Quinoa cultivation (Stefan Brunner)

Drought-resistant crops (Switzerland)

DESCRIPTION

In response to changing environmental conditions, it can be valuable to adopt new plant varieties that offer benefits such as drought tolerance. The technology described covers one such response in Switzerland.

In response to changing environmental conditions, it can be valuable to adopt new plant varieties that offer benefits such as drought tolerance. The key is the improved adaptation of the crops to heat and drought. These adaptations are based on plant physiological and morphological characteristics that confer increased drought tolerance, as well as phenology, which can also affect the plants' water requirements. The goal is to reduce production losses and promote a regional, plant-based food system in Switzerland. To introduce and maintain drought-resistant crops requires specific activities and inputs, such as selecting suitable seeds and ensuring long-term profitable cultivation. This technology is applied to cropland in Switzerland, especially in the Swiss Plateau, where climate change is causing increasingly warmer and drier summers, as well as more intense precipitation in the winter months. These climatic changes favour the cultivation of crops that can better cope with drought periods, allowing for the replacement of crops that require irrigation in the same growing areas.
The main purpose is to adapt agricultural production to the effects of climate change while simultaneously reducing the emissions caused by farming. By cultivating drought-resistant crops, the risk of production losses during drought periods can be minimized, and a transformation towards more diverse, plant-based, and regional food production systems can be promoted. A major advantage of this technology lies in the adaptability of the selected crops to climate change. Since they are better adapted to tolerating drought periods, no additional irrigation is needed: this saves labour and other resources. Moreover, growing drought tolerant crops enables the production of regional, plant-based, and protein-rich foods (especially legumes) that are appreciated by certain consumer groups and can be better marketed.
However, there are also challenges and disadvantages that are not yet appreciated by land users. The lack of knowledge about non-traditional crops in Switzerland is a significant problem. Both theoretical knowledge and practical experience in cultivation are lacking, leading to high risk for farmers who must experiment with cultivation. Additionally, despite climate scenarios predicting drier summers, there is still the risk of cool and wet summers with increased precipitation. Besides the biophysical challenges, there are also socio-economic obstacles, as the demand from wholesalers is often focused on traditional crops, and niche crops like millet are commonly not popular.
This documentation focuses on an example of an innovative farmer in Spins, Switzerland. Stefan Brunner has been testing a wide variety of drought-resistant legumes such as lentils, lupins and black runner beans on his Eichhof farm since 2017. In addition to the large-scale cultivation of these drought-resistant crops, he also cultivates quinoa, peanuts, chia, sorghum, millet and rice in a demonstration plot. Stefan Brunner simultaneously attaches great importance to sustainable cultivation methods which include surface tillage and mulching.

LOCATION

Location: western midlands of switzerland (Broye catchment area), example farm in the canton of berne in Spins (near Aarberg), western midlands of switzerland, Switzerland

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 7.29473, 47.05179

Spread of the Technology: evenly spread over an area (approx. 0.1-1 km2)

In a permanently protected area?: Nee

Date of implementation: 2017

Type of introduction
- [x] through land users' innovation
- [ ] as part of a traditional system (> 50 years)
- [ ] during experiments/ research
- [ ] through projects/ external interventions

Quinoa cultivation on the Eichhof farm in Spins 2019 (Stefan Brunner)

Cultivation of legumes here: black runner beans (Stefan Brunner)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- [x] improve production
- [x] reduce, prevent, restore land degradation
- [ ] conserve ecosystem
- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [ ] preserve/ improve biodiversity
- [ ] reduce risk of disasters
- [x] adapt to climate change/ extremes and its impacts
- [ ] mitigate climate change and its impacts
- [x] create beneficial economic impact
- [ ] create beneficial social impact

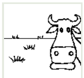
Land use

Land use mixed within the same land unit: Nee

Cropland

- Annual cropping: cereals - maize, cereals - quinoa or amaranth, cereals - sorghum, cereals - wheat (winter), fodder crops - grasses, legumes and pulses - lentils

Number of growing seasons per year: 2
Is intercropping practiced? Nee
Is crop rotation practiced? Ja



Grazing land

- Cut-and-carry/ zero grazing

Water supply

- [ ] rainfed
- [ ] mixed rainfed-irrigated
- [x] full irrigation

Purpose related to land degradation

- [x] prevent land degradation
- [ ] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

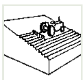
physical soil deterioration - Pc: compaction

biological degradation - Bc: reduction of vegetation cover

SLM group

- improved plant varieties/ animal breeds

SLM measures



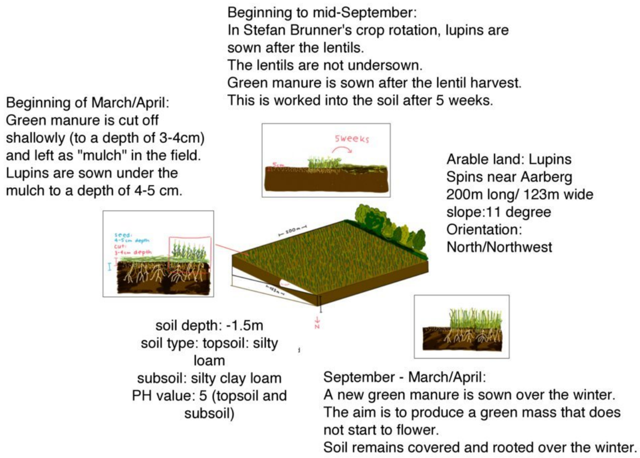
agronomic measures - A5: Seed management, improved varieties

TECHNICAL DRAWING

Technical specifications

The depicted technical drawing shows the farmland of Stefan Brunner, where lupins were sown in the spring of 2024. This field is representative of all the arable land, totaling 14 hectares of crop rotation areas managed by Brunner. The cultivation areas are situated at an altitude of 487 meters above sea level on flat or slightly sloping terrain on a hill range in the Bernese Mittelland. The depicted field is 200 meters long and 100 meters wide, with a slope of approximately 11° and an orientation towards the north/northwest. The soil is classified as silty loam based on the finger roll test, with the subsoil containing more clay compared to the topsoil. The pH value is 5, which is in the slightly acidic range.

The fields in Spins are located near the river "Alte Aare." Due to the proximity to the water, the farmer has the privilege of having irrigation available for all his fields. Since the implementation of large-scale cultivation of drought-resistant crops in 2017, Brunner has been growing a variety of crops on his land. According to Brunner, the following crops that he cultivates can cope well with drought: lentils, lupins, sorghum, corn, peanuts, millet, and cabbage. In combination with the method of surface rotting and mulching, the soil is protected against drying out and erosion and can retain moisture for longer. The cultivation of various crops can be combined with this farming method, leading to better drought resistance.The graphic illustrates the cultivation of lupins using a green manure cultivation method.



Author: Seraina Lerf

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **18 ha**)
- Currency used for cost calculation: **USD**
- Exchange rate (to USD): 1 USD = n.a
- Average wage cost of hired labour per day: n.a

Most important factors affecting the costs

The greatest difficulty in terms of costs lies in the lack of knowledge in the cultivation of these crops. The fact that very little scientific and practical knowledge and experience is available means that farmers take a greater risk in cultivating these crops. If cultivation is not carried out correctly and the farmer suffers production losses as a result, he bears the consequences. This is why they have to look for inventive solutions.

Establishment activities

n.a.

Maintenance activities

1. tillage: and sowing (Timing/ frequency: (once per cultivation period))
2. maintenance: weeding (recurring work step, but less labor-intensive than tillage) (Timing/ frequency: (Recurring work throughout the year))
3. harvesting: threshing (Timing/ frequency: (once a year for grain legumes))
4. Threshing the previous crop. Before the lupins, lentils were grown in Stefan Brunner's crop rotation. (Timing/ frequency: summer (july-september))
5. If there is no undersowing (as with the lentils), the soil must be tilled. This is very shallow, i.e. no more than 5 cm deep. (Timing/ frequency: summer (july-september))
6. A varied green manure is sown in the cultivated soil. The aim of this is to keep the soil rooted and to incorporate nutrients into the soil (Timing/ frequency: summer (july-september))
7. After 6-7 weeks, the green manure is worked back into the soil. When the plants are still young, they have the highest nutrient input before they extract the nutrients from the soil again if they continue to grow. As a result, the nutrients are mineral-bound in the soil, i.e. stored so that they are available to the plants. (Timing/ frequency: autumn (early/mid-September))
8. Another green manure is sown, which produces a lot of mass but freezes off in winter before it starts to flower. The aim is to keep the soil covered and rooted throughout the winter. (Timing/ frequency: autumn)
9. In spring, the soil is again worked shallowly. This means a maximum depth of 3-4 cm. The winter green manure is "planed". This means cutting it to a depth of 3-4 cm and leaving the plant material on the ground. (Timing/ frequency: spring)
10. The lupins are sown under the plant material to a depth of 4-5 cm, so that the soil remains moist and the plant material protects the soil from drying out. (Timing/ frequency: spring (beginning of March/April))

Total maintenance costs (estimation)

22575.0

NATURAL ENVIRONMENT

Average annual rainfall

- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☑ 751-1,000 mm
- ☐ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone

- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 865.0
Name of the meteorological station: Payerne
average maximum temperature 14.2°C, average minimum temperature 5.1°C

Slope

- ☑ flat (0-2%)

Landforms

- ☑ plateau/plains

Altitude

- ☐ 0-100 m a.s.l.

Technology is applied in

- ☐ convex situations

- [ ] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

- [ ] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

- [x] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

- [ ] concave situations
- [x] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [ ] moderately deep (51-80 cm)
- [x] deep (81-120 cm)
- [ ] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [x] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [ ] coarse/ light (sandy)
- [x] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content
- [ ] high (>3%)
- [x] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [ ] < 5 m
- [x] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)
- [ ] good drinking water
- [ ] poor drinking water (treatment required)
- [x] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to: surface water

Is salinity a problem?
- [ ] Ja
- [x] Nee

Occurrence of flooding
- [x] Ja
- [ ] Nee

Species diversity
- [ ] high
- [ ] medium
- [x] low

Habitat diversity
- [ ] high
- [ ] medium
- [x] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [ ] mixed (subsistence/ commercial)
- [x] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [x] individual/ household
- [ ] groups/ community
- [ ] cooperative
- [ ] employee (company, government)

Gender
- [x] women
- [x] men

Age
- [ ] children
- [ ] youth
- [x] middle-aged
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [x] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [ ] medium-scale
- [x] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [x] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [x] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [x] communal (organized)
- [ ] leased
- [ ] individual

Access to services and infrastructure

health	poor ☐ ☐ ☑ good	
education	poor ☐ ☐ ☑ good	
technical assistance	poor ☐ ☐ ☑ good	
employment (e.g. off-farm)	poor ☐ ☐ ☑ good	
markets	poor ☐ ☐ ☑ good	
energy	poor ☐ ☐ ☑ good	
roads and transport	poor ☐ ☐ ☑ good	
drinking water and sanitation	poor ☐ ☐ ☑ good	
financial services	poor ☐ ☐ ☑ good	

IMPACTS

Socio-economic impacts

risk of production failure

increased ☐ ☐ ☐ ☐ ☑ ☐ ☐ decreased

Production losses during periods of drought can be minimised

Impact	Negative end	Positive end	Comment
product diversity	decreased	increased	Product diversity can be increased by growing alternative drought-resistant crops
land management	hindered	simplified	By improving the soil's ability to cope with weather extremes (drought/heavy rainfall), land management in cultivation is simplified through greater flexibility.
drinking water availability	decreased	increased	Gentle tillage without the use of pesticides in the cultivation of drought-resistant crops (good groundwater quality)
demand for irrigation water	increased	decreased	Drought-resistant crops require less irrigation. In addition, the tillage method (surface rotting) also prevents the soil from drying out.
expenses on agricultural inputs	increased	decreased	
farm income	decreased	increased	more diverse market thanks to greater product diversity in the cultivation of alternative crops
diversity of income sources	decreased	increased	more diverse market thanks to greater product diversity in the cultivation of alternative crops
workload	increased	decreased	Gentle soil cultivation with minimal use of machinery (and application of surface rotting) requires more labour, even if the cultivation of drought-resistant crops does not mean additional work compared to conventional crops

Socio-cultural impacts

Ecological impacts

Impact	Negative end	Positive end	Comment
water quantity	decreased	increased	Less water required for irrigation
water quality	decreased	increased	Avoiding the use of pesticides leads to improved water and soil quality Harvesting/collection of water
harvesting/ collection of water (runoff, dew, snow, etc)	reduced	improved	The improved water absorption capacity of the soil (through soil cultivation methods) can lead to improved groundwater recharge
surface runoff	increased	decreased	Surface runoff can be minimised by improving the water absorption capacity of the soil (permanent root penetration).
excess water drainage	reduced	improved	Due to the improved water absorption capacity of the soil (through soil cultivation methods), less excess water is formed
groundwater table/ aquifer	lowered	recharge	The improved water absorption capacity of the soil can lead to improved groundwater recharge
evaporation	increased	decreased	Permanent ground cover can reduce soil drying out
soil moisture	decreased	increased	The permanent ground cover reduces drying out and the permanent root penetration leads to improved water absorption capacity of the soil. This can improve the soil water balance.
soil cover	reduced	improved	The ground should be permanently covered. The permanent ground cover reduces drying out.
soil loss	increased	decreased	The permanent covering and rooting of the soil prevents surface run-off. This can prevent soil loss.
soil accumulation	decreased	increased	Green manuring can ensure an improved hummus structure.

soil crusting/ sealing	increased	☐☐☐☐☐✓☐	reduced	The permanent ground cover reduces dehydration and the permanent root penetration leads to improved water absorption capacity of the soil. This prevents soil sealing.
soil compaction	increased	☐☐☐☐☐✓☐	reduced	The soil should remain permanently rooted and covered and be worked with as few and light machines as possible. This minimises soil compaction.
nutrient cycling/ recharge	decreased	☐☐☐☐☐✓☐	increased	By applying green manure, the soil can be enriched with nutrients (nutrient cycle of the soil).
soil organic matter/ below ground C	decreased	☐☐☐☐✓☐☐	increased	
plant diversity	decreased	☐☐☐☐✓☐☐	increased	greater plant diversity in the cultivation of alternative crops
drought impacts	increased	☐☐☐☐☐✓☐	decreased	Due to the improved ability of plants to cope with drought. to deal with drought. In combination with good water storage capacity of the soil, the effects of drought on the harvest can be minimised.

Off-site impacts

water availability (groundwater, springs)	decreased	☐☐☐✓☐☐☐	increased	In the analysed area (Spins near Aarberg) there is a permanent possibility to irrigate the fields due to the water availability of the nearby river Aare
reliable and stable stream flows in dry season (incl. low flows)	reduced	☐☐☐✓☐☐☐	increased	In the analysed area (Spins near Aarberg) there is a permanent possibility to irrigate the fields due to the water availability of the nearby river Aare
groundwater/ river pollution	increased	☐☐☐✓☐☐☐	reduced	The use of herbicides and fungicides was avoided in the cultivation of drought-resistant crops, thus preventing contamination
buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced	☐☐☐☐☐✓☐	improved	improved water absorption capacity (through soil cultivation methods) of the soil
Stability of production	decreased	☐☐☐☐☐✓☐	increased	Due to the improved adaptability to climatic conditions, production remains more stable

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Benefits compared with maintenance costs

Short-term returns	very negative	☐✓☐☐☐☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

The more equipment has to be used in cultivation, the more expensive the maintenance costs become. As Brunner is able to cultivate drought-resistant crops such as lupins and lentils with the existing equipment, he did not incur any additional costs. Even if a new machine for gentle soil cultivation in the cultivation of drought-resistant crops, such as a "planer", had to be purchased, a plow could be sold in return. As long as the same mechanization can be used as Brunner was already using for conventional crops, the costs remain the same. As a result, Brunner's cost-benefit ratio was assessed as positive, even in the short term. In the long term (over a period of 10 years), Brunner also sees an increased positive cost/benefit ratio. Consistently good soil cultivation regenerates the soil so well that it is able to absorb much more water. The amount of work required to implement this form of cultivation increases in the short term. However, the improved soil conditions in connection with the cultivation of drought-resistant crops have a positive effect on the workload and yield in the long term, as the crops on healthy soil are more flexible in the face of extreme weather conditions such as increasingly frequent droughts. Brunner also emphasizes that, from his perspective, it is worth incurring higher start-up costs for careful cultivation in order to generate long-term benefits. The start-up costs are often relatively high, but the long-term benefits are all the more valuable. Start-up capital is therefore essential to be able to generate long-term benefits.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	☐☐✓☐☐	very well	
seasonal temperature increase	not well at all	☐☐✓☐☐	very well	Season: summer
seasonal rainfall decrease	not well at all	☐☐☐✓☐	very well	Season: summer

Climate-related extremes (disasters)

heatwave	not well at all	☐☐✓☐☐	very well	
cold wave	not well at all	☐☐☐☐☐	very well	Answer: not known
extreme winter conditions	not well at all	☐☐☐☐☐	very well	Answer: not known

drought	not well at all ✓ very well		
epidemic diseases	not well at all very well	Answer: not known	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [x] single cases/ experimental
- [ ] 1-10%
- [ ] 11-50%
- [ ] > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [x] 0-10%
- [ ] 11-50%
- [ ] 51-90%
- [ ] 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- [x] Ja
- [ ] Nee

Continuous adaptation in the context of breeding

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)
- [x] breeding

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- No Irrigation Needed: These crops do not require irrigation, thus saving water and reducing labor.
- Promotion of Soil Health: The cultivation of these crops is beneficial for the soil, as as the tillage is shallow and legumes do not require additional nutrient inputs through fertilization.
- Benefits in Direct Marketing: These crops are niche products produced in limited quantities in Switzerland. Conscious consumers who value regional food products appreciate these items and understand the higher costs due to the high labor requirements.

Strengths: compiler's or other key resource person's view

- Reduced Irrigation Needs: If the crops can tolerate more drought, less irrigation is needed.
- Minimized Economic Risk: Drought tolerance reduces the risk of crop failure during dry periods.
- Crop Rotation Benefits: Better adaptation through diverse crop cultivation.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- High Labour Requirements: initial labour requirements are significantly higher due to limited knowledge and practical experience in cultivation, but with time this reduces - as less and less work is required on healthy and nutrient rich soils. More practical knowledge should be gathered by encouraging more farmers to cultivate these crops and facilitating knowledge exchange.
- Lack of Mechanization: Available market machines are not suited for the desired cultivation methods. Alternative machines are needed, which are smaller and lighter and only minimally till the soil. New approaches and inventions in machinery are required.
- The wholesale market is not particularly interested in domestically produced alternative foods. Wholesalers are profit-oriented and primarily offer what is consumed in Switzerland. A reorientation of dietary habits is necessary. Millet, for example, is ideally suited to the climatic conditions in the Seeland region. Increased consumption could lead to more extensive cultivation.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Lack of knowledge: limited knowledge and practical experience in cultivation More research should be carried out in this area and practical experience in cultivation should be gained through practical implementation. Inovative farmers are in demand.
- Weather Variability: There is no guarantee that heavy rains won't occur, potentially ruining the harvest. The extent to which crops are affected by severe weather events depends on when they occur. Severe weather events have an impact on every crop, but of course you don't know when they will occur. A useful strategy is therefore to build a highly diverse production system at farm and landscape level.
- Practical and Socioeconomic Challenges: Market preferences and practical issues, such as livestock not favoring sorghum feed, can be obstacles. No answer given.

REFERENCES

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Resource persons
Stefan Brunner - land user

Full description in the WOCAT database
https://qcat.wocat.net/af/wocat/technologies/view/technologies_6272/

Linked SLM data
n.a.

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Key references

- Heinz, Malve et al. (2023): How to find alternative crops for climate-resilient regional food production, in: Agricultural Systems, Bd. 213, S. 103793, doi:10.1016/j.agsy.2023.103793.:
- Wuyts, Nathalie et al. (2023): Klimaresilienter Ackerbau 2035, Agrarforschung Schweiz, doi:10.34776/afs13-135.:
- Heinz, Malve. (2021): Prospects of cultivating alternative crops in a changing climate in Switzerland, Master's Thesis, University of Bern.:

Links to relevant information which is available online
- Internet platform of the Eichhof of the Brunner family from Spins near Aarberg: https://www.brunnereichhof.ch

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