SWISS FUTURE FARM

Annual Report 2022

AGCO Your Agriculture Company

arenenberg

GVS Agrar

The Farm

Farm size

81 ha agricultural land

55 ha arable crops

20 ha permanent grassland

6 ha biodiversity area

Dairy barn

Cattle herd Tänikon:

65 dairy cows

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

Cow husbandry:

The farm makes the trial barns available for trials by Agroscope and the Swiss Future Farm.

- Two sites with dairy cattle barns: Emission research barn Waldegg & dairy barn Tänikon
- Cows are milked twice a day with a 2x5 herringbone milking parlor
- Free stall barn with permanently accessible outdoor paddock

Calf rearing:

- Individual housing in igloos with run
- Milk for free disposal
- Rearing calves leave the farm after 3 weeks and spend the time until 4 weeks before the first calving on two partnership farms and on the alpine pasture

Pigpen

Number of animals:	Number of places:
60 breeding hogs	120 fattening places
1 boar	200 rearing places
	18 farrowing pens

The Aim

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

- Highlight the benefits and opportunities of digitalization, connectivity, data acquisition and documentation, and as a decision-making aid in everyday life.
- Demonstrate how Smart Farming technologies can be used to redesign farming processes and thus significantly improve Sustainability (ecological and economic) of food production.
- Support and implement research and development activities of the partners as well as Agroscope and other third parties.
- Set an example in the innovative interaction between companies in the agricultural sector and public research, education and advisory services.
- Permanent experimental farm with visiting opportunities and further training opportunities for employees as well as knowledge transfer to farmers, the public and other stakeholders. To establish Tänikon as an agricultural meeting point.
- Continuously implement innovations and developments in production processes on a farm. The Swiss Future Farm offers a platform for the use and testing of new technologies. In order to continuously stay up to date, Swiss Future Farm conducts targeted research on new solutions (Innovation Survey and Scouting) and integrates them into operational processes.

The Partners

AGCO International GmbH

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

Arenenberg

Agricultural education and extension center of the Canton of Thurgau with three school and experimental farms.

GVS Agrar AG

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

Table of contents

1 Field Trials

1.1 Weed Control Study in Sugar Beets

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield and operating costs in sugar beets grown with different weed control regimes, comprising herbicide-free, herbicide-reduced, and conventional chemical weed control.

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. The trial plot was planted in an intensive tillage system after Phacelia (*Phacelia tanacetifolia*) as a cover crop over winter. Sugar beets were planted on 28th March 2022 with a 6-row precision planter at 50 cm row spacing with 100,000 seeds/ha (hybrid: KWS Smart Manja). Except weed control, all field operations for seedbed preparation, planting, crop care excl. weed control, and harvest were conducted uniformly across all trial strips (Table 1). For chemical weed control, the complementary herbicide Bayer Conviso® One was used, either as one split (1x 0.5 l/ha) for the herbicide-reduced treatment or as two splits (2x 0.5 l/ha) for the conventional herbicide treatment, whereas mechanical weed control was conducted with a camera-steered hoe (Figure 1).

Table 1. Mechanization and crop care options tested for the SFF 2022 Weed Control Study in Sugar Beets.

Trial strip	Weed Control Treatment	Field Operations
1	**Herbicide-free (mechanical)** **0% Herbicide**	• Planting w/ tractor and planter (1x) • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Mechanical weeding w/ tractor and hoe (3x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)
2	**Herbicide-reduced (until 4-leaf stadium)** **50% Herbicide**	• Planting w/ tractor and planter (1x) • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Chemical weeding w/ tractor and sprayer (1x): Bayer Conviso® One (1x 0.5 l/ha)** • **Mechanical weeding w/ tractor and hoe (1x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)
3	**Herbicide-conventional** **100% Herbicide**	• Planting w/ tractor and planter (1x) • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Chemical weeding w/ tractor and sprayer (2x): Bayer Conviso® One (1x 0.5 l/ha)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)

Figure 1. Camera-controlled hoe used for mechanical weed control on the trial plot of the SFF 2022 Weed Control Study in sugar beets.

Results:

The trial was harvested 210 days after planting.

Results show that in comparison to sugar beets grown with only mechanical weed control, 11% higher beet yield was obtained with both herbicide-reduced and herbicide-conventional weed control (Figure 2).

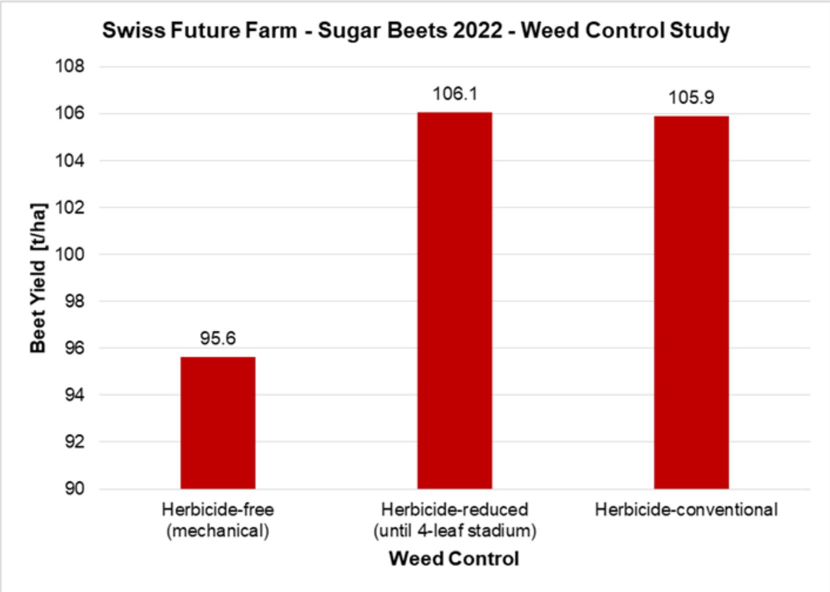


Figure 2. Beet yield results of the SFF 2022 Weed Control Study in sugar beets.

Sugar content was 0.9% to 1.2% higher in sugar beets grown in the herbicide-reduced and herbicide-conventional treatments compared to the herbicide-free treatment (Figure 3).

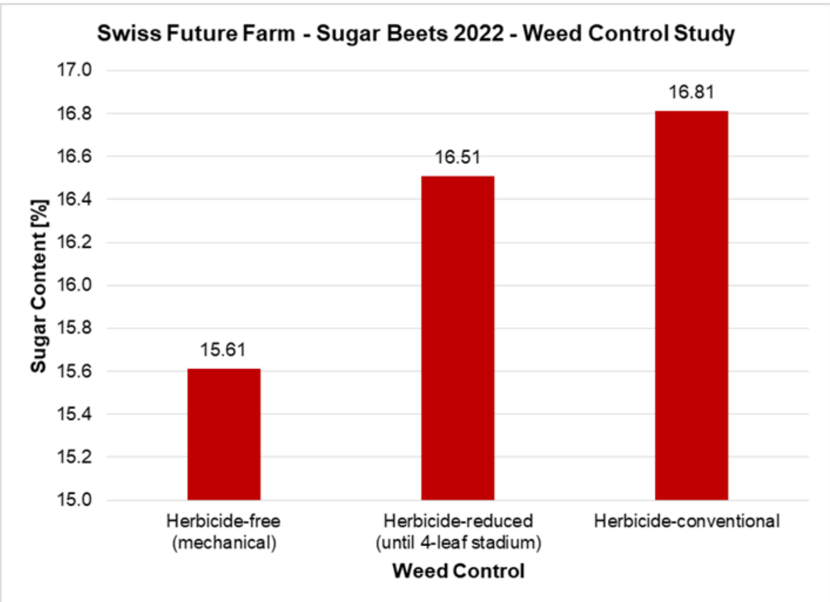


Figure 3. Sugar content results of the SFF 2022 Weed Control Study in sugar beets.

Equivalent to the trend of results in beet yield and sugar content, 18.3% and 20.6% higher sugar yield was obtained under herbicide-reduced and herbicide-conventional weed control compared to the herbicide-free treatment (Figure 4).

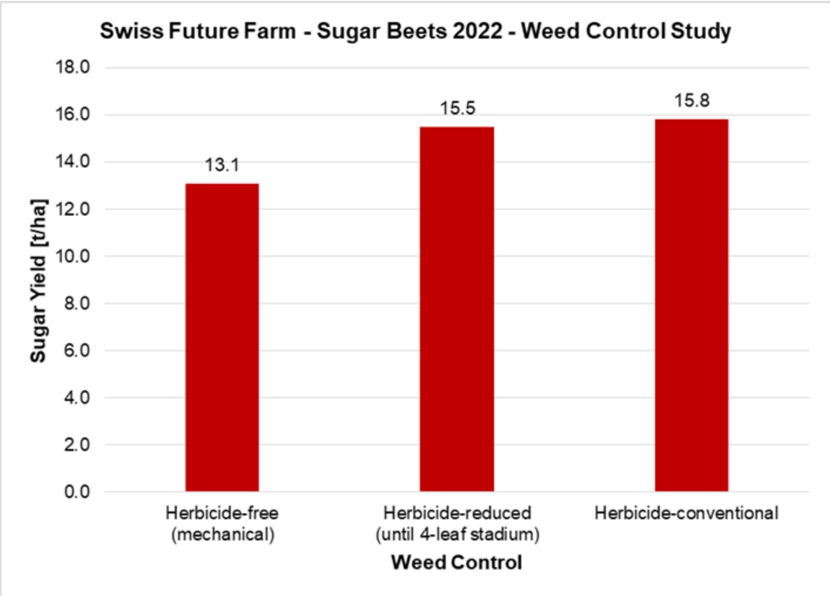


Figure 4. Sugar yield results of the SFF 2022 Weed Control Study in sugar beets.

Table 2 shows the results on revenue, operating costs, production costs per ton of sugar beets, and contribution margin 2 for sugar beets corn grown under the tested weed control regimes. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from pre-planting fertilization, tillage and seed-bed preparation, planting, crop care to sugar beet harvest. Except weed control, all field operations were conducted uniformly across all trial strips. Lowest operating costs resulted for the herbicide-conventional treatment and in line with higher yield and income, this treatment delivered the highest contribution margin in the comparison.

Table 2. Cost accounting results of the SFF 2022 Weed Control Study in sugar beets.

	Herbicide-free (mechanical)	**Herbicide-reduced (until 4-leaf stadium)**	**Herbicide-conven-tional**
Sugar Beet Yield (t/ha)	95.6	106.1	105.9
Sugar Content (%)	15.61	16.51	16.81
Sugar Yield (t/ha)	13.1	15.5	15.8
Deliverables (CHF/ha)			
Crop Value / Revenue	5146.15	6015.50	6244.95
Costs (CHF/ha)			
Tillage	569.11	569.11	569.11
Cover Crop Seeding	155.68	155.68	155.68
Sugar Beet Planting	633.13	633.13	633.13
Fertilization	763.15	763.15	763.15
Herbicide Application	0.00	88.64	186.18
Insecticide Application	136.33	136.33	136.33
Fungicide Application	403.45	403.45	403.45
Mechanical Weeding	336.00	112.00	0.00
Harvest	720.00	720.00	720.00
Labor	348.18	311.29	297.73
Outcomes			
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	4065.03	3892.78	3864.76
Production Costs (CHF/t sugar beets)	42.51	36.70	36.49
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1081.12	2122.72	2380.19
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and sugar beet subsidies	3181.12	4222.72	4480.19

Figure 5 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study.

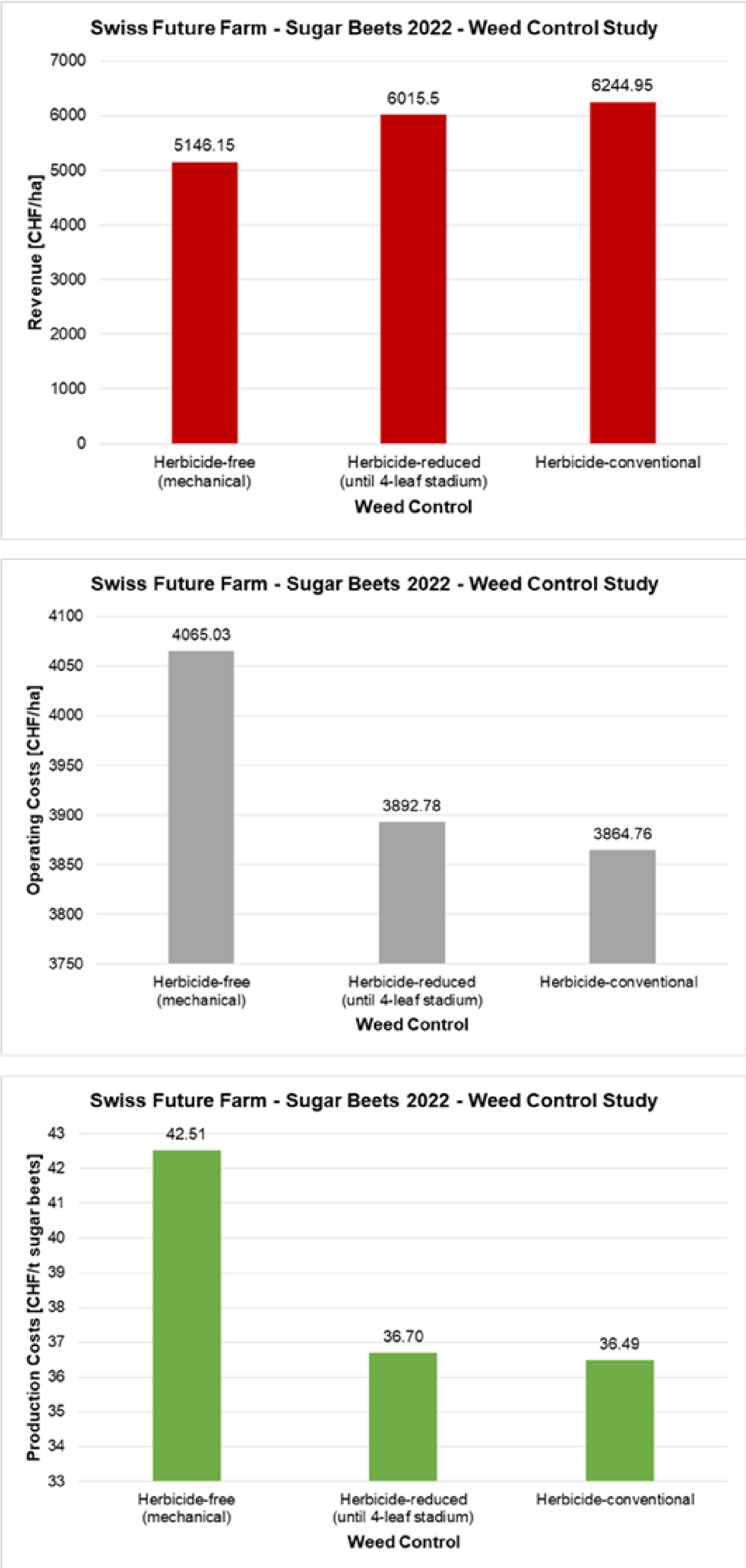


Figure 5. Revenue, operating costs, and production costs per ton of sugar beets for the SFF 2022 Weed Control Study in sugar beets.

Additional Observations:

Morphology of sugar beets grown under different weed control regimes does not show distinct differences between the treatments (Figure 6).

Figure 6. Morphology of sugar beets sampled during the SFF 2022 Weed Control Study in sugar beets.

Recommendations and Equipment Solutions:

- AGCO Guide with RTK ensures planter passes with maximum accuracy and operator comfort and enables to use identical waylines for weed control operations.
- AGCO Contour/Wayline Assistant enables optimum wayline adaption to the contours of the field during planting.

Payback:

For sugar beets grown with conventional herbicide application for weed control, the highest contribution margin of 2380.19 CHF/ha (without subsidies) or 4480.19 CHF/ha (incl. subsidies) could be achieved in the comparison, which is 257.47 CHF/ha to 1299.07 CHF/ha more than for the herbicide-reduced and herbicide-free treatment, respectively (Figure 7).

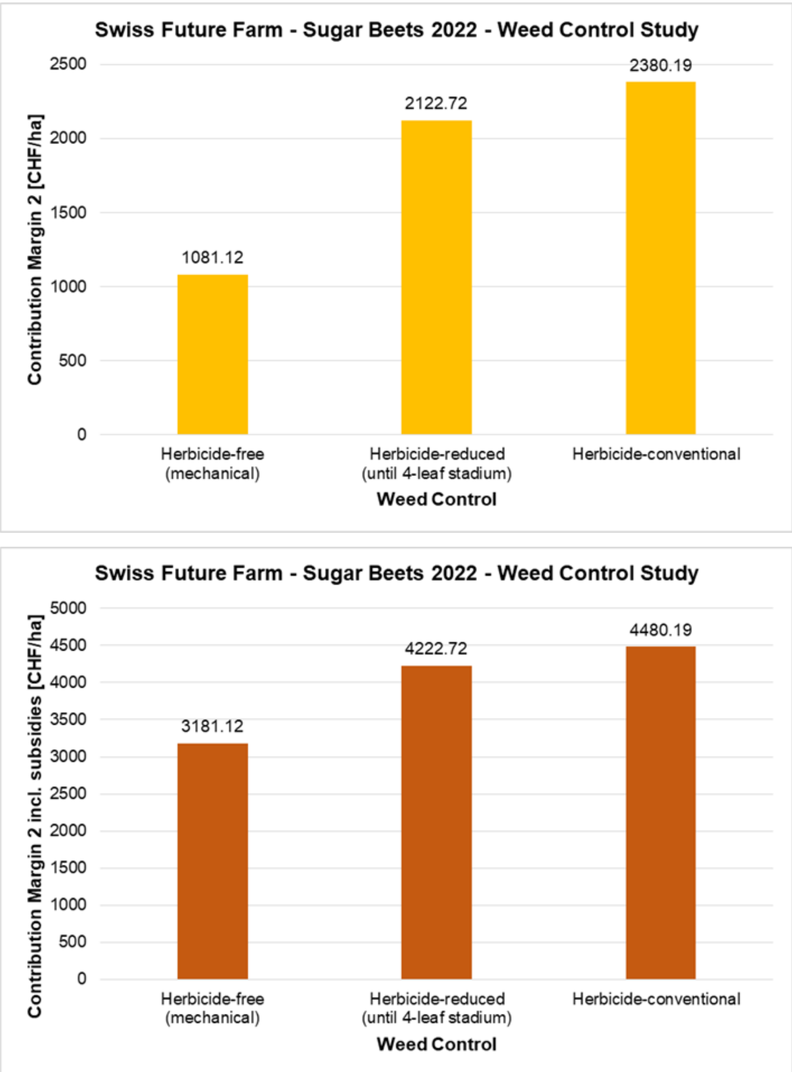


Figure 7. Contribution margin 2 obtained from the SFF 2022 Weed Control Study in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: 50.00 CHF/ton

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team.

1.2 Robotics & Transplanted Beets Study in Sugar Beets

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield and operating costs in sugar beets planted by use of an agricultural robotic solution (FarmDroid FD20, FarmDroid ApS, Vejen, Denmark) and as transplanted beets in comparison to field operations with conventional agricultural machinery (tractors and implements).

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. The trial plot was planted in an intensive tillage system after Phacelia (*Phacelia tanacetifolia*) as a cover crop over winter. Sugar beets were planted on 28th March 2022 by the FarmDroid FD20 robot (hybrid: KWS Smart Manja) and on 14th April 2022 as transplanted beets (hybrid: SESVanderHave Xerus) with 100,000 seeds or plants/ha (Figure 8). Except planting, all field operations for seedbed preparation, crop care incl. mechanical weed control, and harvest were conducted uniformly across all trial strips with conventional machinery and compared to two control treatments with conventional planting via tractor and planter and either mechanical or chemical weed control (Table 3).

The trial strips comprising mechanical weeding were additionally hoed by hand on May 27 and July 29. Without this measure, it would not have been possible to keep the stand in a reasonable weediness.

Table 3. Mechanization and crop care options tested for the SFF 2022 Robotics & Transplanted Beets Study in Sugar Beets.

Trial strip	Treatment	Field Operations
1	**Transplanted Beets + Mechanical Weeding**	• **Planting w/ transplanted sugar beets (1x)** • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Mechanical weeding w/ tractor and hoe (3x)** • **Manual weeding (2x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)
2	**Farmdroid Robot + Mechanical Weeding**	• **Planting w/ Farmdroid FD20 field robot (1x)** • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Mechanical weeding w/ tractor and hoe (3x)** • **Manual weeding (2x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)
3	**Conventional Machinery + Mechanical Weeding (Control 1)**	• **Planting w/ tractor and planter (1x)** • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Mechanical weeding w/ tractor and hoe (3x)** • **Manual weeding (2x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)
4	**Conventional Machinery + Chemical Weeding (Control 2)**	• **Planting w/ tractor and planter (1x)** • Fertilizer application w/ tractor and fertilizer spreader (3x) • **Chemical weeding w/ tractor and sprayer (2x)** • Insecticide application w/ tractor and sprayer (1x) • Fungicide application w/ tractor and sprayer (2x)

Figure 8. FarmDroid FD20 field robot planting sugar beets (left), transplanted beets on the day of planting (right) on the trial plot of the SFF 2022 Robotics & Transplanted Beets Study.

The solar-powered FarmDroid FD20 field robot (https://farmdroid.dk/en/product/) can autonomously plant sugar beets or vegetable crops with RTK precision. Additionally, mechanical weed control is possible by changing the machine-specific implements from planting to weeding tools. Human labor is required for moving from field to field, recording field boundaries for driving route planning of the guidance system, adjusting the implements, and refilling seed.

Transplanted beets emerge in a greenhouse environment and are later on transplanted approx. at 6-leaves stadium to the field, in order to overcome vulnerability of the sugar beets for pests in the emergence phase, for which particularly under organic farming conditions only limited possibilities for interference are given. The process of transplanting beets is labor-intensive and requires several operators for handling and placing the beets on the planting machine.

Results:

The trial was harvested 189 days (transplanted sugar beets), 206 days (Farmdroid robot trial strip), and 210 days (control with conventional machinery) after planting of the respective trial strips.

Results show that highest beet yield was obtained in the control treatment with conventional machinery and chemical weeding (101.0 t/ha), which is a yield advantage of 16.5% vs. transplantes beets, 9.2% vs. Farmdroid robot-planted beets, and 5.7% vs. conventional machinery and mechanical weeding (Figure 9).

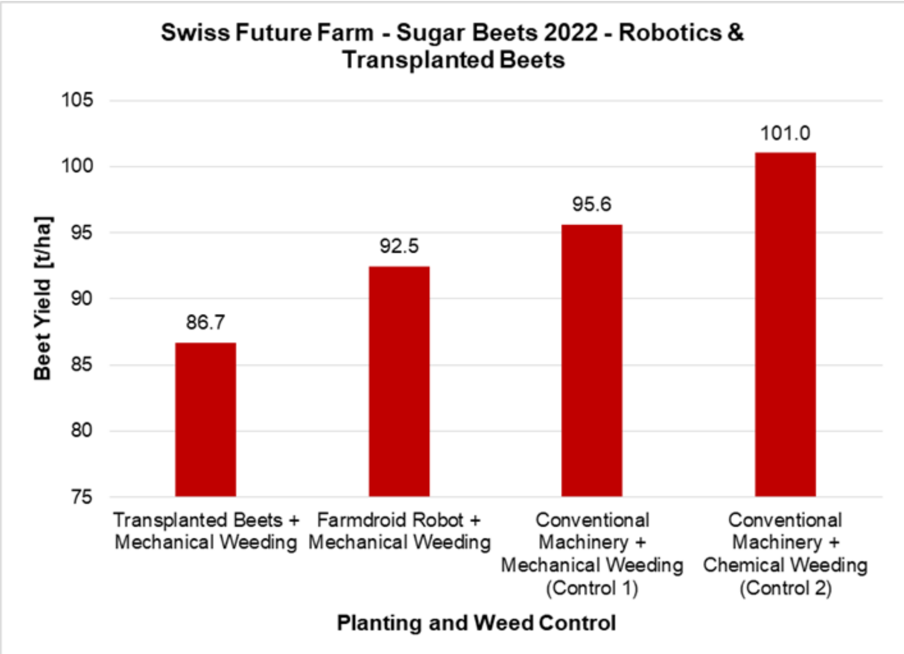


Figure 9. Beet yield results of the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

Sugar content was significantly higher in sugar beets planted by conventional machinery and grown with chemical weeding (Control 2), and as the only treatment in the comparison exceeded the targeted level of >16% sugar (Figure 10).

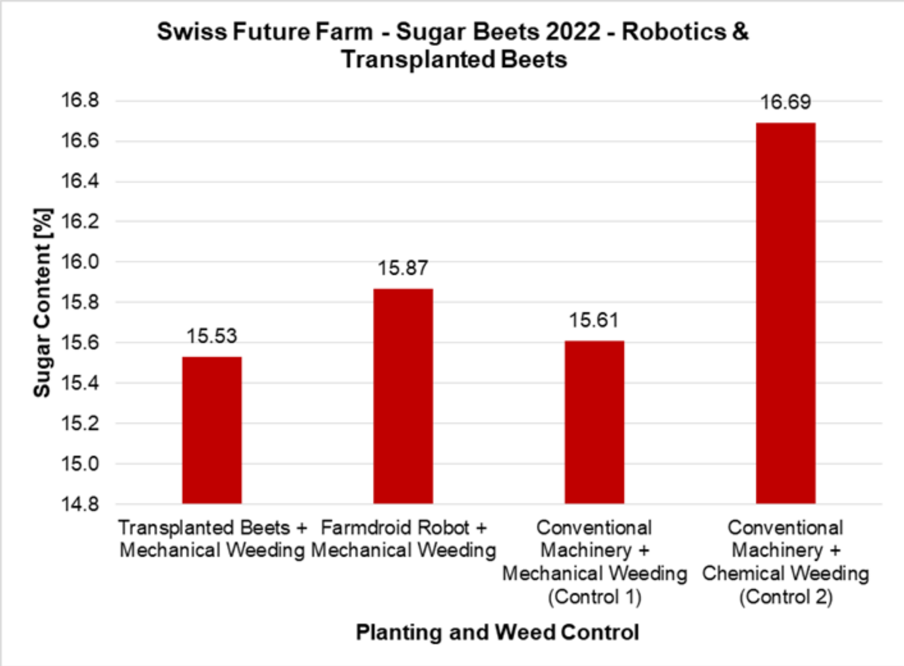


Figure 10. Sugar content results of the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

Equivalent to the trend of results in beet yield, the control treatment with conventional machinery and chemical weeding had a sugar yield advantage of 26.3% vs. trans-plantes beets, 16.4% vs. Farmdroid robot-planted beets, and 13.7% vs. conventional machinery and mechanical weeding (Figure 11).

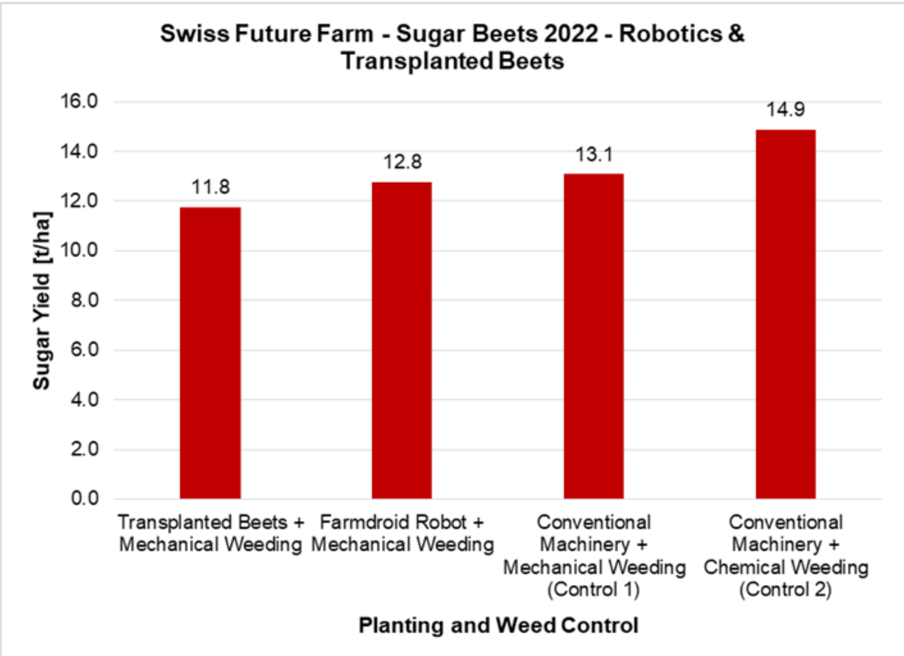


Figure 11. Sugar yield results of the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

Table 4 shows the results on revenue, operating costs, production costs per ton of sugar beets, and contribution margin 2 for sugar beets planted and grown with the tested mechanization options. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from pre-planting fertilization, tillage and seedbed preparation, planting, crop care to sugar beets harvest. Except planting and weed control, all field operations were conducted uniformly across all trial strips.

Highest operating costs resulted for the Transplanted Beets in combination with mechanical weed control, and also after considering subsidies resulted in a deficient contribution margin, whereas for the sugar beets planted with the Farmdroid field robot, it was possible to achieve a positive contribution margin including subsidies. Control treatments were ranging within the usual contribution margin targeted for sugar beet production in Switzerland (Table 4). However, it must be pointed out that for sugar beets grown under certified organic production, a significantly higher sugar beet base price of 159.00 CHF/t for organic sugar beets vs. 50.00 CHF/t for conventional sugar beets can be obtained, which would allow for non-deficient application of transplanted sugar beets or the Farmdroid field robot based on the yield level and operating costs found in this study.

It must be emphasized that the contribution margin calculation with organic beet guide price is only a rough orientation and does not reflect the requirements of certified organic farming, since the de facto insecticide and fungicide applications carried out in the trial are included in the calculation of the operating costs and thus the contribution margin.

Table 4. Cost accounting results of the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

	Transplanted Beets + Mechanical Weeding	**Farmdroid Robot + Mechanical Weeding**	**Conventional Machinery + Mechanical Weeding (Control 1)**	**Conventional Machinery + Chemical Weeding (Control 2)**
Sugar Beet Yield (t/ha)	86.7	92.5	95.6	101.0
Sugar Content (%)	15.53	15.87	15.61	16.69
Sugar Yield (t/ha)	11.8	12.8	13.1	14.9
Deliverables (CHF/ha)				
Revenue conventional	4614.60	4898.00	5146.15	5958.60
Revenue organic	14062.75	14975.65	15568.60	-
Costs (CHF/ha)				
Tillage	569.11	569.11	569.11	569.11
Cover Crop Seeding	155.68	155.68	155.68	155.68
Sugar Beet Planting	5400.00	1844.80	633.13	633.13
Fertilization	763.15	763.15	763.15	763.15
Herbicide Application	0.00	0.00	0.00	186.18
Insecticide Application	136.33	136.33	136.33	136.33
Fungicide Application	403.45	403.45	403.45	403.45
Mechanical Weeding	272.08	336.00	336.00	0.00
Manual Weeding	2525.00	4375.00	6300.00	0.00
Harvest	720.00	720.00	720.00	720.00
Labor	344.14	494.01	348.18	297.73
Outcomes				
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	8763.94	5422.53	4065.03	3864.76
Production Costs (CHF/t sugar beets)	130.24	105.97	108.40	38.26
Contribution margin 2 (CHF/ha) conventional	-6674.34	-4899.53	-5218.88	2093.84
Contribution margin 2 (CHF/ha) incl. sugar beet subsidies conventional	-4574.34	-2799.53	-3118.88	4193.84
Contribution margin 2 (CHF/ha) organic	2773.81	5178.12	5203.57	-
Contribution margin 2 (CHF/ha) incl. sugar beet subsidies organic	4873.81	7278.12	7303.57	-

Figure 12 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study.

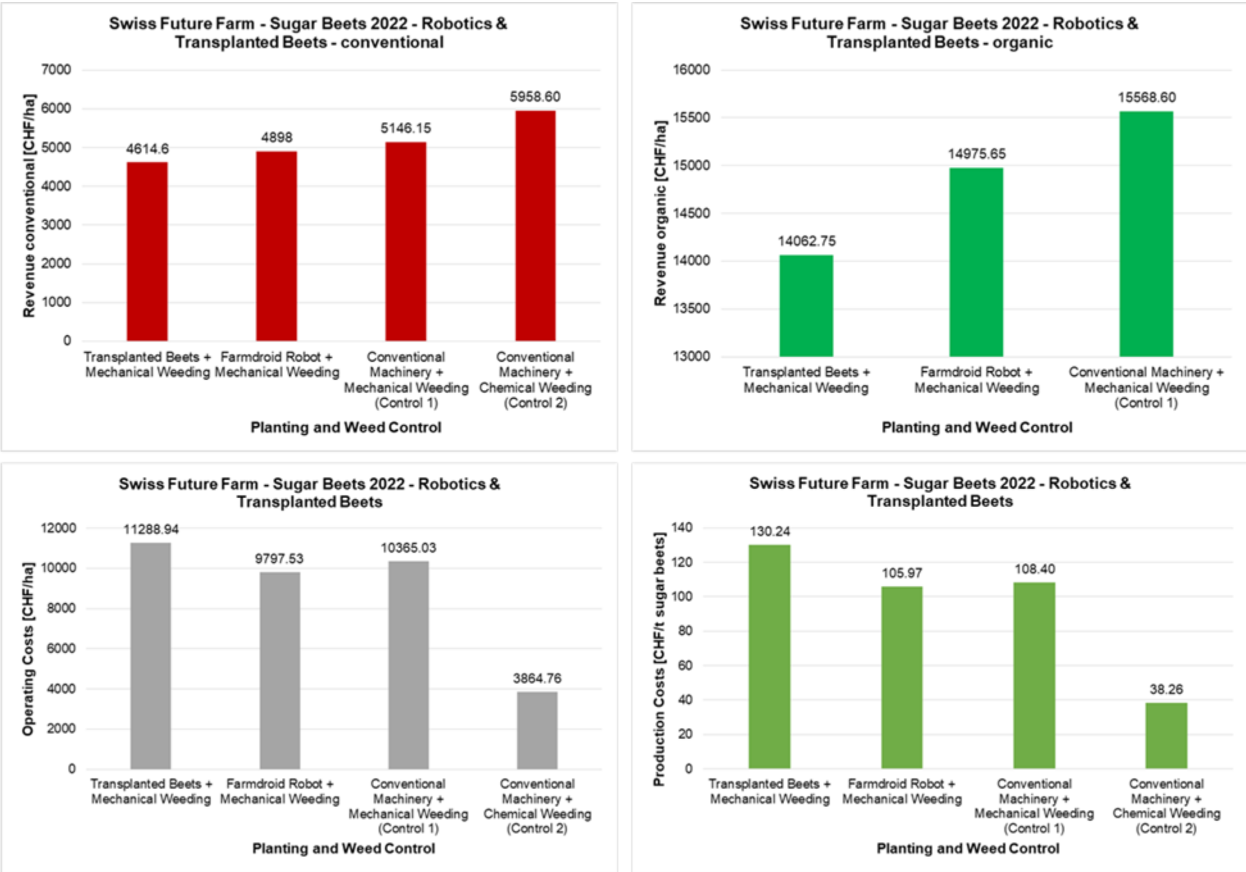


Figure 12. Revenue, operating costs, and production costs per ton of sugar beets for the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

Additional Observations:

The seedlings of the variety Xerus were set at the 4-leaf stage in mid-April. The seedlings already showed typical symptoms of Cercospora leaf spot infection at planting, which could be confirmed microscopically. Due to the dry and warm conditions, the seedlings were irrigated twice, which promoted the early spread of Cercospora infection throughout the stand. Thus, two fungicide treatments had to be applied.

Very high Cercospora pressure was also evident early in the Farmdroid trial strip and in the control treatments, spreading from the adjacent transplanted beets. Consequently, two fungicide treatments took place here as well.

The trial highlights the importance of healthy seedlings. These must therefore be closely inspected on delivery. This requires a trained eye and time. An early infection with Cercospora starting from already infected seedlings not only reduces the yield, but also the sugar content and becomes a problem for surrounding sugarbeet plots. Especially in organic farming, when the use of fungicides is not possible, seedling leaf health must be a top priority if transplanted sugarbeets is to become a common practice.

Figure 13. Sugar beet leaf with Cercospora infection.

Morphology of sugar beets grown as transplanted beets shows striking differences to the other treatments of the study, and a significantly higher average beet weight was recorded for the hand-harvested sample on 12 July 2022 (Figure 14). As a negative phytosanitary aspect, there seemed to be Cercospora infection in some of the transplanted beets that later on spread over the entire sugar beet field including all treatment of this trial and required interference via two fungicide applications.

Figure 14. Morphology of sugar beets sampled during the SFF 2022 Robotics & Transplanted Beets Study.

Recommendations and Equipment Solutions:

- AGCO Guide with RTK ensures planter passes with maximum accuracy and operator comfort and enables to use identical waylines for weed control operations.
- AGCO Contour/Wayline Assistant enables optimum wayline adaption to the contours of the field during planting.

Payback:

For sugar beets planted with conventional machinery and grown with chemical weeding, the highest contribution margin of 2093.84 CHF/ha (without subsidies) or 4193.84 CHF/ha (incl. subsidies) could be achieved in the comparison, which is significantly higher than for the other treatments in this study (Figure 15). Based on these results, limited or no economic benefits could be obtained by the use of robotic planting and transplanted beets for conventional sugar beet production and the corresponding sugar beet base price.

It must be emphasized that the contribution margin calculation with organic beet guide price is only a rough orientation and does not reflect the requirements of certified organic farming, since the de facto insecticide and fungicide applications carried out in the trial are included in the calculation of the operating costs and thus the contribution margin.

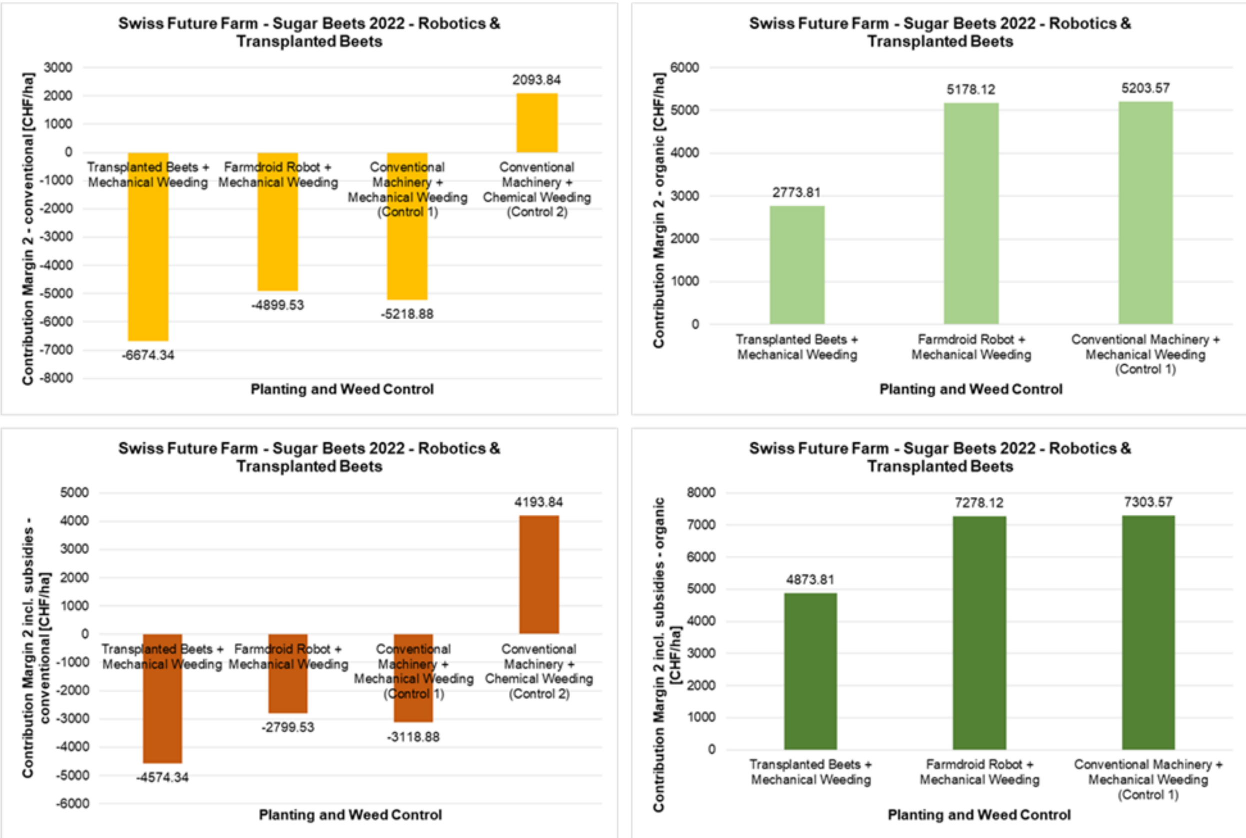


Figure 15. Contribution margin 2 obtained from the SFF 2022 Robotics & Transplanted Beets Study in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price - conventional: 50.00 CHF/ton
Sugar beet basic price - organic: 159.00 CHF/ton

The machine costs were calculated using Agroscope's 2022 cost catalog.

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of David Vetterli for robotic planting as well as Kronengut AG and Rathgeb BioProdukte AG for contracted services in transplanted beets.

1.3 Tillage Study in Sugar Beets

Study Contact:

Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:

The objective of this study was to compare yield and operating costs in sugar beets planted after reduced and conventional tillage regime.

Study Design:

The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. Cover crop seeding on the trial plot was done in fall 2021 for sugar beet planting in spring 2022. Different tillage regimes were applied for seedbed preparation after Phacelia (*Phacelia tanacetifolia*) as a cover crop before corn planting (Table 5). Sugar beets were planted on 24th March 2022, the planted hybrid was KWS Smart Manja with 100,000 seeds/ha.

Table 5. Tillage regimes tested for the SFF 2022 Tillage Study in Sugar Beets.

Treatment	Tillage Regime	Tillage Operations
1	Reduced	• Knife Roller (1x) • **Cultivator** (1x) • Power Harrow (1x)
2	Intensive	• Knife Roller (1x) • **Moldboard Plow** (1x) • Power Harrow (1x)

Results:

The trial was harvested 210 days after planting. Results show that 6% higher beet yield was obtained under intensive tillage regime (Figure 16).

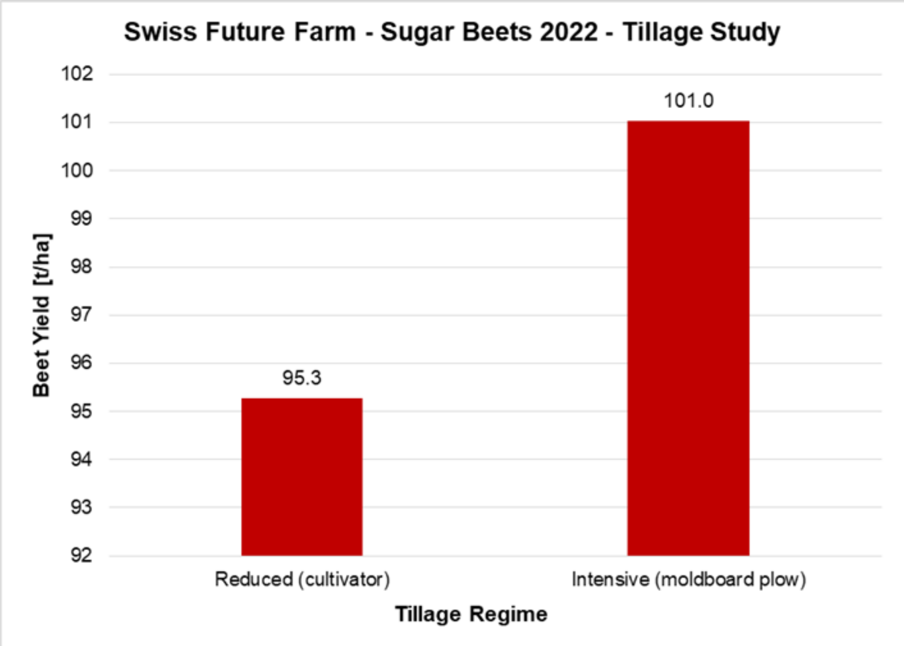


Figure 16. Beet yield results of the SFF 2022 Tillage Study in sugar beets.

Sugar content was 0.44% higher in sugar beets grown under intensive tillage regime but for both treatments on a satisfying level of >16% sugar (Figure 17).

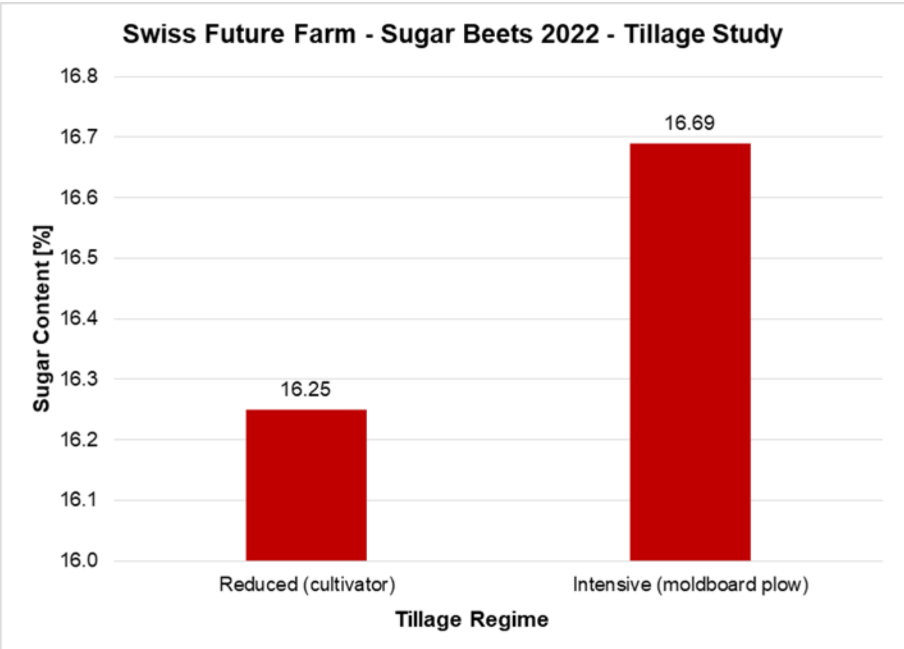


Figure 17. Sugar content results of the SFF 2022 Tillage Study in sugar beets.

Equivalent to the trend of results in beet yield and sugar content, 9.6% higher sugar yield was obtained under intensive compared to reduced tillage regime (Figure 18).

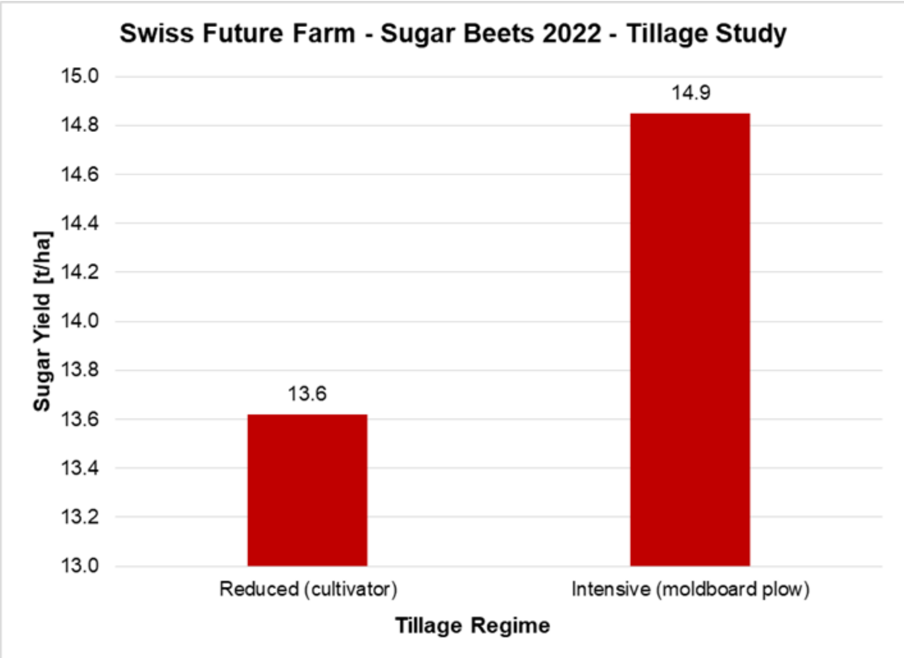


Figure 18. Sugar yield results of the SFF 2022 Tillage Study in sugar beets.

Table 6 shows the results on revenue, operating costs, feed costs, and contribution margin 2 for sugar beets planted in the tested tillage regimes. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for cover crop seeding to sugar beet harvest. Except tillage practice, all other field operations were conducted uniformly across the two trial strips. Higher machine and labor costs occurred in the intensive tillage regime, nonetheless production costs per ton of sugar beets were on an equal level (39.03 vs. 38.26 CHF/t) due to higher yield and crop value in the intensive tillage regime.

Table 6. Cost accounting results of the SFF 2022 Tillage Study in sugar beets.

	Reduced (cultivator)	**Intensive (moldboard plow)**
Sugar Beet Yield (t/ha)	95.3	101.0
Sugar Content (%)	16.25	16.69
Sugar Yield (t/ha)	13.6	14.9
Deliverables (CHF/ha)		
Crop Value / Revenue	5272.35	5958.60
Costs (CHF/ha)		
Tillage	443.41	569.11
Seeding & Planting	788.81	788.81
Fertilization	763.15	763.15
Herbicide Application	186.18	186.18
Insecticide Application	136.33	136.33
Fungicide Application	403.45	403.45
Harvest	720.00	720.00
Labor	277.86	297.73
Outcomes		
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	3719.19	3864.76
Production Costs (CHF/t sugar beets)	39.03	38.26
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1553.16	2093.84
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and sugar beet subsidies	3653.16	4193.84

Figure 19 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study.

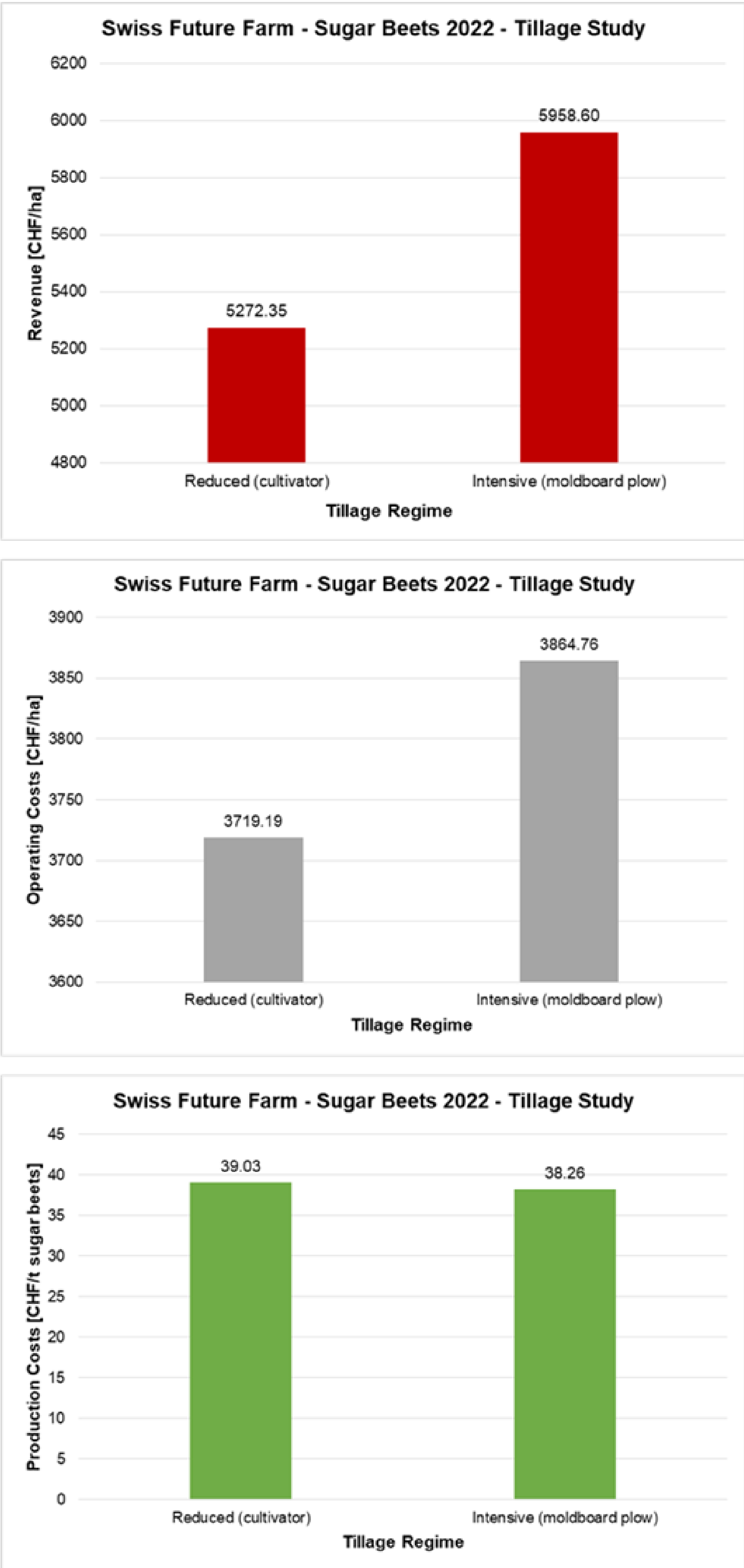


Figure 19. Revenue, operating costs, and production costs per ton of sugar beets for the SFF 2022 Tillage Study in sugar beets.

Additional Observations:

Morphology of sugar beets grown under intensive tillage regime shows a longer tap root penetration depth and more homogeneous, straighter root development than beets grown under reduced tillage regime (Figure 20). Reason for this may be less soil penetration resistance and more homogenous soil aggregates under intensive tillage conditions that impacts the morphology of sugar beets as shown in this comparison.

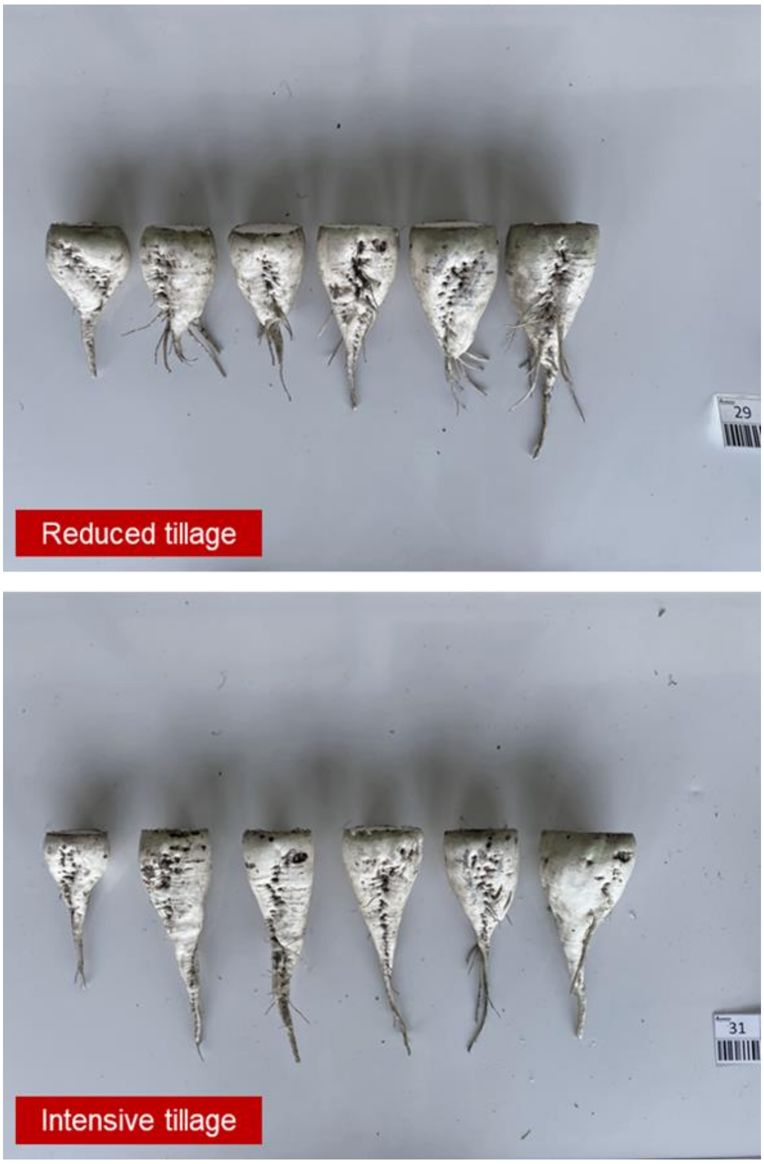


Figure 20. Morphology of sugar beets sampled during the SFF 2022 Tillage Study showing beets grown under reduced (top) and intensive (bottom) tillage regime.

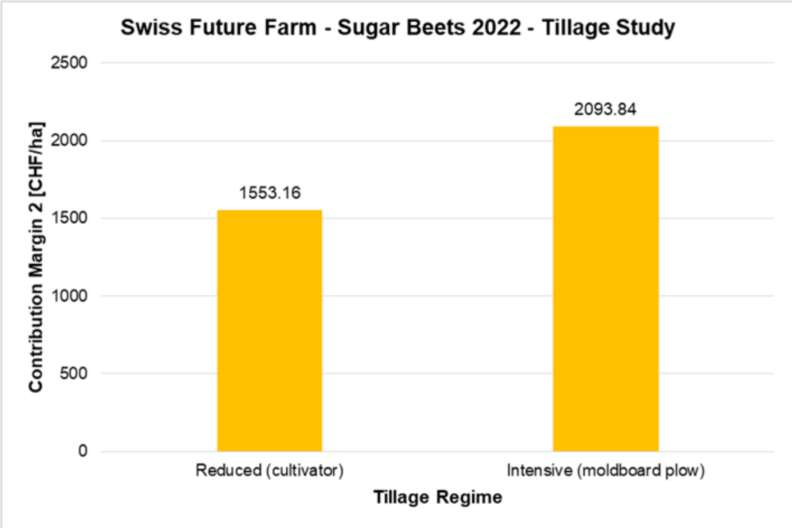
Recommendations and Equipment Solutions:

- Precision Planting CleanSweep™ allows for exact pneumatic adjustment of row cleaners according to the amount of crop residue in reduced tillage systems.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

Figure 21. Precision Planting CleanSweep™ pneumatic row cleaner adjustment system.

Payback:

For sugar beets planted in an intensive tillage regime, an additional contribution margin of 540.68 CHF/ha could be achieved compared to reduced tillage (Figure 22).



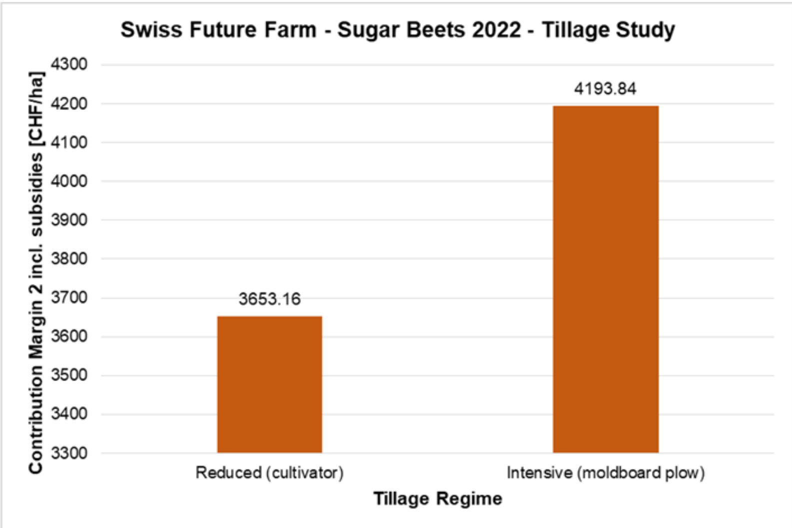


Figure 22. Contribution margin 2 obtained from the SFF 2022 Tillage Study trial strips in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: 50.00 CHF/ton

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team.

1.4 Row Cleaner Study in Sugar Beets

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield in sugar beets planted with different row cleaner settings using a Precision Planting test planter with the CleanSweep™ pneumatic row cleaner control system.

Study Design:
The study was carried out on the Swiss Future Farm in 2022 with a side-by-side strip trial design. A Precision Planting planter equipped with Precision Planting's CleanSweep pneumatic row cleaner control system (Figure 23) was used. The following row cleaner settings were tested:

- Lifted completely (CleanSweep -700 kPa)
- Float clearing (CleanSweep -150 kPa)
- Too deep (CleanSweep +150 kPa)

The trial plot was located in a field with homogeneous soil and residue conditions operated under reduced tillage regime with Phacelia being the preceding cover crop. All treatments were planted at 3.8 cm planting depth with DeltaForce automatic down force control set to a target down force of 35 kg and with a plant population of 100,000 seeds per hectare (hybrid: KWS Smart Manja). Planting date was 24th March 2022.

Figure 23. Precision Planting CleanSweep row cleaner system on planter row unit.

Results:

The trial was harvested 210 days after planting.

Results of the different row cleaner settings applied with the CleanSweep system show that highest sugar beet yield was achieved with a float clearing setting (CleanSweep -150 kPa) properly cleaning the residue in the furrow, whereas no row cleaner application (row cleaners lifted completely) or too deep setting of the row cleaners resulted in 3.9% and 8.6% lower yield, respectively (Figure 24).

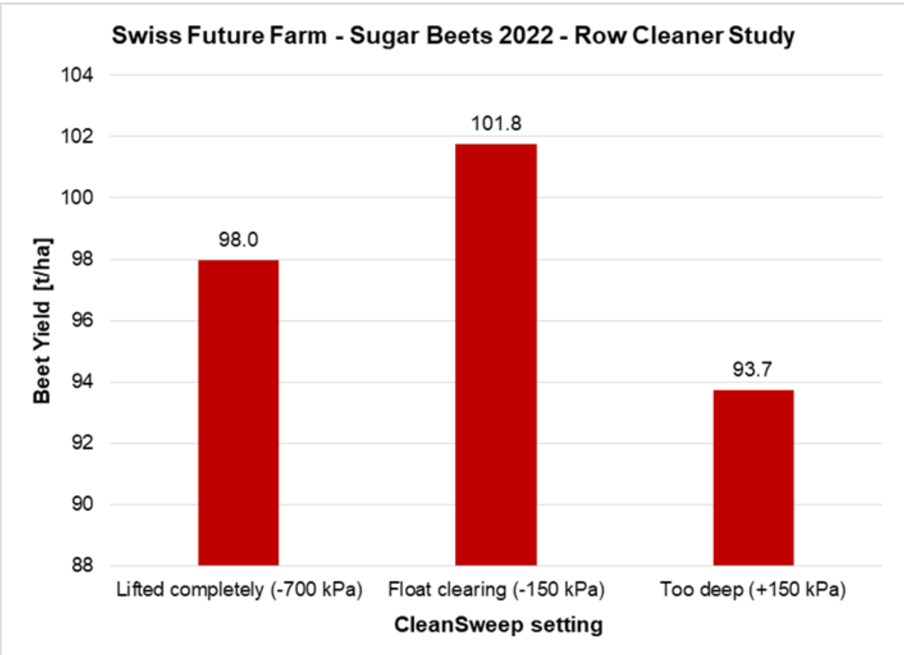


Figure 24. Beet yield results of the SFF 2022 Row Cleaner Study in sugar beets.

Sugar content was higher for sugar beets planted with deep row cleaner setting both compared to lifted and float clearing setting (Figure 25).

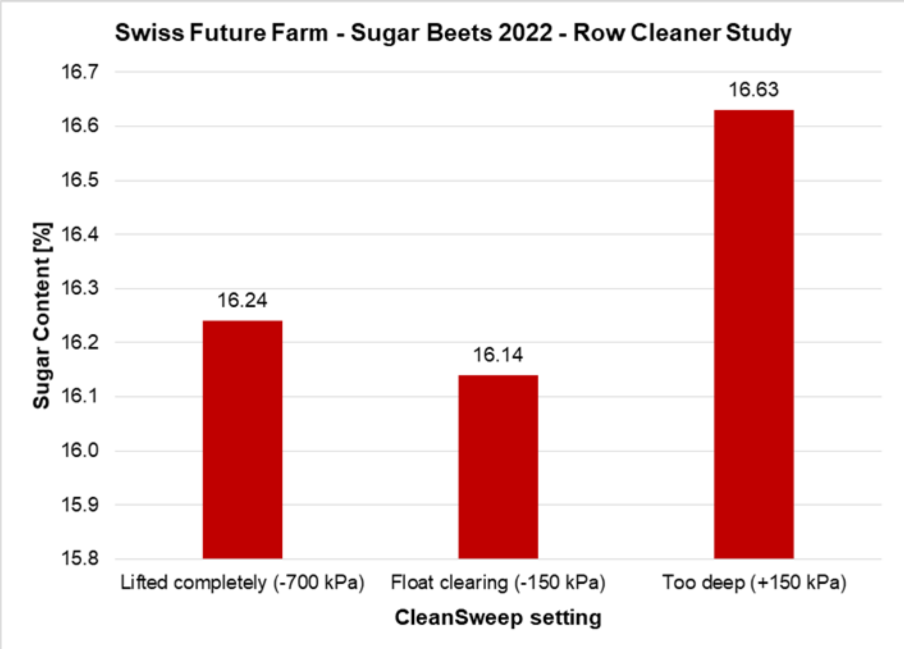


Figure 25. Sugar content results of the SFF 2022 Row Cleaner Study in sugar beets.

Equivalent to the results found for beet yield, higher sugar yield was obtained when properly clearing row cleaner settings was applied, whereas no or too deep row cleaner settings resulted in 3.6% and 5.1% less sugar yield, respectively (Figure 26).

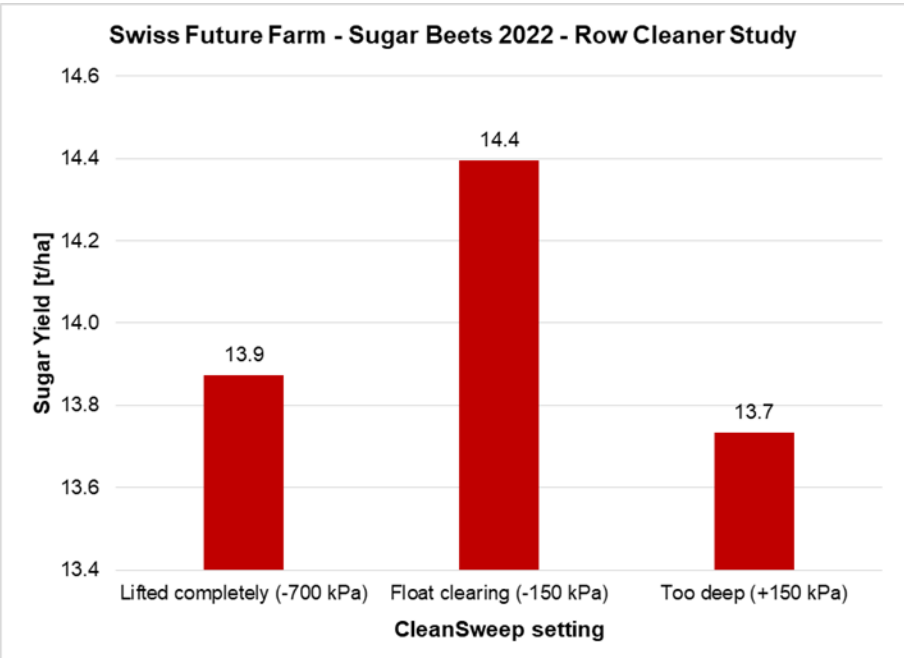


Figure 26. Sugar yield results of the SFF 2022 Row Cleaner Study in sugar beets.

Figure 27 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for the preceding cover crop (Phacelia) to sugar beet harvest. All field operations were conducted uniformly across all trial strips and the row cleaner setting represented the only variable altered between the different treatments. Hence, operating costs were equal across all treatments, and derived from higher beet yield, lower production costs per ton of sugar beets could be realized with proper row cleaner setting during planting.

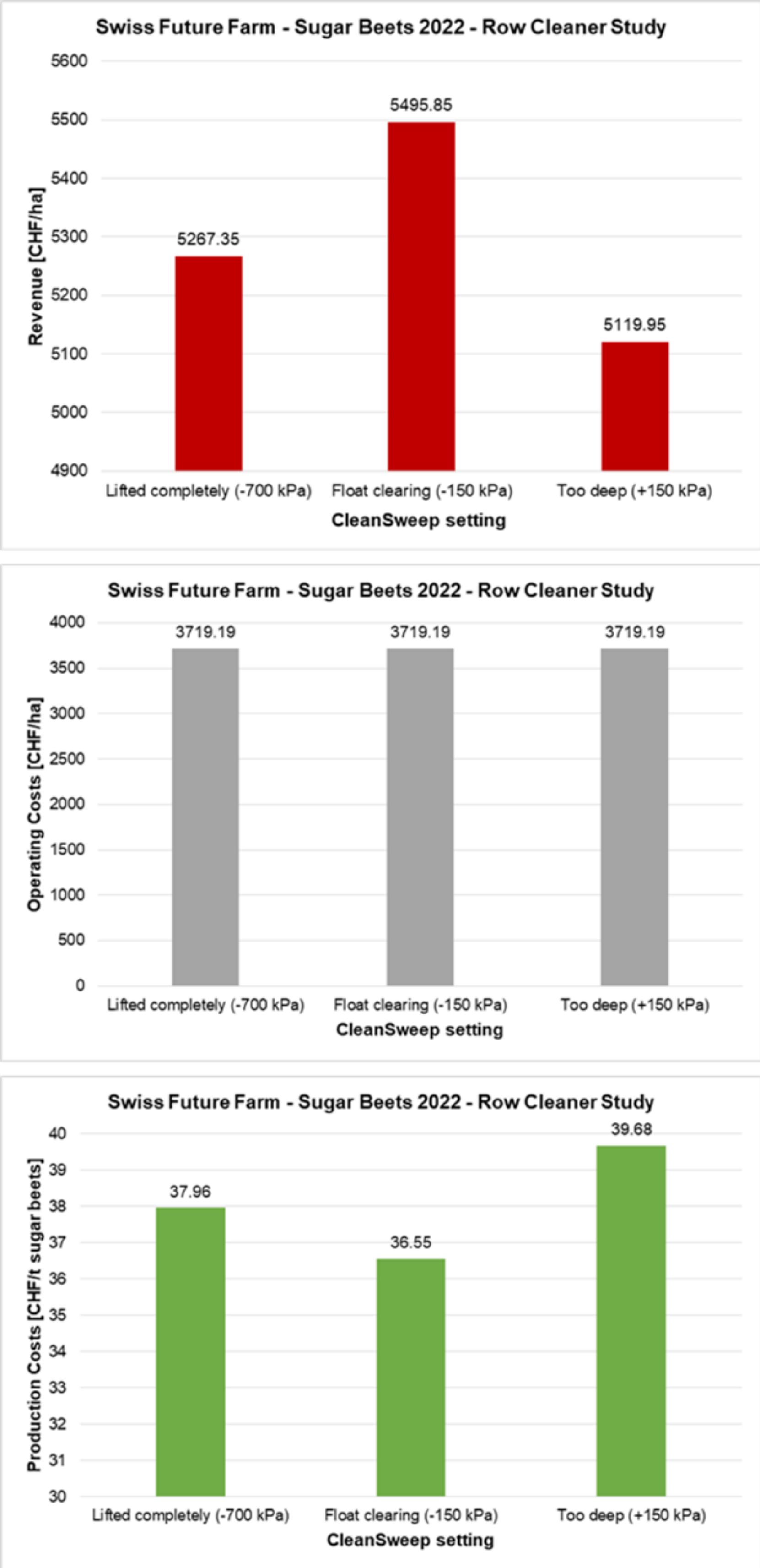


Figure 27. Revenue, operating costs, and production costs for the SFF 2022 Row Cleaner Study in sugar beets.

Additional Observations:

Morphology of sugar beets planted with different row cleaner settings did not differ significantly between the different trial strips (Figure 28).

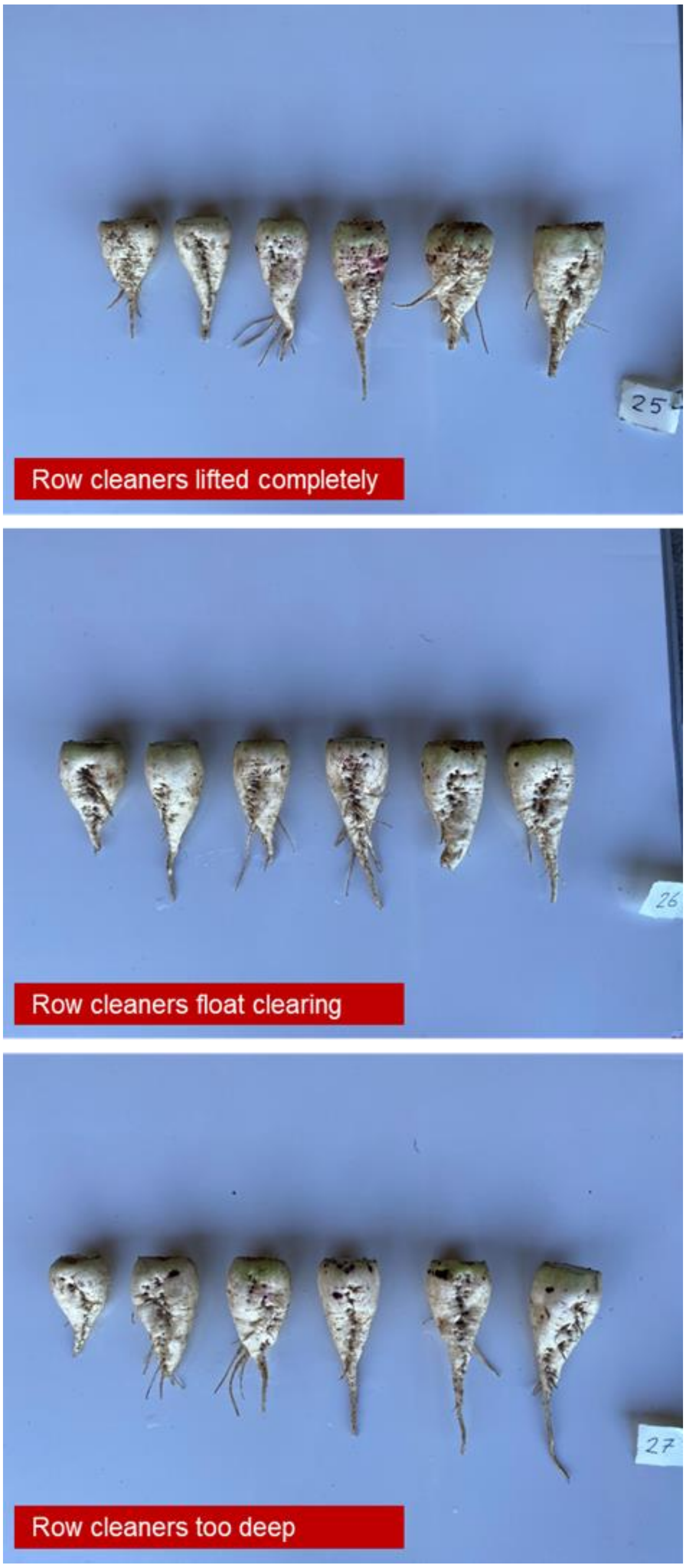


Figure 28. Morphology of sugar beets sampled during the SFF 2022 Row Cleaner Study.

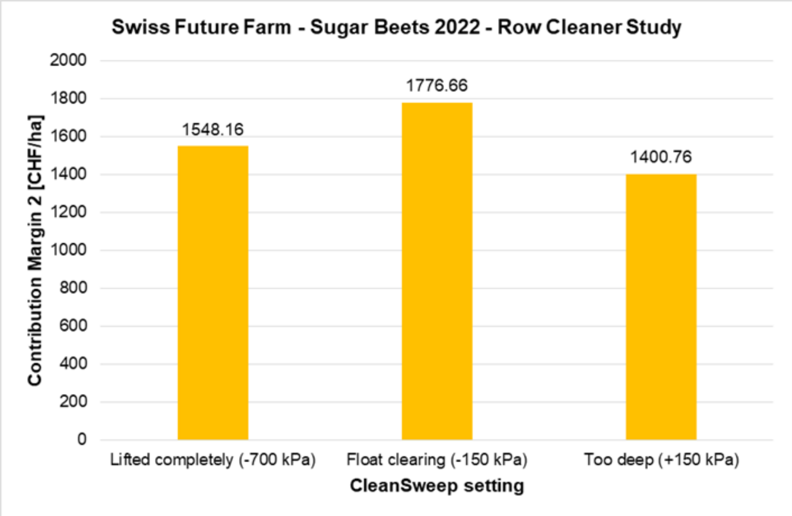
Recommendations and Equipment Solutions:

- Precision Planting CleanSweep™ allows for exact pneumatic adjustment of row cleaners according to the amount of crop residue in reduced tillage systems.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

Figure 29. Precision Planting CleanSweep™ pneumatic row cleaner system.

Payback:

For sugar beets planted proper float clearing row cleaner settings, an additional contribution margin of 228.85 CHF/ha and 375.90 CHF/ha could be achieved compared to no or too deep row cleaner application, respectively (Figure 30). These results underline that ensuring proper row cleaner settings according to the soil and residue conditions present during planting has significant impact on profitability of sugar beet production.



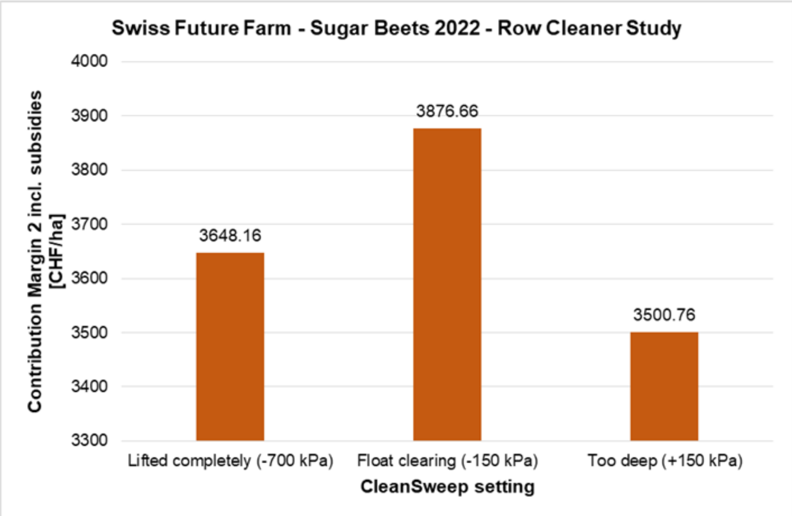


Figure 30. Contribution margin 2 obtained from the SFF 2022 Row Cleaner Study in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: 50.00 CHF/ton

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of Philipp Unfried (Precision Planting Product Support Specialist, DACH Region).

Appendix

Table 7 shows summarized results on revenue, operating costs, and production costs per ton, and contribution margin 2 for sugar beets planted with different row cleaner settings of the Precision Planting CleanSweep system.

Table 7. Cost accounting results of the SFF 2022 Row Cleaner Study in sugar beets.

	Row Cleaners Lifted completely (Clean Sweep -700 kPa)	**Row Cleaners Float clearing (CleanSweep -150 kPa)**	**Row Cleaners Too deep (CleanSweep +150 kPa)**
Sugar Beet Yield (t/ha)	98.0	101.8	93.7
Sugar Content (%)	16.24	16.14	16.63
Sugar Yield (t/ha)	13.9	14.4	13.7
Deliverables (CHF/ha)			
Crop Value / Revenue	5267.35	5495.85	5119.95
Costs (CHF/ha)			
Tillage	443.41	443.41	443.41
Seeding & Planting	788.81	788.81	788.81
Fertilization	763.15	763.15	763.15
Herbicide Application	186.18	186.18	186.18
Insecticide Application	136.33	136.33	136.33
Fungicide Application	403.45	403.45	403.45
Harvest	720.00	720.00	720.00
Labor	277.86	277.86	277.86
Outcomes			
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	3719.19	3719.19	3719.19
Production Costs (CHF/t sugar beets)	37.96	36.55	39.68
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1548.16	1776.66	1400.76
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and sugar beet subsidies	3648.16	3876.66	3500.76

1.5 Closing Study in Sugar Beets

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:

The objective of this study was to evaluate yield 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 in 2022 with a side-by-side strip trial design. A Precision Planting planter equipped with Precision Planting's FurrowForce pneumatic closing system (Figure 31) was used. The following closing pressure settings were tested:

- FurrowForce 0 psi (No closing pressure applied)
- FurrowForce 30 psi (Light closing pressure)
- FurrowForce 60 psi (Medium closing pressure)
- FurrowForce 100 psi (Heavy closing pressure)

The trial plot was located in a field with homogeneous soil conditions operated under reduced tillage regime. All treatments were planted at 3.8 cm planting depth with DeltaForce automatic down force control set to a target down force of 35 kg and with a plant population of 100,000 seeds per hectare (hybrid: KWS Smart Manja). Planting date was 24th March 2022.

Figure 31. Precision Planting FurrowForce closing system on planter row unit.

Results:

The trial was harvested 210 days after planting.

Results of the different closing pressure applied with the FurrowForce system show that sugar beet yield increased, when higher closing pressure was applied (Figure 32). This can be explained by the dry planting conditions, where furrows closed with high closing pressure had the best ability to preserve moisture and were not prone to be compacted.

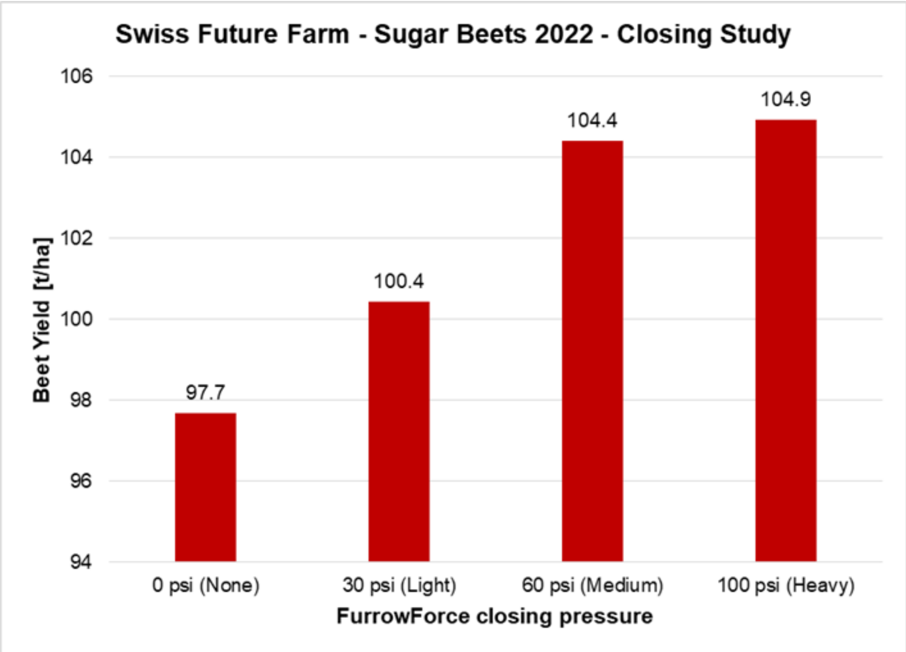


Figure 32. Beet yield results of the SFF 2022 Closing Study in sugar beets.

Sugar content also increased, the more closing pressure was applied (Figure 33). Reasons for this may be better soil moisture availability and preservation under higher closing pressure, as building in the sugar beet essentially requires sufficient water in addition to carbon dioxide.

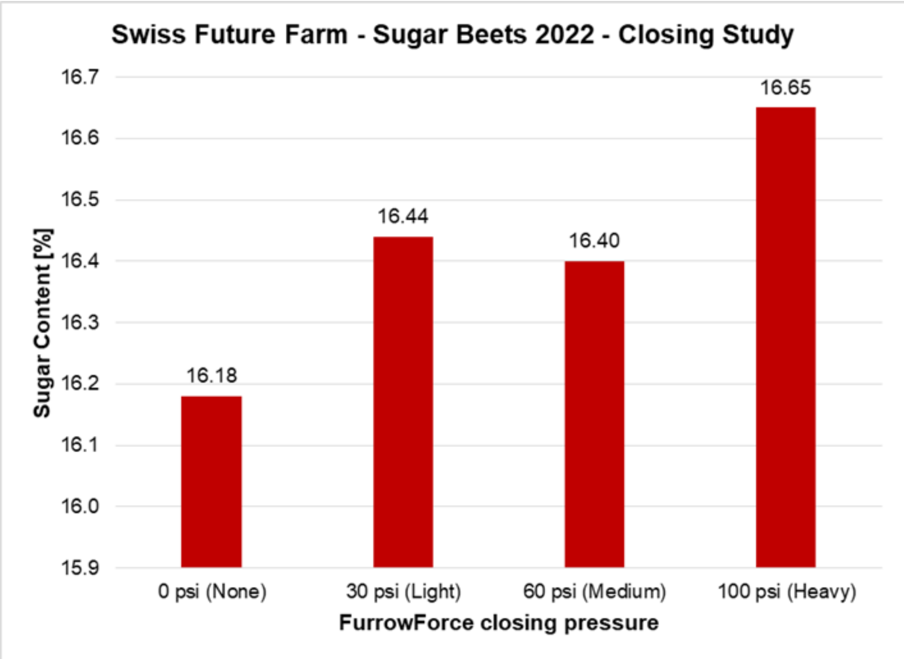


Figure 33. Sugar content results of the SFF 2022 Closing Study in sugar beets.

Equivalent to the trend found in beet yield and sugar content, higher sugar yield was obtained, the more closing pressure was applied (Figure 34).

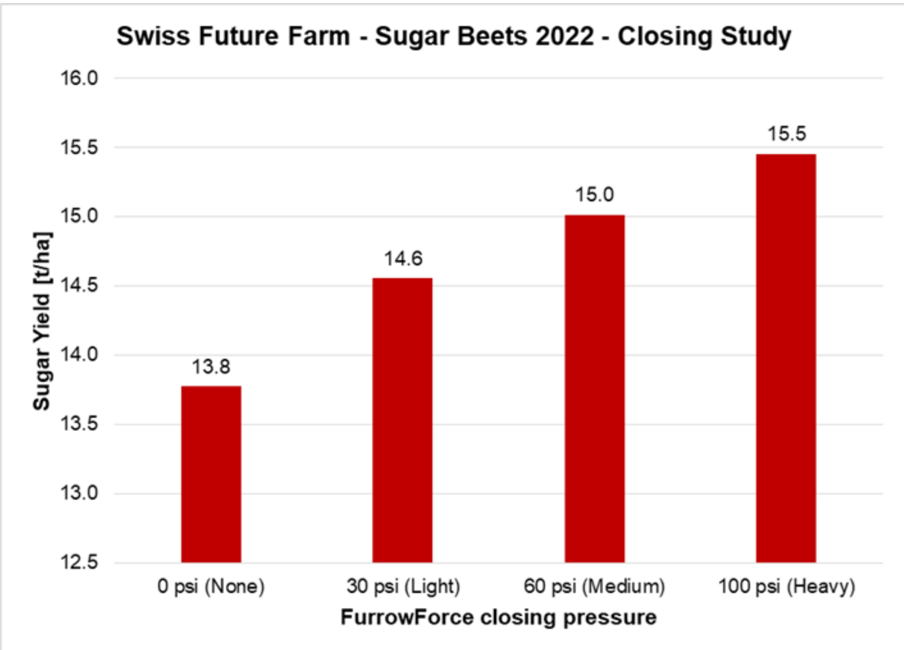


Figure 34. Sugar yield results of the SFF 2022 Closing Study in sugar beets.

Figure 35 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for the preceding cover crop (Phacelia) to sugar beet harvest. All field operations were conducted uniformly across all trial strips and the closing pressure settings represented the only variable altered between the different treatments. Hence, operating costs were equal across all treatments, and derived from higher beet yield, lower production costs per ton of sugar beets could be realized, the more closing pressure was applied during planting.

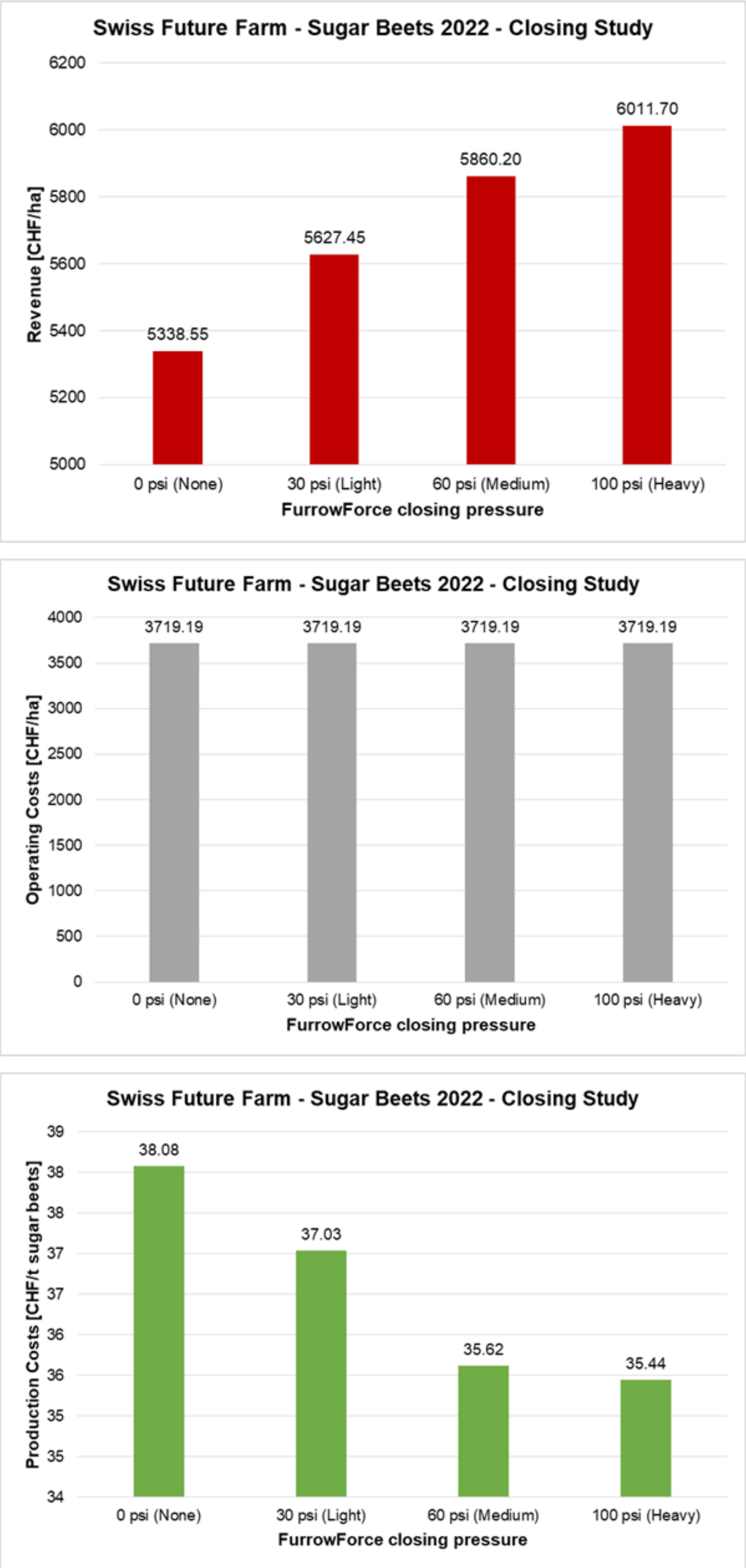


Figure 35. Revenue, operating costs, and production costs for the SFF 2022 Closing Study in sugar beets.

Additional Observations:

The trial plot for sugar beets on the Swiss Future Farm in 2022 was planted under challenging conditions, as we were experiencing a spring period with significantly low precipitation during the planting period for sugar beets in March (2022: 23.1 mm vs. 1991-2010 average: 79.8 mm). These dry planting conditions also explain the high yield impact that increased closing pressure showed due to better soil moisture preservation and hence, more beneficial emergence and growth conditions for sugar beets.

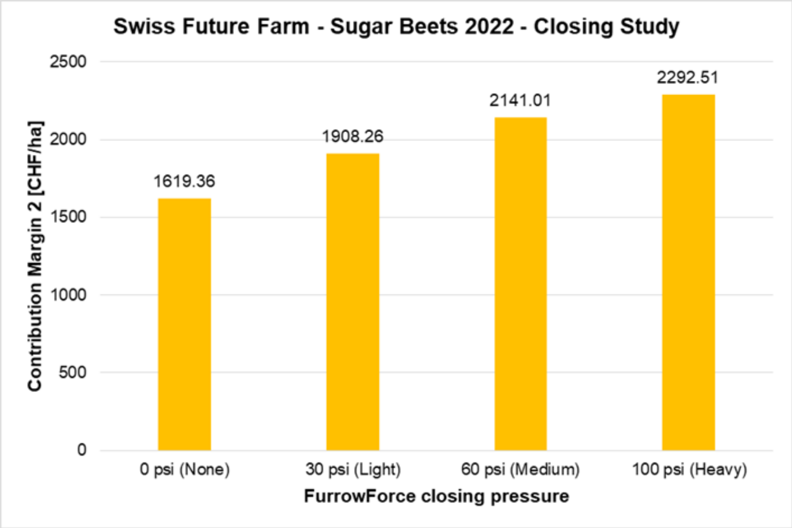
Recommendations and Equipment Solutions:

- In dry planting conditions, a higher closing pressure applied by the Precision Planting FurrowForce system allows a better preservation of soil moisture and therefore a higher population of emerged plants and better uniformity of emergence.
- SmartFirmer™ soil sensors measure soil moisture, soil temperature and organic matter in real time during planting.
- Precision Planting SmartDepth™ automatically adjusts planting depth between a minimum and maximum depth while maintaining the soil moisture target.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Using the Precision Planting 20/20 Gen3 monitor, planter sensor parameters are monitored and documented in high resolution. This will inform you, when adjustment of planter settings due to insufficient soil moisture or temperature is needed.
- Fendt Guide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

Figure 36. The pneumatic closing system Precision Planting FurrowForce enables to preserve soil moisture and to ensure yields under challenging climatic conditions.

Payback:

For sugar beets planted with different closing pressure settings, an additional contribution margin of 673.15 CHF/ha could be generated, comparing the least favorable (0 psi = no closing pressure applied) vs. applying the most favorable closing pressure setting (100 psi = heavy closing pressure) with Precision Planting FurrowForce (Figure 37). These results underline that ensuring proper closing of the furrow according to the conditions present during planting has significant impact on profitability of sugar beet production.



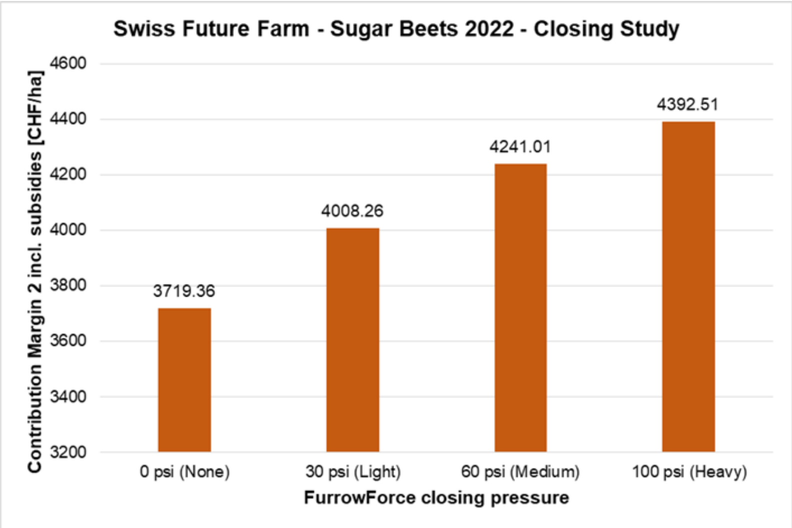


Figure 37. Contribution margin 2 obtained from the SFF 2022 Closing Study in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: 50.00 CHF/ton

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of Philipp Unfried (Precision Planting Product Support Specialist, DACH Region).

Appendix

Table 8 shows summarized results on revenue, operating costs, and production costs per ton, and contribution margin 2 for sugar beets planted with different closing pressure exerted by the Precision Planting FurrowForce system.

Table 8. Cost accounting results of the SFF 2022 Closing Study in sugar beets.

	FurrowForce 0 psi (None)	**FurrowForce 30 psi (Light)**	**FurrowForce 60 psi (Medium)**	**FurrowForce 100 psi (Heavy)**
Sugar Beet Yield (t/ha)	97.7	100.4	104.4	104.9
Sugar Content (%)	16.18	16.44	16.40	16.65
Sugar Yield (t/ha)	13.8	14.6	15.0	15.5
Deliverables (CHF/ha)				
Crop Value / Revenue	5338.55	5627.45	5860.20	6011.70
Costs (CHF/ha)				
Tillage	443.41	443.41	443.41	443.41
Seeding & Planting	788.81	788.81	788.81	788.81
Fertilization	763.15	763.15	763.15	763.15
Herbicide Application	186.18	186.18	186.18	186.18
Insecticide Application	136.33	136.33	136.33	136.33
Fungicide Application	403.45	403.45	403.45	403.45
Harvest	720.00	720.00	720.00	720.00
Labor	277.86	277.86	277.86	277.86
Outcomes				
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	3719.19	3719.19	3719.19	3719.19
Production Costs (CHF/t sugar beets)	38.08	37.03	35.62	35.44
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1619.36	1908.26	2141.01	2292.51
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and sugar beet subsidies	3719.36	4008.26	4241.01	4392.51

1.6 Planting Depth Study in Sugar Beets

Study Contact:

Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:

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

Study Design:

The study was carried out on the Swiss Future Farm (Switzerland) in 2022 as a side-by-side strip trial with the following planting depths:

- Uniform planting depth 2.5 cm (standard)
- Variable planting depth based on soil moisture (SM) measurements of Precision Planting SmartFirmer soil sensors and Precision Planting SmartDepth control with 3 increments: 2.5 - 3.8 - 5.5 cm planting depth:
    - SM >40% = 2.5 cm
    - SM 40%-30% = 3.8 cm
    - SM <30% = 5.5 cm
- Uniform planting depth 3.8 cm (slightly deeper)

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 (hybrid: KWS Smart Manja). Planting date for the study was in last week of March.

Results:

The trial plot was harvested in October 2022 (210 days after planting).

Highest sugar beet yield in the comparison was obtained from the trial strips with shallow standard planting depth (2.5 cm), whereas variable (2.5-5.5 cm) and slightly deeper planting depth (3.8 cm) provided lower yields (Figure 38). The beet yield difference amounts to 1.5% and 4.1% when planting at variable depth of 2.5-5.5 cm or 3.8 cm instead of 2.5 cm planting depth.

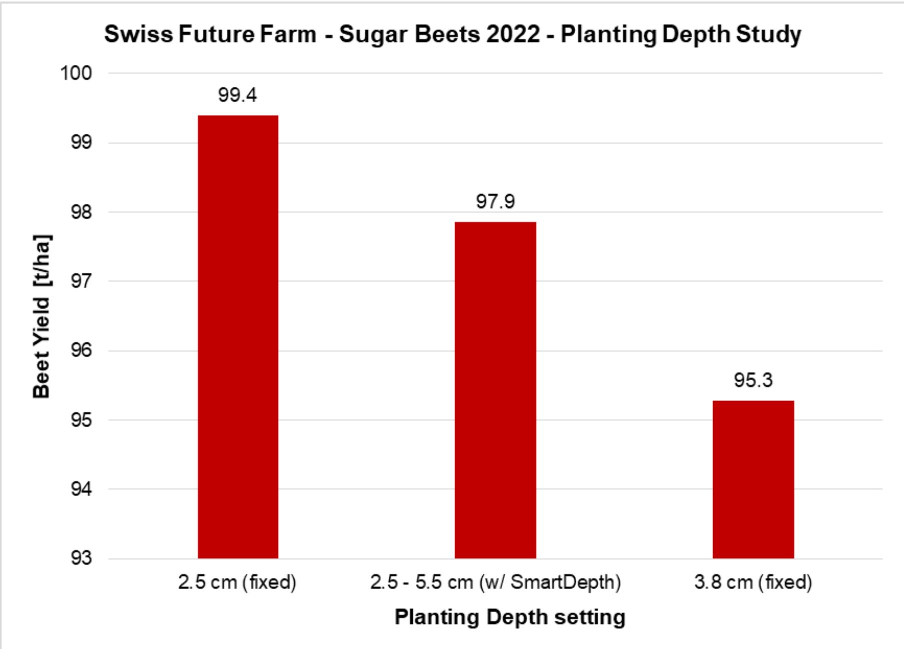


Figure 38. Beet yield results of the Swiss Future Farm 2022 Planting Depth Study in sugar beets.

Highest sugar content was obtained from sugar beets planted at standard planting depth of 2.5 cm (16.92%), whereas variable and slightly deeper planting depth had lower sugar content of 16.39% and 16.25%, respectively (Figure 39). This may be due to lower impurities such as amino acids, potassium and sodium in sugar beets planted at 2.5 cm planting depth, as these impurities reduce the extractable sugar.

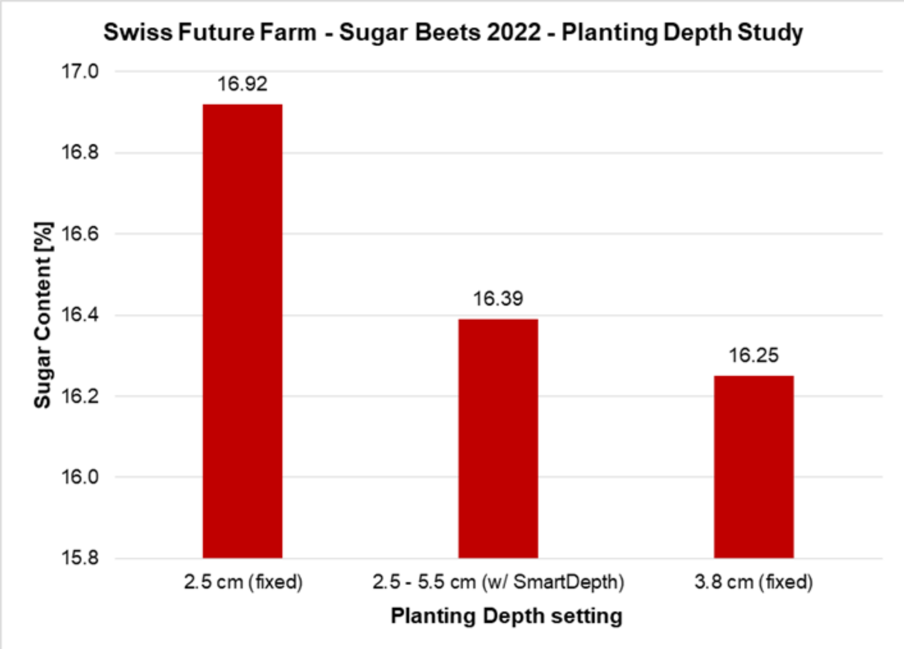


Figure 39. Sugar content results of the Swiss Future Farm 2022 Planting Depth Study in sugar beets.

Highest sugar yield was obtained from the trial strips with 2.5 cm standard planting depth, whereas less sugar yield for variable and slightly deeper planting depth was found (Figure 40). In our study, the increase in sugar yield that can be generated by planting at 2.5 cm instead of 2.5-5.5 cm and 3.8 cm planting depth amounts to 6.0% and 8.7%.

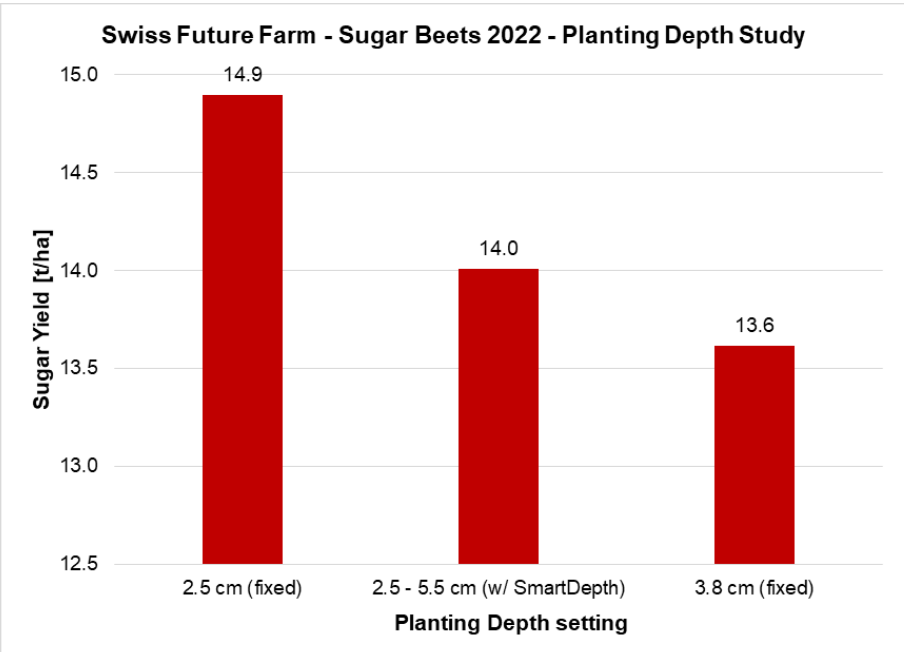


Figure 40. Sugar yield results of the Swiss Future Farm 2022 Planting Depth Study in sugar beets.

Figure 41 shows a graphical comparison for revenue, operating costs, and production costs per ton of sugar beets as results of this study. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for the preceding cover crop (Phacelia) to sugar beet harvest. All field operations were conducted uniformly across all trial strips and the planting depth settings represented the only variable altered between the different treatments.

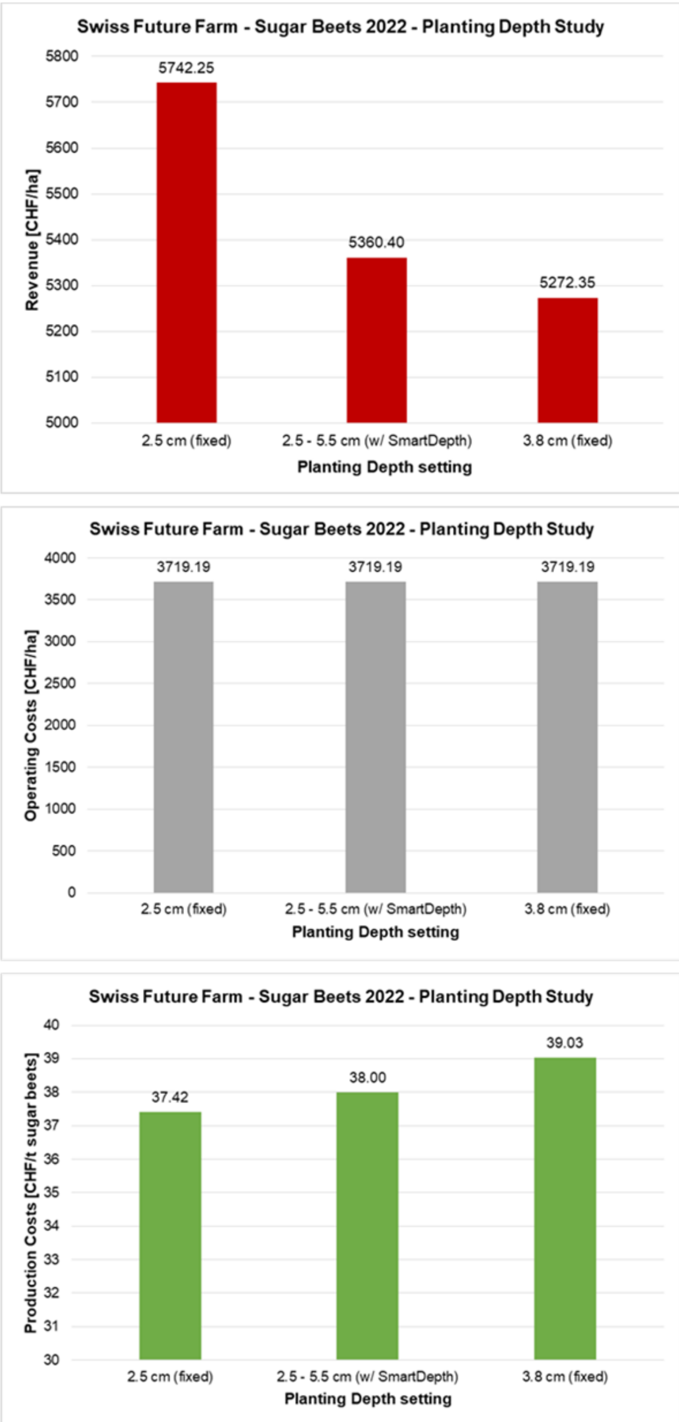


Figure 41. Revenue, operating costs, and feed costs for the SFF 2022 Planting Depth Study in sugar beets.

Additional Observations:

Morphology of sugar beets grown with different planting depth did not differ significantly for the treatments with fixed or variable depth (Figure 42).

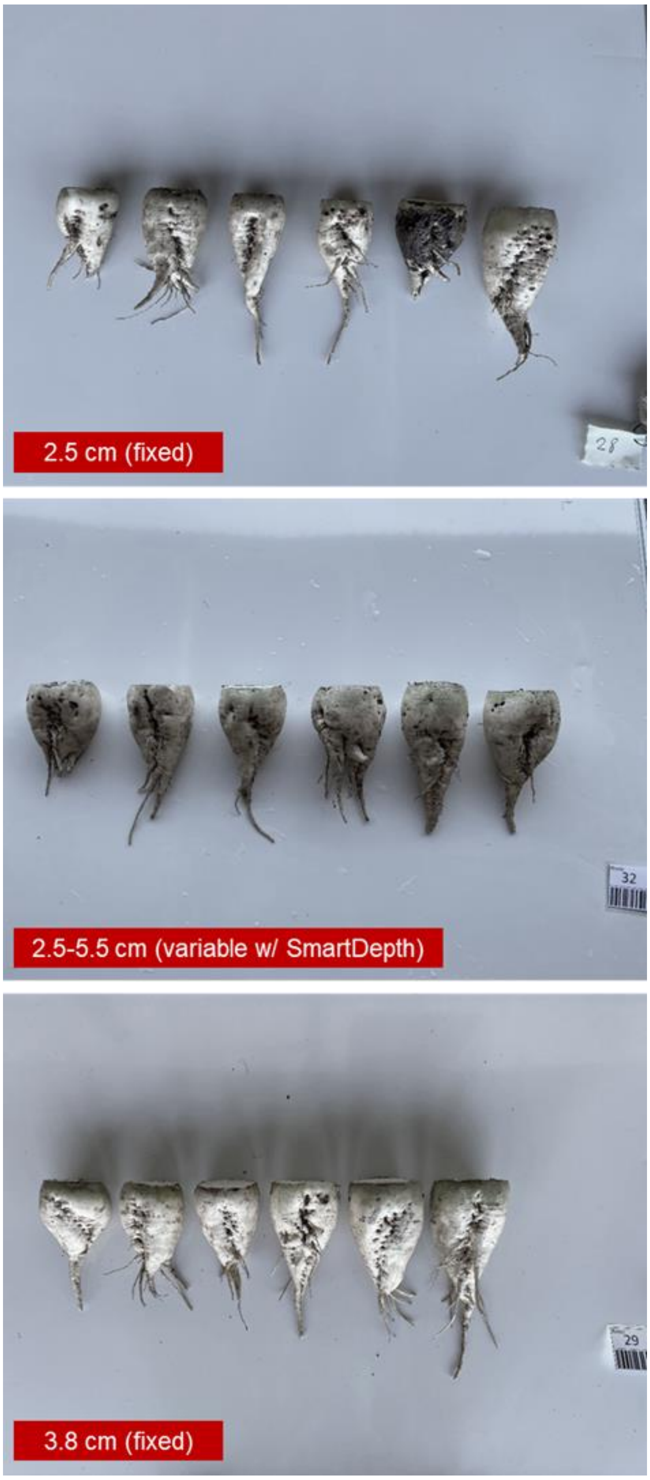


Figure 42. Morphology of sugar beets sampled during the SFF 2022 Planting Depth Study showing beets grown with standard (top), variable (middle), and slightly deeper (bottom) planting depth.

Recommendations and Equipment Solutions:

- Precision Planting SmartFirmer™ soil sensors measure soil moisture, soil temperature and organic matter in real time during planting and provide meaningful information on soil properties and field zones.
- Precision Planting SmartDepth™ automatically adjusts planting depth between a minimum and maximum depth while maintaining the soil moisture target based on SmartFirmer soil sensor measurements.
- vSet™ seed meters and vDrive™ electric drives provide highest accuracy for singulation of row crops and enable real time adjustment of planting rates.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

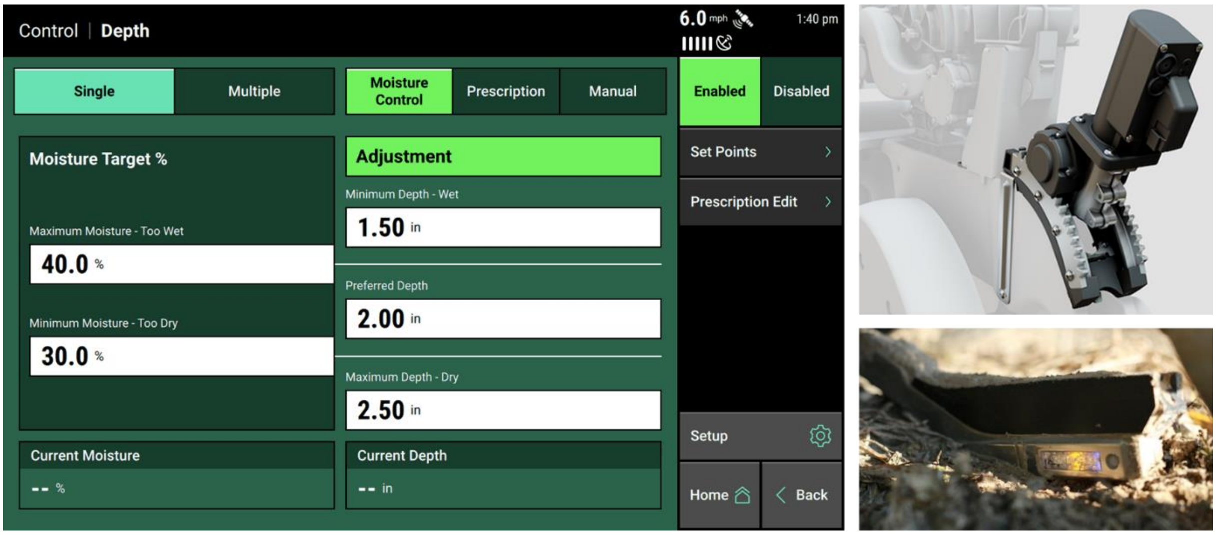
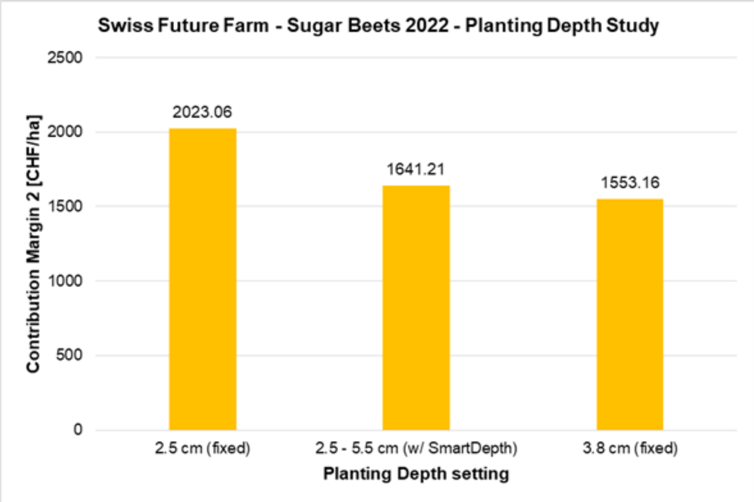


Figure 43. Variable Depth Moisture Control mode in the Precision Planting 20/20 Gen3 monitor (left), Precision Planting SmartDepth gearbox for real-time adaption of planting depth according to soil moisture (top right), and Precision Planting SmartFirmer for measurement of soil moisture in the furrow (bottom right).

Payback:

For sugar beets planted at 2.5 cm fixed planting depth, an additional contribution margin of 381.85 CHF/ha and 469.90 CHF/ha could be achieved compared to 2.5-5.5 cm variable planting depth and 3.8 cm fixed planting depth, respectively (Figure 44).



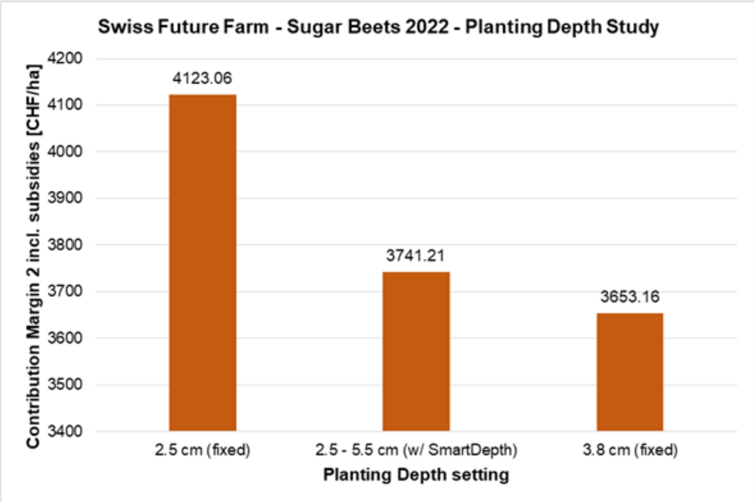


Figure 44. Contribution margin 2 obtained from the SFF 2022 Planting Depth Study in sugar beets.

Assumptions for payback:

The assumptions on payback are based on the conditions in the Swiss Sugar Beet Growing and Delivery Agreement 2022 between Schweizer Zucker AG and the Swiss Sugar Beet Growers Association.

Sugar beet basic price: 50.00 CHF/ton

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of Philipp Unfried (Precision Planting Product Support Specialist, DACH Region).

Appendix

Table 9 shows summarized results on revenue, operating costs, production costs per ton, and contribution margin 2 for sugar beets planted with different planting depth using the Precision Planting SmartDepth system.

Table 9. Cost accounting results of the SFF 2022 Planting Depth in sugar beets.

	Planting Depth 2.5 cm (fixed)	**Planting Depth 2.5 - 5.5 cm (w/ SmartDepth)**	**Planting Depth 3.8 cm (fixed)**
Sugar Beet Yield (t/ha)	99.4	97.9	95.3
Sugar Content (%)	16.92	16.39	16.25
Sugar Yield (t/ha)	14.9	14.0	13.6
Deliverables (CHF/ha)			
Crop Value / Revenue	5742.25	5360.40	5272.35
Costs (CHF/ha)			
Tillage	443.41	443.41	443.41
Seeding & Planting	788.81	788.81	788.81
Fertilization	763.15	763.15	763.15
Herbicide Application	186.18	186.18	186.18
Insecticide Application	136.33	136.33	136.33
Fungicide Application	403.45	403.45	403.45
Harvest	720.00	720.00	720.00
Labor	277.86	277.86	277.86
Outcomes			
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	3719.19	3719.19	3719.19
Production Costs (CHF/t sugar beets)	37.42	38.00	39.03
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	2023.06	1641.21	1553.16
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and sugar beet subsidies	4123.06	3741.21	3653.16

1.7 Cover Crop Study in Silage Corn

Study Contact:
Roman Gambirasio, Technical Manager and Product Specialist, Swiss Future Farm, roman.gambirasio@gvs-agrar.ch
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm, nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield, operating costs and the resulting feed costs in silage corn planted after different cover crop types.

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. Cover crop seeding on the trial plot was done in fall 2021 for corn planting in spring 2022. Different cover crops (Table 10) were seeded on 6th September 2021 as cover crop banding (Figure 45). Silage corn was planted as no-till on 21st April 2022, the planted hybrid was KWS Amaroc with 90,000 seeds/ha. Conventional tillage using moldboard plow and power harrow served as a control treatment for the cover crop comparison.

Table 10. Cover crops before silage corn tested for the SFF 2022 Cover Crop Study in Silage Corn.

Trial strip	Cover crop	Species	Seed rate	Seed price
Cover Crop Banding + No-Till				
1	UFA Inka mixture	• Vetch *(Vicia sativa)*: 54.8% • Egyptian clover *(Trifolium alexandrinum)*: 19.4% • Crimson clover *(Trifolium incarnatum)*: 12.9% • Phacelia *(Phacelia tanacetifolia)*: 12.9%	30 kg/ha	5.10 CHF/kg
2	UFA Lepha mixture	• Vetch *(Vicia sativa)*: 63.3% • Egyptian clover *(Trifolium alexandrinum)*: 20.0% • Phacelia *(Phacelia tanacetifolia)*: 13.3% • Ramtil *(Guizotia abyssinica)*: 3.3%	30 kg/ha	4.70 CHF/kg
3	Brown Mustard	• Brown mustard *(Brassica juncea)*: 100%	7 kg/ha	11.20 CHF/kg
4	Winter Peas	• Pea *(Pisum sativum)*: 100%	140 kg/ha	2.05 CHF/kg
5	Phacelia	• Phacelia *(Phacelia tanacetifolia)*: 100%	8 kg/ha	9.20 CHF/kg
Control: Conventional Tillage w/ Moldboard Plow and Power Harrow				
6	Phacelia	• Phacelia *(Phacelia tanacetifolia)*: 100%	8 kg/ha	9.20 CHF/kg

Figure 45. Cover crop banding with left-out strips for later corn planting: established cover crop stand in fall (top) and seeder operation scheme with blocked outlets for strips with 75 cm row spacing (bottom).

Results:

The trial was harvested 138 days after planting. Highest dry matter yield of 21.3 t/ha was obtained in silage corn planted after UFA Lepha cover crop mixture while the other cover crop types resulted in slightly lower dry matter yield between 19.2 and 20.4 t/ha, respectively (Figure 46). In an overall consideration, the silage corn yield level was within a very satisfying range for all tested cover crop types.

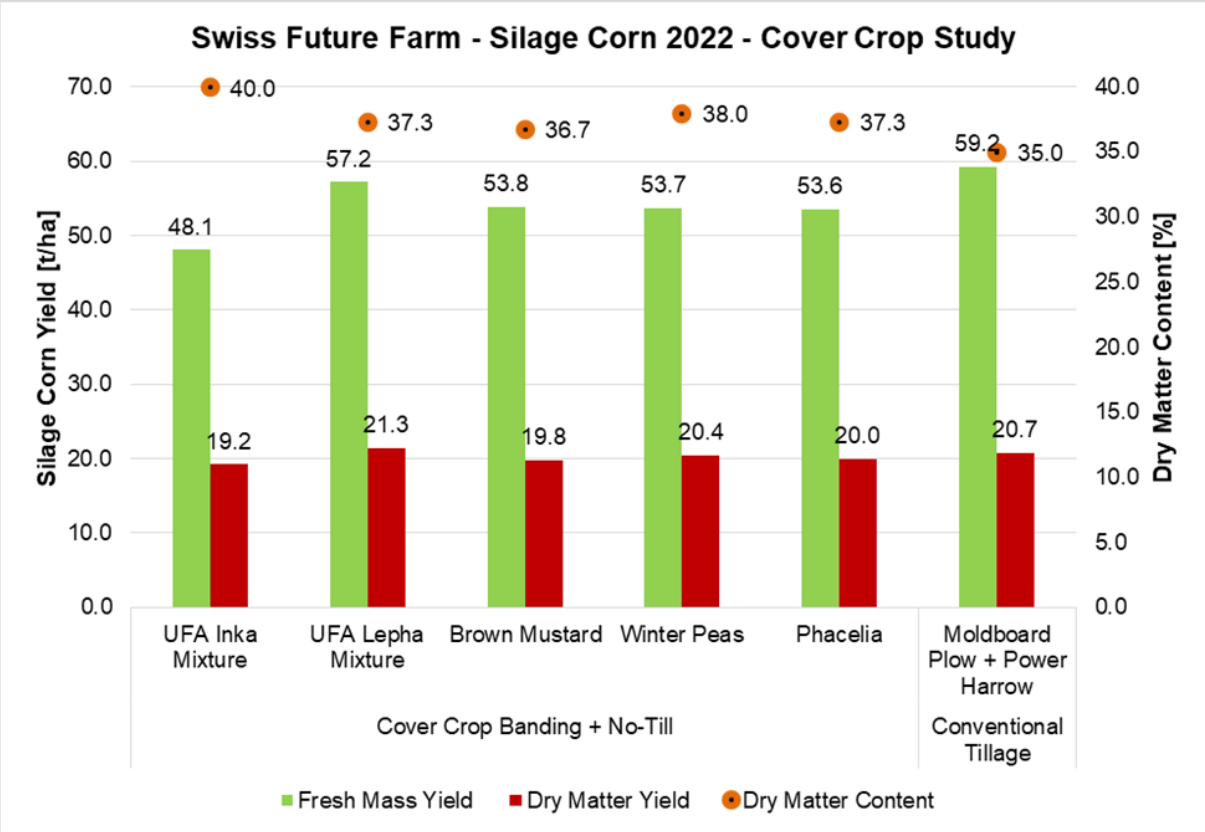


Figure 46. Yield results of the SFF 2022 Cover Crop Study in silage corn.

Table 11 shows the results on revenue, operating costs, feed costs, and contribution margin 2 for silage corn planted after the individual cover crop types. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for cover crop seeding to silage corn harvest. All field operations were conducted uniformly across all trial strips and the cover crop type represented the only variable altered between the different treatments.

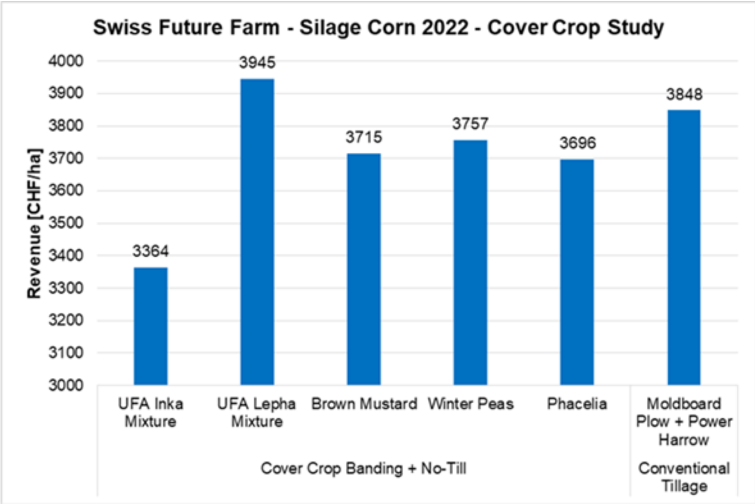
Highest operating costs resulted for the conventional tillage regime due to tillage passes both for plowing and power harrowing and the corresponding equipment and labor costs. Derived from this, lowest feed costs per ton dry matter could be realized in silage corn planted after UFA Lepha cover crop mixture (128.14 CHF/t DM), whereas feed costs were highest for conventional tillage with moldboard plow and power harrow (145.78 CHF/t DM). Feed costs for silage corn planted after Phacelia and Brown Mustard were ranging on a similar level between 133.10 and 134.68 CHF/t DM, whereas comparably high feed costs in the Winter Peas trial strip (140.95 CHF/t DM) can be explained by the higher seed costs for this cover crop type (Table 11). These calculations show that the revenue (crop value) based on obtained yield and seeding cost differences due to seed price differences for the applied cover crop types represent the crucial financial levers in the comparison.

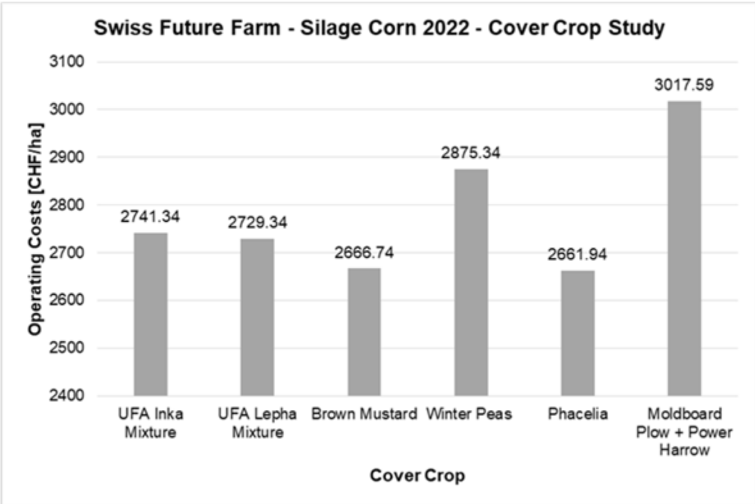
Table 11. Cost accounting results of the SFF 2022 Cover Crop Study in silage corn.

	Cover Crop Banding + No-Till					**Conventional Tillage**
	UFA Inka	**UFA Lepha**	**Brown Mustard**	**Winter Peas**	**Phacelia**	**Moldboard Plow + Power Harrow**
Fresh Mass Yield (t/ha)	48.1	57.2	53.8	53.7	53.6	59.2
Dry Matter Content (%)	40.0	37.3	36.7	38.0	37.3	35.0
Dry Matter Yield (t/ha)	19.2	21.3	19.8	20.4	20.0	20.7
Target price with corresponding dry matter content (CHF/t)*	70.00	69.00	69.00	70.00	69.00	65.00
Deliverables (CHF/ha)						
Crop Value / Revenue	3363.89	3944.85	3714.85	3757.14	3696.43	3848.00
Costs (CHF/ha)						
Tillage	122.20	122.20	122.20	122.20	122.20	466.71
Seeding & Planting	605.60	593.60	531.00	739.60	526.20	526.20
Fertilization	977.35	977.35	977.35	977.35	977.35	977.35
Weed Control	231.41	231.41	231.41	231.41	231.41	172.31
Harvest	488.00	488.00	488.00	488.00	488.00	488.00
Labor	316.78	316.78	316.78	316.78	316.78	387.02
Outcomes						
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	2741.34	2729.34	2666.74	2875.34	2661.94	3017.59
Feed Costs (CHF/t DM)	142.78	128.14	134.68	140.95	133.10	145.78
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	622.54	1215.50	1048.10	881.80	1034.48	830.41

*AGRIDEA base prices 2022

Figure 47 shows a graphical comparison for revenue, operating costs, and feed costs as results of this study.





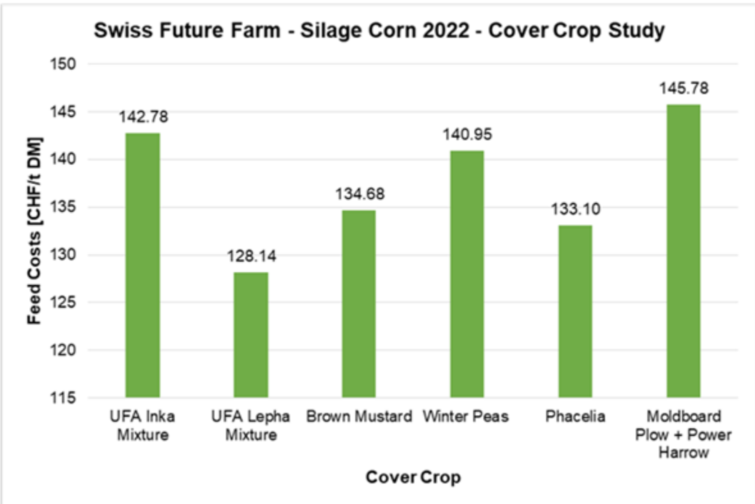


Figure 47. Revenue, operating costs, and feed costs for the SFF 2022 Cover Crop Study in silage corn.

Additional Observations:

Crop measurements with the Precision Planting POGO Stick and Research Pogo App showed better development and lower share of late emergers (LE1 and LE2) for silage corn planted in the conventional tillage trial strip, whereas a higher share of late emergers was found in the Winter Peas and Phacelia trial strips (Figure 48).

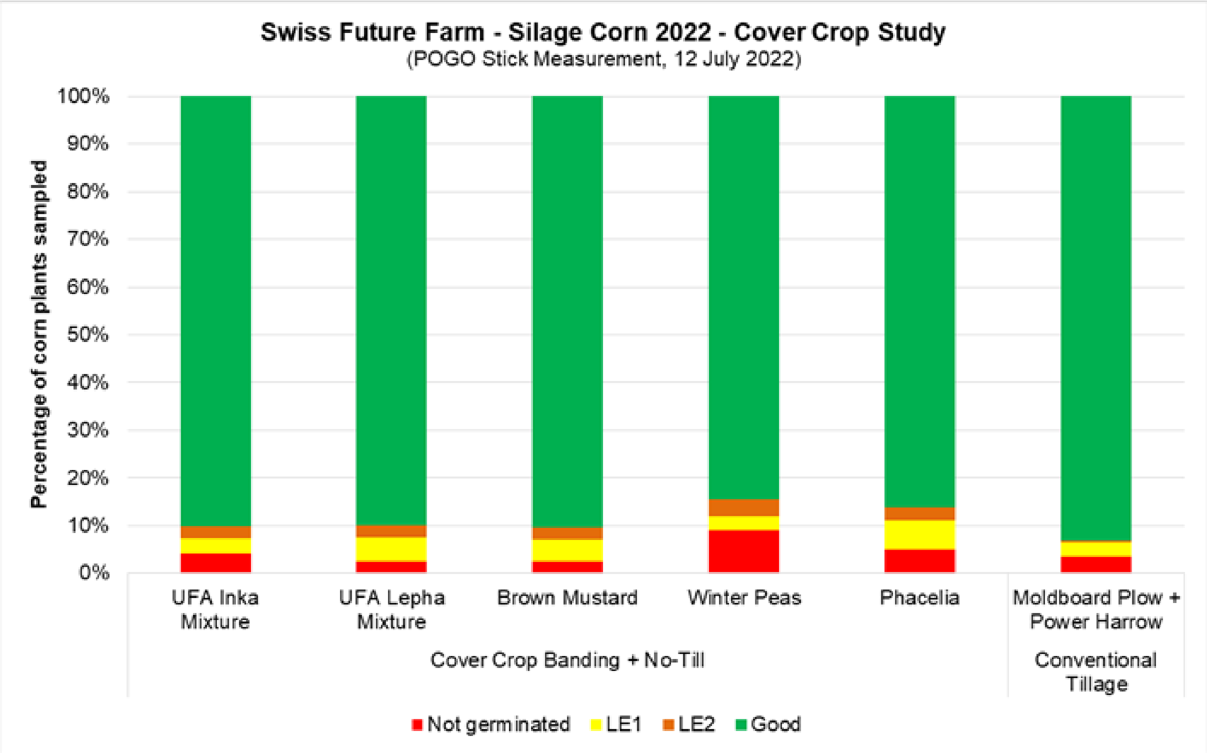


Figure 48. Results of crop measurements of the SFF 2022 Cover Crop Study in silage corn.

Recommendations and Equipment Solutions:

- Precision Planting CleanSweep™ allows for exact pneumatic adjustment of row cleaners according to the amount of crop residue.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

Figure 49. Precision Planting CleanSweep™ row cleaner adjustment system.

Payback:

For silage corn planted in a no-till regime after different cover crops, contribution margins between 622.54 CHF/ha and 1215.50 CHF/ha could be achieved, whereas the control treatment (conventional tillage) provided a contribution margin of 830.41 CHF/ha (Figure 50). Based on these results, an additional contribution margin of 385.09 CHF/ha could be achieved in the highest yielding cover crop and no-till treatment (UFA Lepha mixture) compared to conventional tillage using moldboard plow and power harrow.

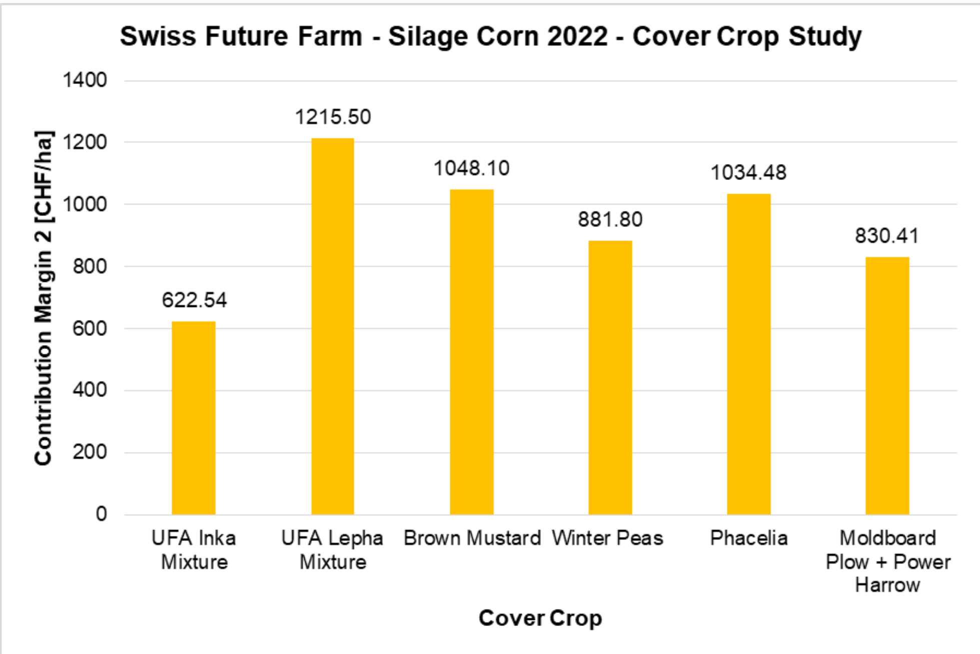


Figure 50. Contribution margin 2 obtained from the SFF 2022 Cover Crop Study trial strips in silage corn.

Assumptions for payback:

Price calculations for silage corn based on the guidelines of AGRIDEA (2022).

Silage corn fresh mass price after harvest by seller:

DM content (%)	≥38	37	36	35	34	33	32	31	30	29	≤28
Price (CHF/t FM)	70.00	69.00	67.00	65.00	63.00	61.00	59.00	57.00	56.00	54.00	52.00

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team.

1.8 Tillage Study in Silage Corn

Study Contact:
Roman Gambirasio, Technical Manager and Product Specialist, Swiss Future Farm, roman.gambirasio@gvs-agrar.ch
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm, nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield, operating costs and the resulting feed costs in silage corn planted after no-till, reduced, and conventional tillage regime.

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. Cover crop seeding on the trial plot was done in fall 2021 for corn planting in spring 2022. Different tillage regimes were applied for seedbed preparation after Phacelia (*Phacelia tanacetifolia*) as a cover crop before corn planting (Table 12). Silage corn was planted on 21st April 2022, the planted hybrid was KWS Amaroc with 90,000 seeds/ha. Due to crow damages, approximately 25% of the area in the conventional tillage trial strip needed to be harrowed and replanted again on 11th May 2022.

Table 12. Tillage regimes tested for the SFF 2022 Tillage Study in Silage Corn.

Trial strip	Tillage Regime	Tillage Operations
1	Mulch Till w/ Cultivator	• Knife Roller (1x) • Cultivator (1x)
2	Mulch Till w/ Disc Harrow	• Knife Roller (1x) • Disc Harrow (1x)
3	No-Till	• Knife Roller (1x)
4	Conventional	• Knife Roller (1x) • Moldboard Plow (1x) • Power Harrow (1x)

Results:

The trial was harvested 138 days after planting. Highest dry matter yield of 21.0 and 21.2 t/ha was obtained in silage corn planted in a mulch-till regime with cultivator and disc harrow while no-till and conventional tillage resulted in slightly lower dry matter yield of 19.2 and 20.7 t/ha, respectively (Figure 51). In an overall consideration, the silage corn yield level was within a very satisfying range for all tillage regimes.

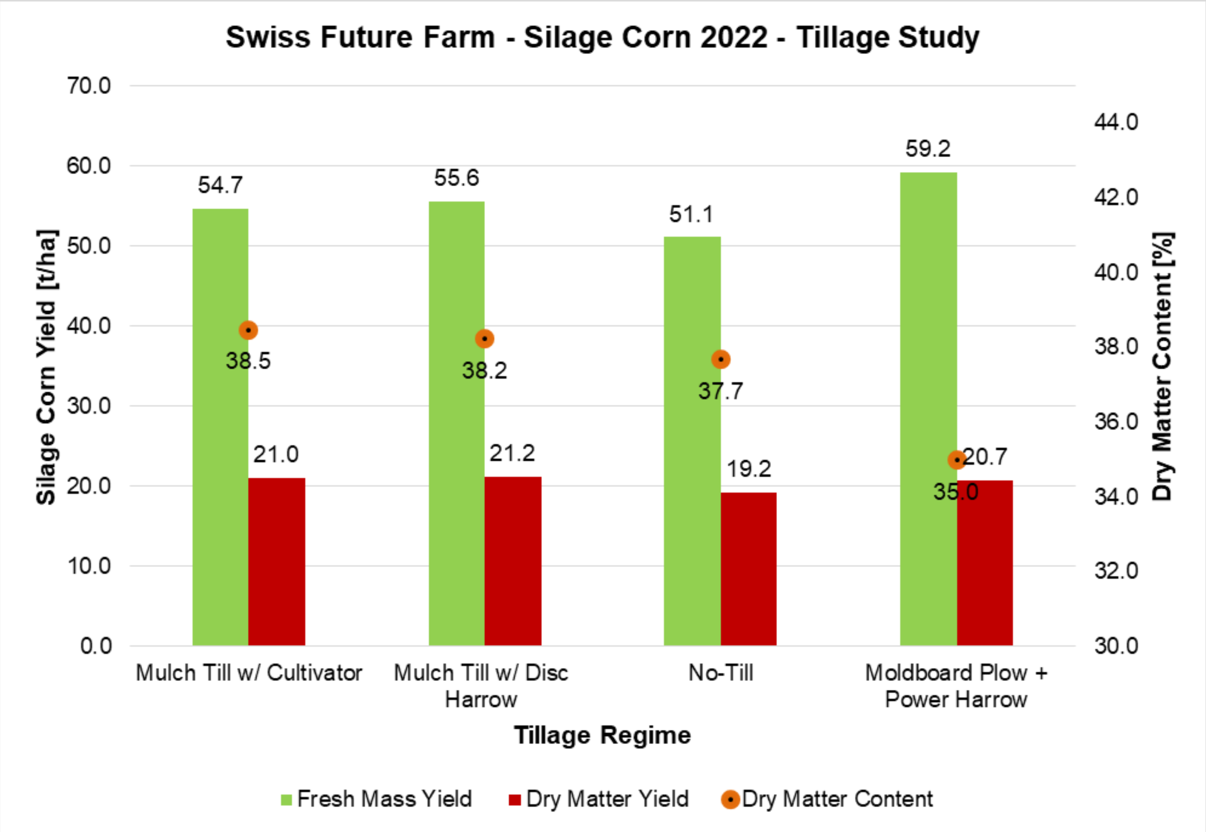


Figure 51. Yield results of the SFF 2022 Tillage Study in silage corn.

Table 13 shows the results on revenue, operating costs, feed costs, and contribution margin 2 for silage corn planted in the tested tillage regimes. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation for cover crop seeding to silage corn harvest. Except tillage and weed control required to the respective weed pressure in the individual trial strip as well as replanting in the conventional tillage trial strip, all other field operations were conducted uniformly across all trial strips.

Highest operating costs resulted for the conventional tillage regime due to tillage passes both for plowing and power harrowing and the corresponding equipment and labor costs. In addition, the replanting required in this trial strip caused additional costs of 193.00 CHF/ha. Derived from this, lowest feed costs per ton dry matter could be realized in silage corn planted after mulch till with disc harrow (127.38 CHF/t DM), whereas feed costs were highest for conventional tillage with moldboard plow and power harrow (155.11 CHF/t DM). Feed costs for silage corn planted in a no-till regime were on an intermediate level of 138.64 CHF/t DM, due to lower dry matter yield and additional herbicide application required in this treatment (Table 13).

Table 13. Cost accounting results of the SFF 2022 Tillage Study in silage corn.

	Mulch Till w/ Cultivator	**Mulch Till w/ Disc Harrow**	**No-Till**	**Moldboard Plow + Power Harrow**
Fresh Mass Yield (t/ha)	54.7	55.6	51.1	59.2
Dry Matter Content (%)	38.5	38.2	37.7	35.0
Dry Matter Yield (t/ha)	21.0	21.2	19.2	20.7
Target price with corresponding dry matter content (CHF/t)*	70.00	70.00	69.00	65.00
Deliverables (CHF/ha)				
Crop Value / Revenue	3828.57	3888.89	3525.90	3848.00
Costs (CHF/ha)				
Tillage	224.06	205.80	122.20	525.05
Seeding & Planting	526.20	526.20	526.20	637.39
Fertilization	977.35	977.35	977.35	977.35
Weed Control	172.31	172.31	231.41	172.31
Harvest	488.00	488.00	488.00	488.00
Labor	341.78	330.78	316.78	410.64
Outcomes				
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	2729.70	2700.44	2661.94	3210.74
Feed Costs (CHF/t DM)	129.99	127.38	138.64	155.11
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1098.87	1188.45	863.96	637.27

*AGRIDEA base prices 2022

Figure 52 shows a graphical comparison for revenue, operating costs, and feed costs as results of this study. Although the no-till treatment entailed the lowest process costs, the feed costs per ton of dry matter were the second highest. This is due to the lower yield with lower DM content compared to the cultivator and disc harrow treatments.

Crow feeding in the intensive tillage trial strip (moldboard plow + power harrow) had a decisive influence. The clean seedbed without any plant residues allowed the crows to find the seeds much better. It seems that the residues of the cover crop and the somewhat more heterogeneous seedbed of the other three trial strips (reduced or no-till) made foraging more difficult for the crows.

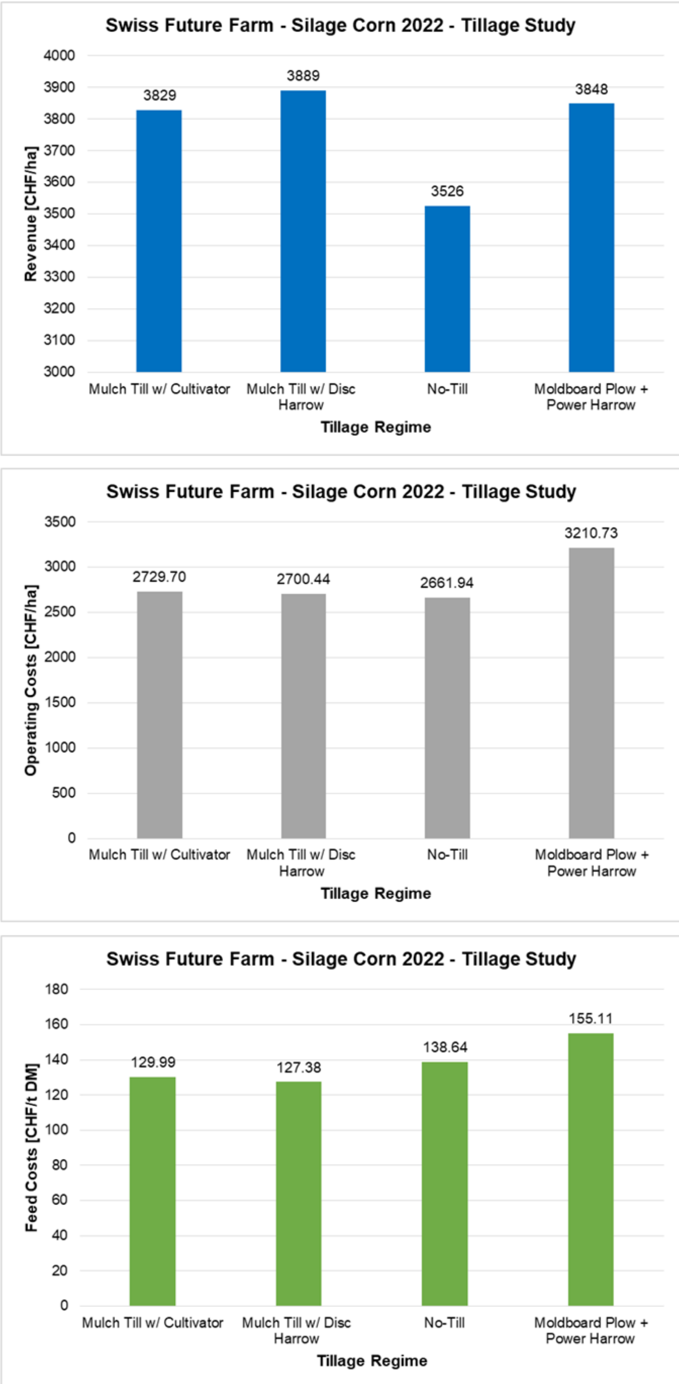


Figure 52. Revenue, operating costs, and feed costs for the SFF 2022 Tillage Study in silage corn.

Additional Observations:

Crop measurements with the Precision Planting POGO Stick and Research Pogo App showed better development and lower share of late emergers (LE1 and LE2) for silage corn planted in the mulch till with disc harrow and the conventional tillage trial strip, whereas a higher share of late emergers was found in the No-Till trial strip (Figure 53).

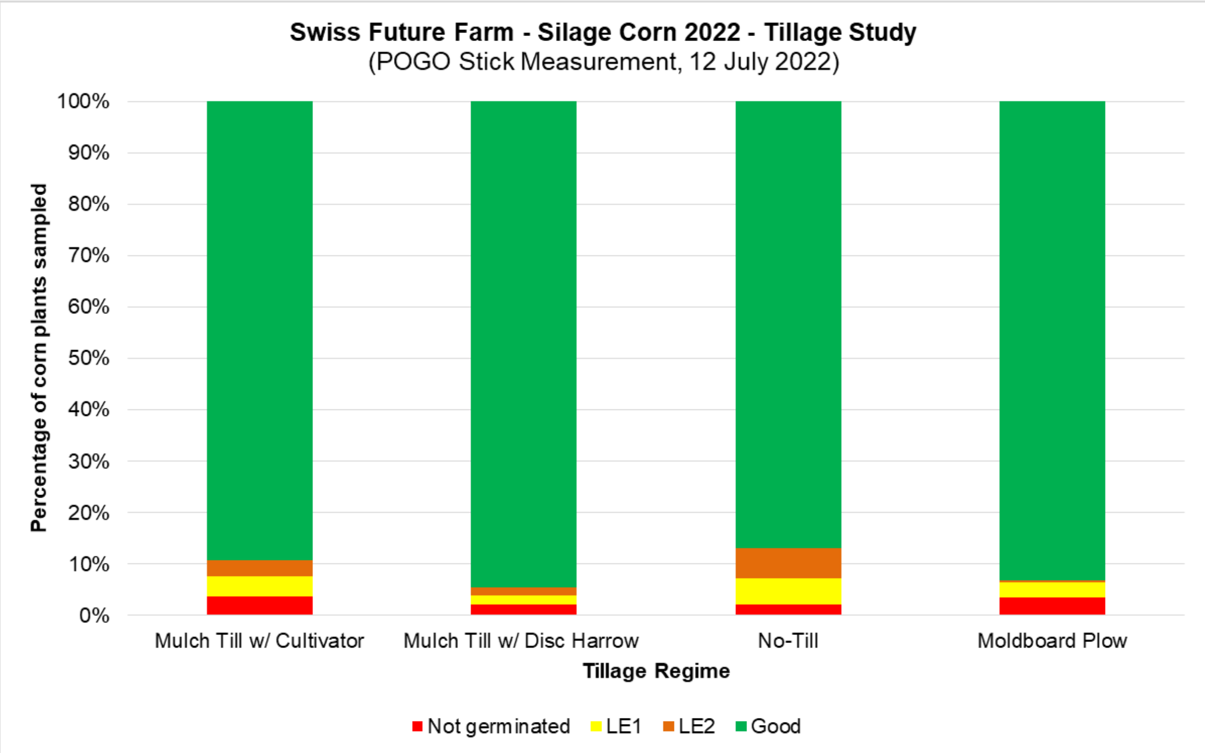


Figure 53. Results of crop measurements of the SFF 2022 Tillage Study in silage corn.

Recommendations and Equipment Solutions:

- Precision Planting CleanSweep™ allows for exact pneumatic adjustment of row cleaners according to the amount of crop residue.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

Figure 54. Precision Planting CleanSweep™ row cleaner adjustment system.

Payback:

For silage corn planted in a no-till or mulch till regime, contribution margins between 863.96 and 1188.45 CHF/ha could be achieved, which are all higher than the control treatment (conventional tillage) with 637.27 CHF/ha (Figure 55). Based on these results, an additional contribution margin of 358.04 CHF/ha could be achieved in the highest yielding mulch till treatment (w/ disc harrow) compared to conventional tillage using moldboard plow and power harrow. However, it can be assumed that the intensive tillage regime using moldboard plow and power harrow would have achieved a significantly higher contribution margin without replanting. On the one hand, the DM content would probably have been closer to the other treatment, on the other hand, additional operating costs of 193.00 CHF/ha would have been saved.

It is important to mention in this context that in a milk producing region like Switzerland, very often a 1-2 year temporary grassland is grown before silage corn. This allows one or even two forage cuts to be harvested in spring before corn planting. For this reason, it is more interesting for many farms, even with even higher costs in the intensive tillage regime, to establish temporary grassland before corn, which is plowed up. The reduced or no-till tillage regimes investigated here are primarily an issue for stockless arable farms or crop rotations without grassland.

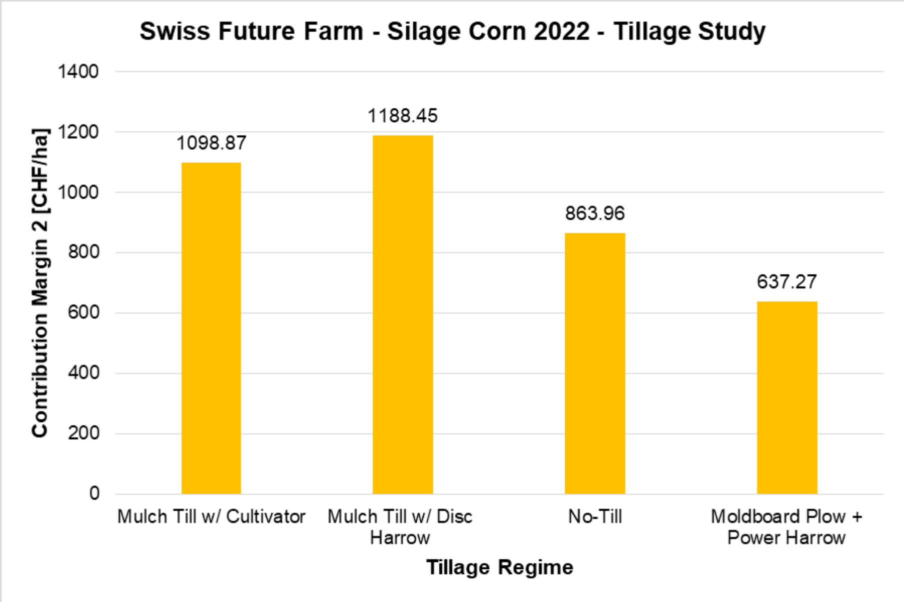


Figure 55. Contribution margin 2 obtained from the SFF 2022 Tillage Study trial strips in silage corn.

Assumptions for payback:

Price calculations for silage corn based on the guidelines of AGRIDEA (2022).

Silage corn fresh mass price after harvest by seller:

DM content (%)	≥38	37	36	35	34	33	32	31	30	29	≤28
Price (CHF/t FM)	70.00	69.00	67.00	65.00	63.00	61.00	59.00	57.00	56.00	54.00	52.00

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team.

1.9 Robotics & Autonomy Study in Silage Corn

Study Contact:
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Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield, operating costs and the resulting feed costs in silage corn operated with different robotic and autonomous mechanization by use of an agricultural robotic solution (Agrointelli Robotti 150D) for planting and an agricultural drone (DJI Agras T10) for crop care in comparison to field operations with conventional agricultural machinery (tractors and implements).

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. The trial plot was planted after Oil Radish (*Raphanus sativus var. oleiformis*) as a cover crop over winter. Silage corn was planted on 12th May 2022, the planted hybrid was KWS Stabil with 87,000 seeds/ha. All field operations for pre-planting fertilization, seed-bed preparation and harvest were conducted uniformly across all trial strips with conventional machinery, whereas planting, in-season fertilizer application, and herbicide application were conducted with different robotic and autonomous vs. conventional mechanization in the respective treatments (Table 14, Figure 56).

Table 14. Mechanization options tested for the SFF 2022 Robotics & Autonomy Study in Silage Corn.

Trial strip	Treatment	Field Operations
1	Robot Planting + Tractor Crop Care	• Planting w/ robot and planter (1x) • Fertilizer application w/ tractor and fertilizer spreader (2x) • Herbicide application w/ tractor and sprayer (1x)
2	Robot Planting + Drone Crop Care	• Planting w/ robot and planter (1x) • Fertilizer application w/ drone and fertilizer distribution unit (2x) • Herbicide application w/ drone and spraying unit (1x)
3	Tractor Planting + Tractor Crop Care	• Planting w/ tractor and planter (1x) • Fertilizer application w/ tractor and fertilizer spreader (2x) • Herbicide application w/ tractor and sprayer (1x)

Figure 56. Agrointelli Robotti 150D field robot with planter (left), DJI Agras T10 drone with sprayer unit (right) on the trial plot of the SFF 2022 Robotics & Autonomy Study in Silage Corn.

The Robotti 150D (Agrointelli, Aarhus, Denmark, https://agrointelli.com/robotti/150d/) is an autonomously driving, diesel-powered implement carrier that can be equipped with conventional implements with 3 meters working width in the intermediate axle area. In this trial, a pneumatic Monosem NG+ 4 precision planter was used. Waylines and field boundaries as well as implement information are created in advance in the web-based planning platform and a task is created. As soon as the Robotti field robot is set to automatic mode for task execution in the field, it travels the driving route specified in the plan and operates the implement. In this trial setup, planting was done only in the main tillage direction, and the cross rows in the headland were omitted. As there is a strip of meadow at both ends of this field, this was used for turning.

The DJI Agras T10 (DJI Ltd, Shenzhen, China, https://www.dji.com/ch/t10) is a modular-built compact agricultural drone that can be equipped with 10 liter sprayer tank or 10 kg fertilizer tank for a maximum working width of 6 meters. Flying route planning can be done with the remote control and enables fully autonomous operation. In this trial setup, field boundaries were recorded by the drone in advance to create a flying route plan that was used for all field operations (spraying and fertilizing). Human labor was required for drone setup, chemical or fertilizer refill to the tank, and battery exchange during task execution.

Results:

The trial was harvested 117 days after planting. Highest dry matter yield of 18.3 t/ha was obtained in silage corn using conventional tractors and implements for planting and crop care, whereas trial strips with robotic planting and drone crop care resulted in significantly lower dry matter yield of 15.5 and 16.6 t/ha, respectively (Figure 57). In an overall consideration, the silage corn yield was on a comparably low level for the region and year, which can be partially explained by the late planting date and resulting short growth period.

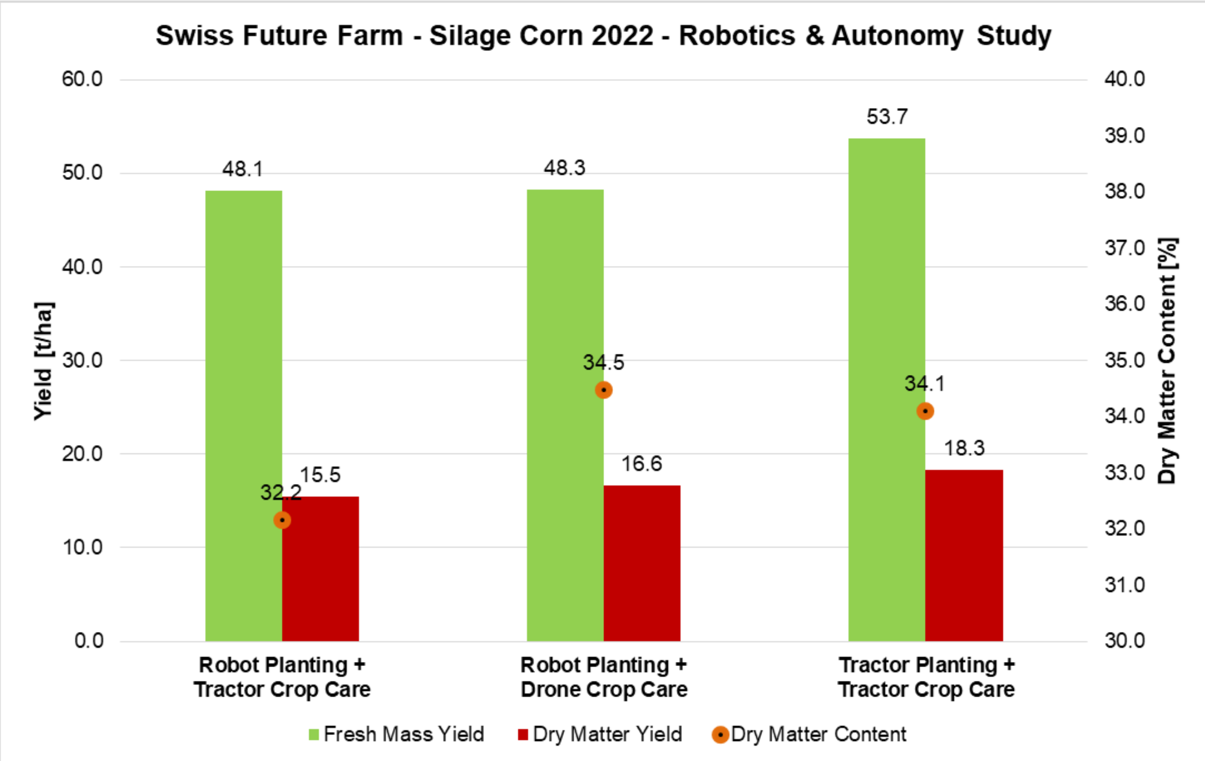

Figure 57. Yield results of the SFF 2022 Robotics & Autonomy Study in silage corn.

Table 15 shows the results on revenue, operating costs, feed costs, and contribution margin 2 for silage corn planted in the tested mechanization options. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from pre-planting fertilization, tillage and seedbed preparation, planting to silage corn harvest. Except planting, in-season fertilization and herbicide application, all field operations were conducted uniformly across all trial strips.

Highest operating costs resulted for the Robot Planting + Drone Crop Care treatment due to lower area efficiency of both the robot for planting, and drone for fertilizer and herbicide application, and labor costs for in-field supervision of robot and drone, as these are legally only allowed to operate in a supervised autonomy setting. Derived from this, lowest feed costs per ton dry matter could be realized in silage corn grown solely with conventional machinery (143.39 CHF/t DM), whereas feed costs were highest for silage corn grown with the aid of robot for planting and drone for crop care applications with 180.16 CHF/t DM (Table 15).

Table 15. Cost accounting results of the SFF 2022 Robotics & Autonomy Study in silage corn.

	Robot Planting + Tractor Crop Care	Robot Planting + Drone Crop Care	Tractor Planting + Tractor Crop Care
Fresh Mass Yield (t/ha)	48.1	48.3	53.7
Dry Matter Content (%)	32.2	34.5	34.1
Dry Matter Yield (t/ha)	15.5	16.6	18.3
Target price with corresponding dry matter content (CHF/t)*	59.00	63.00	63.00
Deliverables (CHF/ha)			
Crop Value / Revenue	2839.67	3040.87	3383.71
Costs (CHF/ha)			
Tillage	384.24	384.24	384.24
Planting	363.50	363.50	340.38
Fertilization	871.95	1055.95	871.95
Weed Control	168.41	287.65	168.41
Harvest	488.00	488.00	488.00
Labor	381.27	418.16	373.97
Outcomes			
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	2657.37	2997.50	2626.95
Feed Costs (CHF/t DM)	171.68	180.16	143.39
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	182.31	43.37	756.76

*AGRIDEA base prices 2022

The significantly lower dry matter yields in the two robot trial strips are to some extent due to the work quality and planter performance. Already during planting it could be observed that the planter was too light for the rather heavy soil on the trial plot and not enough down force could be applied. The weather conditions prior to planting did not allow the seedbed to be prepared even finer. This shows that in challenging planting conditions, proven technology is more convincing to ensure yield security.

Figure 58 shows a graphical comparison for revenue, operating costs, and feed costs as results of this study.

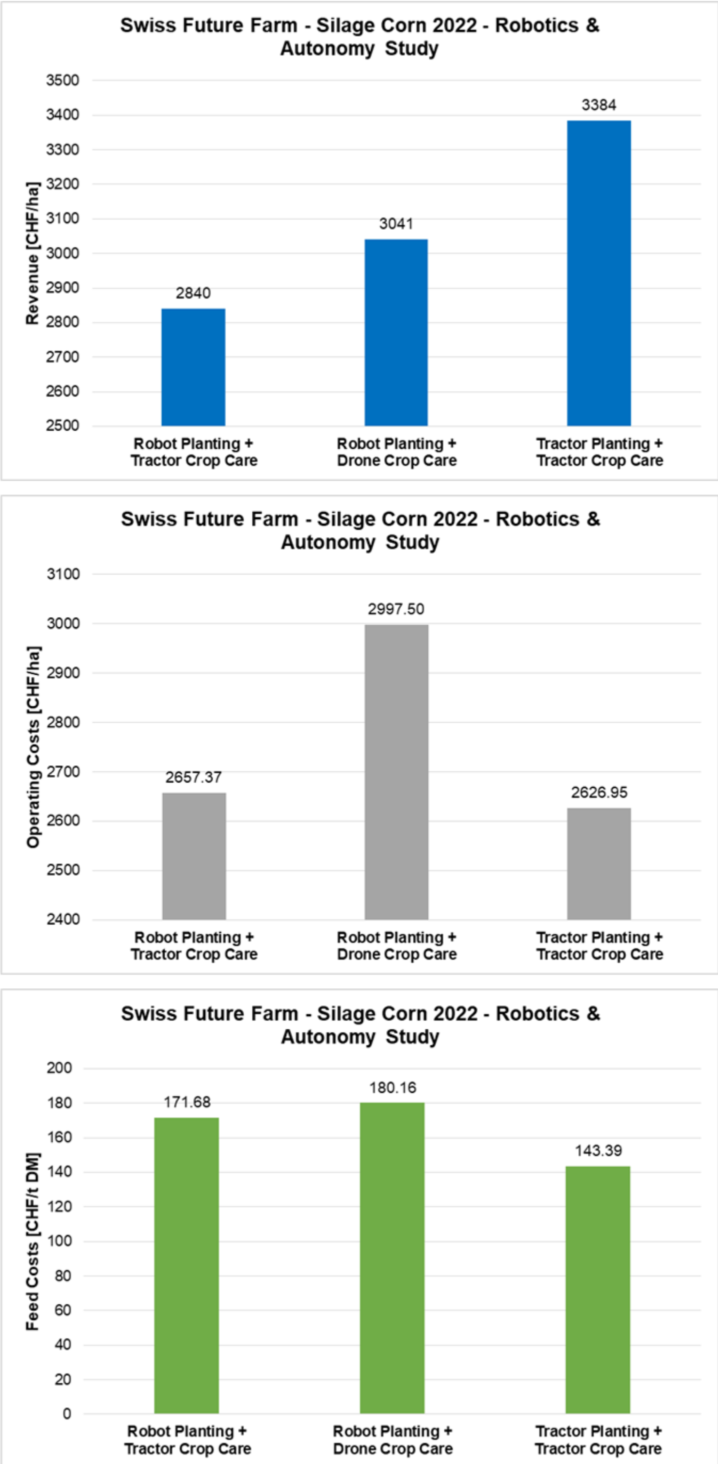

Figure 58. Revenue, operating costs, and feed costs for the SFF 2022 Robotics & Autonomy Study in silage corn.

Additional Observations:

Crop measurements with the Precision Planting POGO Stick and Research Pogo App showed a retarded development of corn plants in the trials strip operated with robot planting and tractor crop care which can, to a lesser degree, also be found in the trial strip with robot planting and drone crop care, whereas best crop development was found in silage corn operated with conventional machinery (Figure 59).

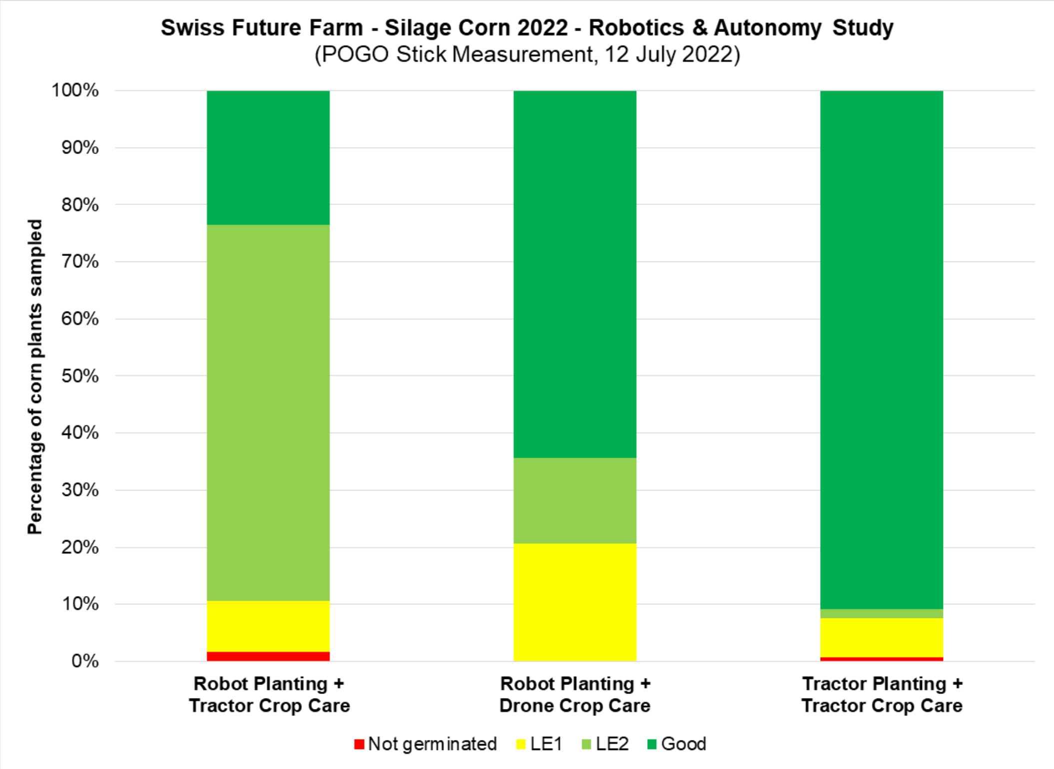

Figure 59. Results of crop measurements of the SFF 2022 Robotics & Autonomy Study in silage corn.

Concerning labor time requirements, additional time expenditure needs to be considered for planning and preparation works, i.e. wayline and driving route planning for the field robot (Figure 60), and for set-up, battery change and re-fill works (fertilizer, chemicals) during field operations of the agricultural drone, which results in reduction of the theoretically possible area efficiency.

Figure 60 shows the plan with the exact wayline sequence and the turning processes of the Robotti field robot. In the field, it executes the field work according to this already pre-planned plan. This plan can be evaluated in detail after implementation or cloned for a next operation. For example, a mechanical weeding implement could be driven in the exact same waylines.

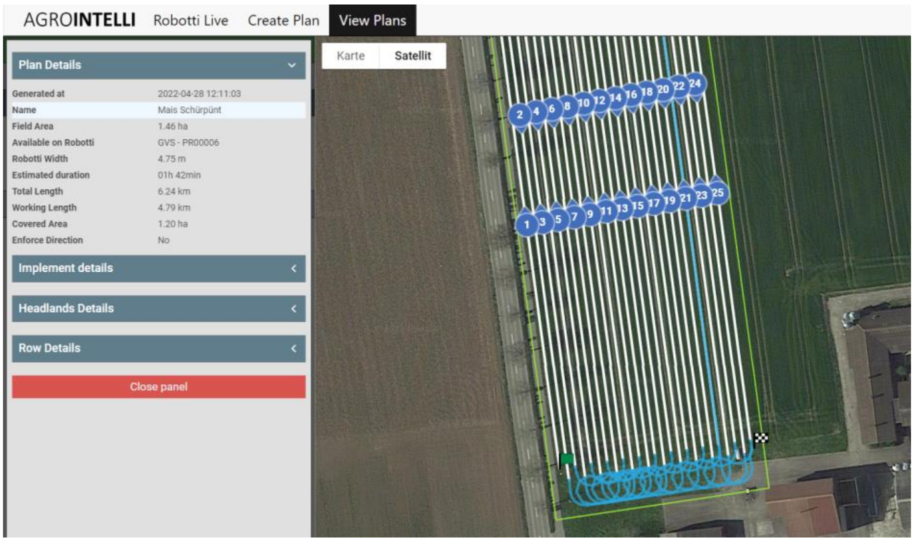

Figure 60. Wayline and driving route planning for Agrointelli Robotti field robot for the SFF 2022 Robotics & Autonomy Study in silage corn.

Payback:

For silage corn grown with conventional machinery, the highest contribution margin of 756.76 CHF/ha could be achieved in the comparison, which is significantly higher than for the robotic and drone treatments with 182.31 and 43.37 CHF/ha (Figure 61). Based on these results, no economic benefits could be obtained by the use of robotic and autonomous solutions at the current stage of area efficiency and labor time requirements for supervised autonomy.

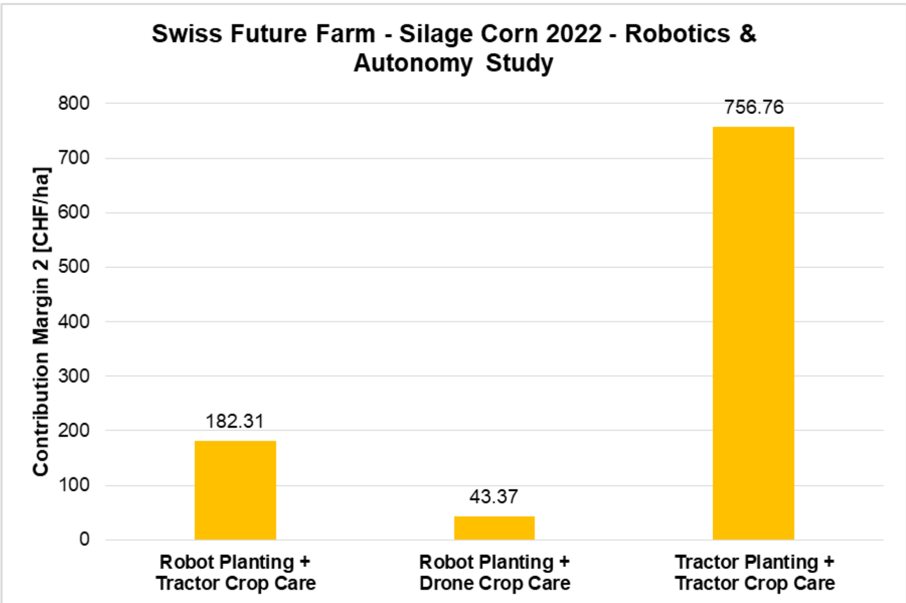

Figure 61. Contribution margin 2 obtained from the SFF 2022 Robotics & Autonomy Study trial strips in silage corn.

Assumptions for payback:

Price calculations for silage corn based on the guidelines of AGRIDEA (2022).

Silage corn fresh mass price after harvest by seller:

DM content (%)	≥38	37	36	35	34	33	32	31	30	29	≤28
Price (CHF/t FM)	70.00	69.00	67.00	65.00	63.00	61.00	59.00	57.00	56.00	54.00	52.00

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of Jens Adank (Remote Vision AG, https://www.remotevision.ch/) for drone applications contracted services.

1.10 Planting Depth and Population Study in Silage Corn

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com

Objective:
The objective of this study was to evaluate yield, operating costs and the resulting feed costs in silage corn planted at variable planting depth and planted population. The settings were done with the unique Precision Planting SmartDepth™ Moisture Control and vSet™ Organic Matter Control based Precision Planting SmartFirmer™ soil sensor readings in comparison to uniform standard planting depth and planted population.

Study Design:
The study was carried out on the Swiss Future Farm in 2022 as a side-by-side strip trial. The following planting depth and planted population settings were tested:

- Uniform planting depth 5.1 cm and 90,000 seeds/ha
- Uniform planting depth 5.1 cm and Variable Rate Organic Matter Control planted population with 5 increments:
    - OM >2.5% = 70,000 seeds/ha (not applied during planting)
    - OM 2.5-2.8% = 80,000 seeds/ha
    - OM 2.8-3.5% = 85,000 seeds/ha
    - OM 3.5-3.8% = 90,000 seeds/ha
    - OM >3.8% = 95,000 seeds/ha (not applied during planting)
- Variable planting depth based on soil moisture (SM) measurements of Precision Planting SmartFirmer soil sensors and Precision Planting SmartDepth control with 3 increments: 3.5 - 5.1 - 6.5 cm planting depth:
    - SM >40% = 3.5 cm
    - SM 40%-30% = 5.1 cm
    - SM <30% = 6.5 cm

Planting date was 21st April 2022, the planted hybrid was LG 31245. The Precision Planting SmartDepth Moisture Control mode automatically adjusts planting depth according to the amount of moisture available to the seed measured by the SmartFirmer soil sensors in order to ensure consistent crop stand also under heterogeneous soil moisture conditions. The planted population was set to 90,000 seeds/ha as base population and adjusted based on organic matter content measured by SmartFirmer soil sensors for the trial strip with Variable Rate planted population.

Results:

The trial was harvested 138 days after planting. Highest dry matter yield of 22.4 t/ha was obtained in the treatment planted with uniform planting depth and flat rate population while Variable Rate planted population and planting depth resulted in slightly lower dry matter yield of 21.3 and 21.0 t/ha, respectively (Figure 62). In an overall consideration, the silage corn yield level was within a very satisfying range for all tested planting depth and population settings.

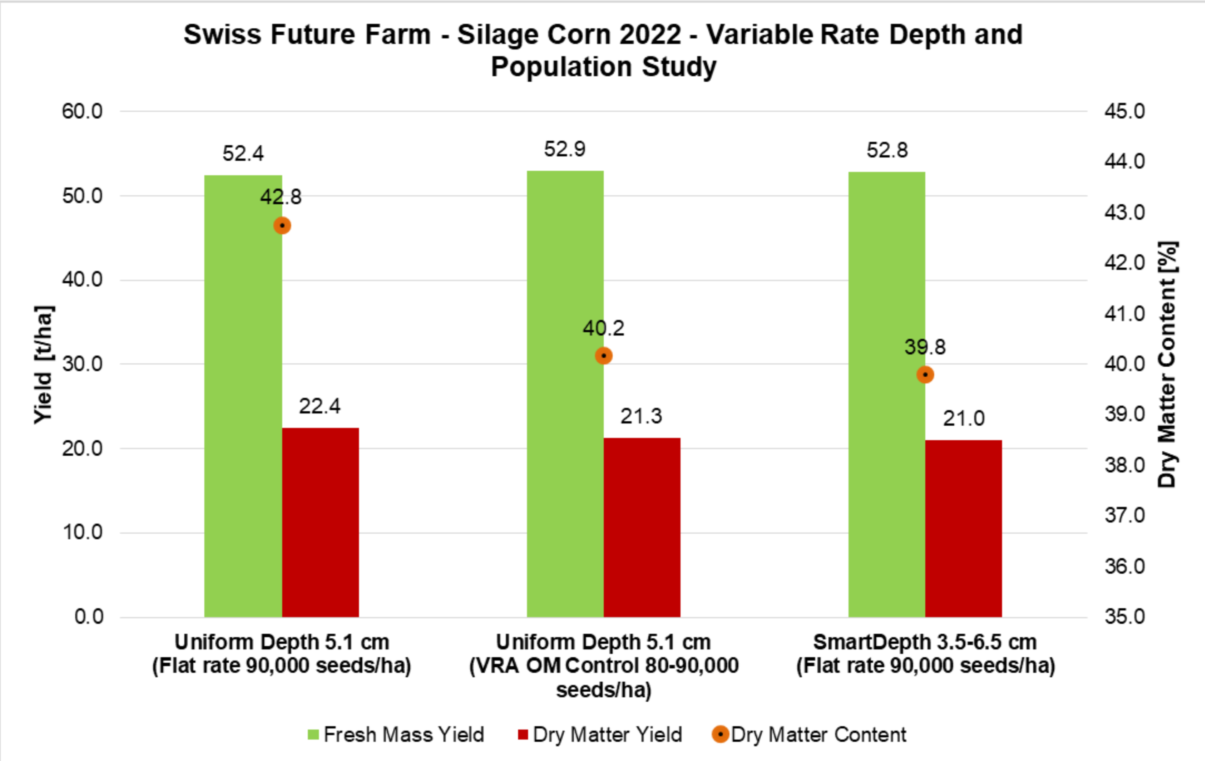

Figure 62. Yield results of the SFF 2022 Planting Depth and Population Study in silage corn.

In our study, the dry matter yield advantage of uniform planting depth at 5.1 cm and flat rate population of 90,000 seeds/ha amounted to 5.2% and 6.7% compared to Variable Rate planted population and Variable Rate planting depth, respectively. Contrary, slightly higher fresh matter yield (52.9 and 52.8 t/ha) could be obtained from trial strips with Variable Rate planted population or planting depth in comparison to uniform planting depth and flat rate population (52.4 t/ha).

Table 16 shows the results on revenue, operating costs, feed costs, and contribution margin 2 for silage corn planted with different planting depth and population settings. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from seedbed preparation to harvest. The trial plot was planted as a corn after corn and all field operations except planting were conducted uniformly across all trial strips and the planting depth and population settings represented the only variable altered between the different treatments. Minimally higher operating costs resulted for the treatments with flat rate planted population due to slightly lower seed costs in the treatment planted with Variable Rate population. Derived from higher dry matter content, lowest feed costs per ton dry matter could be realized in silage corn planted with uniform planting depth and flat rate population (108.03 CHF/t DM).

Table 16. Cost accounting results of the SFF 2022 Planting Depth and Population Study in silage corn.

	Uniform planting depth 5.1 cm, 90,000 seeds/ha	Uniform planting depth 5.1 cm, Variable Rate OM Control 80-90 KS/ha	Variable planting depth 3.5-6.5 cm, 90,000 seeds/ha
Fresh Mass Yield (t/ha)	52.4	52.9	52.8
Dry Matter Content (%)	42.8	40.2	39.8
Dry Matter Yield (t/ha)	22.4	21.3	21.0
Target price with corresponding dry matter content (CHF/t)*	70.00	70.00	70.00
Deliverables (CHF/ha)			
Crop Value / Revenue	3671.43	3706.32	3697.98
Costs (CHF/ha)			
Tillage	412.59	412.59	412.59
Seeding & Planting	337.68	334.36	337.68
Fertilization	728.05	728.05	728.05
Weed Control	216.33	216.33	216.33
Harvest	488.00	488.00	488.00
Labor	237.22	237.22	237.22
Outcomes			
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	2419.86	2416.55	2419.86
Feed Costs (CHF/t DM)	108.03	113.45	115.23
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1251.56	1289.77	1278.12

*AGRIDEA base prices 2022

Figure 63 shows a graphical comparison for revenue, operating costs, and feed costs as results of this study.

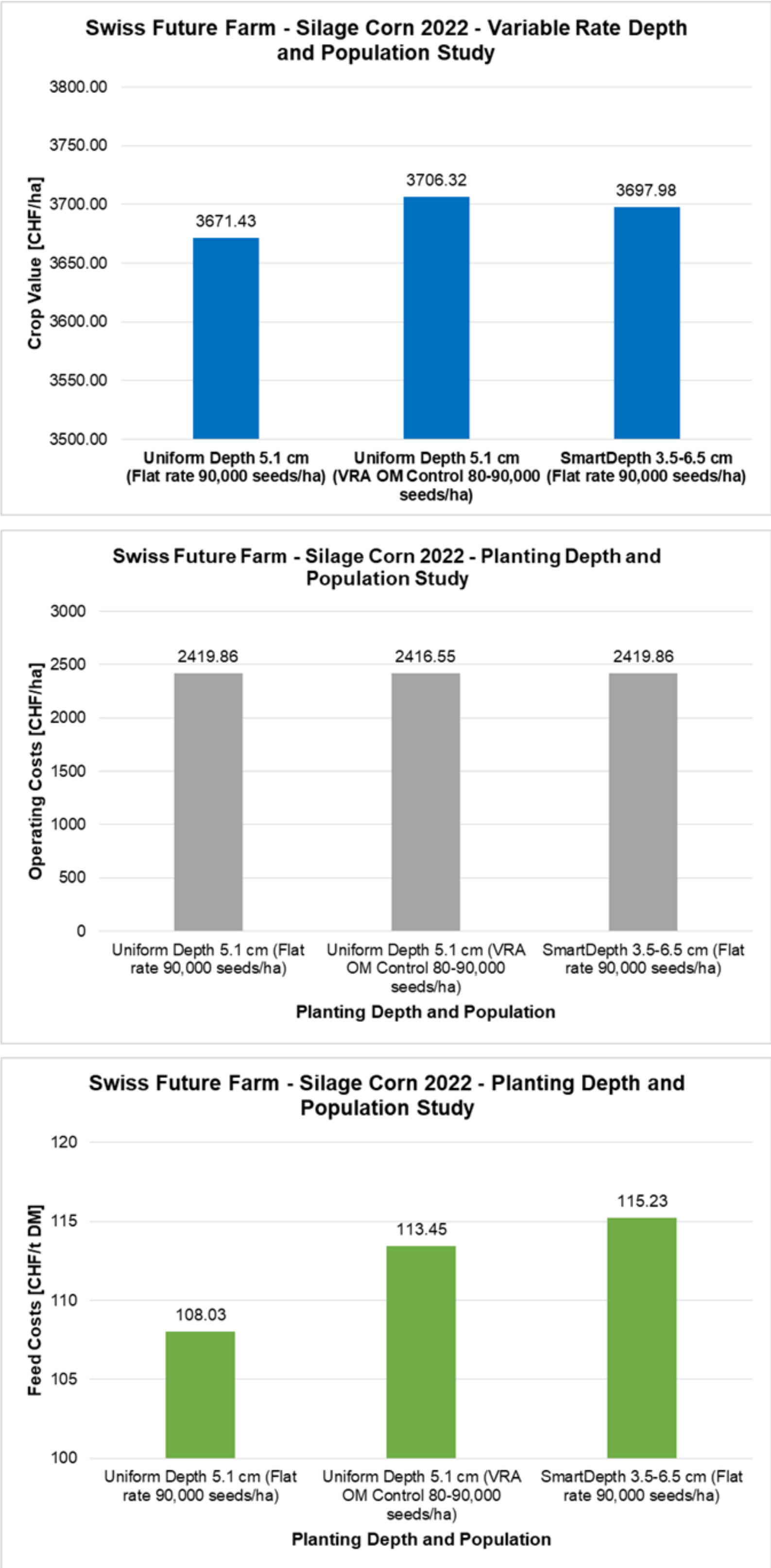

Figure 63. Revenue, operating costs, and feed costs for the SFF 2022 Planting Depth and Population Study in silage corn.

Additional Observations:

Crop measurements with the Precision Planting POGO Stick and Research Pogo App showed better development and lower share of late emergers (LE1 and LE2) for Variable Rate planted population (Figure 64), which corresponds to the higher fresh matter yield in this trial strip.

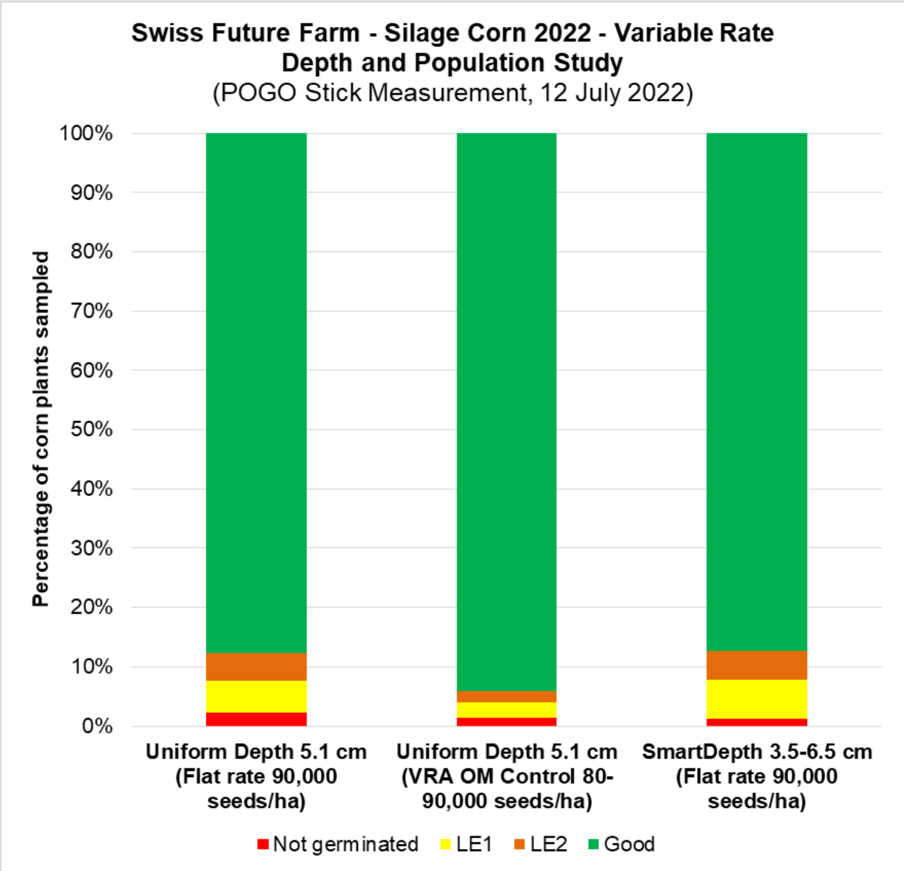

Figure 64. Results of crop measurements of the SFF 2022 Planting Depth and Population Study in silage corn.

Recommendations and Equipment Solutions:

- Precision Planting SmartFirmer™ soil sensors measure soil moisture, soil temperature and organic matter in real time during planting and provide meaningful information on soil properties and field zones.
- Precision Planting SmartDepth™ automatically adjusts planting depth between a minimum and maximum depth while maintaining the soil moisture target based on SmartFirmer soil sensor measurements.
- vSet™ seed meters and vDrive™ electric drives provide highest accuracy for singulation of row crops and enable real time adjustment of planting rates.
- Automatic down force control with Precision Planting DeltaForce™ ensures consistent planting depth also under heterogeneous soil conditions.
- Fendt VarioGuide with RTK ensures planter passes with maximum accuracy and operator comfort.
- Fendt Contour Assistant enables optimum wayline adaption to the contours of the field during planting.

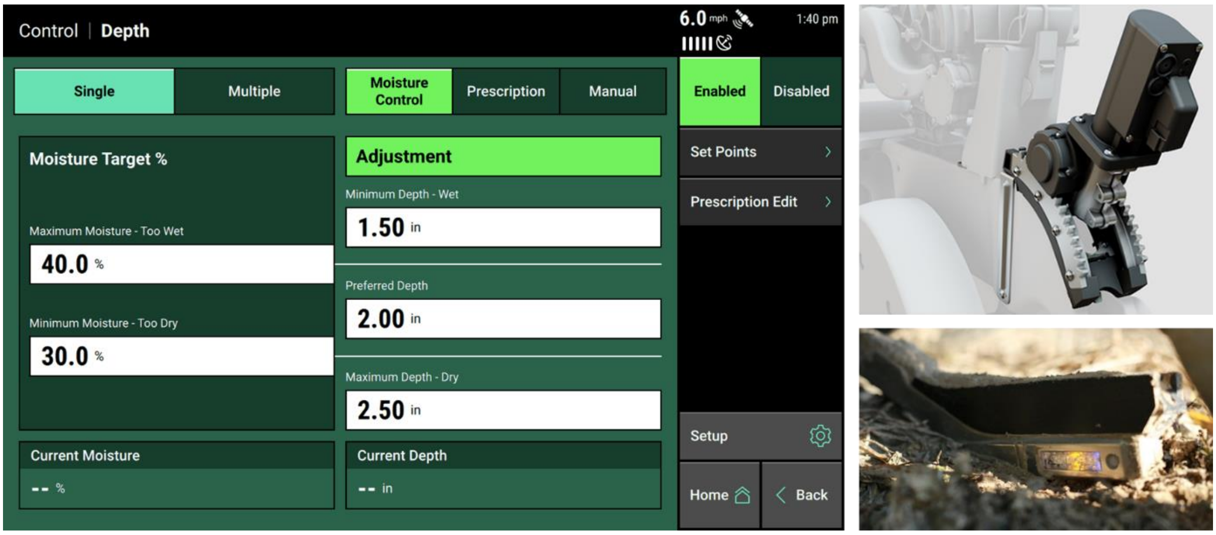

Figure 65. Variable Depth Moisture Control mode in the Precision Planting 20/20 Gen3 monitor (left), Precision Planting SmartDepth gearbox for real-time adaption of planting depth according to soil moisture (top right), and Precision Planting SmartFirmer for measurement of soil moisture in the furrow (bottom right).

Payback:

For silage corn planted at variable rate population with Precision Planting Organic Matter Control or variable planting depth with SmartDepth based on SmartFirmer soil sensor readings, an additional contribution margin between 26.56 and 38.21 CHF/ha could be generated in comparison to planting with uniform standard planting depth at 5.1 cm (Figure 66).

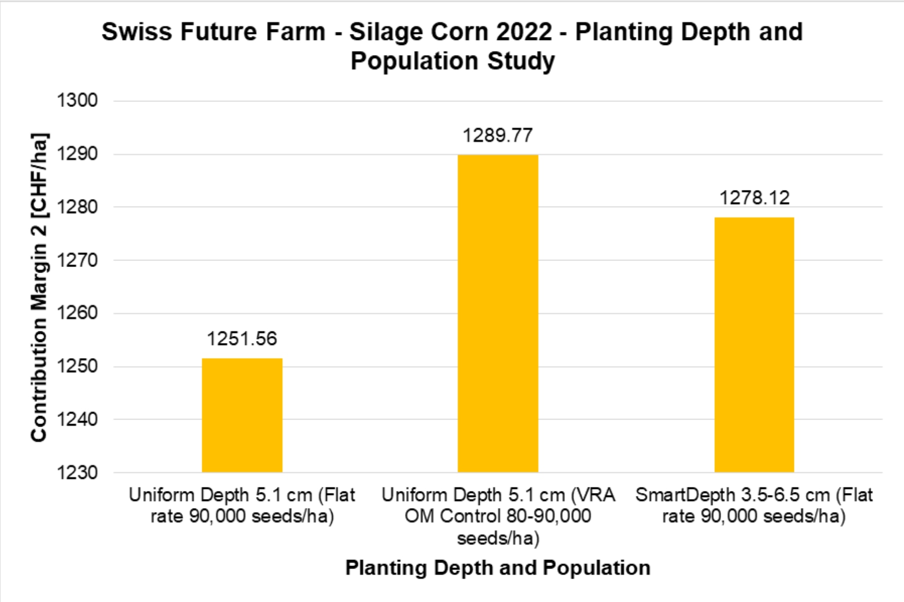

Figure 66. Contribution margin 2 obtained from the SFF 2022 Planting Depth and Population Study trial strips in silage corn.

Assumptions for payback:

Price calculations for silage corn based on the guidelines of AGRIDEA (2022).

Silage corn fresh mass price after harvest by seller:

DM content (%)	**≥38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**≤28**
Price (CHF/t FM)	70.00	69.00	67.00	65.00	63.00	61.00	59.00	57.00	56.00	54.00	52.00

Trial Team:

The trial was carried out by the Swiss Future Farm Operating Team.

1.11 Cultivation of white oats for the production of processed oat products

Contact

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Trial objectives

Oats are becoming increasingly popular with consumers. Processed products such as oat drink are a major contributor to this. However, the production volume of edible oats in Switzerland remains low. In order to promote the cultivation of Swiss oats, fenaco GOF has been offering cultivation contracts for producers since 2022 and remunerates the processed edible oats with a premium of CHF 10/dt compared to the target price for fodder oats. The delivered and processed oats must reach a hectoliter weight of at least 50kg/HL.

In the present trial, it was investigated in the context of this cultivation contract on the Swiss Future Farm whether the required hectoliter weight is achieved and how different seed strengths and fertilization strategies affect this. Furthermore, the economic benefit of oat cultivation under consideration of the cultivation contracts is calculated on the basis of the contribution margins.

Trial design

The trial was conducted on the Löhre Spitz plot (total 2.04ha), which is characterized by low heterogeneity. Sugar beets were grown as the previous crop on the area. Due to the late harvest time of the previous crop, summer oats and the Husky oat variety available for this purpose were grown.

The trial was implemented as follows:

Treatment 1 (approx. 0.5 ha, V1):

- Seed rate: 400 grains/m^2
- Fertilization: 45kgN (slurry) before sowing + 30kgN (Mg ammonium nitrate 24%)

Treatment 2 (0.3 ha, V2)

- Seed rate: 350 grains/m^2
- Fertilization: 45kgN (slurry) before sowing

Treatment 3 (0.2 ha, V3)

- Seed rate: 350 grains/m^2
- Fertilization: 45kgN (slurry) before sowing + 30kgN (Mg ammonium nitrate 24%)

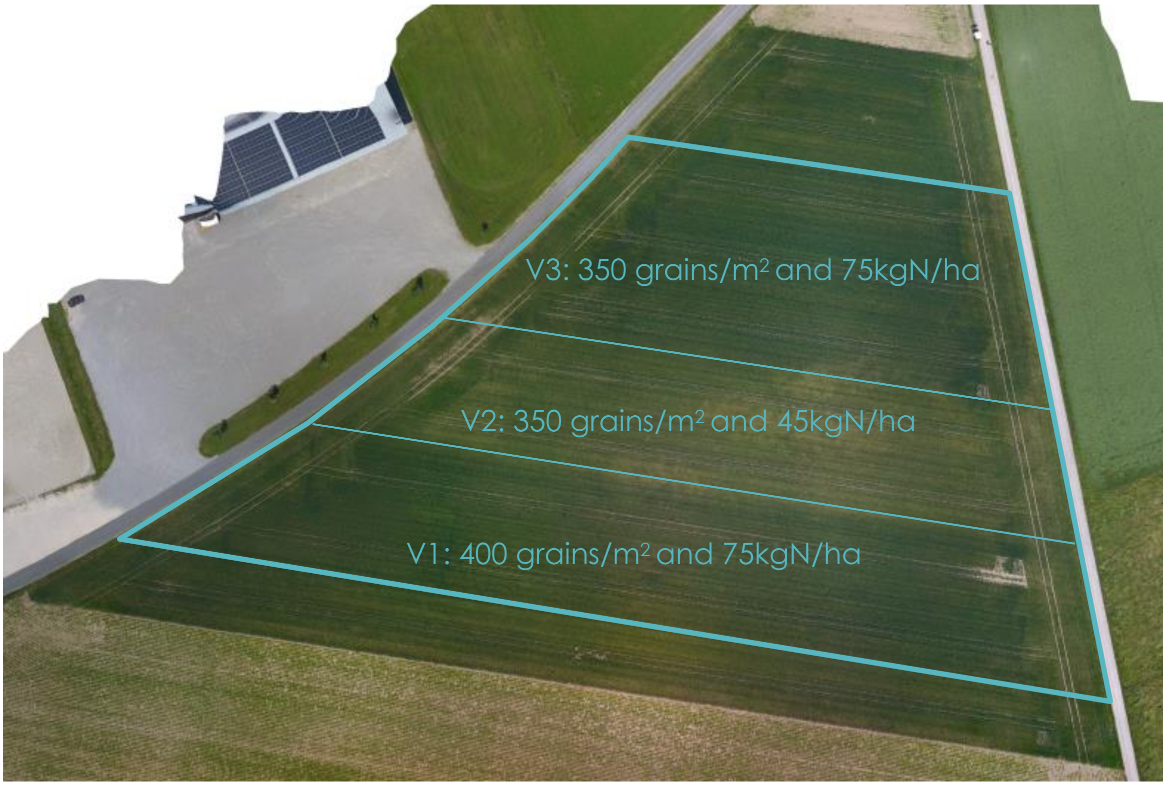


Figure 67: Trial plot design on the field Löhre Spitz.

Table 17 shows the field calendar for the cultivation of spring oats. The first fertilizer application with slurry was made by a contractor immediately before sowing in March. The second application was fertilized at panicle pushing on May 20, 2022 (treatments 1 and 3).

Table 17: Field calendar for the trial field Löhre Spitz.

Date	Field Operations
March 2022	Slurry spreading (45 m^3/ha of dairy slurry) by contractor Cultivator pass Sowing with seeder combination (March 4) Rolling
22 April 2022	Herbicide application: Concert SX: 0.1kg/ha Starane XL: 1.5l/ha
13 May 2022	Growth regulator application: Moddus: 0.6l/ha
20 May 2022	Mineral fertilization in treatments 1 and 3: MG ammonium nitrate 24%: 30kgN/ha
14 July 2022	Harvest

Crop Measurements

On June 20, 2022, the number of panicle-bearing culms per square meter was determined in the trial strips (Figure 68). In the treatments with a seeding rate of 350 grains/m^2 , 245 (V2) and 295 panicles/m^2 (V3) were counted, respectively. In Treatment 1 with 400 grains/m^2 , 325 panicles/m^2 were counted. Thus, all procedures were below the expected value. One reason for the low number of panicle-bearing culms per square meter is the cold temperatures at the beginning of April 2022 and the associated weak tillering of the stand.

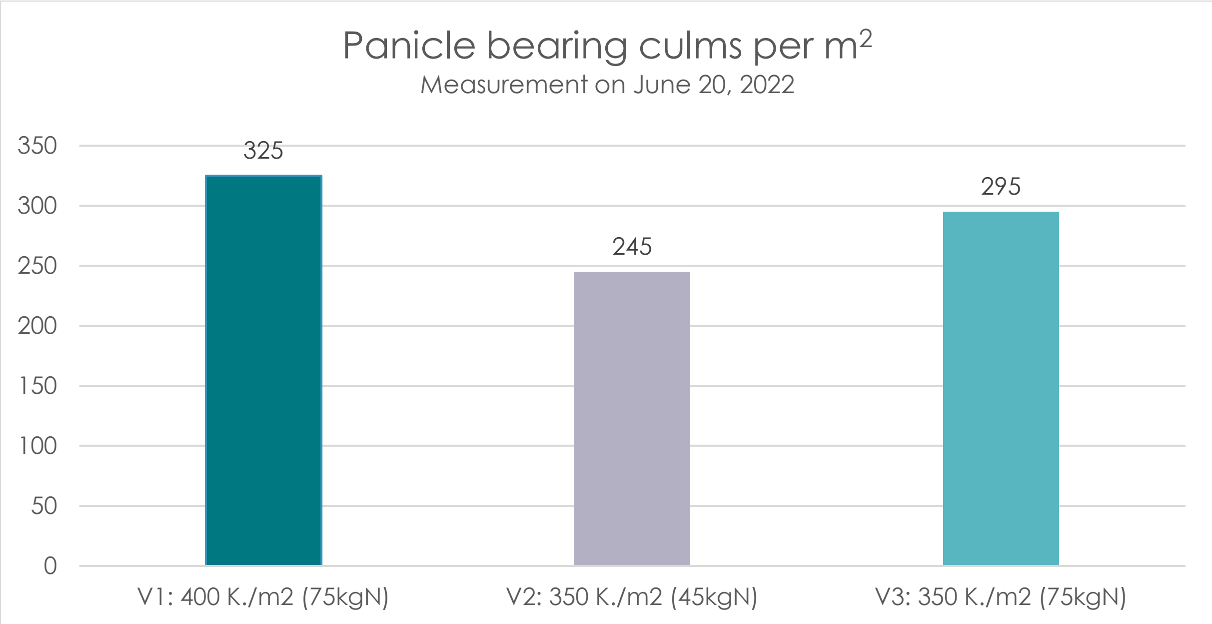


Figure 68: Measurement of the number of panicle-bearing culms on June 20, 2022.

Results

Yields

The experimental strips were individually threshed on July 14, 2022, at summer temperatures and weighed separately on the weighbridge. The average yield for the areas (2.04 ha) according to the account of the grain collection center is 60.2 dt/ha (incl. headland). Yields in the trial strips (each excluding headland) ranged from 61.2 dt/ha (V2) to 75.1 dt/ha (V3) (see Figure 69). The highest yield was obtained in treatment 3 with a seed rate of 350 grains/m^2 and a total applied fertilizer rate of 75 kgN/ha. In treatment 1 with seed rate 400 grains/m^2 and fertilizer rate of 75 kgN/ha, 71.5 dt/ha was achieved. Treatment 2 with a fertilizer application reduced by 30 kgN/ha was the lowest in terms of yield with 61.2 dt/ha.

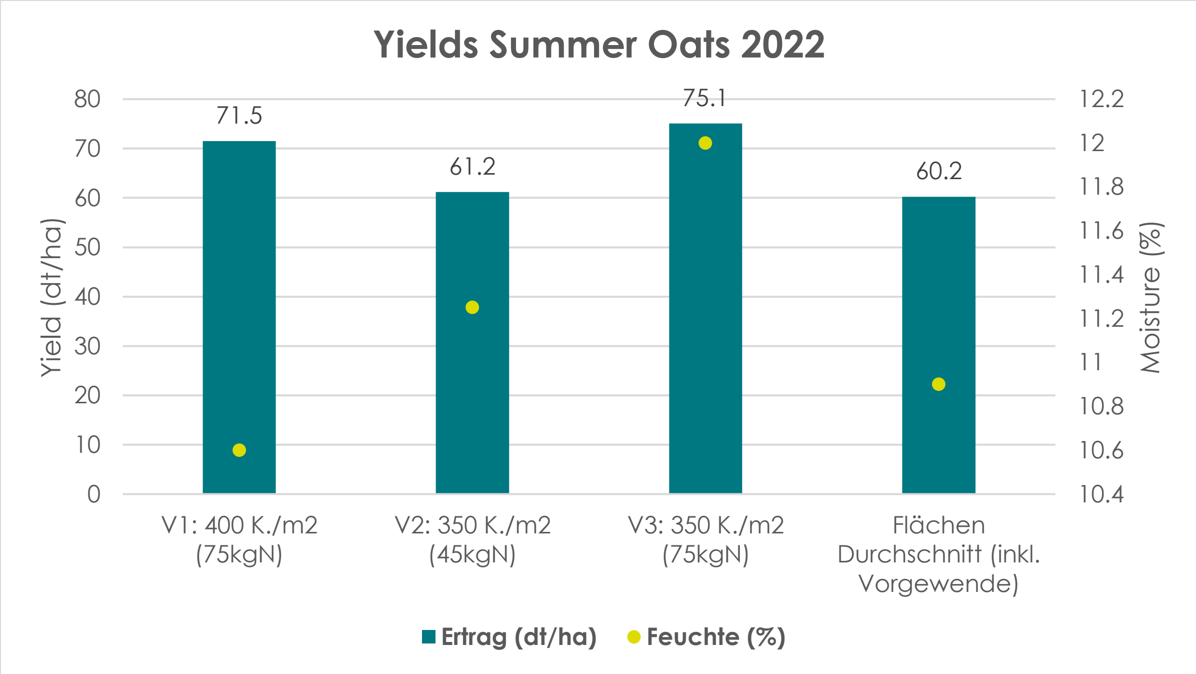


Figure 69: Overview of yield and moisture in the different trial strips.

Hectoliter weight

Fortunately, the hectoliter weight of 50 kg/HL prescribed for contract growing was achieved in all treatments. As an area average, 54.5 kg/HL was measured at the grain collection point (see Table 18). The hectoliter weight of the individual trial strips was determined separately in Tänikon.

Table 18: Overview of hectoliter weight and protein content in the different test strips.

Comparison of hectoliter weight (kg/HL) and protein content		
	kg/HL	**Protein content (%)**
V1: 400 grains/m² (75kgN)	50 (measured on SFF)	7.8%
V2: 350 grains/m² (45kgN)	52 (measured on SFF)	8.7%
V3: 350 grains/m² (75kgN)	50.5 (measured on SFF)	10%
Area average (incl. headland):	54.5 (measured in grain collection center)	10.7%

Operating costs

In addition to investigating the achievable hectoliter weights, a trial objective is to evaluate the economic benefit of oat cultivation through the new surcharges of CHF 10/dt guaranteed by fenaco GOF. For this purpose, the first step was to determine the operating costs for the three trial treatments. These were calculated based on the guideline values of the Agroscope machine cost report 2022 (Gazzarin et al. 2022). The operating costs in the trial strips differ only slightly and come from the different fertilizer and seed rates. The highest operating costs were recorded in treatment 1 with 3057 CHF/ha. The lowest costs were incurred in treatment 2 with 2860 CHF/ha.

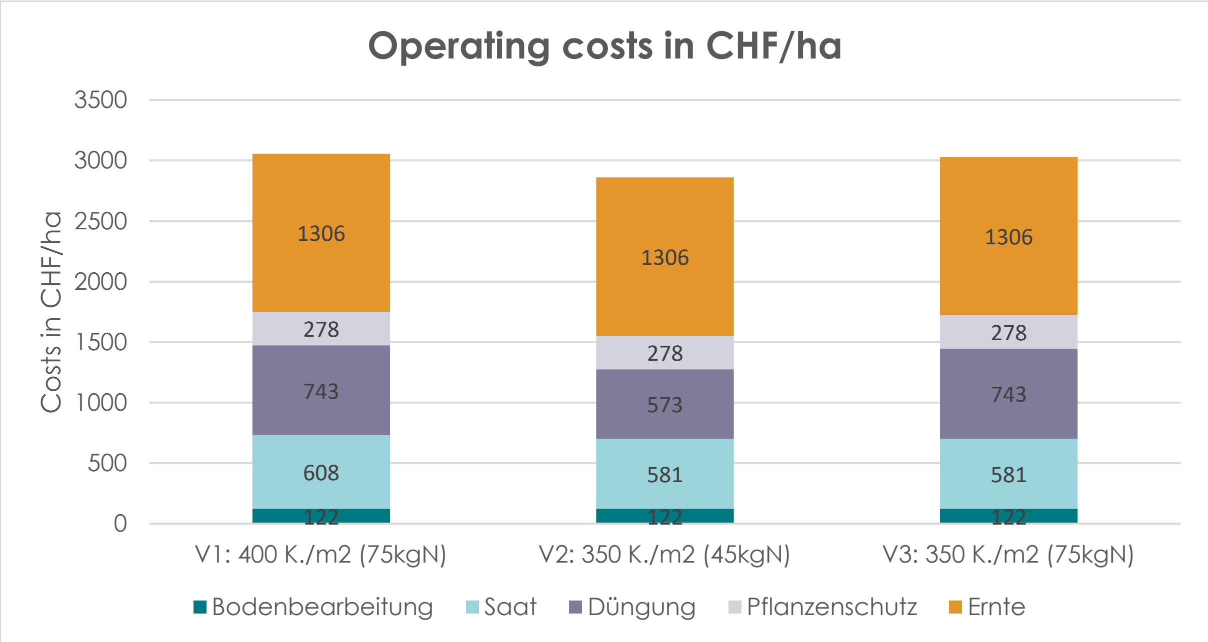


Figure 70: Operating costs in CHF/ha in the different trial strips.

Contribution margins

Table 19 shows the contribution margins including machinery, labor and input costs for all treatments. The highest contribution margin was achieved with CHF 942 in treatment 3, since the yield was highest with 75.1 dt/ha and the additional fertilizer costs amounted to only CHF 170/ha compared to treatment 2. Furthermore, 27 CHF/ha of seed could be saved in this treatment compared to treatment 1.

Table 19: Overview of the contribution margins of the three trial strips.

	V1: 400 grains/m² (75kgN)	V2: 350 grains/m² (45kgN)	V3: 350 grains/m² (75kgN)
Yield (dt/ha)	71.5	61.2	75.1
Moisture (%)	10.6	11.3	12
Indicative price forage oats plus premium 10 CHF/dt	CHF 43.5	CHF 43.5	CHF 43.5
Deliverables			
Revenue per ha	CHF 3'110	CHF 2'662	CHF 3'267
Subsidies arable land	CHF 900	CHF 900	CHF 900
Deliverables total	CHF 4'010	CHF 3'562	CHF 4'167
Costs			
Tillage	CHF 122	CHF 122	CHF 122
Seeding	CHF 608	CHF 581	CHF 581
Fertilization	CHF 743	CHF 573	CHF 743
Crop protection	CHF 278	CHF 278	CHF 278
Harvest	CHF 1'306	CHF 1'306	CHF 1'306
Acceptance, cleaning, disposal (excl. association fees of CHF 4.8/dt)	CHF 186	CHF 159	CHF 195
Contribution margin (incl. machine, labor and operating costs)	**CHF 767**	**CHF 543**	**CHF 942**

<u>Comparison of the contribution margin with other crops</u>

In order to investigate the economic attractiveness of oat cultivation in the context of the premiums of CHF 10/dt in contract farming, which have been in force since 2022, the comparable contribution margin (VDB) from the farm branch results published by Agroscope (Schmid et al. 2022) is listed below for various crops. In contrast to the contribution margins calculated in our trial, this VDB only includes direct costs (excl. labor and machinery costs) and reflects the results from a sample of Swiss farms.

For wheat (non-extenso ÖLN) with the yield class 65-70 dt/ha, the VDB is 2232 CHF/ha (Agroscope 2022, p.14). Rye (ÖLN) with yield class >60 dt/ha is 1908 CHF/ha (Agroscope 2022, p.16). Spelt in the yield class 40-45 dt/ha is at 2306 CHF/ha (Agroscope 2022, p.18) and for oats in the yield class >50 dt/ha a VDB of 2121 CHF/ha is calculated (Agroscope 2022, p.24). Interestingly, the average producer price for oats within the sample is 46.33 CHF/dt for farms in the oat yield class >50 dt/ha in 2021. This value is far above the price for forage oats (30.50 CHF/dt in 2021). This may be due to the fact that the farms in the sample already produced feed oats (e.g. for IP Suisse) and could therefore achieve a higher proudent price. The value of 46.33 CHF/dt is also within the producer price for fodder oats 2022 plus the fenaco premium (total 43.5 CHF/dt) and the achieved VDB in this oat category serves as a good indicator to estimate the lucrativeness of oat cultivation and to compare it with other crops.

In Table 20, we have carried out a comparable contribution margin according to Agroscope calculation from the trial data available to us plus the detailed contribution margin (incl. labor and machine costs). With the calculated 2026 CHF/ha, we are slightly below the value calculated from the data of the Agroscope farm sample.

Table 20: Comparable contribution margin for the Löhre Spitz 2022 oat trial plot in Tänikon.

Calculation VDB for oat area in Tänikon 2022		
Yield	**dt/ha**	60.2 (Average yield oats SFF 2022)
Price	**CHF/dt**	43.50
Deliverables Product	**CHF**	2619
Direct costs		
Seeds	CHF	190
Fertilization	CHF	71
Crop protection	CHF	175
Acceptance, cleaning, disposal		157
Direct costs total		593
Comparable contribution margin (VDB)		2026

Conclusion and next steps

In this year's trial of oat cultivation, it was shown that the hectoliter weights of 50kg/HL prescribed for contract cultivation could be achieved in all three treatments. The highest contribution margin was achieved in the treatment with the seed rate of 350 grains/m^2 and a fertilizer rate of 75 kgN/ha. Further, a comparison of the comparable contribution margins shows that the attractiveness of oat cultivation can be increased by the premiums of 10 CHF/dt, but in comparison it is below the contribution margin of wheat. The cultivation trial will be continued in the coming years within the framework of the Forum Ackerbau at various locations in Switzerland. Three different seed rates and two fertilization strategies will be distinguished.

Literature

Gazzarin et al. 2022: Kostenkatalog 2022: Richtwerte für die Kosten von Maschinen, Arbeit, Gebäude und Hoftechnik, Agroscope Transfer 448, 2022
Link: https://www.kostenkatalog.ch/

Schmid et al. 2022: Betriebszweigergebnisse 2021 – Stichprobe Betriebsführung, Hrsg. Agroscope Ettenhausen, 4. Oktober 2022.
Link: https://doi.org/10.34776/betr21-d

1.12 Row Spacing & Weed Control Study in Winter Wheat

Study Contact:
Nils Zehner, Agronomy and Farm Solutions Manager, Swiss Future Farm,
nils.zehner@agcocorp.com
The trial was conducted by Forum Ackerbau and supervised by Anna Brugger, Arenenberg.

Objective:
The objective of this study was to evaluate yield and operating costs in winter wheat grown with different row spacing, seed rates and weed control regimes, comprising standard and wide row spacing as well as herbicide-free and conventional chemical weed control.

Study Design:
The study was carried out on the Swiss Future Farm in the field season 2021-2022 as a side-by-side strip trial. The trial plot was planted in an intensive tillage system after silage corn. Winter wheat was seeded on 20th October 2021 with a seed drill at either normal (12.5 cm) or wide (37.5 cm) row spacing and full (100%) or reduced seed rate (60%) with hybrid DSP Montalbano and grown with either chemical or mechanical weed control (Table 21, Figure 71). Except seeding and weed control, all field operations for seedbed preparation, fertilizer application (total 156 kg N/ha), and harvest were conducted uniformly across all trial strips.

Wide row spacing in combination with herbicide-reduced or herbicide-free weed control in cereals is a new biodiversity scheme in the Swiss Agricultural Policy to promote the endangered species of brown hare (*Lepus europaeus*) and field lark (*Alauda arvensis*) as well as to promote field flora. The grain field is sown in such a way that a striped pattern with at least 30cm wide gaps in unsown areas is created. At least 40% of the rows must remain unsown distributed over the width of the drill; the distribution may vary. There are no specifications for the amount of seed in the sown rows, but a reduction in the amount compared to normal sowing is recommended. Normally, three sown rows are created followed by two unsown rows (closed outlets). Weeds may be controlled in the spring either by a single harrowing by April 15th or controlled by a single herbicide application. In fall, herbicide application and harrowing are allowed. Crop protection treatments with products in categories other than herbicides (e.g., fungicides) are allowed. Farmers applying this biodiversity scheme are compensated with additional direct payments of up to 300.00 CHF/ha.

Table 21. Row spacing and weed control treatments tested for the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Trial strip	Row Spacing & Weed Control	Field Operations
1	Normal (12.5 cm, 100% seed rate) + Herbicide	• Seeding w/ seed drill at 350 seeds/m^2 = 177 kg/ha (1x) • Chemical weeding w/ tractor and sprayer (1x)
2	Normal (12.5 cm, 100% seed rate) + Mechanical	• Seeding w/ seed drill at 350 seeds/m^2 = 177 kg/ha (1x) • Mechanical weeding w/ tine harrow (1x)
3	Wide (37.5 cm, 60% seed rate) + Herbicide	• Seeding w/ seed drill at 200 seeds/m^2 = 101 kg/ha (1x) • Chemical weeding w/ sprayer (1x)
4	Wide (37.5 cm, 60% seed rate) + Mechanical	• Seeding w/ seed drill at 200 seeds/m^2 = 101 kg/ha (1x) • Mechanical weeding w/ tine harrow (1x)

Figure 71. Seeding patterns for wide row spacing and 40% reduction of seed rate (left), winter wheat with wide row spacing after emergence in fall (right) on the trial plot of the SFF 2022 Row Spacing & Weed Control Study in Winter Wheat.

Results:

The trial was harvested on 25th July 2022. Highest yield was achieved in winter wheat grown with normal row spacing and chemical weed control (7.3 t/ha), whereas with normal row spacing and mechanical weed control a yield reduction by 5.5% was found. Wide row spacing with chemical weed control yielded 24.7% less grain, and wide row spacing and mechanical weed control showed a yield reduction by 32.9% compared to winter wheat grown with normal row spacing and chemical weed control (Figure 72). Thus, both methods with wide row spacing partially compensated for the reduced seed rate.

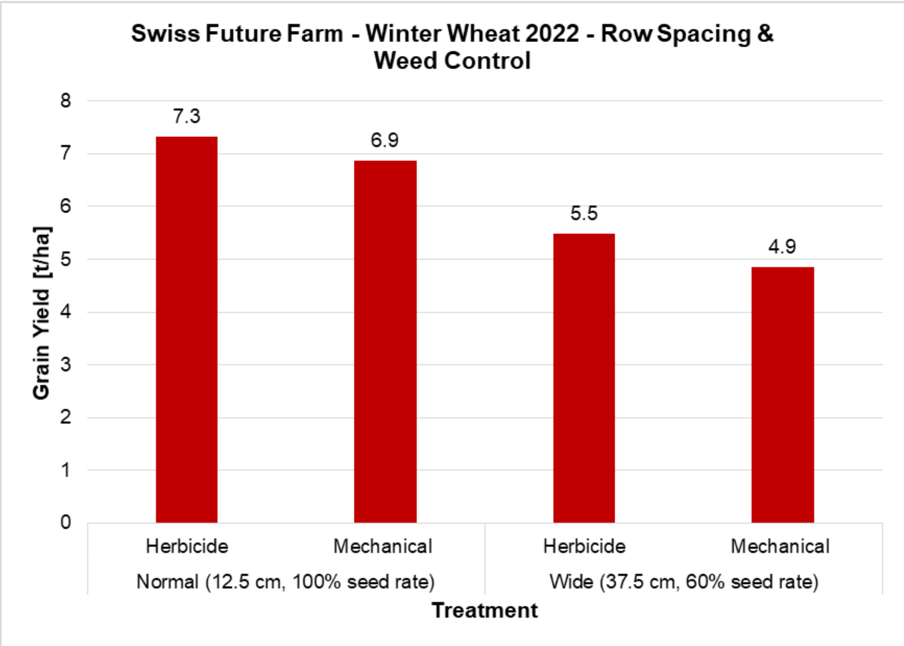


Figure 72. Grain yield results of the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Highest hectoliter weight was obtained for grain harvested from the trial strip with normal row spacing and mechanical weed control, whereas all other row spacing and weed control treatments were on an equivalent, slightly lower level, hence a clear correlation cannot be identified (Figure 73).

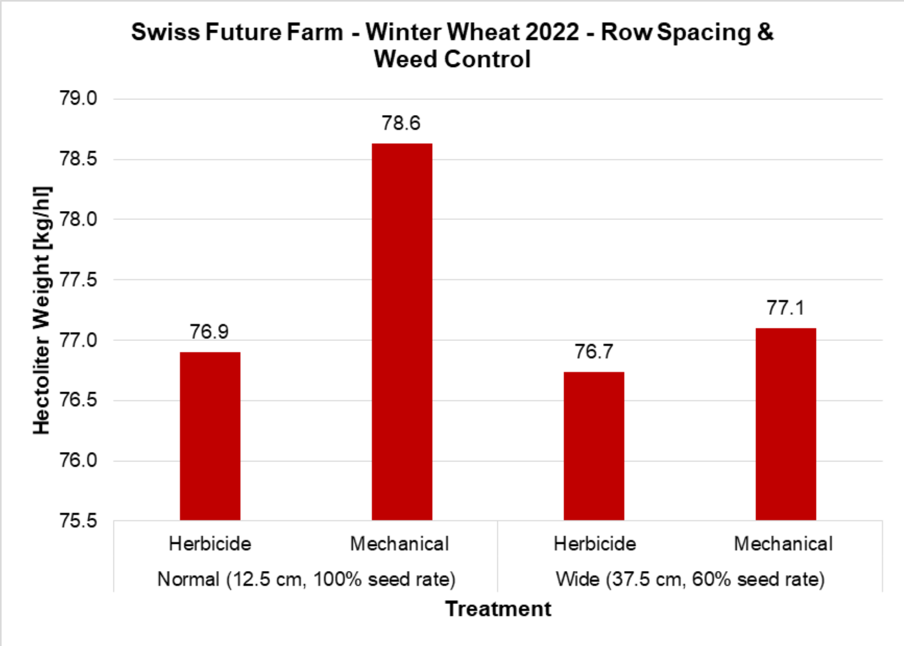


Figure 73. Hectoliter weight results of the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Protein content was significantly higher for winter wheat grown with wide row spacing, both under chemical and mechanical weed control (Figure 74). This may be due to lower grain yield in these trial strips, which facilitates wheat plants to generate higher protein contents.

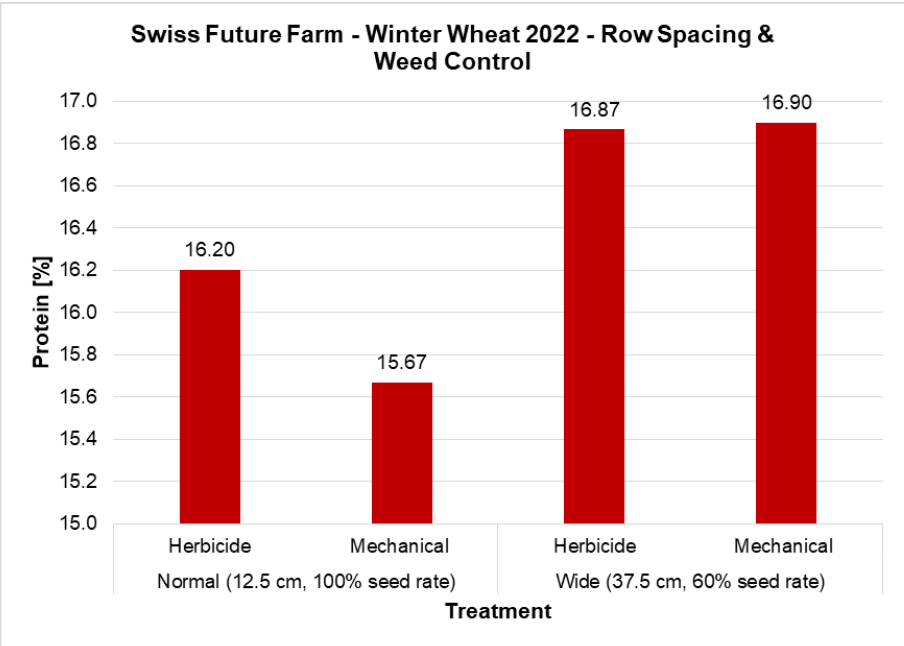


Figure 74. Protein content results of the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Table 22 shows the results on revenue, operating costs, production costs per ton of grain, and contribution margin 2 for winter wheat gown with different row spacing and weed control methods. Operating costs comprise machinery, input, and labor costs for all field operations along the crop cycle from pre-planting fertilization, tillage and seedbed preparation, seeding, crop care to harvest. Except seeding and weed control, all field operations were conducted uniformly across all trial strips.

Highest operating costs resulted for the Normal Row Spacing + Herbicide treatment, nonetheless, due to the higher yield and income, this treatment delivered the highest contribution margin in the comparison (Table 22). Although operating costs were lower for all other treatments, this did not compensate for the yield reduction obtained either with mechanical weed control or wide row spacing.

Table 22. Cost accounting results of the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

	Normal (12.5 cm, 100% seed rate) + Herbicide	**Normal (12.5 cm, 100% seed rate) + Mechanical**	**Wide (37.5 cm, 60% seed rate) + Herbicide**	**Wide (37.5 cm, 60% seed rate) + Mechanical**
Grain Yield (t/ha)	7.3	6.9	5.5	4.9
Hectoliter Weight (kg/hl)	76.9	78.6	76.7	77.1
Protein (%)	16.20	15.67	16.87	16.90
Deliverables (CHF/ha)				
Crop Value / Revenue*	4302.15	4037.90	3228.20	2852.50
Costs (CHF/ha)				
Tillage	250.92	250.92	250.92	250.92
Seeding	333.05	333.05	227.49	227.49
Fertilization	1159.49	1159.49	1159.49	1159.49
Herbicide Application	143.76	0.00	143.76	0.00
Insecticide Application	0.00	0.00	0.00	0.00
Fungicide Application	0.00	0.00	0.00	0.00
Mechanical Weeding	0.00	38.93	0.00	38.93
Harvest	549.86	549.86	549.86	549.86
Labor	222.93	225.66	222.93	225.66
Outcomes				
Operating Costs (CHF/ha) incl. machine, labor, inputs costs	2660.02	2557.91	2554.45	2452.35
Production Costs (CHF/t winter wheat)	363.56	327.48	465.28	505.51
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs	1642.13	1479.99	673.75	400.15
Contribution margin 2 (CHF/ha) incl. machine, labor, inputs costs and biodiversity subsidies (hare or skylark)	1642.13 (no subsidies)	1479.99 (no subsidies)	973.75	900.15

*swiss granum target prices conventional bread grain - winter wheat TOP quality: 585.00 CHF/ton

Figure 75 shows a graphical comparison for revenue, operating costs, and production costs per ton of winter wheat as results of this study.

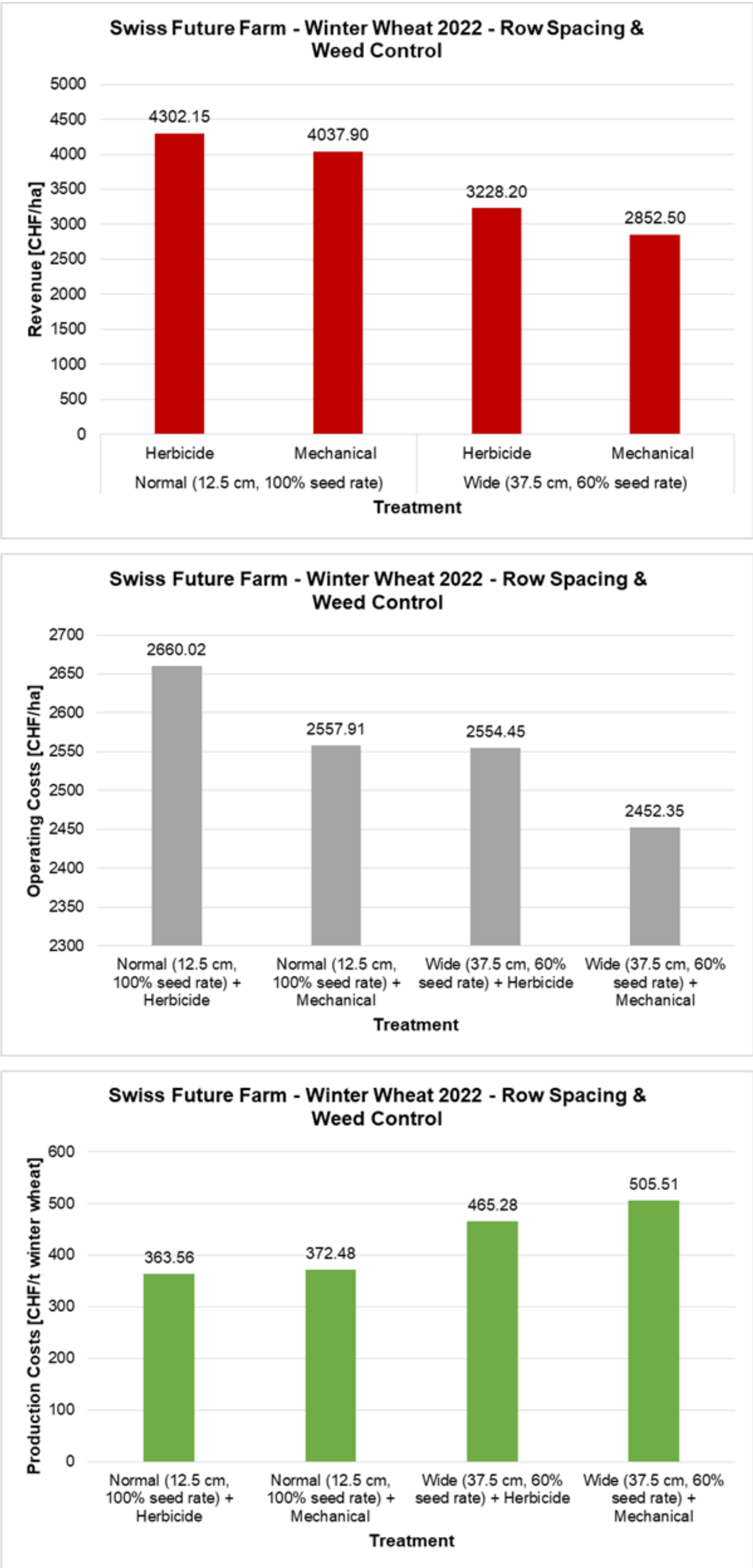


Figure 75. Revenue, operating costs, and production costs per ton of winter wheat for the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Additional Observations:

Ear count results in BBCH stadium 50-60 show that the targeted amount of 600 ears per square meter in winter wheat was only achieved in the Normal Row Spacing treatment (Figure 76). This observation is in line with the results on grain yield, where normal row spacing and full seed rate provided significantly higher yield than wide row spacing, independent of the weed control method applied. Nevertheless, it should be noted that the Wide Row Spacing plots with only 60% less seed rate resulted in only a 22% spike reduction (with chemical weed control) and 26% spike reduction (with mechanical weed control). Therefore, the wheat plants sown in Wide Row Spacing showed more tillering.

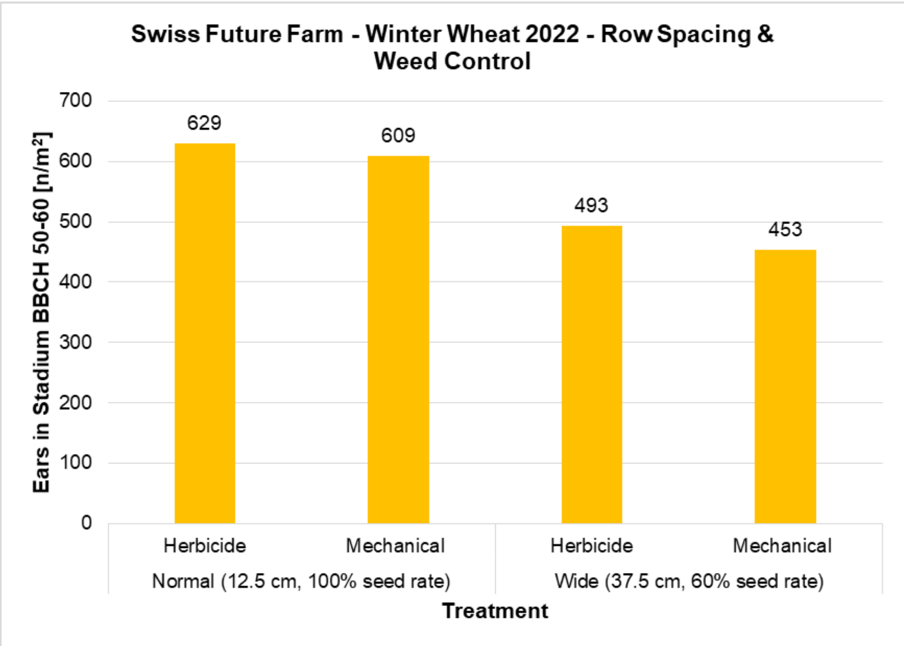


Figure 76. Ear count results of the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

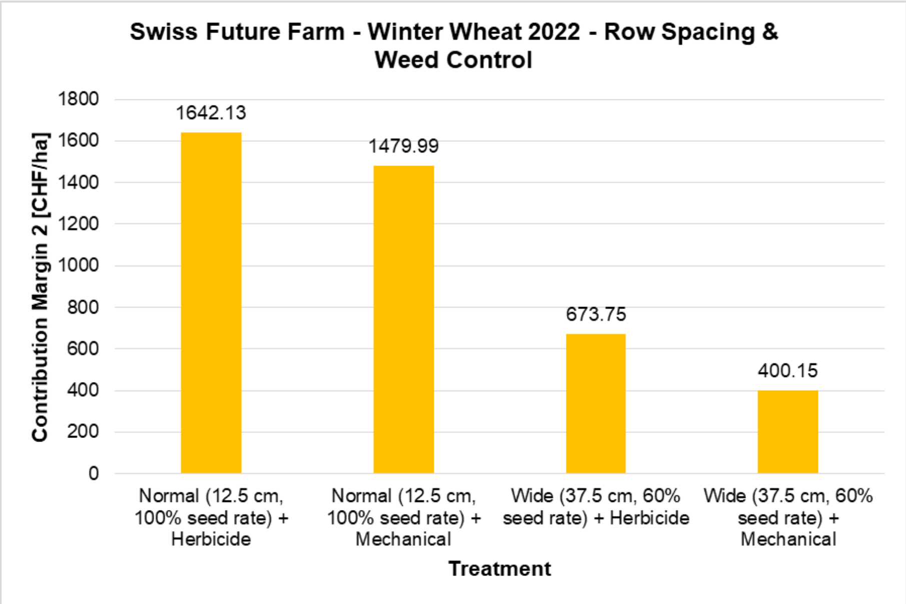
Recommendations and Equipment Solutions:

- AGCO Guide with RTK ensures planter passes with maximum accuracy and operator comfort and enables to use identical waylines for weed control operations.
- AGCO Contour-/Wayline-Assistent enables optimum wayline adaption to the contours of the field during planting.

Figure 77. Tractor with tine harrow for mechanical weed control in winter wheat.

Payback:

For winter wheat grown with normal row spacing and chemical weed control, the highest contribution margin of 1642.13 CHF/ha could be achieved, which is between 162.14 and 1241.98 CHF/ha more than applying mechanical weed control or wide row spacing in this comparison (Figure 78). Based on these results, no economic benefits could be obtained by the use of wide row spacing and mechanical weed control under the conditions of our study.



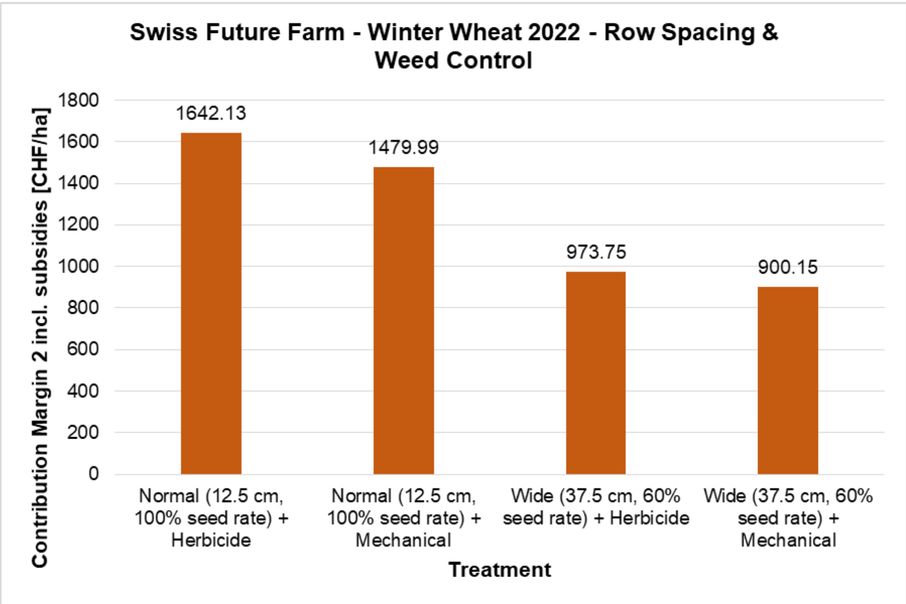


Figure 78. Contribution margin 2 obtained from the SFF 2022 Row Spacing & Weed Control Study in winter wheat.

Assumptions for payback:

Harvest or autumn guide price for bread grain, ex collection point and in accordance with the Swiss Granum (Swiss trade organization for cereals, oilseeds and protein crops) takeover conditions.

Indicative prices conventional bread cereals – Winter Wheat TOP Quality: 585.00 CHF/t

Trial Team:

The multi-location trial was planned by Forum Ackerbau, carried out by the Swiss Future Farm Operating Team for the Tänikon trial site, and supervised by Anna Brugger, Arenenberg.

1.13 Agronomic evaluation of Controlled Traffic Farming in the management of agricultural land on the basis of a practical trial

Study Contact:

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Objective:

In this bachelor thesis, the objective was to compare the fresh matter yield and soil condition effects of a controlled traffic farming (CTF) system in temporary grassland with management without a traffic strategy (random traffic farming, RTF).

Study Design:

The trial was started after the temporary grassland was sown in the fall of 2021. From then on, the northern 30 meters of the field were only managed with working widths of 6 or 12 meters on defined tracks (tramlines) with RTK guidance systems. The southern 30 meters were managed without strategy with different working widths. For the sake of simplicity, a uniform track or tire width was dispensed with; the existing SFF tractors with standard tires were used.

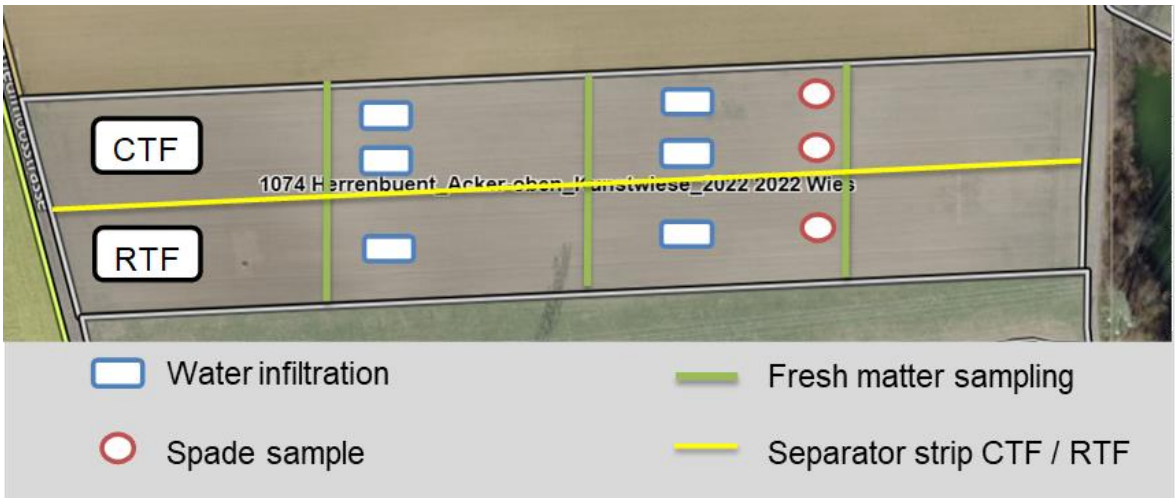

Figure 79: Experimental plan of the trial field divided into CTF and RTF.

The fresh matter yield of the temporary grassland was evaluated in two cuts, as well as the water infiltration. In addition, a qualitative soil analysis was made using a spade sample. The water infiltration was done with a 17.6 liters cylinder, which was completely filled with water and buried 5 cm into the soil. Then the volume of water infiltrated during 60 seconds was determined and compared. Unfortunately, measuring the penetration resistance of the soil with a penetrometer was not possible due to the high skeletal content in the soil.

For the measurement of the fresh matter yield, a 1.8 m wide strip was mowed with a motor mower over the entire field width at three locations in the field. Sections of two meters width each were weighed with the aim of determining differences between the track and the untraveled area.

Results:

Yield data of the temporary grassland was collected on July 5th and August 12th 2022, both on the same day of the regular harvest. Figure 80 shows the mean value of the three sampling strips on the two dates.

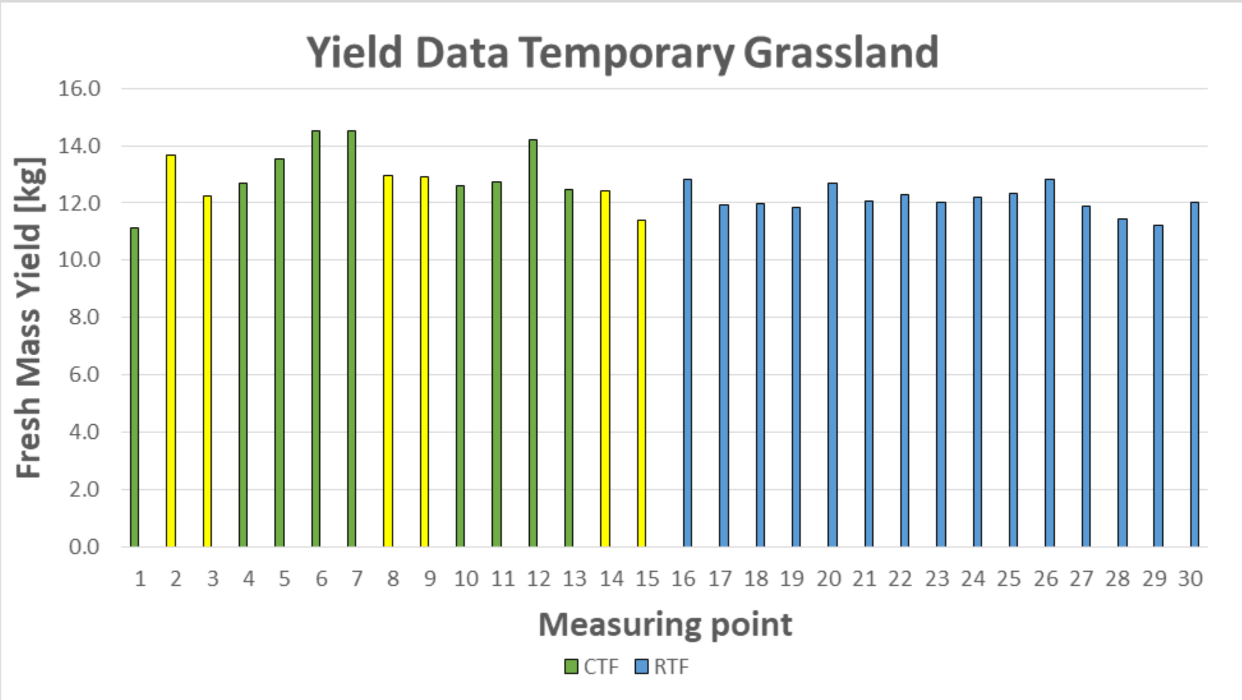

Figure 80: Yield measurement from north (1) to south (30), the measurement points containing a 12 m tramline are marked in yellow.

Figure 80 shows that the highest yields of 14.5 and 14.2 kg per measuring point were measured in the untraveled CTF area. In general, yield variations were higher in the CTF area than in the RTF area, without a compelling relationship with driving being identified. In the RTF area, yields were more evenly distributed, but the total yield was about 6.8% lower. Since the soil in the southern part of the field (RTF) tends to have slightly lower yields due to an increasing skeletal content and thus reduced water holding capacity, this figure must be put into perspective.

Table 23: Results of water infiltration measurements.

Water infiltration measurement July 4th 2022			
Measuring point	**Treatment**	**Infiltrated water volume in liters**	**In %** 100% = 17.67l
1	CTF tramline	9.4	53.2
2		8.4	47.5
3	CTF non-tramline	14.8	83.8
4		17.1	96.8
5	RTF	14.1	79.8
6		13.5	76.4

Water infiltration measurement August 10th 2022			
Measuring point	**Treatment**	**Infiltrated water volume in liters**	**In %** 100% = 17.67l
1	CTF tramline	10.4	58.9
2		10.1	57.2
3	CTF non-tramline	16.1	91.1
4		17.67	100.0
5	RTF	16.4	92.8
6		15.5	87.7

Measurement of water infiltration on two dates shows that significantly less water can be absorbed from the soil in 60 seconds in the CTF tracks than in the rest of the area (Table 23). The difference between CTF without tramline and RTF is noticeable, but not enormous.

Additional Observations:

Restricting the machinery to 6 or 12 m working widths meant a certain amount of work for the farm. As can be seen in Figure 81, the 6 m tramlines are barely visible in the crop, but the 12 m tramlines are clearly visible. Figure 82 shows the view of the RTF area where no clear tracks are visible. The strong pronouncement of the 12 m tramlines was apparently caused by the slurry tank, which carried by far the highest axle loads. In the fall, the pre-compacted tramlines of the slurry tank were an advantage during slurry application in wet terrain because they were more load bearing. The turf also adapted to the weight and the compaction-sensitive species between the tramlines were less affected, even in suboptimal conditions in fall.

Figure 81: CTF area in spring 2023, view from the west. The 12 m lanes are clearly visible.

Figure 82: RTF area in spring 2023, view from the west. No tracks are visible here.

Recommendations and Equipment Solutions:

- Neither significant yield increases, nor yield decreases between systems were observed.
- In this trial, the greatest risk of compaction came from the slurry tanker, which is why it can make sense in this work step to always drive on the same, load-bearing tracks with RTK guidance system, especially in wet years.
- Adjusting all other grassland implements to a CTF-capable working width may represent a not inconsiderable effort for a farm. Since no significant benefit was measurable in this trial, no clear recommendation can be made in this regard.

1.14 Binding and Bale Density Study in Grass Silage

Study Contact:
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Objective:

The objective of this study was to evaluate fermentation and feed quality in round bale grass silage baled with different bale density and binding material (net and film) using the Fendt Rotana 130 F Combi round baler.

Study Design:

The study was carried out on the Swiss Future Farm in 2022 during the 3rd cut in the first week of July. A Fendt Rotana 130 F Combi round baler equipped with net and film binding system was used (Figure 83). The following settings for baling were tested:

Table 24. Baler settings applied for the SFF 2022 Bale Density and Binding Study in Grass Silage.

No. of bales	Bale Density	Binding	Wrapping
3	Medium (6)	Net (3 layers)	8 layers
3	Maximum (10)	Net (3 layers)	8 layers
3	Medium (6)	Film (4.5 layers)	8 layers
3	Maximum (10)	Film (4.5 layers)	8 layers

The trial plot was located in a legume-rich, temporary grassland field with homogeneous grass stand conditions. Grass for all treatments was mowed and tedded on 5th July, and raked and baled the following day.

A baseline sample of the fresh mass grass stand was taken on the day of baling (5 samples across the trial field) and submitted for lab analysis (UFAG Laboratories, Sursee, Switzerland) to characterize the nutritional value and for later assessment of feed and forage quality of silage bales after the examined storage period.

Figure 83. Fendt Rotana 130 F Combi round baler with film binding option (left) and legume-rich temporary grassland on the trial field (right).

Results:

Bale core samples were taken 2 months and 7 months after baling to determine fermentation and feed quality parameters via lab analysis at UFAG Laboratories, Sursee, Switzerland. Core sampling results 2 months after baling show that higher sugar content could be retained in silage bales with film binding, which differs marginally from sugar content of the fresh mass sample with -1.4 g/kg DM, whereas silage in round bales with net binding showed higher reduction of sugar content with -4.9 g/kg DM (Figure 84).

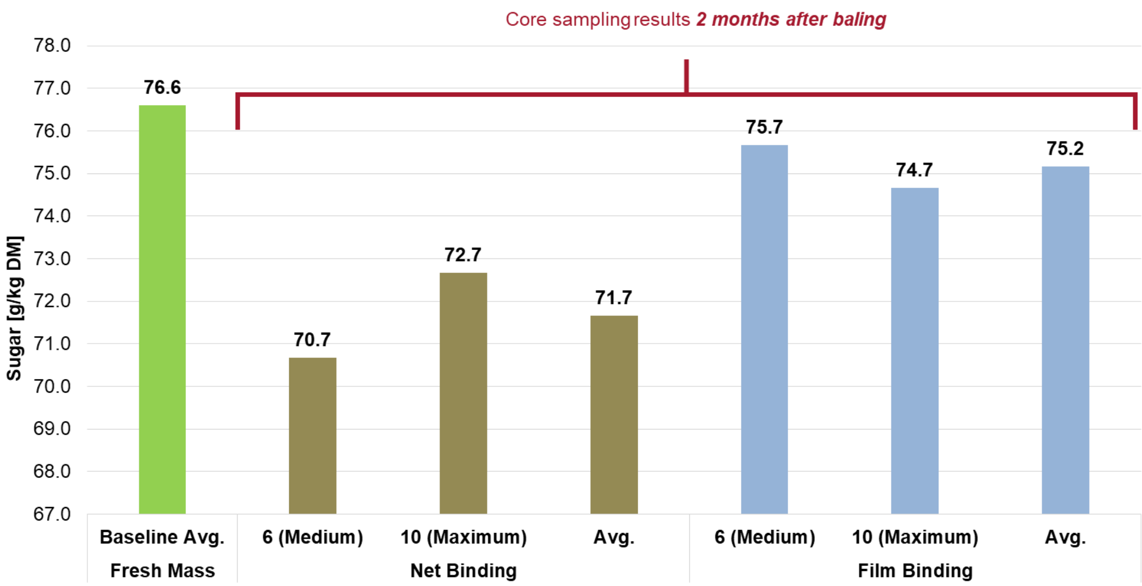

Figure 84. Sugar content results of the SFF 2022 Bale Density and Binding Study in Grass Silage after 2 months storage period.

Energy content was higher in bales with film binding after 2 months storage period, whereas in silage bales with net binding it was around 0.1 MJ NEL/kg DM lower (Figure 85). These results are in line with the better conservation of sugar content found when comparing net and film binding bales versus the fresh mass baseline sample.

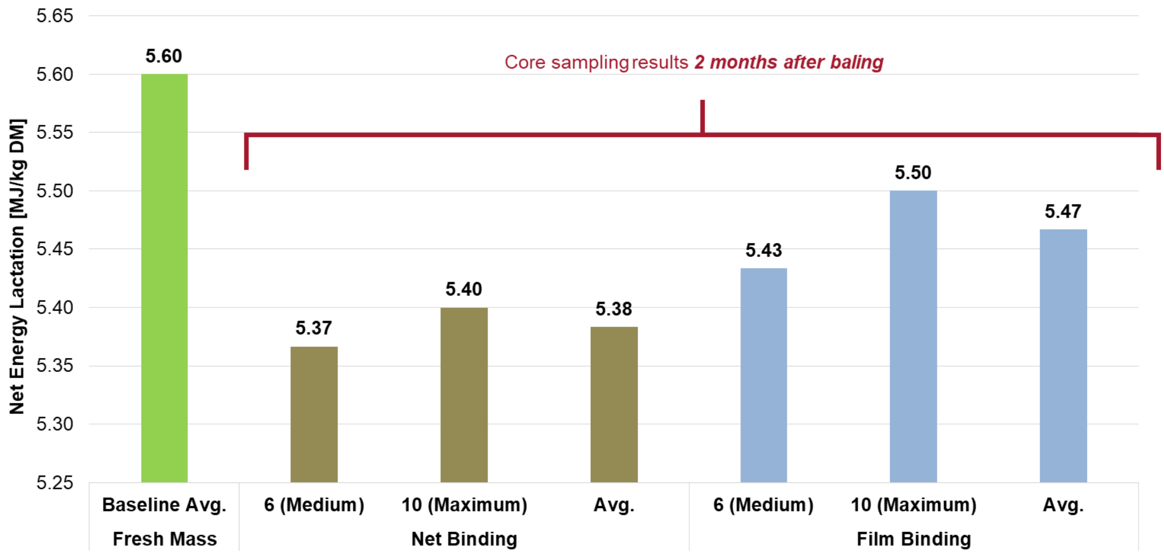

Figure 85. Energy content results of the SFF 2022 Bale Density and Binding Study in Grass Silage after 2 months storage period.

Marginally higher sugar content retained in silage bales with film binding after long-term storage of 7 months (Figure 86). However, the value to be obtained for the sugar content of 50.0 g/kg DM for grass silage after this storage period was reached with all applied bale densities and binding types.

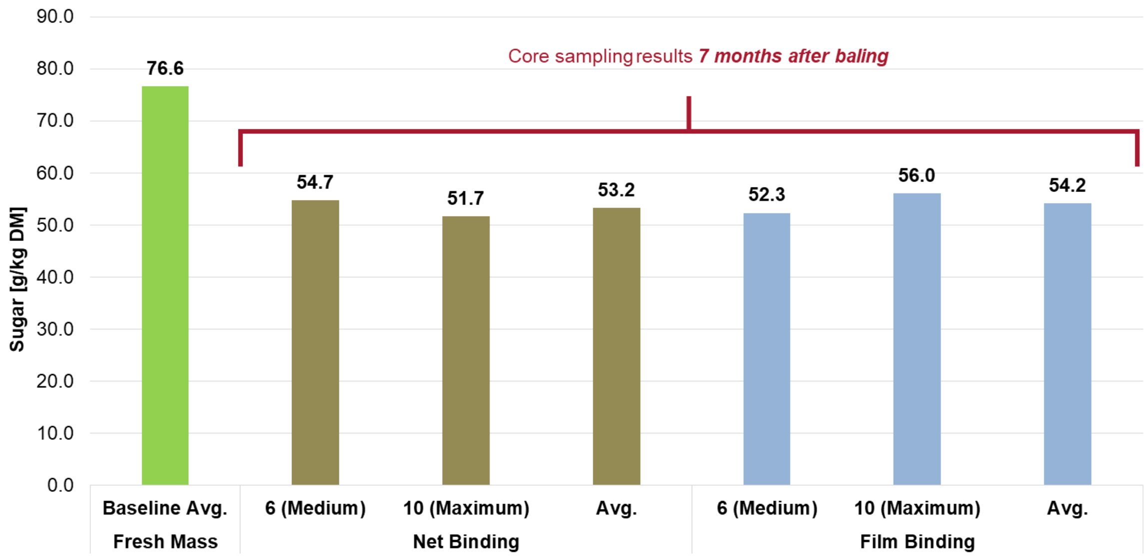

Figure 86. Sugar content results of the SFF 2022 Bale Density and Binding Study in Grass Silage after 7 months storage period.

For maximum bale density (10), the feed energy content was better preserved with film binding, whereas for net binding it was around 0.1 MJ NEL/kg DM lower after 7 months of storage period (Figure 87).

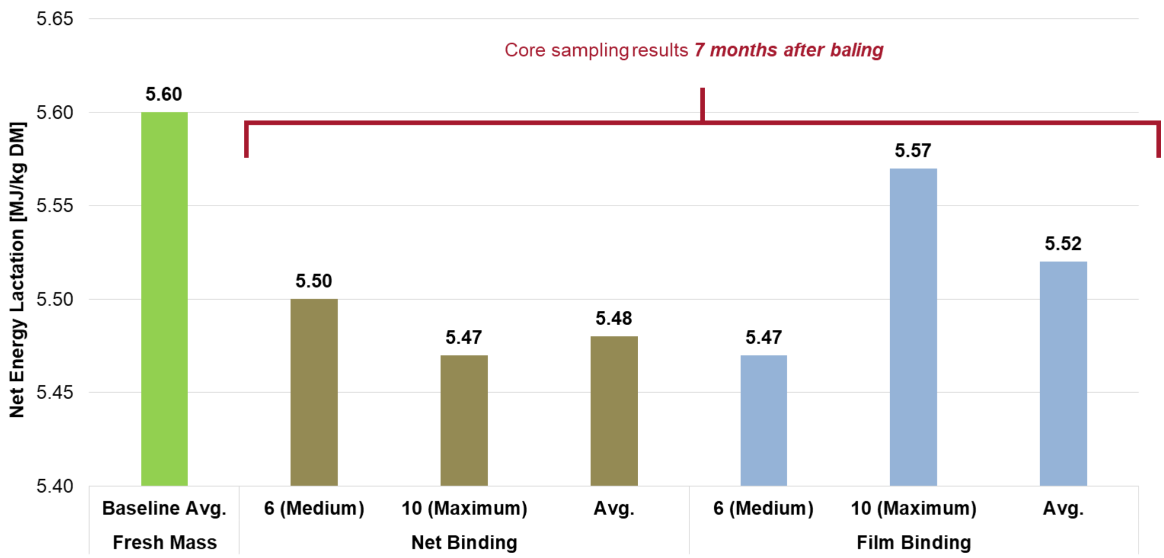

Figure 87. Energy content results of the SFF 2022 Bale Density and Binding Study in Grass Silage after 7 months storage period.

Recommendations and Equipment Solutions:

- Fendt Rotana 130 F Combi round baler can be ordered with the direct film binding option.
- With film binding, the bales are pressed and wrapped exclusively with film.
- Forage losses are reduced due to higher fermentation stability.
- The option for net binding is still available.
- The positioning of rollers allows fast switching between film and net binding.
- This allows drivers to switch quickly from silage bales to straw bales in tight time windows.

Payback:
At an annual dry matter yield of 10.0 t/ha in grassland, increased energy content by 0.1 MJ NEL/kg DM from 5.4 to 5.5 MJ NEL/kg DM using the film bind option for production of round bale silage as found in this study, results in additional 305 kg milk per hectare. Given a milk price of 0.70 CHF/kg, this is an additional revenue from milk of 213.50 CHF/ha of grassland.

Assumptions for payback:
1 kg of milk (ECM: 4.0% fat, 3.4% protein) requires 3.28 MJ NEL.
Milk price 12/2022: 0.70 CHF/kg ECM

Trial Team:
The trial was carried out by the Swiss Future Farm Operating Team with the grateful support of Sepp Christen (AGCO Field Service Specialist, Technical Service Green Harvest).

1.15 Technology test of SEAR technology from startup Digit Soil to measure soil enzyme activity

Contact

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Tatjana Wais, Intern Swiss Future Farm from August to November 2022

Helene Iven, CEO, Digit Soil

Objective

The aim of this technology test is to measure the enzyme activity in the soil in different soil types using the novel sensor from the Zurich-based startup Digit Soil and to test what added value the device can offer for use on farms. The soils studied had different soil types, on the one hand, but also different crop management. The measurement was carried out on six different areas on the Swiss Future Farm. Digit Soil calculates indicators for biological soil quality from the measured soil enzyme activity.

Digit Soil methodology

Decomposition of organic matter is an important factor in nutrient cycling and is often initiated by enzyme-catalyzed reactions in the soil (Burns et al., 2013). ositive correlations have been shown to exist between soil enzyme activity and nutrient mineralization in agricultural soils (Tabatabai et al. 2010). For the experiment, the extracellular enzyme activity of five enzyme groups was measured using the Soil Enzymatic Activity Reader (SEAR) from Zurich-based Digit Soil. The measurements are based on the reaction of soil enzymes with enzyme-specific fluorogenic substrates. The substrates used are called 4-methylumbelliferyl-N-acetyl-β-D-glucosaminide (NAG), 4-methylumbelliferyl--β-D-glucopyarnoside (GLS), 4-methylumbelliferyl phosphate (MUP), 4-methylumfelliferyl- β-D-xylopyranoside (MUX) and L-leucine-7-amido-4-metylcoumarin hydrochloride (LAP). Based on the reaction of the soil enzymes with the substrates, Digit Soil calculates the following indicators:

- Biological Activity Index:
  - The biological activity index relates the measured activity of all enzymes on the experimental plot to the total data set, which consists of all measurements made by Digit Soil to date (currently over 3000 data points). A scale of 0-3 (0-1: Low, 1-2: Medium, 2-3: High) is used to indicate the activity of soil organisms in each soil.
- C:N degradation ratio

Further, Digit Soil calculates the following three indicators, but they were not included in our evaluation:

- Carbon decomposition (enzyme NAG)
- Nitrogen mineralization (enzyme LAP)
- Phosphorus mineralization (enzyme MUP)

Description of the test site

The test plots were selected so that different soil types could be analyzed with the SEAR technology and the measured values could be compared. The test plots were selected on the basis of the Tänikon soil mapping from 1977. Table 25 describes the sampled areas and their properties.

Table 25: Description of the soil type of the sampled areas.

Field	Soil type	Description according to soil mapping	Crop at the time of sampling
Schürpunt	Brown earth	• Partially decarbonated, stagnogley brown soil, skeletal, weak clay loam and weak sandy loam, stagnant moisture, good water retention. • Very good meadow and arable land, locally suitable for fruit and vegetable growing.	Silage corn
Altkloster	Calcareous brown earth	• Regosolic calcareous brown soil, skeletal, weak sandy loam and weak clay loam, fairly low water retention. • Good, moderately dry meadow or pasture.	Cover crop mixture, before that sugar beet
Löhre Spitz & Bach	Para brown earth	• Developed parabrown soil, skeletal, subsoil strongly skeletal, sandy loam and weak clay loam, very good water retention. • Excellent meadow and arable land, well suited for fruit and vegetables.	Löhre Spitz: Summer oats (harvested) Löhre Bach: Sugar beets

Field	Soil type	Description according to soil mapping	Crop at the time of sampling
Rüedimoos	Gley	• Partially decarbonated pale gley, skeletally poor, clayey loam with peat subsoil, water-logged. • Moderately good, rather wet meadow	Temporary grassland
Weid links	Brown earth	• Partially decarbonated, stag-nogley brown earth, skeletal, weak clay loam and weak sandy loam, stagnant moisture, good water retention. • Very good meadow and arable land, moderately good arable land (periodically moderately wet, difficult soil cultivation).	Permanent grassland

Sampling methodology

Sampling took place during the week of September 5, 2022. Eight samples were analyzed per selected plot. Samples were distributed across five sampling sites and mixed to form a composite sample (Figure 88). One sample consisted of two tablespoons of soil from the rhizosphere and was collected at a depth between three and ten centimeters. The rhizosphere describes the area of soil that is covered and influenced by plant roots. In this area, an elementary exchange of nutrients takes place between the roots and the surrounding soil.

Figure 88: Field "Weid links" with the sample points drawn in. The five points that were mixed to form a composite sample are shown in the same color.

Analysis

During the measurement, a small amount of the sample was evenly distributed on the sampling area. Roots and stones were carefully removed. In a next step, a gel membrane was placed on the sample and pressed onto the sample. The next step was to take measurements using the SEAR Digit Soil measuring device (Figure 89). Most samples were measured with SEAR on the day of collection. Samples that were not measured directly were stored in the dark at 4° degrees Celsius.

Figure 89: The SEAR measuring device from Digit Soil.

Results

Figure 90 shows the enzyme activity of the five enzymes measured. The activity of b-glucosidase (GLS) and phosphatase (MUP) is highest. Further, the highest variability within and between the sampled fields is also evident for these two enzymes. In a second step, the biological activity index (Figure 92) is formed from the measured enzyme activities.

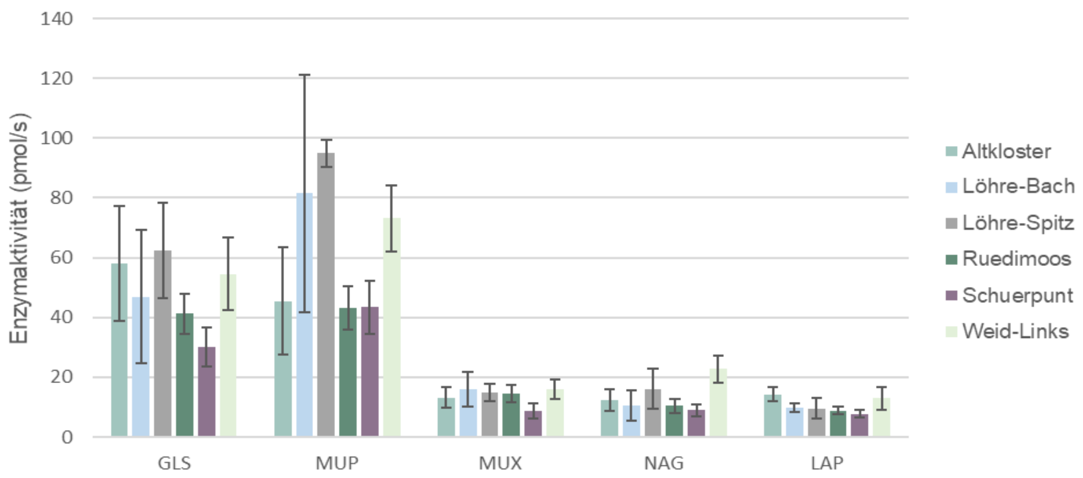

Figure 90: Enzyme activities of the five enzymes analyzed:. GLS, MUP, MUX, NAG and LAP.

<u>Enzymatic C:N ratio</u>

Figure 91 shows the calculated enzymatic C:N ratio. It can be seen in the graph that the "Weid Links" area has the highest enzymatic C:N ratio with a value of 7.97. The lowest enzymatic C:N ratio was found in the area "Altkloster" with a value of 4.49, which according to Digit Soil indicates the highest mineralization activity. Currently, Digit Soil is conducting experiments to test this hypothesis.

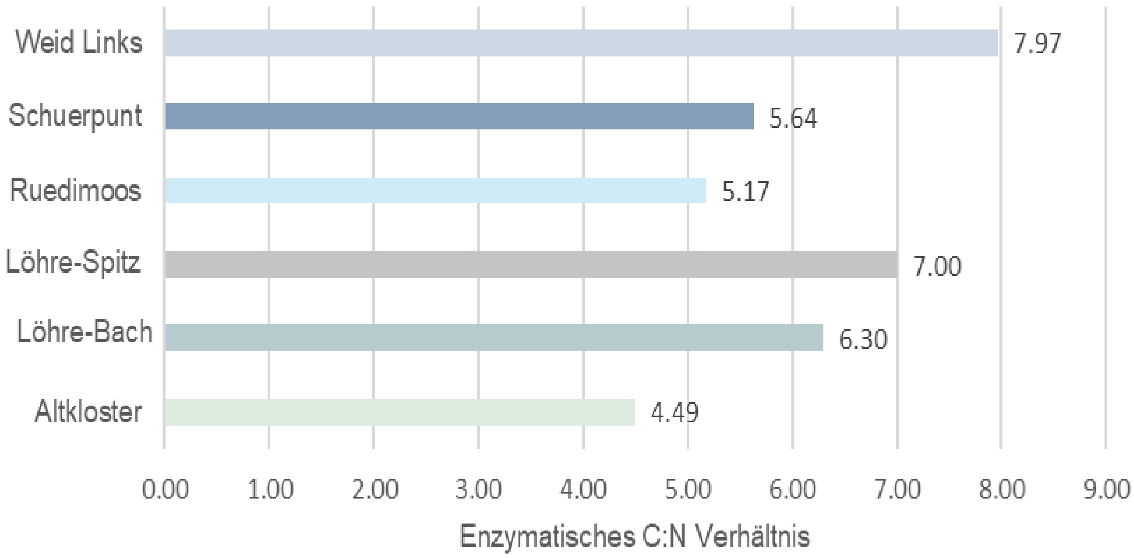

Figure 91: C:N ratio on the sampled area.

Biological activity index

The biological activity index relates the values measured on the trial plots to the Digit Soil reference data set. The index shows only medium and low values for the sampled plots in Tänikon (Figure 92). The highest biological activity was measured on the plot "Weid Links".

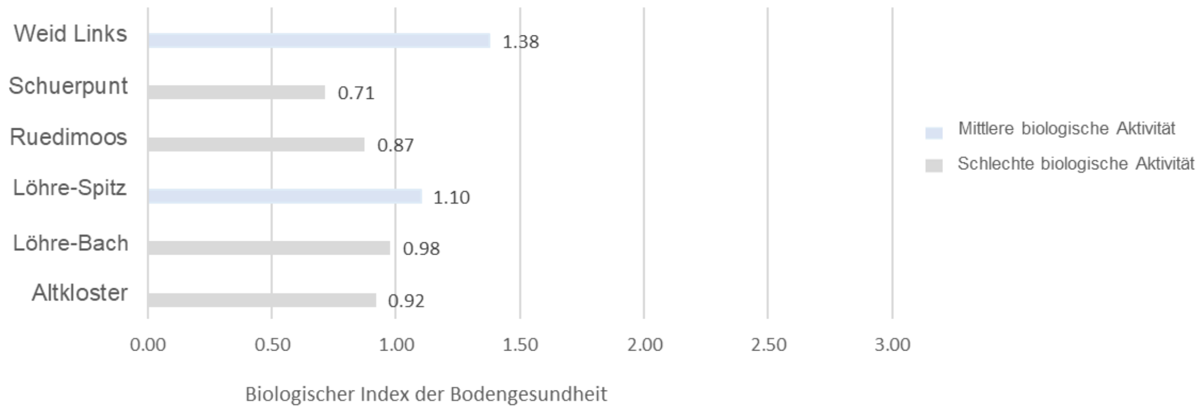

Figure 92: The graph shows the biological index of soil health. In beige is shown a low biological activity and in brown a medium biological activity.

On the area Weid Links there has been a natural meadow for many years. Likewise, a medium activity could be measured on the area Löhre Spitz. The area was characterized as excellent arable and meadow land in the soil mapping from the 1970s. The plot was planted to oats in 2022, sugar beets in 2021, silage corn in 2020, and an artificial meadow in 2019 and 2018. Humus content was 2.7% at the last measurement in 2019. To better illustrate the variability of the results, Figure 93 categorizes each biological activity measurement by color. Green indicates high activity, orange indicates medium activity, and red indicates low activity. In the background of the test plots, the soil types according to the soil map are shown, in which the corresponding measurements were carried out.

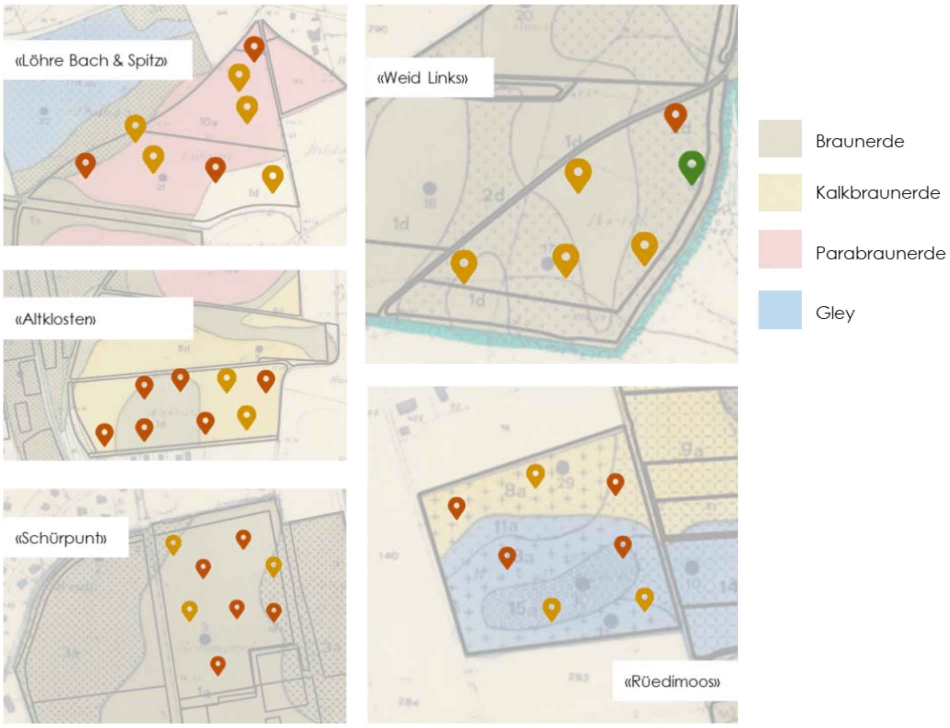

Figure 93: The figure shows the biological activity index on the different sampled plots.

Discussion and Summary

The objective of this technology test was to gain initial experience in the application of SEAR technology and to assess its usefulness for agricultural applications. Plots with different characteristics in terms of soil type, but also management history and crops were selected in order to obtain the widest possible range of results.

On the area "Weid Links" a natural meadow has existed for many years and accordingly no soil cultivation took place on the area. According to soil samples from the year 2023, the area has a humus content of 5.8% and showed the highest biological activity when measured with the SEAR sensor. Overall, the Schürpunt plot had the lowest biological activity. The soil samples from 2019 showed a rather low humus content between 3.4 and 3.5% for the Schürpünt area and the area shows a high compaction. For a more detailed investigation of the reasons for the different measured enzyme activities, more differentiated tests with more repetitions and at different measuring times would be needed.

To assess the user-friendliness of the device, it can be said that it was easy to operate after a short introduction by Digit Soil and provided results within 40 minutes. Sampling with eight measuring points per area proved to be suitable for obtaining a good overall impression of the area. We found the quick and easy use of the sensor to be very good.

For the broad application of SEAR technology in agriculture, there is currently still a lack of clear derivations or recommendations for action resulting from the measured enzyme activities. It could be exciting to use the sensor to continuously estimate the N supply from the soil and thus better estimate the N quantities to be fertilized. Furthermore, the application of the biological activity index could be used to monitor the success of plant cultivation measures (cover crops, reduced tillage, herbicide reduction).

Acknowledgements

A big thank you goes to Tatjana Wais, who conducted the test during her internship at SFF, evaluated it and co-authored the report. We would also like to thank Davide Silvestri, who assisted Tatjana with the sampling during his professional internship at the Fachmittelschule Frauenfeld. Last but not least, a big thank you goes to Hélène Iven, Sonia Meller and Jasmin Fetzer from Digit Soil who helped us with the sampling and evaluation of the results.

References

Burns, R. G., DeForest, J. L., Marxsen, J., Sinsabaugh, R. L., Stromberger, M. E., Wallenstein, M. D., Weintraub, M. N., & Zoppini, A. (2013). Soil enzymes in a changing environment: Current knowledge and future directions. Soil Biology and Biochemistry, 58, 216–234. https://doi.org/10.1016/j.soilbio.2012.11.009

Tabatabai, M. A., Ekenler, M., & Senwo, Z. N. (2010). Significance of enzyme activities in soil nitrogen mineralization. Communications in Soil Science and Plant Analysis, 41(5), 595-605. https://doi.org/10.1080/00103620903531177

Further information

Website Digit Soil: www.digit-soil.com

2 Projects

2.1 Smart-N consulting project successfully launched

Contact

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Background

The consulting project Smart-N is the first project within the framework of the Experimental Station Smart Technologies in Agriculture in the Application Region Schaffhausen and Thurgau. The experimental station is a consortium of the Agroscope Research Station, the cantons of Thurgau and Schaffhausen, and the AGRIDEA advisory center with the goal of testing the digitalization possibilities in agriculture for the benefit of resource- and climate-friendly management and to further develop them specifically for use in practice. To this end, projects are carried out in collaboration with and on commercial farms. In the project, Swiss Future Farm is responsible for the technological implementation and for advising the farms.

Project goals

In Smart-N, a methodology for satellite-based, Variable Rate nitrogen fertilization in winter wheat is applied on commercial farms in the cantons of Schaffhausen and Thurgau. By using the technology, the nutrient requirements of the plants are to be better estimated, nitrogen use efficiency improved and nitrogen surpluses reduced. The focus is on the advisory support of the farms as well as the transfer of the methodology into practical application.

Trial setup

In 2021, the first three commercial farms plus a trial area on the Swiss Future Farm were recruited for the start of the first trial year in 2022.
The farms each provide at least one area per project year on which different fertilization treatments are implemented simultaneously. Figure 94 shows the distribution of a project area on a commercial farm in the first trial year 2022. The trial is set up in such a way that the methodology of satellite-based Variable Rate fertilization can be compared with the farm strategy as well as the GRUD N_{min} methodology (GRUD = Fertilization recommendations according to the "Fundamentals of Fertilization of Agricultural Crops in Switzerland"). The treatments are described in more detail below.

Figure 94: Trial design for a project area in the first project year 2022.

Trial strip Standard (ST):

In the standard strips, the amount of fertilizer to be applied is determined according to the N_{min} methodology of the GRUD. To calculate the first application, the N_{min} values measured in spring are subtracted from a reference value of 120 kgN/ha specified in the GRUD. The reference values of 30 and 40 kg N/ha for the second and third application are, if necessary, corrected upwards or downwards by 10 kg N/ha on the basis of general growing conditions, crop development and disease pressure.

Trial strip Farm (FA):

In the farm treatment, the fertilization quantity and strategy specified by the farm managers is applied.

Trial strip Variable Rate Application (VRA):

For the implementation of the satellite-based, Variable Rate fertilization method, the project cooperates with the company Vista - Geowissenschaftliche Fernerkundung GmbH. As part of its TalkingFields® products, Vista produces fertilizer prescription maps based on previously calculated yield potential maps, current satellite images for crop development and the determined previous N uptake of the crop (further information at: www.talkingfields.de). The maximum permissible amount of N per field is specified by the farm managers at the beginning of each year.

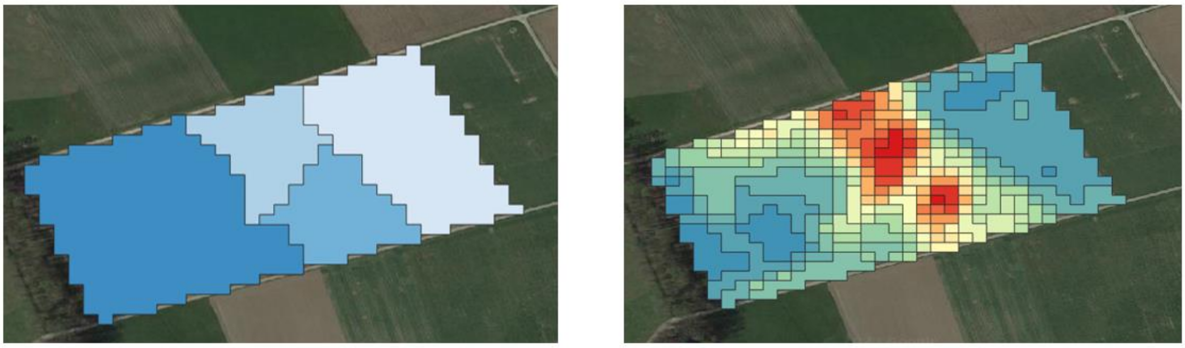

Figure 95: The left figure shows the zone map created by Vista GmbH from long-term biomass maps based on satellite images. The right figure shows the current fertilizer recommendation for a fertilization application.

<u>Zero plots</u>

Zero plots (4x6 meters) are created on each trial plot and are covered by the project team before each fertilizer application. In Figure 94, these zero plots are marked in yellow. At the end of the year, the zero plots serve as an indicator for the subsequent supply of nitrogen from the soil.

Technical implementation of fertilization

The project is looking for farms that already have a tractor and fertilizer spreader for automatic rate control based on a prescription map. Two of the three farms from the first project year meet this criterion (see Figure 96).

Figure 96: Tractors and fertilizer spreaders with automatic rate control via prescription map.

The third farm has a fertilizer spreader where the fertilizer quantity can be adjusted manually in 10% steps on the terminal. For this farm, the prescription map is loaded onto a smartphone, on which the position and the fertilizer quantity to be applied are displayed. The control is then carried out manually via actuation on the terminal (see Figure 97).

Figure 97: Fertilizer spreader with manual switching on the terminal incl. the smartphone app for orientation on the field.

The technical implementation in the first year of the project was challenging because we had different brands of fertilizer spreaders, tractors as well as terminals in use and had to make the correct settings in each separate case. This required close supervision of the project farms. Despite this supervision, errors also occurred in the fertilizer applications. For example, the amount of fertilizer applied was not correct for certain types of fertilizer, or the application map was not loaded correctly. All irregularities are neatly documented in the project so that they can be included in the evaluation.

Yields and fertilizer amounts

Figure 98 shows the yields and applied fertilizer quantities per method for the four project areas in the trial year 2022. It should be mentioned here that the yields were determined by hand sampling and the actual yields according to weighing at the grain collection center are lower. For farm 4, for example, the average yield according to weighing at the grain collection center was 86.4 dt/ha at 85% DM (incl. headland), with the hand samples about 100 dt/ha were determined.

Yields from farm 1 ranged from 62 dt/ha (0 plot) to 85 dt/ha in the FARM treatment. The N_{min} value measured in spring was 56 kgN/ha. The applied nitrogen amounts were lowest in the GRUD treatment with 124 kgN/ha. In the VRA treatment, the most nitrogen was applied with 163 kg. In the GRUD treatment, the ratio between the amount of nitrogen applied and the grain yield obtained is the highest (see Figure 99). The protein content is highest in the VRA treatment with 15% (Figure 100).

On the area of farm 2, very high N_{min} contents of 173 kg N/ha were measured in spring. The yields in the unfertilized 0-plots averaged 67 dt/ha. The highest yield was achieved in the GRUD treatment with 94 dt/ha. Due to the high N_{min} values in the soil, the GRUD variant was able to exploit its full potential. Nothing was fertilized for the first application and a total of only 66 kg N/ha was applied to the area. Accordingly, the ratio between kg grain and kg applied N is by far the highest in this method. Neither in the FARM treatment nor in the VRA variant was the measured N_{min} included, which is noticeable in the ratio between yield and fertilizer applied. However, the protein content benefited from the additional fertilizer applied in the FARM and VRA variants. This is with 16% each above the value of the GRUD variant.

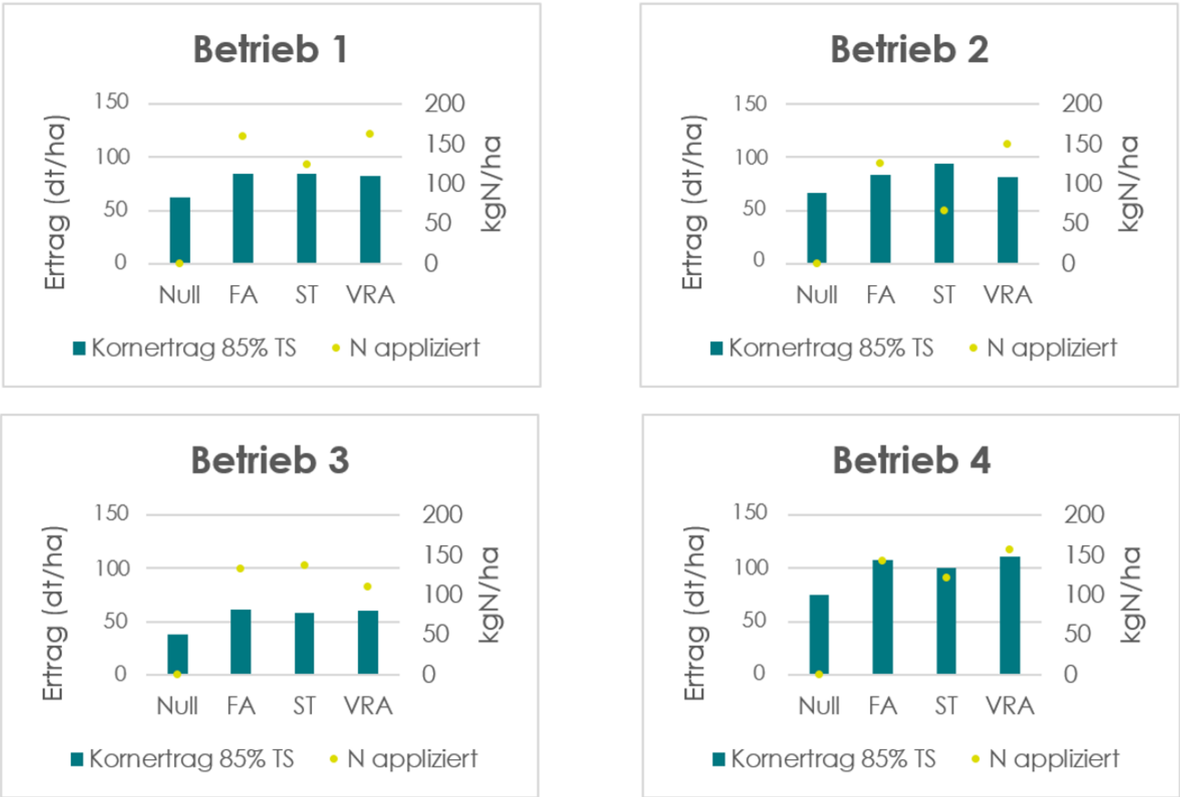

Figure 98: Yields and total kgN/ha applied on the four project plots in the trial year 2022.

The trial plot on farm 3 shows a clear heterogeneity in yield potential due to large soil differences. The wheat there also came into drought stress early, which resulted in significantly lower yields compared to the other trial plots with values between 38 dt/ha (0 plot) and 61 dt/ha (FARM treatment). Spring N_{min} levels were also low at 33 kg N/ha. Due to the heterogeneity of the trial plot, the VRA method was able to show its strength. In the lower-yielding areas of the field, the amount of fertilizer was reduced in this treatment. However, the average grain yield was comparable to the other two treatments. In terms of the ratio between fertilizer used and grain yield obtained, the

VRA method accordingly performed best. In terms of protein content, there are hardly any differences between the individual treatments.

Yields on farm 4 ranged from 75 dt/ha (unfertilized 0 plot) to 111 dt/ha in the VRA treatment. The N_{min} content in spring was 49 kgN/ha. On this plot, the VRA treatment was able to show some of its strength. The fertilizer quantity was somewhat reduced in the second application in favor of the third application, since the plants had not yet absorbed the fertilizer of the first application according to the satellite image. Accordingly, the highest yield and protein content was achieved in the VRA treatment. The FARM treatment, on the other hand, showed the best ratio between yielded grain and applied fertilizer.

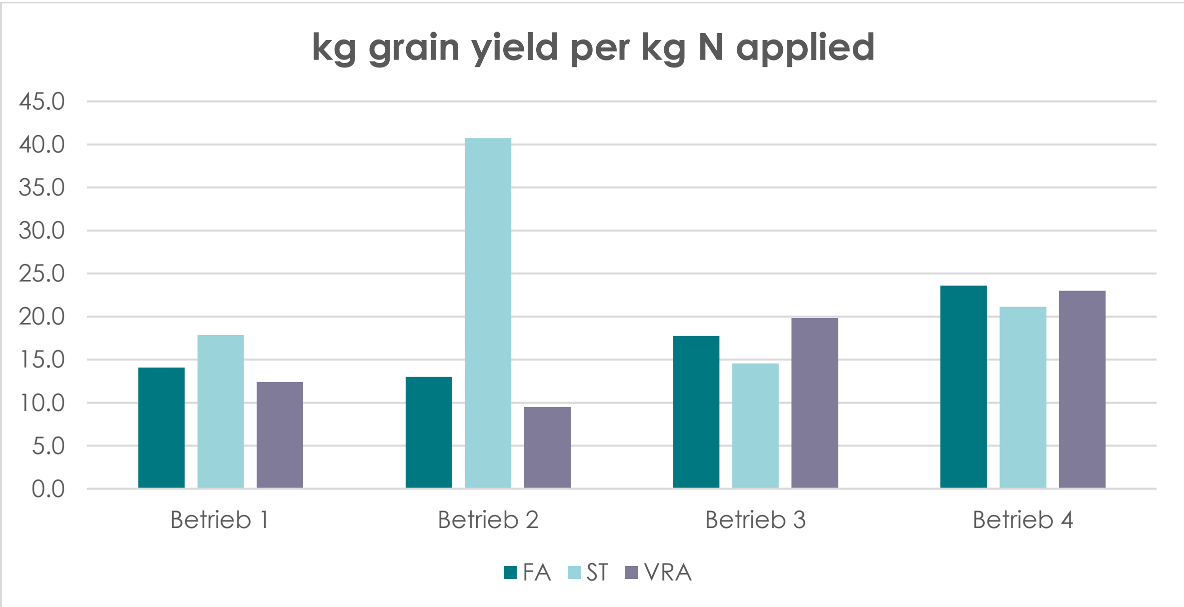

Figure 99: Ratio between grain yield and applied amount of nitrogen in kilograms.

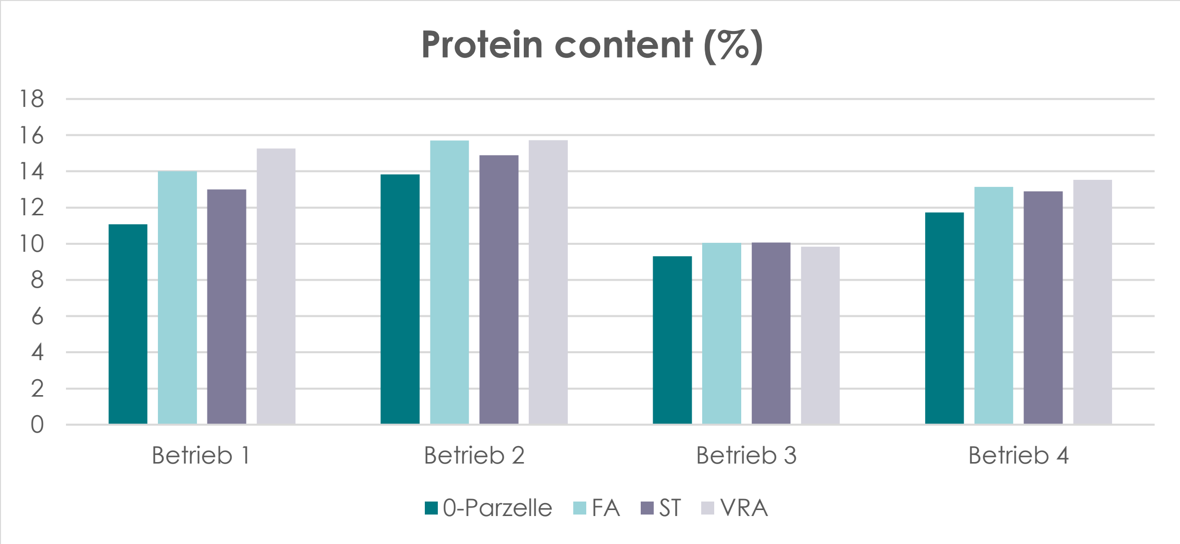

Figure 100: Protein content (%) in the individual fertilization treatment.

N efficiency and reduction of N surpluses

One project goal in Smart-N is the reduction of N surpluses. These are defined in the project as nitrogen that is not taken up by the wheat.

$$N_{Surplus} = N_{applied} + N_{from\ soil} - (N_{Straw} + N_{Grain})$$

The surpluses are made up of the fertilized N quantity plus the N replenishment from the soil minus the N quantity taken up by the wheat. To determine these surpluses, the N content of grain and straw is determined in the laboratory at the end of the year. The values of the 0 plots serve as an indicator for the soil replenishment. Figure 101 shows the N surpluses of the fertilization treatments on the four experimental plots and highlights the importance of the N_{min} samples in spring. On the plot of farm 2, N_{min} contents of 173 kg N/ha were measured, which are reflected in the high N replenishment from the soil. In the GRUD method, these N_{min} values were taken into account and the amount of fertilizer to be applied was reduced accordingly. As a result, the GRUD method shows the lowest surpluses at farm 2. On the remaining trial plots, the VRA method shows the lowest surpluses in each case. This observation is encouraging and may be due to the fact that in the VRA method, before each fertilizer application, it is analyzed how the current biomass is developed and how much nitrogen of the previous applications has already been taken up by the plants. This allows the required N application to be remeasured before each application. In addition, the VRA method also addresses heterogeneity within the field compared to the other treatments. This was particularly relevant in farm 3.

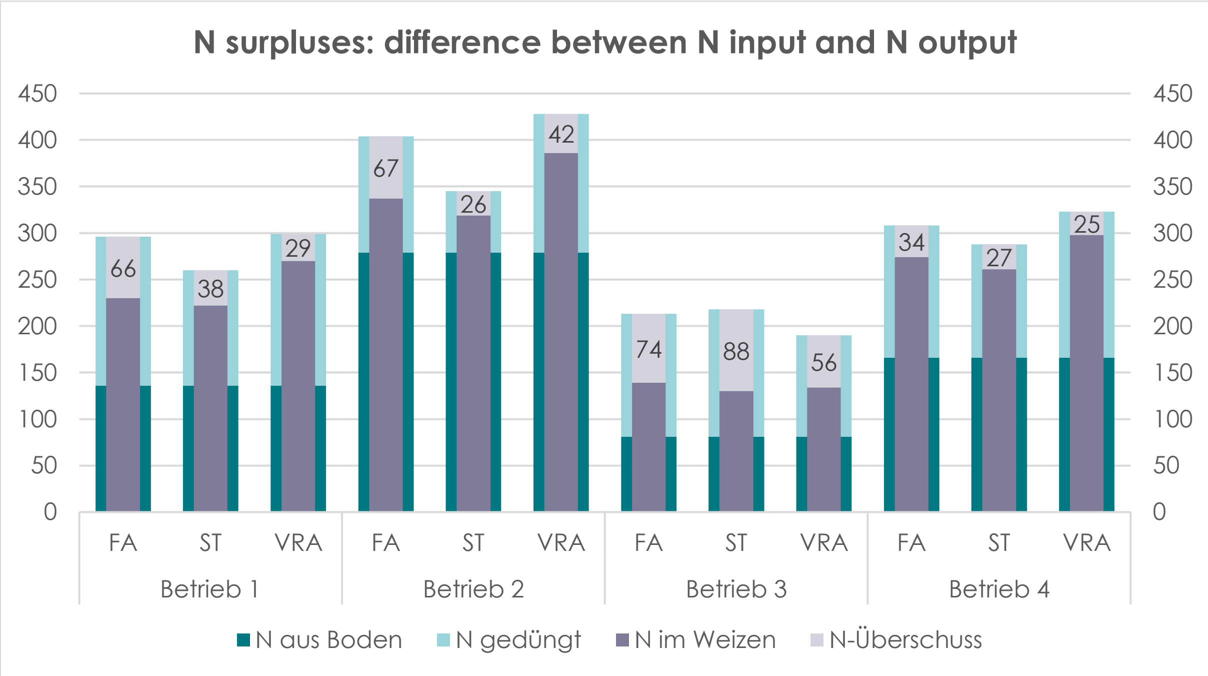

Figure 101: N surpluses as difference between N input and N output.

Conclusion and outlook

The first year of the project has shown that a high level of supervision is required to carry out these on-farm trials so that the technique is applied correctly and evaluable results are obtained.

It also became clear that the inclusion of the N_{min} content is an indispensable component for improving N efficiency and reducing N surpluses. For this reason, these will also be taken into account in the VRA methodology from 2023. Further, it was found that the lowest N surpluses were achieved in ¾ of the project trial plots in the VRA method. This may be related to the fact that the N uptake by the plants can be continuously analyzed and heterogeneity can be addressed.

For 2023, the trial will be extended to seven project farms and a total of 11 project trial plots. This will provide a further data basis on the potential of sensor-based, Variable Rate fertilization. In addition, work will continue on simplifying the process of creating the prescription maps so that they can be used by the farms without much additional effort.

Further information on the Experimental Station Smart Technologies in Agriculture in the Application Region Schaffhausen and Thurgau and the Smart-N project:

Link: https://www.agroscope.admin.ch/agroscope/de/home/ueber-uns/standort-strategie/versuchsstationen/versuchsstation-smarte-technologien.html

Videos:
https://www.agroscope.admin.ch/agroscope/de/home/aktuell/newsroom/2022/11-24_intelligente-duengung.html

2.2 Activities of the Agrar Academy of GVS Agrar AG

Contact:

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The brand "Agrar Academy" was created in 2019 by the project partner GVS. One goal of this reestablishment was to make the opportunities offered by SFF accessible to broader target groups, in particular dealers, customers and local farmers, but also the non-agricultural population. In addition, the Agrar Academy serves to enhance the image and personnel marketing for agriculture and agricultural technology.

Corona initially put the brakes on the project for almost 3 years. In February 2022, GVS therefore created a new management position and filled it with Mr. Frieder Demmer, previously the head of the AGCO Academy in Europe for many years. The basic idea of this "new beginning" remains that the establishment of digital technologies in the market requires a broader knowledge and communication base than can be achieved by Swiss Future Farm alone. As a first step, an Agrar Academy homepage was created in 2022, closely based on that of the SFF in terms of color and design. In addition, dedicated communication channels were established on the social media platforms LinkedIn, Facebook and Instagram. These channels are also used to actively document SFF events to the outside world, explicitly for an audience that is not primarily agricultural.

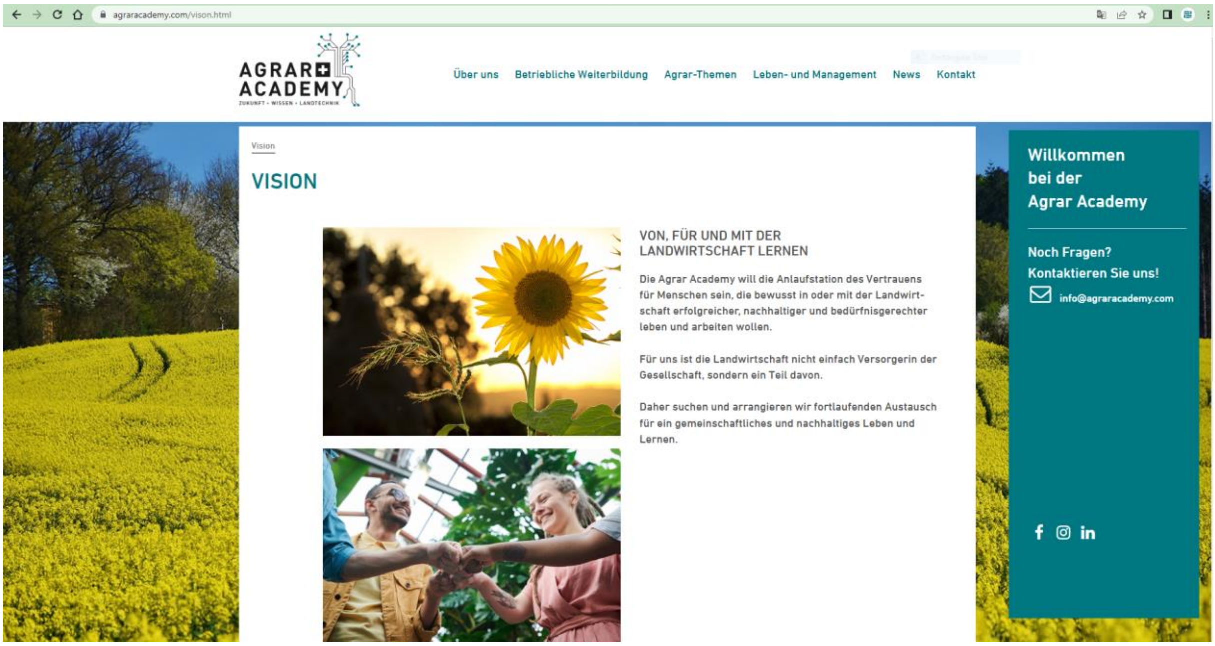

Figure 102: The Agrar Academy website.

SFF's Roman Gambirasio also designed a 3-step "Precision Farming" qualification program for sales staff in the agricultural equipment trade, which was implemented in Q1 and 2 2022. A correspondingly broad training for service staff has been planned and implemented for 2023.

In parallel, the collection and updating of driver training documents began for the resumption of driver training in Q1 and 2 2023. These are also currently underway. On this basis, 130 people have so far received targeted training on high-technology topics since November 2022.

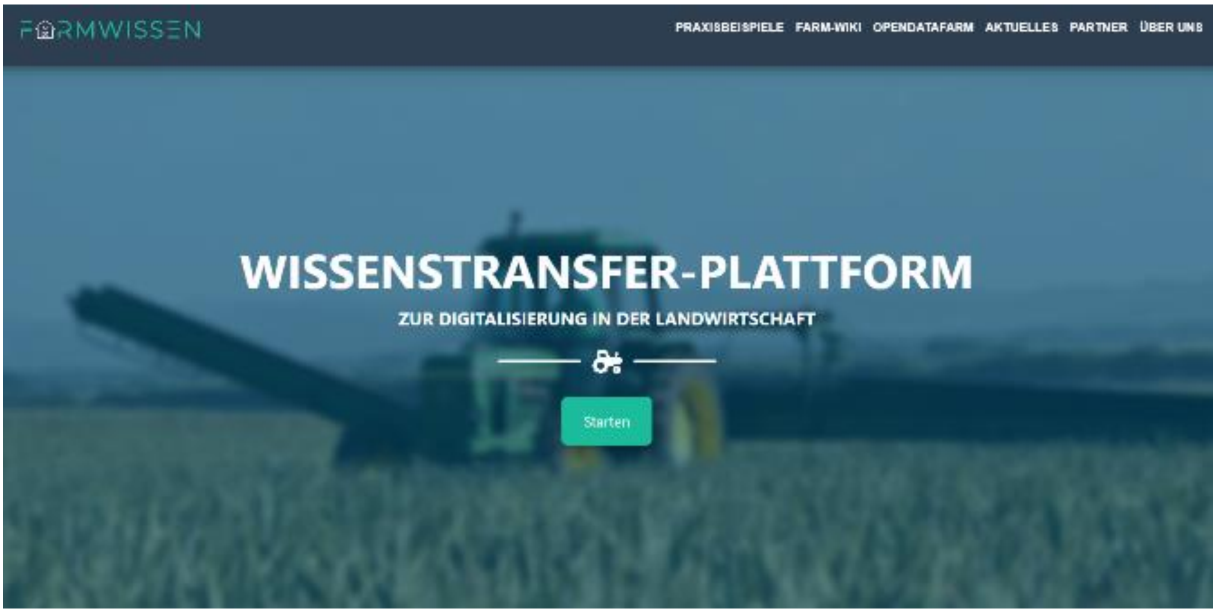

Figure 103: The homepage of the farmwissen.de platform.

On the topic of user support closer to everyday life, the Agrar Academy initiated an interdisciplinary exchange on the model project "farmwissen.de". This is an agricultural knowledge transfer platform developed in Germany as part of the 14 so-called "digital experimental fields" of the Federal Ministry of Food and Agriculture. The Agrar Academy conducted two concept workshops that dealt with the necessities, opportunities and problems of expanding the design into a general technology exchange platform for the entire German-speaking region.

Such a platform could quickly make the latest findings of the SFF - but also of other research farms, universities and manufacturers - available to a wider audience in a simple standard format. All participants agreed that there are currently serious gaps in knowledge about existing technical possibilities on the user side. This gap is currently still a significant handicap with regard to the implementation of sustainability goals.

Accordingly, a faster distribution of knowledge would make urgent sense. However, the practical implementation, especially the reliable content editing in the interest structure of manufacturers, associations, universities and users, proved to be extraordinarily complex in this exploration. A strategic project development linked to these challenges is currently underway. Further results are expected in mid-2023.

For the second half of 2023, the Agrar Academy is planning broader customer training courses on the use of tracking systems on the basis of a 4-level concept from "beginner" to "comfort user" and "field manager" to "farm manager". In addition, in cooperation with Brigitte Frick from Arenenberg, the broader use of the SFF as a school learning site is currently being examined in Cycle 3 of the Swiss framework curriculum, in the subject areas "Sustainability of scientific technical applications", "Sustainable resource management", "Interactions in terrestrial ecosystems", "Human influences on regional ecosystems".

2.3 Cultivation of perennial rye, spelt and einkorn for the Rüedi bakery in Aadorf

Contact

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In 2022, grain was produced for the second time for the local bakery Rüedi from Aadorf. This was after the crop could not be used as food grain due to wet weather in 2021. In 2022, the three cereal species perennial rye, einkorn and spelt were cultivated on a total of 0.7 hectares. The crop was managed without the use of pesticides or growth regulators. To reduce the risk of lodged grain, no fertilizer was used either. Replenishment from the previously cultivated temporary grassland was sufficient to provide adequate supplies to the crop. Weed control in the crops was accomplished by repeated use of the harrow. Spelt was harvested first on 07/14/2022 with a yield of 38 dt/ha and then einkorn (46 dt/ha) and perennial rye (43 dt/ha) on 07/20/2022. The grain was then processed in the Heitertal mills (spelt and einkorn) and in the Lamperswil mill (perennial rye). The cultivation for the Rüedi bakery will continue in 2023 on a total of 2 ha.

Figure 104: In the background, the three crops spelt, einkorn and prennial rye can be seen (left). On the right picture the bakers Rüedi are standing in front of the crop.

3 Public Relations

2022, a large number of people were again welcomed to Tänikon as part of the visitor program. In addition to excursions by clubs, associations as well as political groups and representatives of authorities from Switzerland and abroad, numerous learners from various agricultural schools and student groups again visited the SFF.

3.1 Field Visit Event on 06/22/2022

On June 22, 2022, a field visit event took place at the Swiss Future Farm in collaboration with the Arenenberg crop consulting team..

In the field, three stations provided information on the following topics::

- Drones for plant protection and fertilizer application (in cooperation with the company Remote Vision GmbH)
- Use of the Robotti robotic implement carrier for corn planting
- New ÖLN biodiversity scheme "cereals in wide row" in winter wheat and contract cultivation of white oats

The event was well attended with about 100 participants. After completion of the three field stations, the social part of the event was kicked off in test hall 1 with an exciting input presentation by two representatives of Precision Planting on the topic of precise seeding.

Figure 105: After the field tour (right picture) the social part of the event started with a presentation on the topic "Precise sowing with Precision Planting" (left picture).

3.2 Innovation Forum Food Industry

On December 08, 2022, the third Innovation Forum Food Industry took place on site in Tänikon on the topic of *circular economy as a solution*.

The aim of the annual Innovation Forum is to network researchers, companies and agricultural producers along the entire value chain.

The exciting program attracted over 150 people to Tänikon. In the morning, after two input presentations on the current supply situation and on regenerative agriculture, the visitors were free to choose between different presentations. These ranged from energy self-sufficient farms, agri-photovoltaics, the production of vegan mozzarella and the operation of a climate-positive wood-fired power plant to vertical farming. In the afternoon, the participants went on a tour of the Swiss Future Farm and received information at the stations of the Swiss Future Farm, Agroscope, and OST about the current research priorities in the field of smart irrigation, robotics, and Variable Rate fertilization. Furthermore, the Thurgau organic tofu producer Ensoy presented their tofu as an example of the circular economy in the food industry.

The next edition of the Innovation Forum Food Industry will take place on Thursday, November 30, 2023, in Tänikon.

Figure 106: The Innovation Forum Food Industry 2002 was very well attended with more than 150 people. The picture on the left shows the visitors during the presentations in the morning. In the afternoon, a tour of the Swiss Future Farm was organized in smaller groups.

More information can be found on the following page:
https://innovationsforum-ernaehrungswirtschaft.tg.ch

4 Training and Education

4.1 Knowledge transfer activities

Program for agricultural schools in Switzerland

This year, in addition to the learners from Arenenberg, we were pleased to welcome students from the agricultural schools Plantahof, Wallierhof and St. Gallen to the SFF. In half-day excursions, information was provided on the Swiss Future Farm projects and on the topics of guidance systems and ISOBUS, as well as on the emissions research barn in collaboration with researchers from Agroscope.

Figure 107: Agricultural visitor group as part of the BF 30 farm manager module (left) and a class from the Arenenberg's agricultural partner school Hatzendorf (right picture).

Smart Farming Module BF30

In 2022, the module "BF30 Smart Farming" was held for the second time together with Strickhof and the St. Gallen Agricultural Center. In this basic Smart Farming module, participants gain insights into the areas of guidance systems, ISOBUS, sensor technology in arable and livestock farming, Geographic Information Systems and Farm Management and Information Systems.

Figure 108: Yield mapping on the combine was explained as part of the module half-day on GIS (left picture). The camera-steered hoe was presented at the module day on the topic of ISOBUS (right picture).

Smart Farming Block in the ZHAW Master's Module Agroecology and Food Systems

On Thursday, November 3, 2022, the module day on Smart Farming in the ZHAW master's module Agroecology and Foodsystems took place for the second time at SFF. During the course day, students gained a broad insight into practical farming and its challenges, as well as the application of digital technologies in arable and livestock farming. For optimal learning success, the program was divided into theoretical and practical parts.

5 Links

5.1 Websites

www.swissfuturefarm.ch

www.agcocorp.com

www.bbz-arenenberg.ch

www.gvs-agrar.ch

www.fusesmartfarming.com/de

www.agrar-landtechnik.ch

www.precisionplanting.com

eu.precisionplanting.com

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

5.2 Social Media

https://www.instagram.com/swissfuturefarm

https://www.facebook.com/swissfuturefarm

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

6 Publishing Information

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