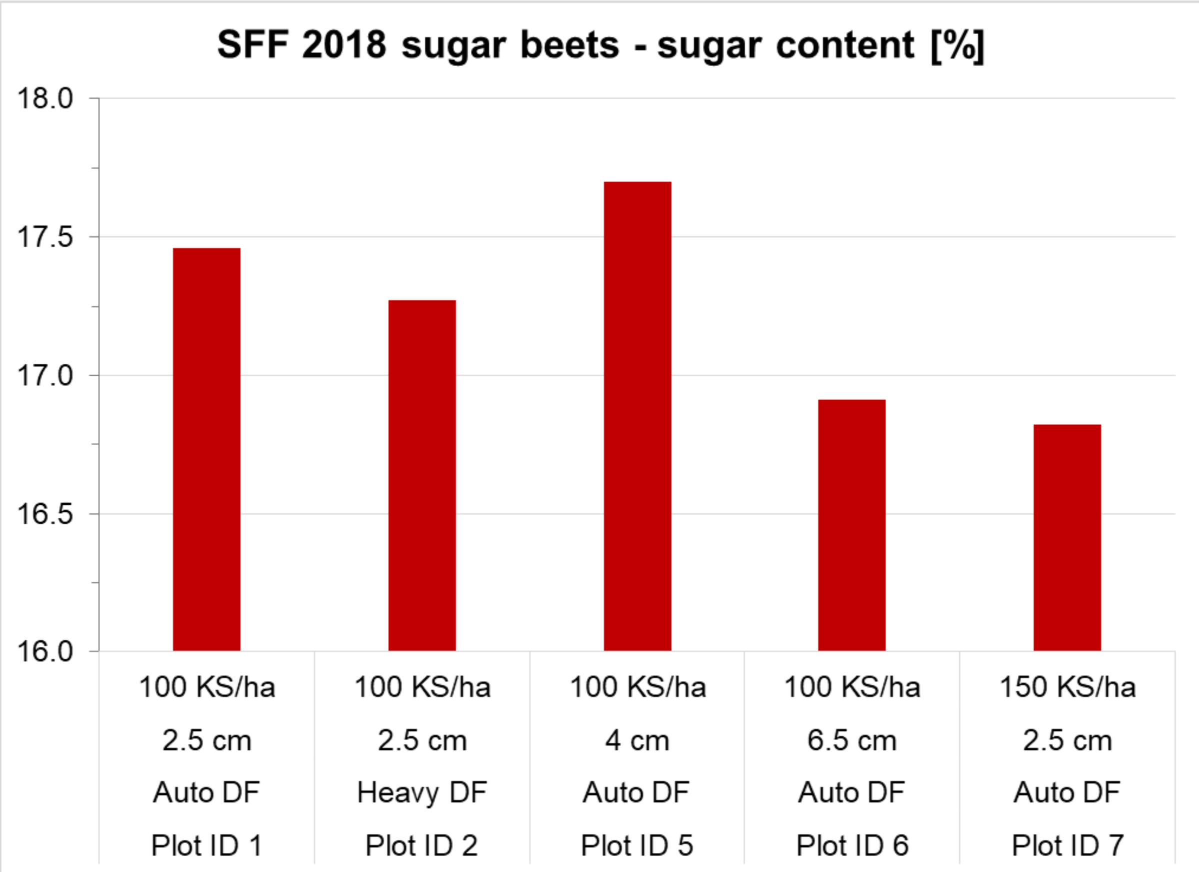


Figure 10. Sugar content (%) of the sugar beet trial strips at Swiss Future Farm.

Determination of sugar yield

The final evaluation of the yield from the sugar beet trial was carried out for the sugar yield as a product of the fresh mass yield and the sugar content. Figure 11 shows a comparison of the sugar yield in tonnes per hectare for the various trial strips.

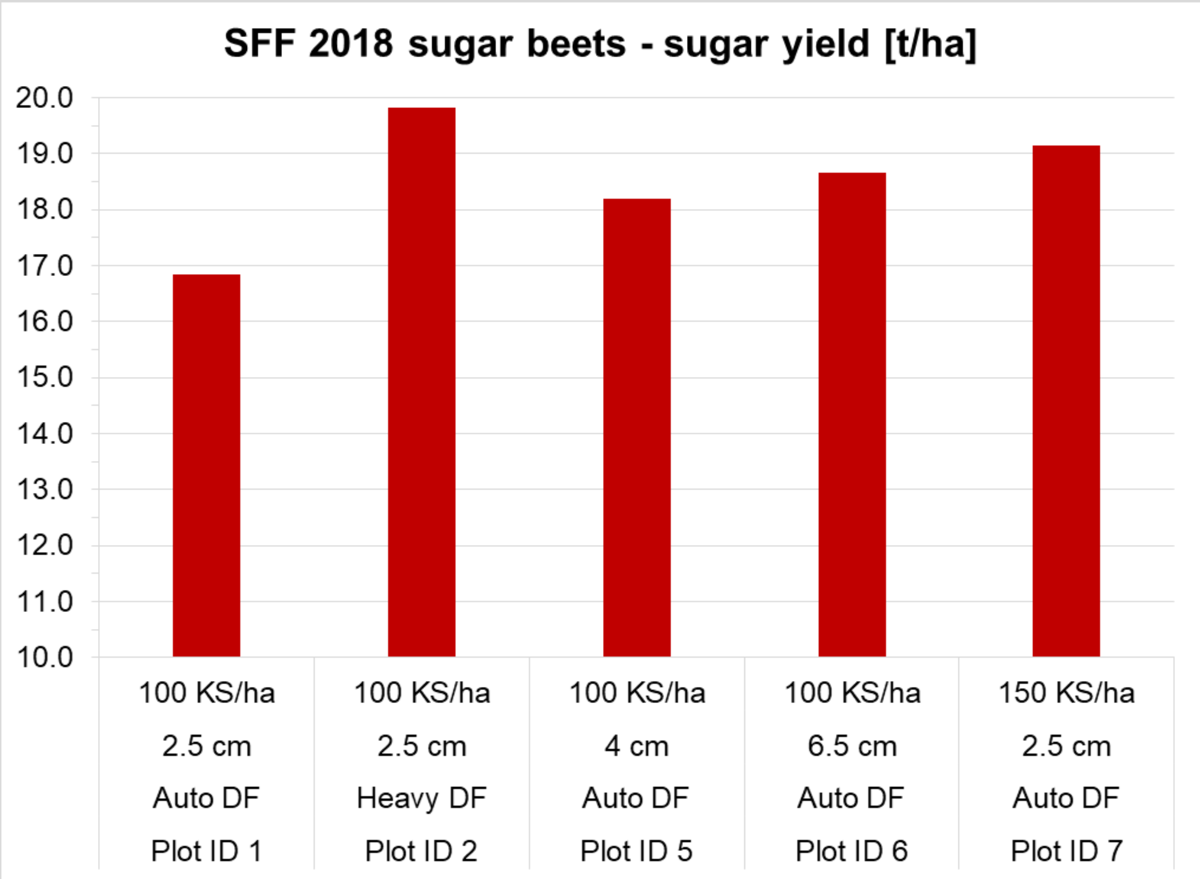


Figure 11. Sugar yield (t/ha) of the sugar beet trial strips on the Swiss Future Farm.

Down Force Study: The highest sugar yield under the experimental conditions in 2018 was obtained from beets planted with heavy down force and a planting depth of 2.5 cm (Figure 12). As already pointed out, this result must be interpreted with caution, as too heavy down force under normal conditions leads to compaction in the seed furrow and severely impairs root development. In this particular case, with a coarse seedbed with high clod content in the 2018 harvest year, heavy down force may have allowed closer soil contact of the seed, higher capillary action in the soil and therefore more uniform moisture in the furrow to enable beet emergence. However, in a well-prepared, crumby seedbed the higher down force may have negative effects.

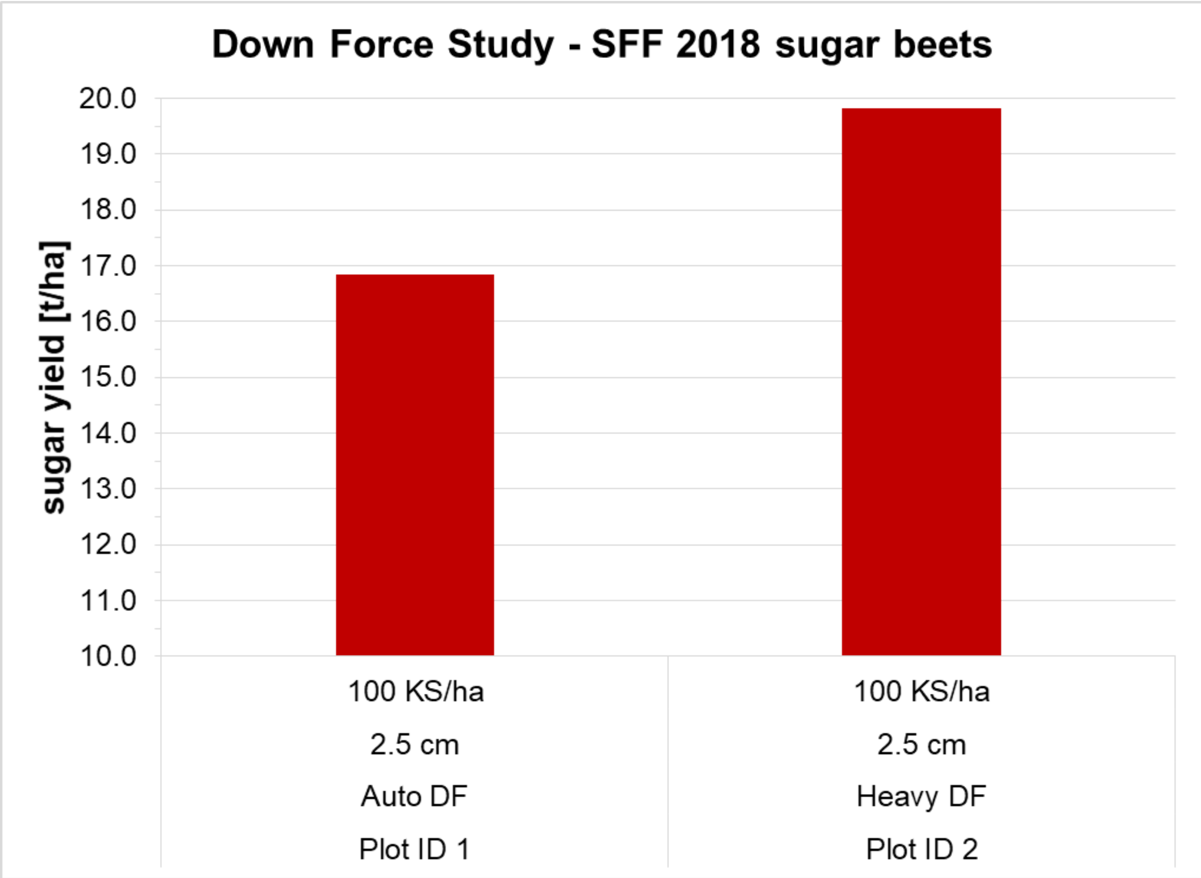


Figure 12. Down Force Study - sugar yield in t/ha. The sugar yield for the trial strip with heavy down force was higher, but this must be interpreted with caution as these results were obtained in a coarse seed bed with high clod content. Heavy or maximum down force has negative effects in a fine, crumby seedbed.

Planting Depth Study: Regarding the different planting depths, the results shown in Figure 13 show that in this dry year of 2018 the beets with a planting depth of 6.5 cm were placed closer to the moisture horizon and could accumulate more sugar than beets planted at the usual 2.5 cm planting depth for sugar beets. The increasing yield level with deeper planting depth shows that the moisture horizon was deeper under this year's conditions.

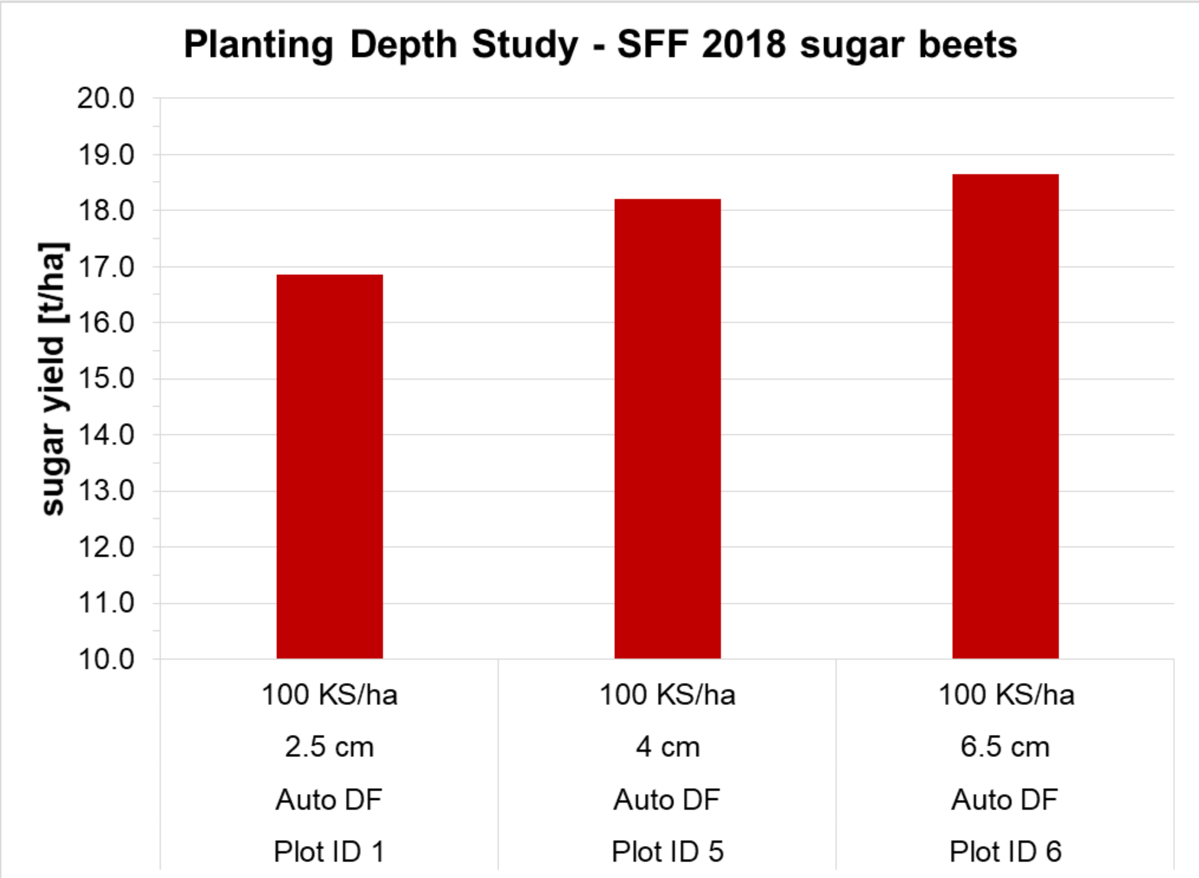


Figure 13. Planting Depth Study - sugar yield in t/ha. The sugar yield increased with deeper planting depth, which was closer to the moisture horizon.

Population Study: Our results show that a higher seed strength of 150,000 vs. 100,000 plants per hectare increases the sugar yield by 2.3 tonnes (sugar yield 19.1 vs. 16 tonnes/ha) (Figure 14). In our case, the revenue thus rose from CHF 6722 to CHF 7171 per hectare (+ CHF 449). The higher planted population of 150,000 plants/ha resulted in additional seed costs of CHF 152 (CHF 333 compared with CHF 485 for the different populations). This analysis shows an economic benefit of CHF 297 per hectare for the higher planted population of 150,000 beets per hectare.

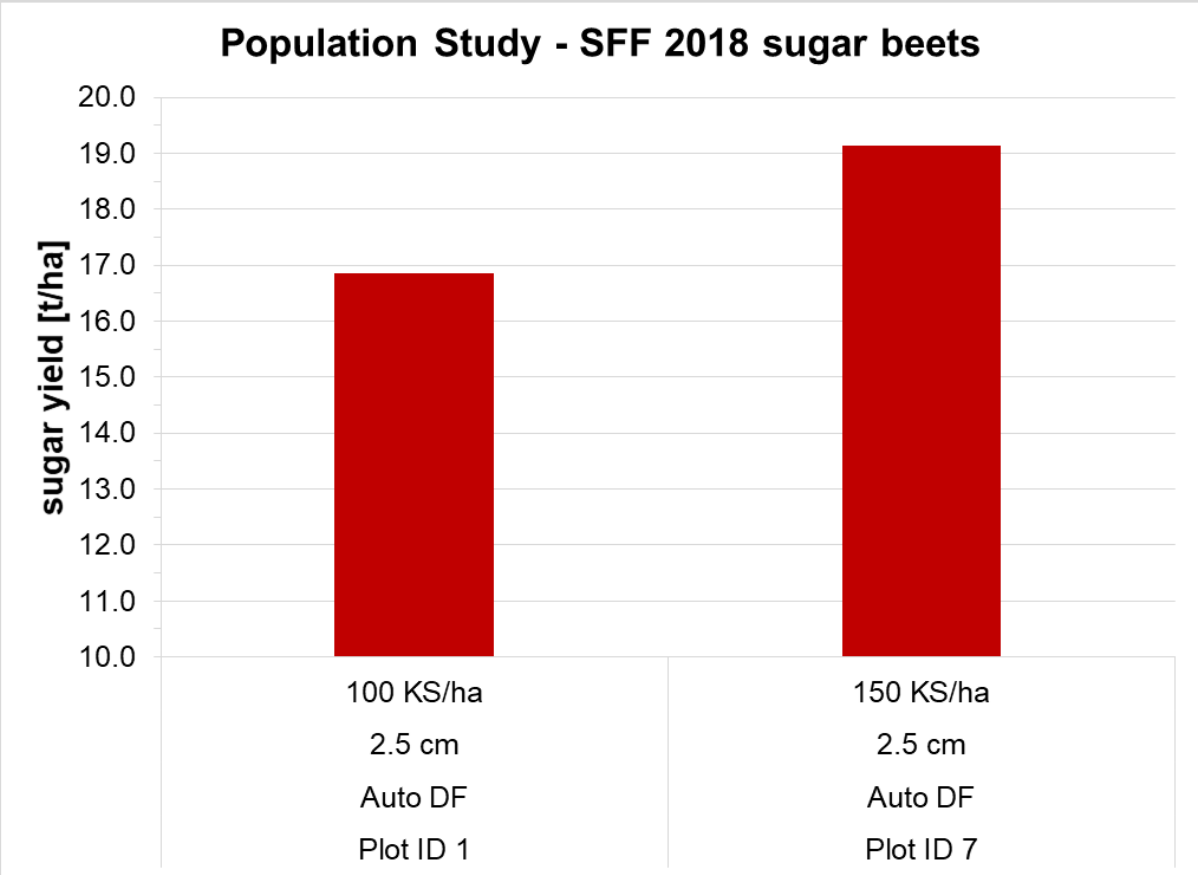


Figure 14. Population Study - sugar yield in t/ha. The sugar yield increased by 2.3 tonnes comparing planted populations of 100,000 vs. 150,000 plants per hectare.

Table 3 summarizes the yield data of the 2018 sugar beet trial on the Swiss Future Farm.

Table 3. Yield data of the 2018 sugar beet trial strips at the Swiss Future Farm.

Study	Down Force			Planting Depth			Population
Plot	1	2	3	4	5	6	7
Setting	Auto DF	Heavy DF	Light DF	1.0 cm	4.0 cm	6.5 cm	150 KS/ha
Fresh mass yield [t/ha]	97	115	NA	NA	103	110	114
Sugar content [%]	17.5	17.3	NA	NA	17.7	16.9	16.8
Sugar yield [t/ha]	16.8	19.8	NA	NA	18.2	18.7	19.1

NA = not analyzed

Knowledge transfer

The Precision Planting technology, which was used for the first time at the Swiss Future Farm, and the sugar beet trial were presented to numerous interested sugar beet growers at a dedicated Sugar Beet Field Day (Figure 15) and the official opening ceremony of the Swiss Future Farm. The results of the 2018 sugar beet trial were made available to the broad national and international public through press contributions and blog articles. The economic evaluation of the trial variants was carried out in cooperation with the team from the Agricultural Consultancy of the BBZ Arenenberg and the Swiss Sugar Beet Growing Centre (Schweizerische Fachstelle für Zuckerrüben-Anbau).

Figure 15. Impressions from the Sugar Beet Field Day on 4 May 2018 at the Swiss Future Farm.

The publications on the 2018 Swiss Future Farm sugar beet trial can be found under the following links:

- AGCO Blog Article Precision Planting Prototype Planter: https://blog.agcocorp.com/2018/07/precision-planting-testing-a-planter-prototype-on-swiss-future-farm/
- AGCO Blog Article Sugar Beet Trial Swiss Future Farm 2018: https://blog.agcocorp.com/2019/03/can-sugar-beet-yield-influenced-planter-force-planting-depth-planted-population/
- Report Sugar Beet Field Day Swiss Future Farm 2018 in Thurgauer Bauer: http://www.vtgl.ch/thurgauer-bauer/archiv/so-geht-zuckerruebenanbau-mit-den-reb-programmen-4112.html
- Trial Report Sugar Beet Trial 2018 on Swiss Future Farm Homepage: http://www.swissfuturefarm.ch/index.php/projekte/zusammenhang-zwischen-ertrag-und-schardruck
- Video Sugar Beet Field Day Swiss Future Farm 2018: https://www.youtube.com/watch?v=HhBy9iUNfAc

Outlook and next steps

In the 2019 harvest year, Swiss Future Farm will continue to investigate the effects of different down force settings and planting depths on sugar beet and corn. The trials will therefore be repeated on other trial plots in order to review the findings from this year's results. As a novel approach, we will investigate how liquid fertilization can strengthen sugar beet development in the juvenile stage.

Trial team

The Swiss Future Farm sugar beet trial 2018 with Precision Planting was carried out in cooperation between AGCO, GVS Agrar and BBZ Arenenberg. The fiedl trial was planned by the SFF Operating Team of Nils Zehner, Marco Landis and Florian Abt with the support of Jens Christian Jensen (AGCO Agronomy and Farm Solutions Team). Through the commitment of Darren Goebel (AGCO Agronomy and Farm Solutions Team), the components required to build the planter prototype were imported from the USA to Switzerland. Special thanks go to Ivo Fausch, Michael Stacher and Claudio Kern from Agrar Landtechnik AG in Balterswil TG for providing the workshop and energetic support in setting up the planter prototype. Special thanks also go to Andrew Feucht from the Precision Planting Headquarters in Tremont, Illinois, USA, under whose expert guidance and committed support the Precision Planting planter was assembled at Agrar Landtechnik in Balterswil and tested on the land of the Swiss Future Farm. The trial area was integrated into the 2018 sugar beet focus trial of the BBZ Arenenberg under the direction of Viktor Dubsky.

2.3 Precision Drilling of winter wheat

Objectives

Experiments on Precision Drilling in cereals with singulation of grains by the seed drill have shown in scientific and practical trial setups that the technology can achieve more uniform crops and higher yields with reduced seed rates. At the Swiss Future Farm in 2018, the first experiences with Precision Drilling were gathered and the advantages were practically demonstrated in a strip trial.

Trial design

The trial setup was carried out as a strip trial with a comparison of conventional seed drilling without singulation and Precision Drilling with singulation of grains, applying different seed rates on the Rüedimoos field of Swiss Future Farm. The individual experimental variants are shown in Table 4.

Table 4. Experimental variants of the strip trial on Precision Drilling of winter wheat at the Swiss Future Farm.

Strip width	**Technology**	**Seed rate**
6 m	Conventional Seed Drilling	92.4 kg/ha
6 m	Conventional Seed Drilling	50.4 kg/ha
3 m	Precision Drilling	220 seeds/m^2 (92.4 kg/ha)
6 m	Precision Drilling	170 seeds/m^2 (71.4 kg/ha)
6 m	Precision Drilling	120 seeds/m^2 (50.4 kg/ha)

The implementation on the Rüedimoos plot is shown in Figure 16. The trial was sown on 16 August 2018 with a trial strip width of three or two seed drill widths as part of the demonstration areas for the official opening of the Swiss Future Farm. The trial strips were sown with a precision air seeder and a conventional seed drill. Seed of the winter wheat variety Arnold with a thousand grain weight of 42 g was used.

Figure 16. Trial design in winter wheat with Conventional Seed Drilling strips (green), Precision Drilling strips (orange), and a buffer strip (yellow).

Applied technology

Horsch provided a Horsch Express KR with singulation units for implementation of this field trial (Figure 17). Grain singulation is carried out via special dosing discs (Funck dosing units) with pockets adapted to the seed (Figure 18). In order to ensure comparability of the different seeding technologies and seed rates, the use of calibrated seed is a prerequisite (Figure 19).

Figure 17.

Precision air seeder Horsch Express KR with singulation units above the sowing coulters

Figure 18.

Dosing disc (Funck dosing unit) for Precision Drilling of cereals

Figure 19.

Calibrated seed is a prerequisite for trouble-free seeding

Results

Field emergence: To determine the coefficient of variation of the field emergence, two evaluation areas of 1 m^2 each were selected on each of the trial strips and the distance between the plants within the rows within these areas was determined (Figure 20).

Figure 20. Field emergence of wheat sown with Precision Drilling and 120 seeds/m^2.

The sampling was carried out on 3 September 2018 and showed more favourable coefficients of variation for Precision Drilling because they were lower than for Conventional Seed Drilling (Table 5). It should be noted that the coefficient of variation refers to the distribution of the plants and not to the seed spacing accuracy.

Table 5. Coefficient of variation (CV) of the plant distribution on 1 m^2 area in comparison of Conventional Seed Drilling and Precision Drilling.

Seed rate	120 seeds/m^2, 50.4 kg/ha		220 seeds/m^2, 92.4 kg/ha	
Technology	Conv. Drilling	Precision Drilling	Conv. Drilling	Precision Drilling
CV	77	61	79	72

Tillering: During the bonitation on 9 October 2018 a number of 40 plants were exposed per trial strip and the parameters shown in Table 6 were determined.

Table 6. Results of the bonitation of tillering in winter wheat for the comparison of Conventional Seed Drilling and Precision Drilling.

		120 seeds/m², 50.4 kg/ha		220 seeds/m², 92.4 kg/ha	
		Conv.	**Precision**	**Conv.**	**Precision**
Leaf length	**[mm]**	545	511	563	574
Roots length	**[mm]**	71	73	58	64
Number of roots	**[n]**	14	16	12	15
Number of tillers	**[n]**	2.93	3.85	2.23	2.65
Plant weight	**[g]**	13.99	15.20	10.05	14.51

A graphical comparison of the bonitation results is shown in Figure 21 and Figure 22.

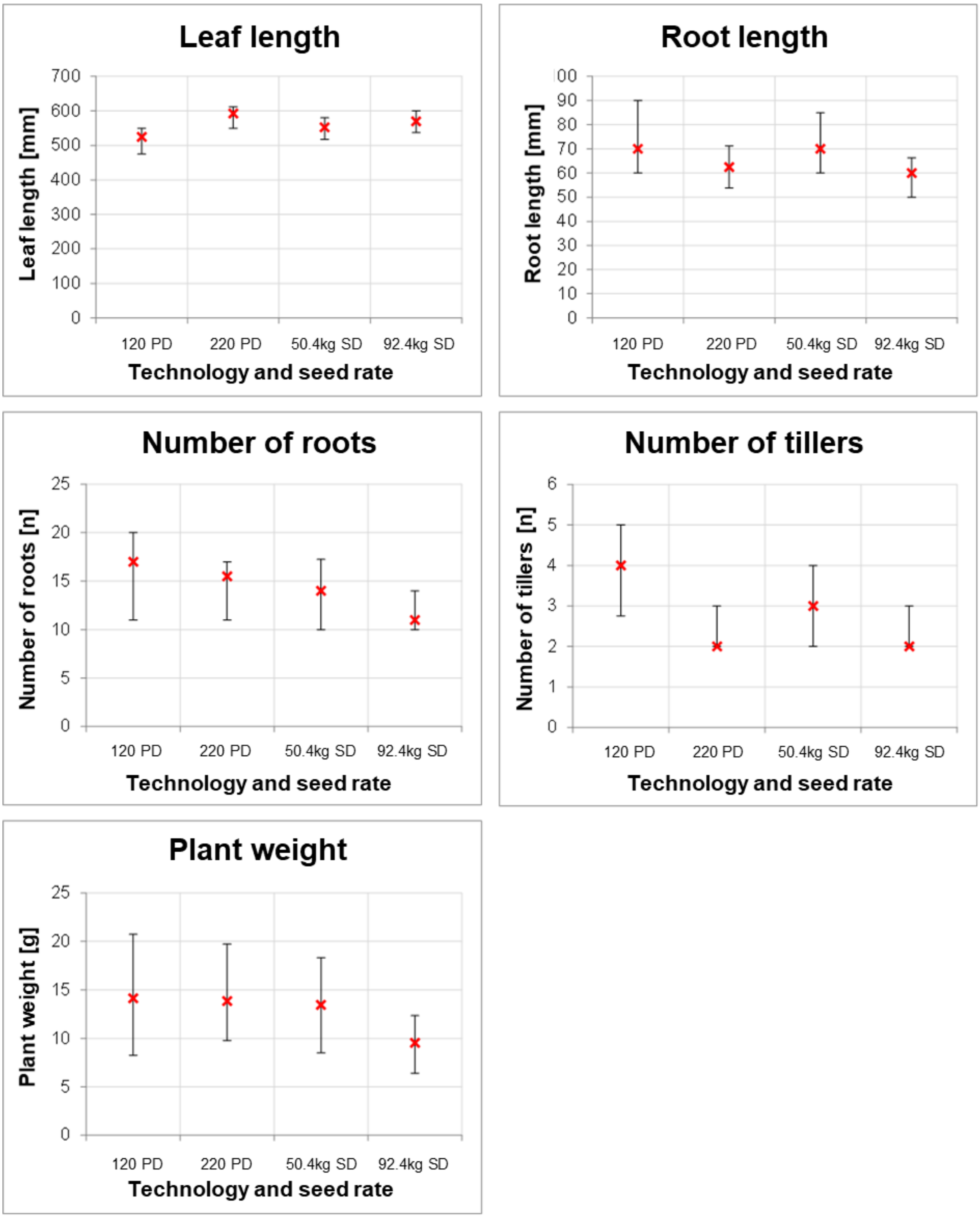


Figure 21. Results of the bonitation of winter wheat for the comparison of Precision Drilling (PD) and Conventional Seed Drilling (SD) with seed rates of 120 seeds/m^2, 50.4 kg/ha and 220 seeds/m^2, 92.4 kg/ha on the Swiss Future Farm 2018.

SD 50.4	PD 120	SD 92.4	PD 220

Figure 22. Comparison of the plant and root length in Conventional Seed Drilling (SD) and Precision Drilling (PD) trial plots with seed rates of 120 seeds/m^2, 50.4 kg/ha and 220 seeds/m^2, 92.4 kg/ha on the Swiss Future Farm 2018.

Knowledge transfer

The Precision Drilling technology for wheat was used for the first time at the Swiss Future Farm and the trial area were presented at the official opening in September 2018 and made accessible to the public. Impressions of the Precision Drilling application for wheat can be viewed in a video report under the following link: https://www.youtube.com/watch?v=_qrOGKgMhxQ

Outlook and next steps

Experiments on Precision Drilling in cereals and canola will be continued in the coming years and the comparison of Precision Drilling and conventional seed drilling will be examined more closely, particularly with regard to economic efficiency.

Trial team

Nicolas Helmstetter and Marco Landis from GVS Agrar initiated and supervised the test operation of the precision air seeder and the Precision Drilling trial in winter wheat on Swiss Future Farm. Andrea Schellenberg is cordially thanked for her support of the bonitations on the trial site.

2.4 Corn planting with Precision Planting

Objectives of the 2018 corn trial at the Swiss Future Farm

At the Swiss Future Farm, the Precision Planting prototype planter with a working width of 3 metres was once again used for planting the 2018 corn trial. This planter can optimize the seed spacing accuracy with innovative planting technology and thus contribute to improving yields.

In a comparative study, different machine settings were tested for planting 2.5 hectares of silage corn (KWS Karibous). The parameters down force, planting depth, and driving speed were varied in order to investigate the following practice-oriented questions regarding planting:

- How does down force influence the yield?
- How does planting depth influence the yield?
- How does the driving speed during planting influence the yield?

This machinery deployment as part of on-farm research represents an important contribution to the aims of the Swiss Future Farm: to test new technologies on site and to gain practical insights that can be made available to the public through the Swiss Future Farm visitor program and field events.

Trial design

The trial setup was carried out as a strip trial on the 2.5 hectare Scheuerbünt field of Swiss Future Farm. This plot is characterized by majorly homogeneous soil conditions. The down force settings, planting depth, and driving speed during planting were varied for the different trial strips with a width of 6 metres (Table 7). A partial area of 0.8 hectares was previously used as a setup and testing area for the planter, which was used for the first time for planting corn, and was not used for later evaluation. The planting date was 11 May 2018 with a planted population of 90'000 seeds per hectare. Crop care was conducted uniformly for the entire trial area in order to ensure comparability of the trial strips. The total amount of fertiliser was 122 kg N/ha.

Table 7. AGCO Crop Tour corn trial plot 2018 at the Swiss Future Farm: Trial strips 1-3 down force, 4-7 planting depth, 8-10 driving speed. Planted population 90'000 seeds per hectare. Planting date 11 May 2018.

		Down Force			Planting Depth				Driving Speed		
Trial Plot ID		1	2	3	4	5	6	7	8	9	10
Planter		PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Parcel Width	cm	600	600	600	600	600	600	600	600	600	600
Rows	n	8	8	8	8	8	8	8	8	8	8
Down Force	Mode	**Auto**	**Auto**	**Auto**	Auto	Auto	Auto	Auto	Auto	Auto	Auto
Down Force	kg	**45**	**70**	**25**	45	45	45	45	45	45	45
Planting Depth	cm	5	5	5	**2.5 cm**	**5 cm**	**7.5 cm**	**9 cm**	5	5	5
Planting Depth	inch	2	2	2	1	2	3	3.5	2	2	2
Population	KS/ha	90	90	90	90	90	90	90	90	90	90
Driving Speed	km/h	10	10	10	10	10	10	10	**8 km/h**	**15 km/h**	**10 km/h**

Applied technology

Precision Planting technology has so far been used primarily in the USA, where large working widths are common. In 2018, Swiss Future Farm brought the individual components to Switzerland and adapted them to local requirements. A prototype planter with a working width of 3 meters was assembled exclusively for Swiss Future Farm at Agrar Landtechnik AG in Balterswil.

The following components represent the special features of Precision Planting technology:

- With the hydraulic "DeltaForce" down force control, the down force is automatically and individually adapted to the soil conditions for each row.
- With the "SpeedTube" seed placement system, this is not done in free fall, but directly into the seed furrow via a conveyor belt to enable precise seed spacing even at higher driving speeds.
- The "SmartFirmer" soil sensors measure soil moisture, soil temperature and organic matter in each row during planting.
- In the "20/20" monitor the machine settings can be adjusted and monitored during planting and documented in high resolution.

Timely planting and adequate planter settings for the respective soil conditions are a prerequisite for optimum yield. Working time, soil and resources are thus optimally used and the seed is precisely placed, with documentation via the monitor and an app being guaranteed.

When planting the corn trial area on the Swiss Future Farm, the automatic, row-individual down force control system "DeltaForce" from Precision Planting was used for all trial strips. In contrast to the conventional, mechanical down force setting, this technology is intended to prevent soil compaction by the gauge wheels and the resulting impairments of root development and yield reductions (Figure 23).

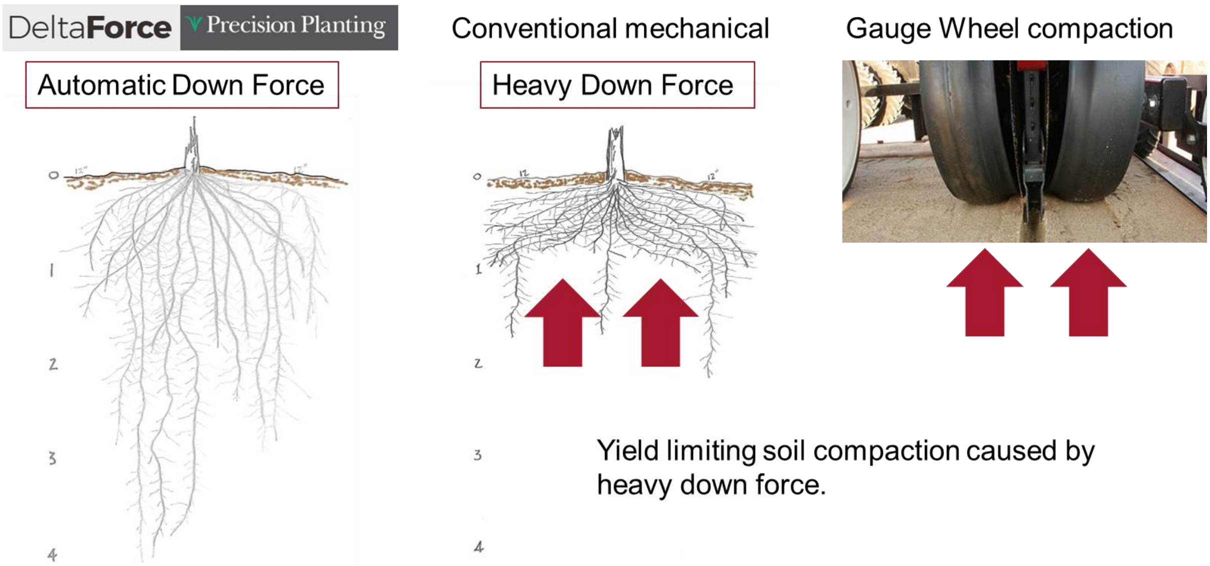


Figure 23. Comparison of the expected root development in corn using automatic down force control and conventional, mechanical down force adjustment.

The Precision Planting 20/20 monitor was also used in conjunction with the Climate FieldView app for automatic real-time documentation of machine performance during planting (Figure 24).

Figure 24: Documentation of planter performance with 20/20 monitor and Climate FieldView app.

In order to validate the performance and resolution accuracy of the automatic documentation, a compaction strip was created for experimental purposes across all trial strips of the trial plot using a tractor with row crop tyres. The sensor-based down force and soil penetration resistance measurement of the DeltaForce system enabled the compaction strip to be correctly located, as a loss of ground contact of the planter row units was registered in the compaction strip (Figure 25).

Figure 25. Down force measurement with Precision Planting DeltaForce and visualization in the Climate FieldView app with clearly recognizable compaction strip (blue) on the trial plot.

The Precision Planting PogoStick was used for the bonitation of the trial plot. A measuring tape in combination with an iPad enables the digital recording of plant distances and growth stages and an app evaluates and visualizes the measured data (Figure 26).

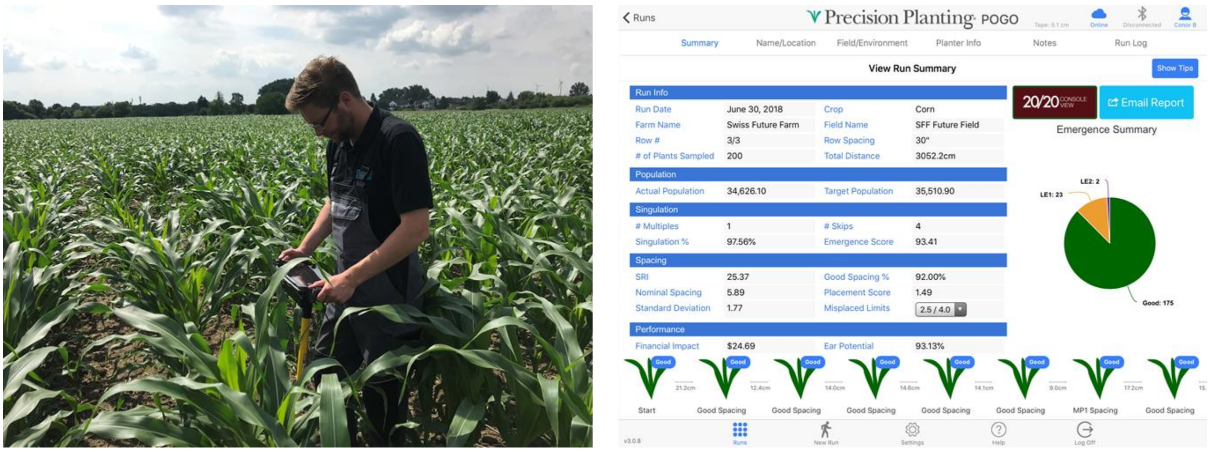


Figure 26. Measurement of seed spacing accuracy and growth stage in corn using the Precision Planting PogoStick and ResearchPogo app.

Results

Based on the automatic documentation of the planter performance, the parameters shown in Table 8 were measured on a planted trial area of 1.7 hectares and 89,512 effectively planted seeds per hectare. This confirms the very good performance of the Precision Planting planter in seed singulation and spacing accuracy. For the down force measurement, the proportion of loss of ground contact on the trial area is due to the compaction strip that in an experimental approach was created across all trial strips in order to validate the measurements.

Table 8. Planter performance for the corn trial area on the Swiss Future Farm.

Planter Performance			Down Force		
Correct Singulation	Good Spacing	Good Ride	Loss Ground Contact	Good Down Force	Excess Compaction
99.3%	98.8%	94.7%	4.1%	95.2%	0.6%

For yield measurement, the trial strips were harvested separately with the Fendt Katana forage harvester and the fresh mass was weighed on a weighbridge. Based on the subsequent determination of the dry matter content of the crop, the dry matter yield of the silage corn could be determined. At the harvest date on 26 September 2018, the dry matter content was 46.3%, which was due to the exceptional drought in 2018. Overall, despite the difficult growing conditions in 2018, good to very good yields were achieved on the corn trial area of the Swiss Future Farm (Table 9).

Table 9. Dry matter yields (t/ha) of the corn trial strips 2018 at the Swiss Future Farm.

Study	Down Force			Planting Depth				Driving Speed		
Plot	1	2	3	4	5	6	7	8	9	10
Setting	Auto 45 kg	Auto 70 kg	Auto 25 kg	2.5 cm	5 cm	7.5 cm	9 cm	8 km/h	15 km/h	10 km/h
Dry matter yield [t/ha]	18.3	17.9	16.2	16.9	19.2	15.2	19.4	19.2	19.0	19.6

A graphical comparison of dry matter yields across all trial strips is shown in Figure 27.

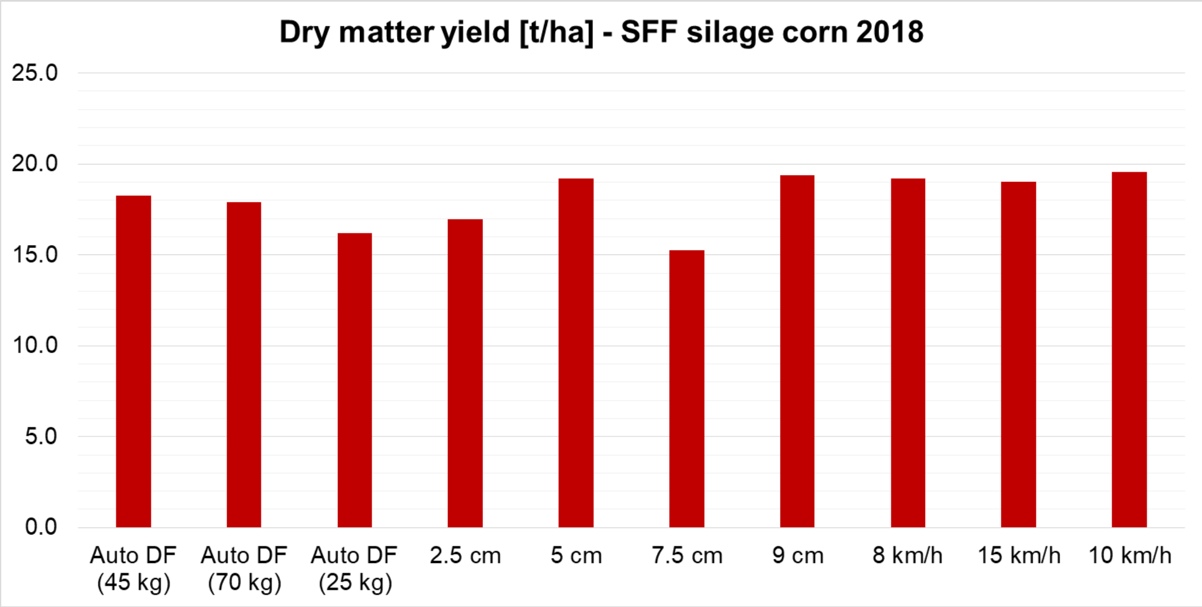


Figure 27. Dry matter yields (t/ha) of the silage corn trial strips 2018 at the Swiss Future Farm.

Down Force Study: A comparison of the down force settings in Figure 28 revealed the highest yield (18.3 t/ha dry matter) for the trial strip, which was planted with an automatically adjusted down force target value of 45 kg. With a higher down force target setting of 70 kg (17.9 t/ha) and a lower down force target setting of 23 kg (16.2 t/ha) only lower yields could be achieved, which means a difference of -0.4 t/ha and -2.1 t/ha respectively. It can be seen here that the down force target of 45 kg used as the standard setting for the Precision Planting DeltaForce system was the most suitable setting under the soil conditions of the trial area for the automatic row-individual down force adjustment.

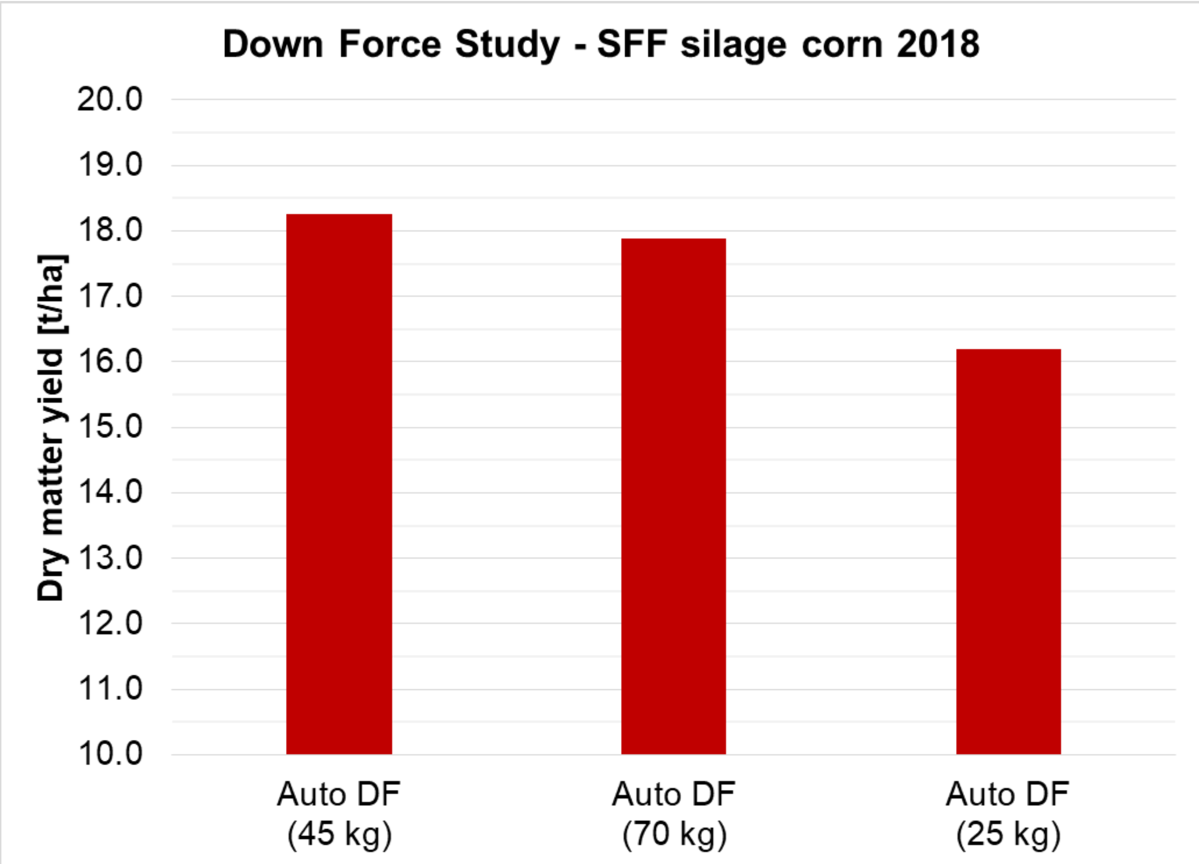


Figure 28. Down Force Study – Dry matter yield in t/ha. The automatic DeltaForce setting with 45 kg down force target value delivered the highest yield in comparison with higher and lower down force settings.

Planting Depth Study: The comparison of the planting depths in Figure 29 shows that with planting depths of 5 cm (19.2 t/ha) and 9 cm (19.4 t/ha) significantly higher yields could be achieved than with shallow placement of the seed at a depth of 2.5 cm (16.9 t/ha). This shows that deeper planting depth and thus better connection to the moisture horizon was an advantage in the drought year 2018. The improved and more continuous availability of water and nutrients enabled these crops to achieve the highest yields within this comparison. The lowest yield at a planting depth of 7.5 cm cannot be clearly explained.

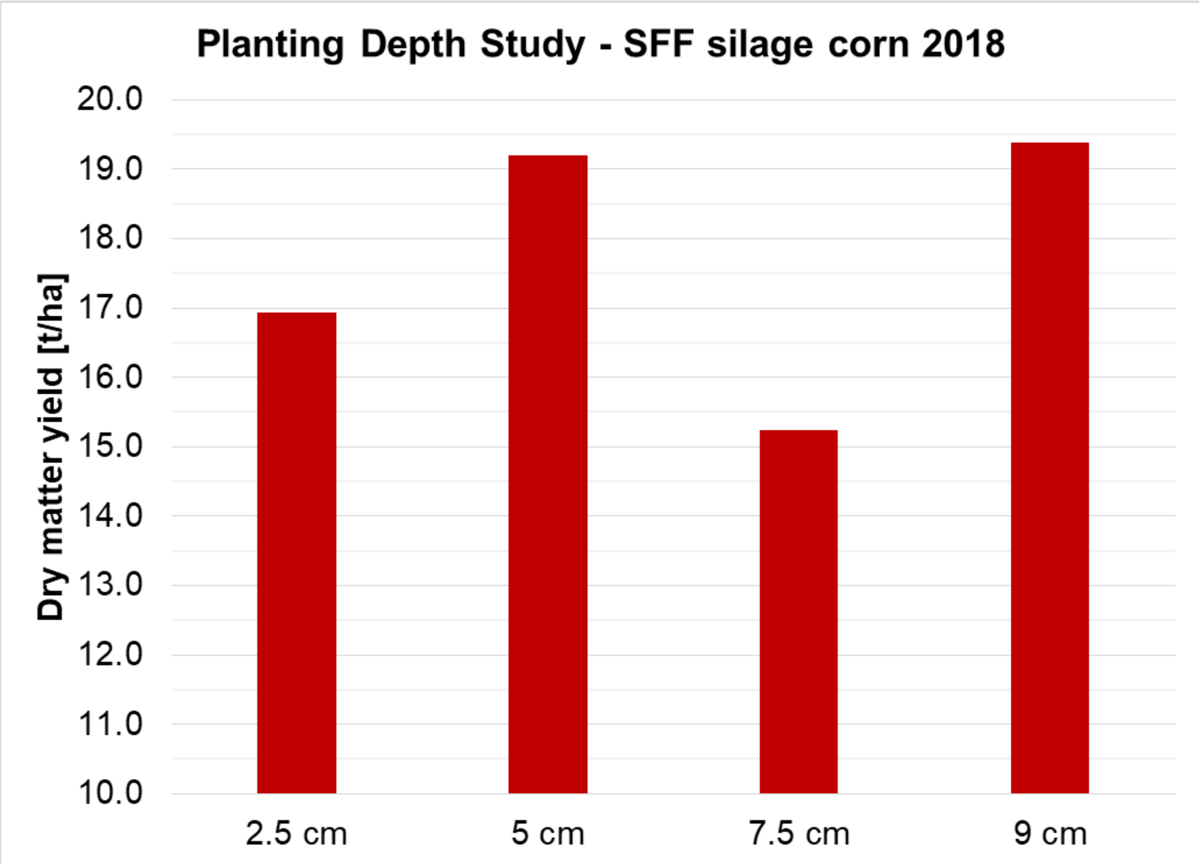


Figure 29. Planting Depth Study – Dry matter yield in t/ha. The yield increased with increasing planting depth, which was closer to the moisture horizon. It is not possible to clearly explain the deviating result at a planting depth of 7.5 cm on this trial plot.

Driving Speed Study: No significant differences in yield could be observed in the trial strips planted at different driving speeds (Figure 30). The highest yield (19.6 t/ha) could be determined on the trial strip planted at 10 km/h, which corresponds to the standard driving speed with the Precision Planting prototype planter when planting corn. However, the yield difference to the test strips with driving speeds of 8 km/h (19.2 t/ha) and 15 km/h (19.0 t/ha), respectively, was not clearly distinct. This shows that with Precision Planting technology, good to very good yields can be achieved even at higher working speeds with increasing area efficiency during planting.

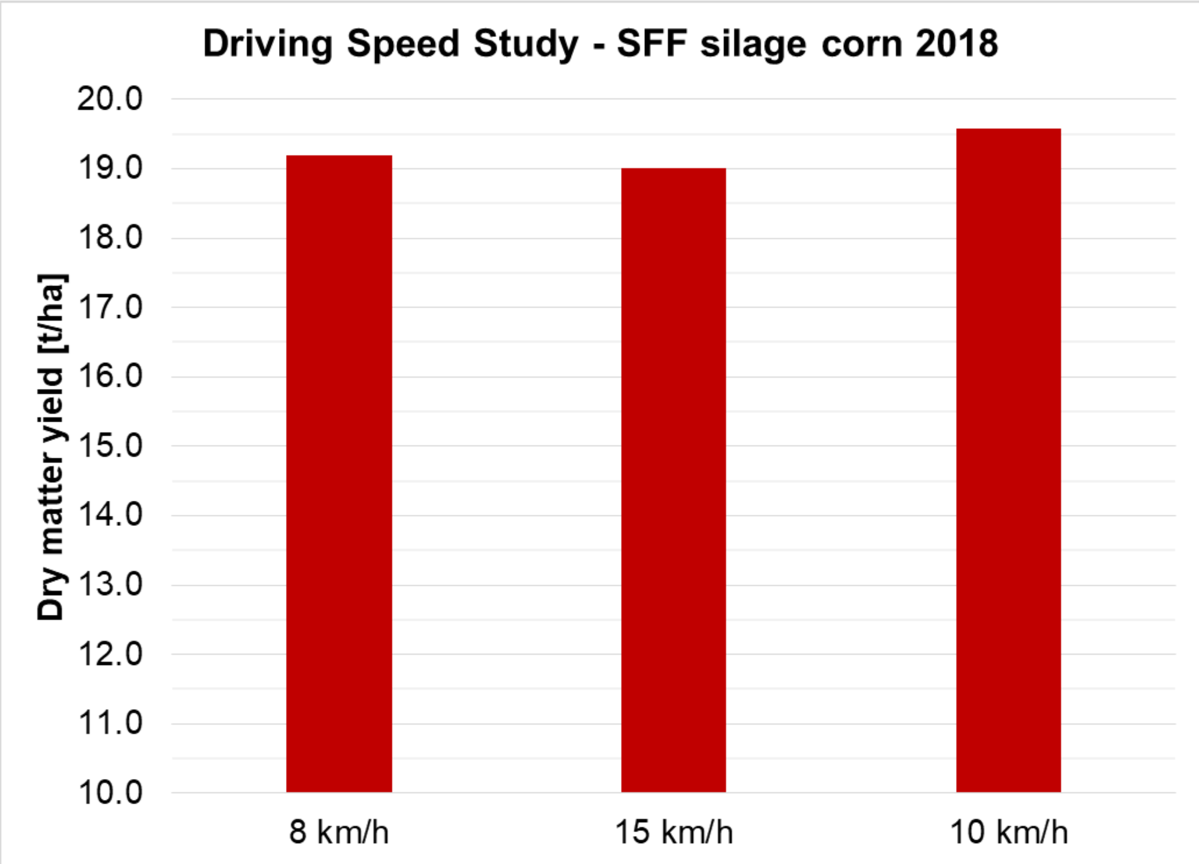


Figure 30. Driving Speed Study – Dry matter yield in t/ha. There are no significant differences in yield when planting at 8 km/h, 10 km/h and 15 km/h.

Knowledge transfer

The Precision Planting technology, which was used for the first time at the Swiss Future Farm, and the silage corn trial area were presented to numerous interested parties from agricultural practice, science, consulting and the ag business as part of the visitor programme and the official opening of the Swiss Future Farm (Figure 31). The results of the silage corn trial were made available to the general national and international public through handouts and video reports.

Figure 31. Impressions from the presentation of the silage corn trial area during the official opening of the Swiss Future Farm from 21 to 23 September 2018.

The publications can be viewed under the following links:

- Video Precision Planting Technology Swiss Future Farm:
  https://www.youtube.com/watch?v=HhBy9iUNfAc
- Video Corn Trial 2018 Swiss Future Farm:
  https://www.youtube.com/watch?v=_qrOGKgMhxQ
- Fendt TV Swiss Future Farm Opening:
  https://www.youtube.com/watch?v=3BnuCWe1ddI

Outlook and next steps

The corn trials with Precision Planting technology will be continued over the next 2 years at the Swiss Future Farm. The focus will be on different planting depths and down force settings for different soil types. Furthermore, application of liquid starter fertilizer during planting will be investigated.

Trial team

The silage corn trial with Precision Planting technology was carried out in cooperation between AGCO, GVS Agrar and BBZ Arenenberg. The trial design and execution of the trial planned by the SFF Operating Team of Nils Zehner, Marco Landis and Florian Abt also included the experience of Darren Goebel and Jens Christian Jensen (AGCO Agronomy and Farm Solutions Team) based on previous international field trials with Precision Planting technology.

2.5 Digital Data Management

Objectives

In 2018, the digital recording of farm data on the Swiss Future Farm began. Whenever possible, farm data is recorded in the Farm Management and Information System (FMIS) NEXT Farming Office (formerly Agrar-Office) of FarmFacts (Figure 32). In the FMIS, the machine and task data as well as the working times of the farm employees are recorded centrally. The farm employees were equipped with a smartphone for this purpose, so that the time recording can be made mobile from now on.

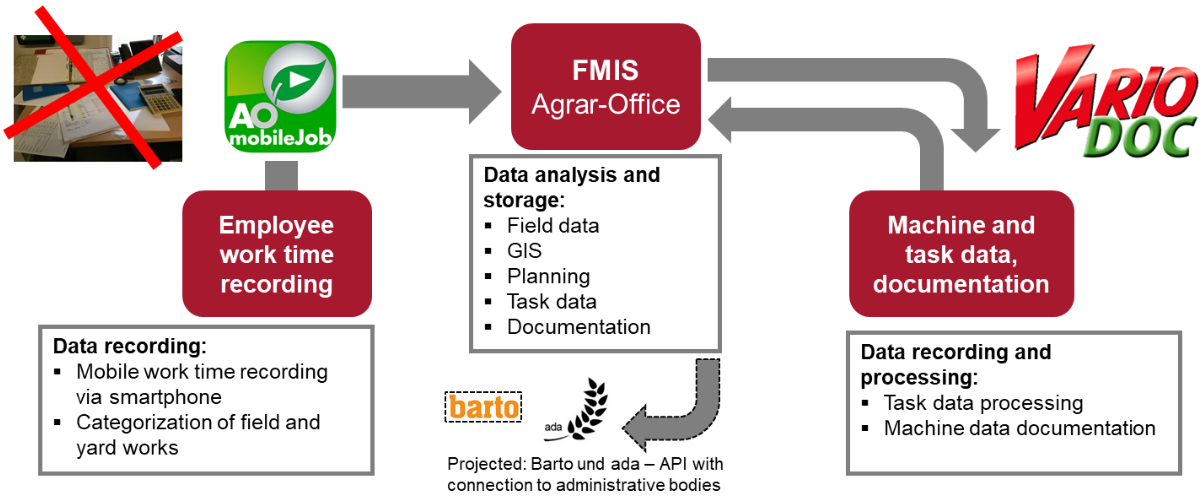


Figure 32. Overview of the data collection system on the Swiss Future Farm.

Excerpt from the recorded operating data

By using the VarioDoc Pro documentation system, the machine and task data could be recorded georeferenced and stored in the FMIS (Figure 33).

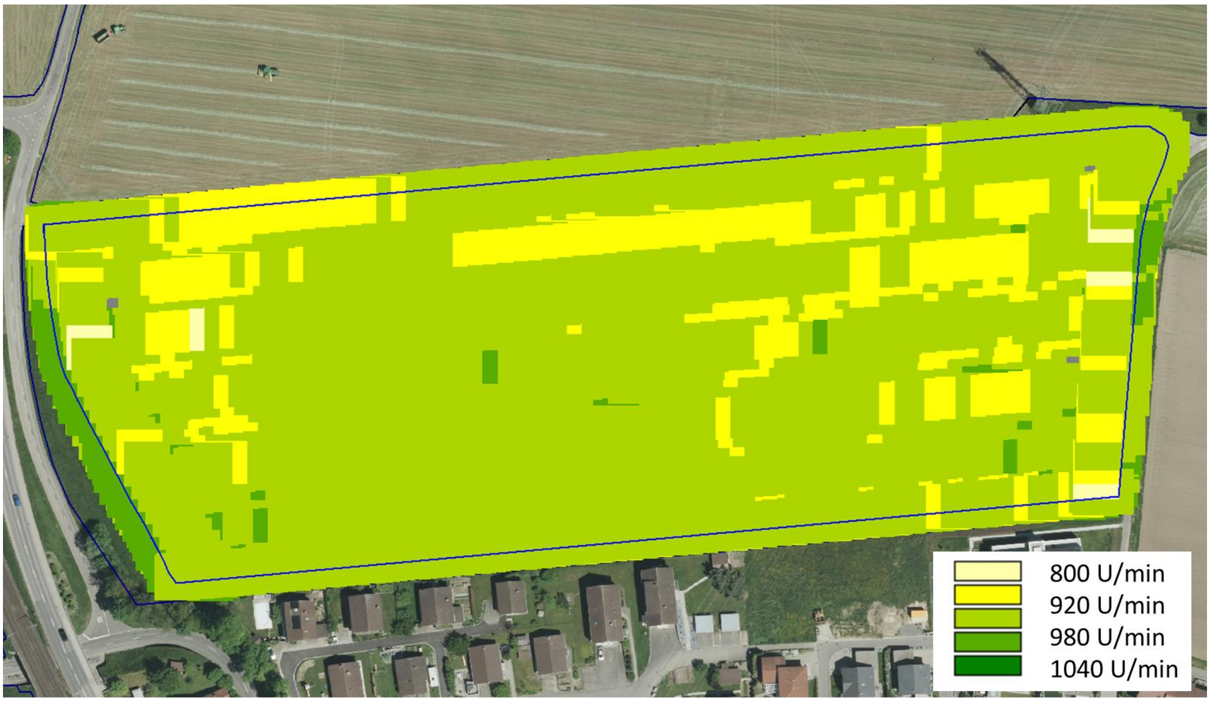


Figure 33. Seedbed preparation on the Altkloster plot. PTO shaft speed (revolutions per minute) when working with the power harrow as the parameter shown.

In addition to machine and task data, measured values from other data sources can also be transferred to the FMIS. Figure 34 shows the measurement data from the Swiss Future Farm weather station, which are also transferred to the FMIS.

	Niederschla...	Blattfeuchte [min]	HC Lufttemperatur [°C]			HC Relative Luftfeuchtigk...			Taupunkt [°C]		
▼ Date/Time	sum	time	avg	max	min	avg	max	min	avg	min	Verdunstung ETo [mm]
2018-07-02 14:00:00	0.0	0	27.51	27.97	26.60	41.21	43.59	39.41	13.1	12.7	
2018-07-02 13:00:00	0.0	0	27.36	27.64	27.01	42.44	44.18	40.73	13.4	12.8	
2018-07-02 12:00:00	0.0	0	25.75	26.52	24.97	44.87	47.92	42.32	12.8	12.1	
2018-07-02 11:00:00	0.0	0	24.09	24.96	23.08	47.03	48.77	44.41	12.0	10.8	
2018-07-02 10:00:00	0.0	0	22.35	23.38	21.43	45.82	49.34	44.05	10.0	9.3	
2018-07-02 09:00:00	0.0	0	20.21	20.97	19.30	52.50	55.43	47.96	10.1	9.3	
2018-07-02 08:00:00	0.0	0	18.38	19.25	17.53	58.73	63.95	54.99	10.0	9.6	
2018-07-02 07:00:00	0.0	0	16.75	17.58	14.96	66.42	75.97	58.41	10.3	9.2	
2018-07-02 06:00:00	0.0	0	13.01	14.66	11.79	83.67	88.05	78.43	10.2	9.7	
2018-07-02 05:00:00	0.0	0	11.70	12.13	11.19	87.17	89.57	84.67	9.6	9.5	
2018-07-02 04:00:00	0.0	0	12.25	12.77	11.83	84.59	87.32	81.93	9.7	9.6	
2018-07-02 03:00:00	0.0	0	11.99	12.49	11.59	87.36	89.53	84.16	9.9	9.6	
2018-07-02 02:00:00	0.0	0	12.61	13.54	11.89	85.11	89.12	80.47	10.1	9.9	
2018-07-02 01:00:00	0.0	0	15.22	17.36	13.44	71.03	81.47	57.01	9.8	8.7	
2018-07-02 00:00:00	0.0	0	17.42	17.88	17.06	58.05	58.89	56.63	9.0	8.7	
2018-07-01 23:00:00	0.0	0	18.64	19.37	17.97	56.18	58.10	54.95	9.6	9.4	5.2
2018-07-01 22:00:00	0.0	0	19.52	19.93	19.36	56.98	58.95	54.89	10.7	10.1	
2018-07-01 21:00:00	0.0	0	20.93	21.92	20.11	53.21	56.12	49.68	10.9	10.9	

Figure 34. Weather data from the iMetos weather station from Pessl Instruments, which is located on the Swiss Future Farm. The data is transferred directly to the FMIS.

In addition, the layers of the satellite-based soil zoning are stored in the FMIS and, in practical application at the Swiss Future Farm, represent the database for a site-specific soil sampling in December 2018 (Figure 35).

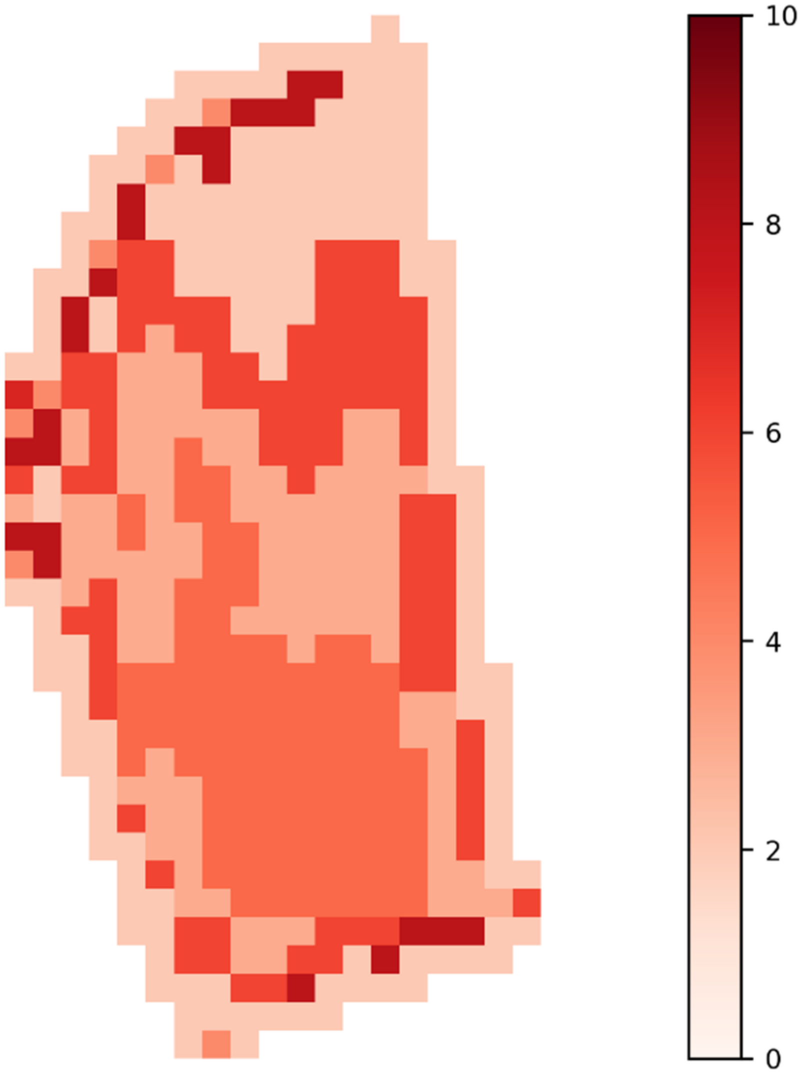


Figure 35. Satellite-based soil zoning provided a basis for site-specific soil sampling in December 2018. The figure shows the homogeneity of the field Chaiblen, which was divided into 10 zones by satellite imagery. Areas with the same colour represent homogeneous zones.

In addition, NDVI measurements were carried out with drone images (Figure 36).

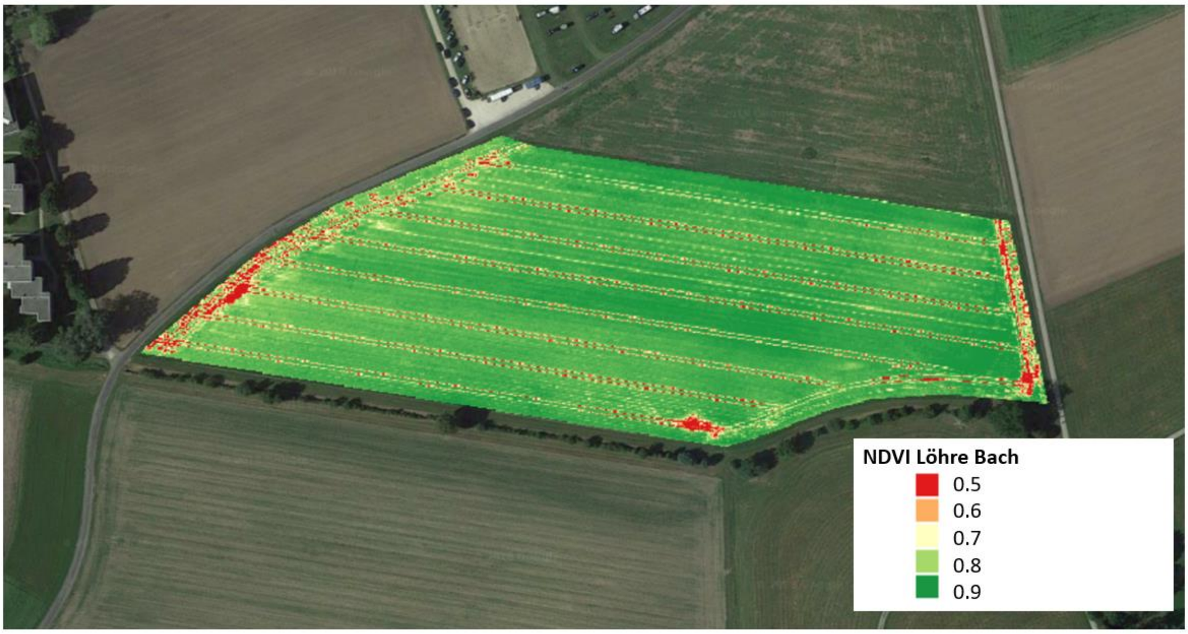


Figure 36. The drone recording on 28 May 2018 with DJI Phantom 4 Pro and Parrot Sequoia camera shows the distribution of the biomass using the NDVI. The higher the value, the more biomass there is in the given place.

Knowledge transfer

The findings on data management and digitalization gained at the Swiss Future Farm were presented to numerous interested parties from agricultural practice, science, politics, consulting and ag business as part of the Swiss Future Farm visitor program. In addition, lessons on data management were integrated into the BBZ Arenenberg training program and carried out at the Swiss Future Farm, supplemented by practical exercises.

The publications can be viewed under the following links:

- Video Series „Visits to the Swiss Future Farm“:
  https://www.youtube.com/watch?v=B70L0iWiPps
  https://www.youtube.com/watch?v=cpAoE1n5g-s
- Project Report "Observations from the air" on the Swiss Future Farm homepage:
  http://www.swissfuturefarm.ch/index.php/projekte/beobachtungen-aus-der-luft-nutzen-sie-ein-aktuelles-luftbild-und-profitieren-sie-von-erkenntnissen-aus-dem-trockenjahr-2018-772

Trial team

The experimental data management projects were planned and carried out by the Swiss Future Farm Operating Team.

3. Public Relations

In the first year of operation, 2018, public relations work at the Swiss Future Farm was already considered to be very important and the Operating Team offered numerous groups from practical agriculture, politics, business, education, consulting and the press an insight into the activities at the SFF. From 21 to 23 September 2018, the Swiss Future Farm opened its doors to some 10,000 people from all over Switzerland and neighbouring countries (Figure 37).

Figure 37. More than 10,000 visitors were welcomed at 10 field stations at the opening of the Swiss Future Farm from 21 to 23 September 2018.

4. Trainings

One of the main objectives of the Swiss Future Farm is the transfer of knowledge from the project into practice. For this purpose, a course room for up to 80 people was renovated and a training room for practical machine training was rebuilt. In 2018, numerous AGCO internal training courses on Fuse Smart Farming and Precision Planting were held (Figure 38). A module for Precision Farming was offered in the Agricultural Machinery and Renewable Energy training course for the Arenenberg and Salez School of Farm Management as well as for the Agricultural Machinery elective module for students of the BBZ Arenenberg. GVS Agrar used the Swiss Future Farm to introduce customers and the Swiss dealer network to new technologies and innovations in its product portfolio and to provide training courses in this area.

Figure 38. Impressions from the Swiss Future Farm training courses.

5. Outlook

For the 2019 field season, the focus will be on mechanical weed control with camera-controlled hoeing equiment and tine harrows. In addition, the influence of different down force settings, planting depths and liquid fertilization on juvenile development and crop yield will be investigated in the sugar beet and silage corn plots. On three wheat fields with a total area of 6 hectares, the effect of a site-specific nitrogen fertilization based on aerial imagery on the yield will be investigated.

On 20 and 21 September 2019, the Swiss Future Farm Days will take place with field stations, machine demonstrations and a technology exhibition. The focus will be on mechanical weed control strategies and straw and residue management. Further information can be found at www.swissfuturefarm.ch.

Acknowledgement

The Operating Team of Swiss Future Farm would like to express its thanks for the committed support in the 2018 harvest year. Special thanks go to:

- SFF Senior Sponsors
- SFF Steering Team
- GVS Service Teams Schaffhausen and Balterswil
- GVS Marketing Team
- BBZ Team Arable Farming Consulting
- BBZ Team Regional Development
- AGCO Fuse EME Team
- AGCO Agronomy and Farm Solutions Team
- Precision Planting, Tremont, IL, USA

and all visitors and friends of the Swiss Future Farm!

Links

Homepages:

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/

Social Media:

https://www.facebook.com/swissfuturefarm

https://www.instagram.com/explore/locations/1483068711800385/swiss-future-farm?hl=de

https://www.youtube.com/channel/UCzsEm9mMLs0X_lT3MoaCJXQ

Swiss Future Farm Video Chronology 2018:

https://www.youtube.com/watch?v=RJZ54bILm2k

https://www.youtube.com/watch?v=irgDa8_Jg6U

https://www.youtube.com/watch?v=jBVkmdf_sCQ&t=6s

https://www.youtube.com/watch?v=z4un9efdVq0

https://www.youtube.com/watch?v=4Ey6WBYtZiU

https://www.youtube.com/watch?v=_qrOGKgMhxQ&t=13s

https://www.youtube.com/watch?v=NqhKDGoc1FU

https://www.youtube.com/watch?v=752pdRP0YnE&t=1s

Imprint

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