Stubble cultivation under minimum tillage (KULUNDA)

Minimum Tillage (Russian Federation)

Минимальная обработка

DESCRIPTION

Minimum tillage is a one-pass operation combined with sowing, using a classic Russian seeder modified for seedbed preparation and soil mixing. It can include shallow stubble cultivation after harvesting.

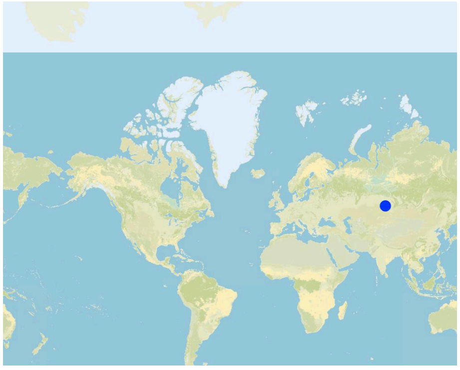
Minimum tillage is a key element of the "adapted Soviet cropping system", which aims at more sustainable land use but based on predominantly local technologies. For successful implementation of minimum tillage, adaption of the whole cropping system is required, including crop rotation. Rotation includes a succession of cereal crops (e.g. spring wheat), legumes (peas), and oil seed crops. Stubble cultivation in autumn is best performed with the "Catros" compact disc harrow for a quick, shallow operation. Seedbed preparation is carried out using a classic Russian seeder modified with wing shares for shallow seedbed preparation including soil mixing. In general, the performance of this drill is very close to that of a cultivator.

Minimizing tillage, saves time and fuel, and also helps to reduce evaporation, as well as protecting the soil against erosion. Shallow tillage with disc harrows after harvest ensures better stubble mixing and stimulates the germination of weed seeds. The adapted seeder, SZS 2.1, works with wing shares that open the soil and place the seed. Thus traditional deep tillage operations for the preparation of the seedbed can are omitted: that helps to reduce costs. With respect to crop protection, the first and most important element is to implement a full crop rotation. To control late germinating weeds and seeds of the previous crop, a disc harrow is used for shallow cultivation – this can be supplemented by the application of a non-selective herbicide if there is germination - to avoid the risk of flowering before the hard frost sets in. Fertilization becomes more important, because of the decreased mineralization rate under minimized soil tillage, especially at the beginning of the conversion of the cropping system.

The Technology including crop rotation was tested in the field in 4 test plots with 4 repetitions at the test site in Poluyamki. Results showed that the intensity of soil tillage and seeding methods used had a great influence on crop establishment and expected yields. It was demonstrated that minimizing tillage leads to higher water use efficiency and highest yields. Positive effects were also observed regarding soil structure and soil fertility already after 3 years. Minimized soil disturbance led to higher aggregate stability, which leads to a lower risk of wind erosion, increased soil organic carbon storage and soil fertility as well as available soil water content. The adapted Soviet system is more profitable, due to higher gross margins.

The test site in Poluyamki is located in the dry steppe of the border region next to Kazakhstan, where, due to the climatic conditions, no natural afforestation occurs, and the planted windbreaks don't grow vigorously due to the prevailing aridity. The annual precipitation is under 300 mm a year. Probably the greatest climatic influence factor is the precipitation - in terms of quantity and space/ time distribution and, due to high summer temperatures, the high rates of evapotranspiration. The total yearly precipitation rate is the primary yield-limiting factor in all steppe regions. The ratio between precipitation and evaporation is negative. In the late weeks of spring, prolonged droughts must be expected in 5-year cycles, limiting germination and crop establishment. The soils are classed among those of cool-tempered grasslands. Due to their physical and chemical characteristics, these soils (Chernozems and Kastanozems) have high agronomic potential.

LOCATION



Location: Mikhaylovski district (Pavlovski district, Mamontovski district), Russian Federation/Altai Krai, Russian Federation

No. of Technology sites analysed:

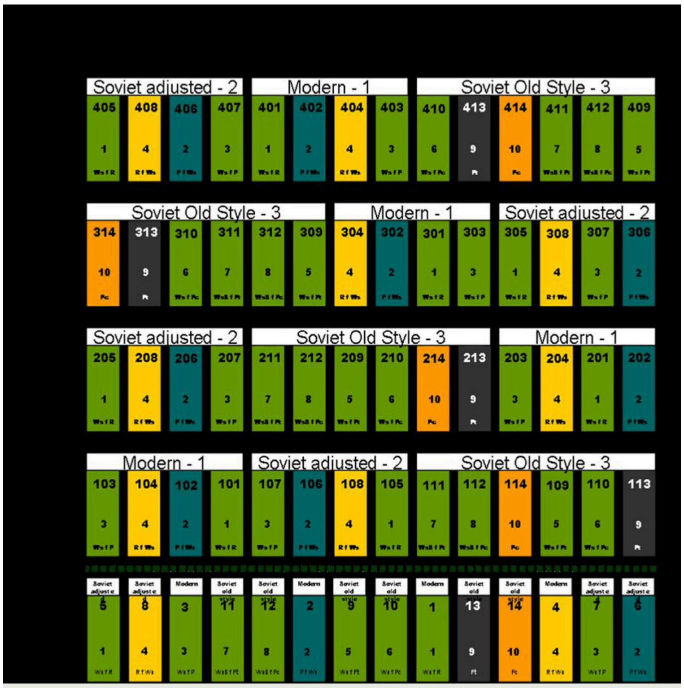
Geo-reference of selected sites
- 79.90727, 52.0675

Spread of the Technology: evenly spread over an area (0.13 km²)

In a permanently protected area?:

Date of implementation: less than 10 years ago (recently)

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



The scheme shows the design of the test field “KULUNDA II” in Poluyamki. It consists of various test plots bellowing to different farming systems (Lars-Christian Grunwald)

Test plots of the three cropping systems studied: conventional, adapted and modern in Poluyamki, . Between the test plots, the protective strips can be seen. (Patrick Illiger)

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
- [ ] adapt to climate change/ extremes and its impacts
- [ ] mitigate climate change and its impacts
- [ ] create beneficial economic impact
- [ ] create beneficial social impact

Land use

Cropland
- Annual cropping

Number of growing seasons per year: 1

Water supply

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

Purpose related to land degradation

- [x] prevent land degradation
- [x] 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

soil erosion by wind - Et: loss of topsoil, Ed: deflation and deposition, Eo: offsite degradation effects

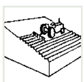
chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

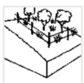
SLM group

- minimal soil disturbance

SLM measures



agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A3: Soil surface treatment (A 3.2: Reduced tillage (> 30% soil cover))



management measures - M2: Change of management/ intensity level

TECHNICAL DRAWING

Technical specifications

Soviet Seeder SZS 2.1 with wing shares for shallow soil mixing and seed bed preparation.
Location: Poluyamki. Altai Krai
Date: 20.05.2015

Technical knowledge required for field staff / advisors: high
Technical knowledge required for land users: high
Main technical functions: improvement of topsoil structure (compaction), increase in organic matter, increase of infiltration, increase / maintain water stored in soil, sediment retention / trapping, sediment harvesting
Secondary technical functions: control of raindrop splash, control of dispersed runoff: retain / trap, control of dispersed runoff: impede / retard, control of concentrated runoff: retain / trap, control of concentrated runoff: impede / retard, improvement of surface structure (crusting, sealing), improvement of subsoil structure (hardpan), stabilisation of soil (eg by tree roots against land slides), increase in nutrient availability (supply, recycling,…), reduction in wind speed, increase of biomass (quantity)


Author: Lars-Christian Grunwald

Better crop cover
Material/ species: Crop rotation without bare fallow
Mulching
Material/ species: stubble cultivation with disc harrow or harrow weeder
Quantity/ density: 1/year
Green manure
Material/ species: pea
Mineral (inorganic) fertilizers
Material/ species: fertilization with calcium ammonium nitrate
Quantity/ density: yearly
Remarks: (100kg/ha (spring wheat and rape), 50kg (pea)
Rotations / fallows
Material/ species: wheat-pea-wheat-raps
Minimum tillage
Material/ species: Catros (disc harrow) and Seeder C3C2.1 (wing shares)
Remarks: Catros (depth: 10 cm) after harvest (autumn) and Seeder in May)
Non-inversion tillage
Material/ species: Catros (disc harrow) and Seeder C3C2.1 (wing shares)
Remarks: Catros (depth: 10 cm) after harvest (autumn) and Seeder in May)

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs
- Costs are calculated:
- Currency used for cost calculation: **n.a.**
- 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 highest cost factors of minimum tillage are equipment, fuel, fertilizer and seeds. Compared to the conventional deep ploughing often without fertilizer application, fertilizer and pesticides are the main additional cost factors.

Establishment activities
n.a.

Maintenance activities
1. Stubble cultivation (Timing/ frequency: september)
2. Seeding (Timing/ frequency: late april/early may)
3. Seeding (extension) (Timing/ frequency: None)
4. Pest management (Timing/ frequency: period of vegetation)
5. Pest management (extension) (Timing/ frequency: None)
6. Harvest (Timing/ frequency: september)

Maintenance inputs and costs

Specify input	Unit	Quantity	Costs per Unit (n.a.)	Total costs per input (n.a.)	% of costs borne by land users
Labour					
labour	ha	1.0	4.34	4.34	100.0
Equipment					
machine use	ha	1.0	37.4	37.4	100.0
fuel	ha	1.0	47.34	47.34	100.0
Plant material					

seeds	ha	1.0	25.3	25.3	100.0
Fertilizers and biocides					
fertilizer	ha	1.0	30.83	30.83	100.0
pesticides	ha	1.0	9.42	9.42	100.0
Total costs for maintenance of the Technology				**154.63**	
Total costs for maintenance of the Technology in USD				*154.63*	

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [x] 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
- [x] semi-arid
- [ ] arid

Specifications on climate
Thermal climate class: temperate

Slope
- [x] flat (0-2%)
- [ ] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [x] plateau/plains
- [ ] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [ ] 0-100 m a.s.l.
- [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.

Technology is applied in
- [ ] convex situations
- [ ] concave situations
- [ ] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [x] shallow (21-50 cm)
- [x] moderately deep (51-80 cm)
- [ ] 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)
- [ ] 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
- [ ] good
- [ ] medium
- [ ] poor/ none

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

Water quality refers to:

Is salinity a problem?
- [ ] Yes
- [ ] No

Occurrence of flooding
- [ ] Yes
- [ ] No

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

Habitat diversity
- [ ] high
- [ ] medium
- [ ] 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
- [x] very rich

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

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

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

Gender
- [ ] women
- [x] men

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

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha

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

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

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

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

- ☐ 500-1,000 ha
- ☑ 1,000-10,000 ha
- ☐ > 10,000 ha

- ☐ 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

Crop production

Crop production	decreased				✓				increased	In the first years after the change of the cropping system, there is an increased risk of crop losses due not correct/suitable management of the new cropping system
expenses on agricultural inputs	increased			✓					decreased	mainly for initial investments and herbicides in the first years
farm income	decreased						✓		increased	but increase of costs for herbicides and fertilizer; decrease for fuel and labor
Increase use of herbicide applications	increased		✓						decreased	particular necessary in the first years after the imlementation of the minimum tillage system

Socio-cultural impacts

food security/ self-sufficiency	reduced				✓				improved	In general yes, but food security is not a problem in this region.
conflict mitigation	worsened						✓		improved	

Ecological impacts

surface runoff	increased					✓			decreased	
evaporation	increased					✓			decreased	
soil moisture	decreased					✓			increased	
soil cover	reduced						✓		improved	
soil loss	increased					✓			decreased	
soil compaction	increased					✓			reduced	
nutrient cycling/ recharge	decreased					✓			increased	
soil organic matter/ below ground C	decreased					✓			increased	
beneficial species (predators, earthworms, pollinators)	decreased					✓			increased	
emission of carbon and greenhouse gases	increased					✓			decreased	
wind velocity	increased						✓		decreased	
Increased use of herbicide application	increased		✓						decreased	Especially in the first years after the implementation of the minimum tillage system.

Off-site impacts

water availability (groundwater, springs)	decreased					✓			increased	there is a higher content of soil moisture under minimum tillage than under traditional ploughing especially in dry weather periods / drought periods.
wind transported sediments	increased					✓			reduced	
damage on neighbours' fields	increased					✓			reduced	

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

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

Benefits compared with maintenance costs

Short-term returns — very negative ☐☐☐☐☑☐☐ very positive
Long-term returns — very negative ☐☐☐☐☐☑☐ very positive

CLIMATE CHANGE

Gradual climate change
annual temperature increase — not well at all ☐☐☐☑☐ very well

Climate-related extremes (disasters)
local rainstorm — not well at all ☐☐☐☑☐ very well
local windstorm — not well at all ☐☐☐☑☐ very well
drought — not well at all ☐☐☐☑☐ very well

Other climate-related consequences
reduced growing period — not well at all ☐☑☐☐☐ very well

ADOPTION AND ADAPTATION

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

- ☐ 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?

- ☐ 0-10%
- ☐ 11-50%
- ☐ 51-90%
- ☐ 91-100%

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

- ☐ Yes
- ☐ No

To which changing conditions?

- ☐ climatic change/ extremes
- ☐ changing markets
- ☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

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

- Increase of soil aggregate stability and improved soil structure thus better erosion control and protection of soil organic matter will improve soil fertility and water holding capacity
- Minimization of evaporation losses through the mulch layer
- Protection of soil organisms thus ensuring natural soil forming processes
- Lower input costs (materials, fuel, labour, time) and quicker field operations.
- A great advantage of the tested ‘minimum tillage’ in contrast to ‘no till‘ is that the former needs no new machinery because of the use and adaptation of old Soviet machinery.

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

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

- Need for comprehensive system knowledge and risk of significant crop losses in case of incorrect implementation Knowledge transfer, Capacity building and extension services, State support (subsidies for new technologies)
- Application of chemical herbicides leads to higher costs and possible ecological risks Selective spraying using the “Amaspot” system that is based on infrared detection of weeds.
- Higher requirements for fertilizers, especially at the beginning, due to lower mineralization rates and less nutrient availability compared to conventional cultivation Higher fertilizer application in the first years after conversion.
- Challenging straw management that leads to higher risk of fungal infestation and poorer field crop emergence Good straw management: effective straw chopping and spreading as well as stubble cultivation for an optimal straw/ soil ratio.

REFERENCES

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Date of documentation: June 23, 2016

Last update: June 17, 2019

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_1315/

Linked SLM data
Approaches: Vocational Training https://qcat.wocat.net/en/wocat/approaches/view/approaches_2544/
Approaches: Field days https://qcat.wocat.net/en/wocat/approaches/view/approaches_2617/

Documentation was faciliated by

Institution
- n.a.

Project
- Book project: Making sense of research for sustainable land management (GLUES)
- Sustainable land management in the Russian steppes (KULUNDA / GLUES)