The soil and water conservation effects and key issues by conservation tillage in Loess Plateau

HAO Mingde

Institute of soil and water conservation, CAS & MWR;
Institute of soil and water conservation, Northwest A & F University

Outline report

- Background
- The soil and water conservation effects of conservation tillage
- New problems in dryland farming
- Conservation tillage experiments of rainfall-collecting and mulching
- Set up technology system of conservation tillage in Loess Plateau

Background

Stages of dryland farming on Losses Plateau

- **Loess Plateau —— traditional farming area in China**
  - **a rotation system of one-year-one-harvest and two-year-three-harvest**

    Maintain fertility by manure, straw and leguminous crops.

    Control soil water and fertilizer by tillage (deep plowing, harrow and repression)
  - **soil management system like "furrowing-harrowing- raking- pressing-hoeing**".
- **Before 1960s:** deep plowing and fallow in summer or autumn
- **In 1980's,mulching techniques are promoted.**

  2-year-3-harvest or 3-year-4-harvest rotatory or continuous by wheat and maize
- **Presently:** Comprehensive application of mulching, rain gathering and conservation tillage

Background

The role of traditional dryland farming techniques in agricultural production.

◆Coverage Technology: storing precipitation, increased infiltration, prevent soil erosion; prevent evaporation, change soil moisture and temperature, increase fertility and prevent drought and land desertification

◆Farming for preventing soil moisture: “early plow to store precipitation, implement conservation tillage in summer to keep soil moisture, well managed to prevent moisture in spring and winter, harrow to protect moisture after rainfall, cultivate before seeding to protect basic moisture ”

◆Contour line contour plant : Ditching ridge contouring, earthing up in channel, storing precipitation in subsection, ridging and ditching or change each others. Those all can increase ground roughness, and enhance soil permeability, reduce runoff, resistant soil corrosion

Conservation tillage—— a revolution of traditional cultivation

- Traditional dryland farming based on tillage, frequent plow bring about runoff easily, causing erosion. The erosion area accounted for 50%, 70% population and 80% cultivated land located in erosion area. The silt importation of the Yellow River was 1.6 billion tons every year.
- Conservation tillage are practical techniques in dryland farming, which adapted for environment protection and production development. It was in favor of soil and water conservation, increasing soil fertility, prevent drought, yield stability. The core technology is to prevent soil erosion and promote water resources efficiency. It was take an important role on dryland farming, and it was a revolution of traditional farming

The soil and water conservation effects of conservation tillage

➢ **This experiment was carried on in the simulated rainfall hall in the National Key Laboratory on the Loess Plateau Soil Erosion and Dry Farming**

➢ **Using side gush automatic simulated rainfall system, the sprinkler is 16 above, its velocity was 98% the amount of that natural raindrop arrived to the land. The rainfall intensity was 120mm/h, and the time was 60 min.**

- **The trough we used was:**

length×width×height=2m×0.5m×0.3m, and its gradient can be altered, we gather samples of runoff and sediment at the end of it.

★ The soil were Eum-Orthic soil in Yangling, Loessal soil in Yanan and Aeolian soil in Yulin.

★ Mulching with wheat straw

Mulching rate：

0, 20, 40, 60, 80, 100%

Mulching amount：

0, 1000, 2000, 3000, 4000, 5000kg/hm²

Different coverage rate

Earlier stages

Medium stages

Last stages

1.Influence of Runoff by Straw Mulching

Straw mulching can postpone the forming of runoff, which extended the interaction time between soil and water and increased the infiltration. When the coverage rate is higher the lag of the runoff will be longer. In the condition of 120 mm/h rainfall intensity, 10° gradient and 100% straw mulching, the original time of runoff was 15 minutes later than the comparison. Original time increased with coverage rate.

Table1: Changes of original time, lagged time under the condition of different straw mulching ratios

Treatment	CK	20%	40%	60%	80%	100%
Original Time（s）	93	109	457	544	693	989
Lagged Time（s）	0	16	364	451	600	896

The higher coverage ratio was, the distinct on runoff reduction will be. When the ratio was 20-40％, the runoff reduction was not distinctly3-4%, while the ratio was 60-80％, the reduction were 10-30%, while the ratio was100％, the reduction was above 40%. It was to say, only when the ratio was more than 40%, erosion can be prevented effectively.

Table2: Average runoff quantity and percentage of reduction in different coverage ratios

Treatment	CK	20％	40％	60％	80％	100％
Runoff（cm^3/min）	1479	1432	1420.8	1319	1030.9	849.1
Decrease percent(％)	0	3.17	3.99	10.82	30.36	42.60

Coverage increased infiltration significantly. There was a positive relationship between coverage rate and cumulative infiltration. When the rate was 40%, the cumulative infiltration increased by 37%, and when the rate was100%, it was increased by 113%

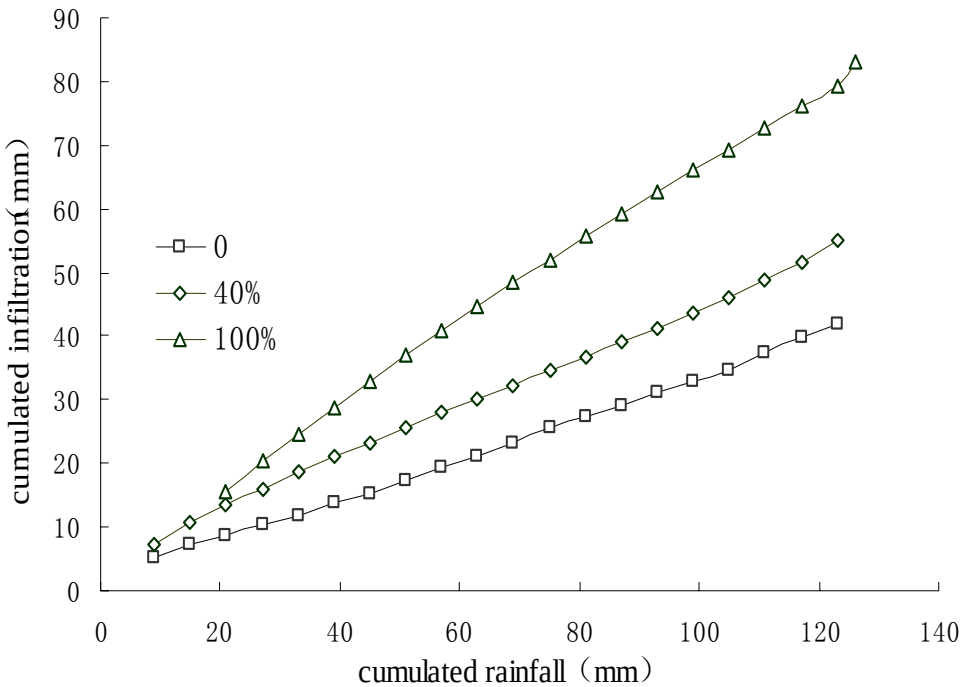


Fig1: Comparisons of Cumulated Seeping Quantity among Different Mulching Ratios

2.Effect on runoff process by straw mulching

When coverage rate was 20%, runoff reduced a little. The greater coverage rate, the smaller the runoff will be.

The rario of 40% will relieve the soil closure, increase infiltration, and play an important role in reducing runoff

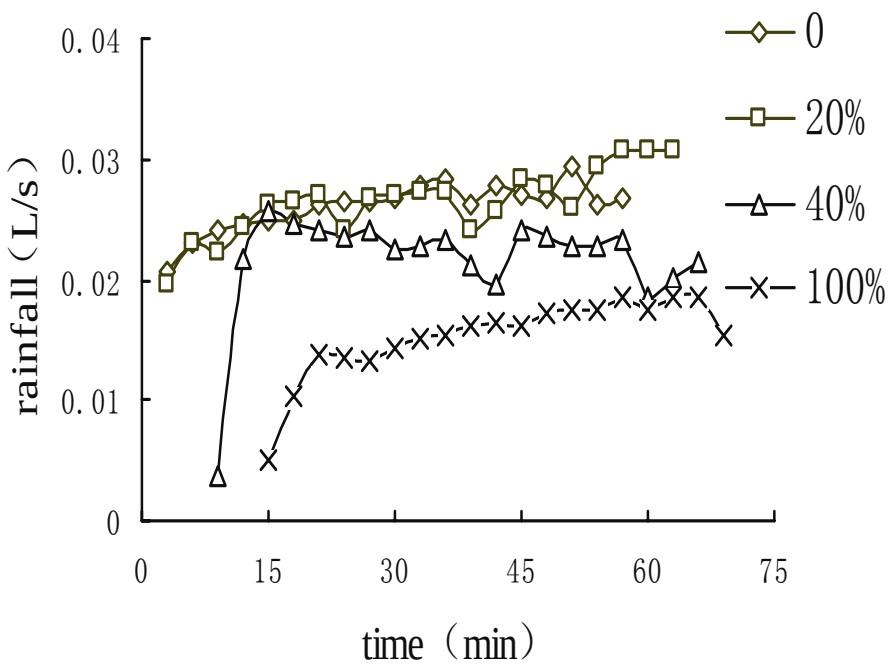


Fig2 Rainfall changes by the time

3.The effect of straw mulching on the process of sediment produced

In the beginning, sediment concentration was very large in bare land, and then reduced sharply, and moving toward to stability gradually

Low coverage rate will prevent soil erosion a little

The rate of 100% reduce sediment about 80%, and the runoff was very small. The kinetic energy impact surface was small, and then soil erosion was not strong.

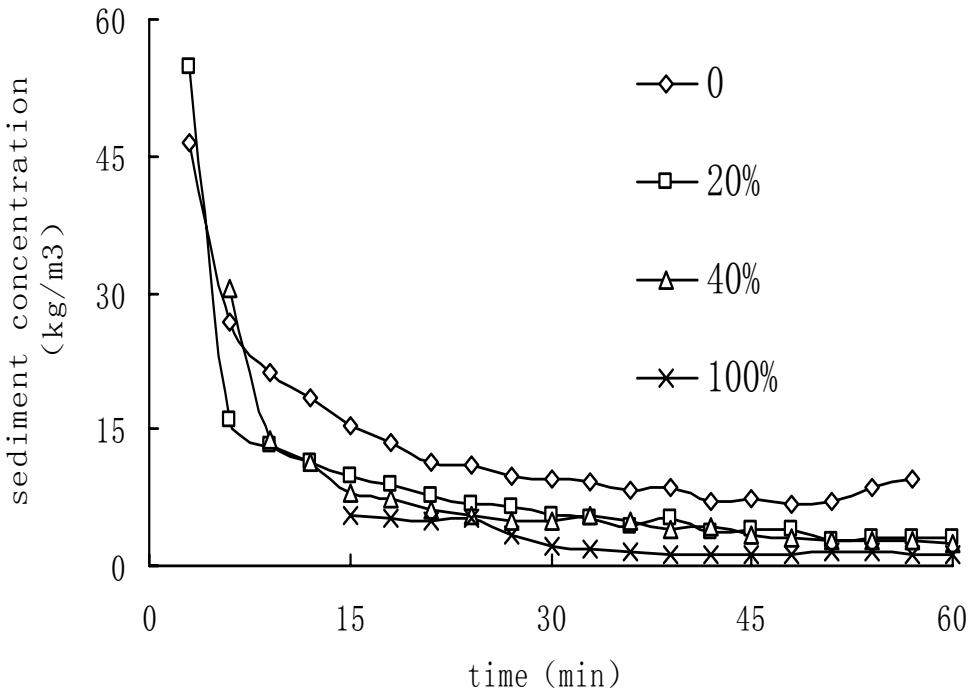


Fig3 sediment concentration changes with time

4.Relationship between coverage and runoff or sediment concentration

The roughness of soil surface increase and the sediment yield reduce when coverage rate became bigger. Cumulated runoff will be changed by an equation such as “y=-2.2139x2+8.9312x+80.422, R^2=0.9735” when the coverage proportion increased; And sediment yield changed like a power function, y=135.13x-1.2047 (R^2=0.8958).

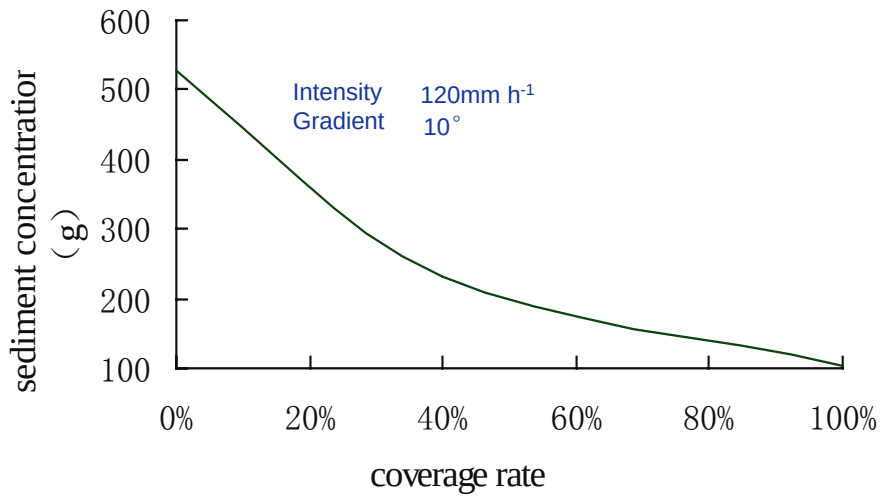


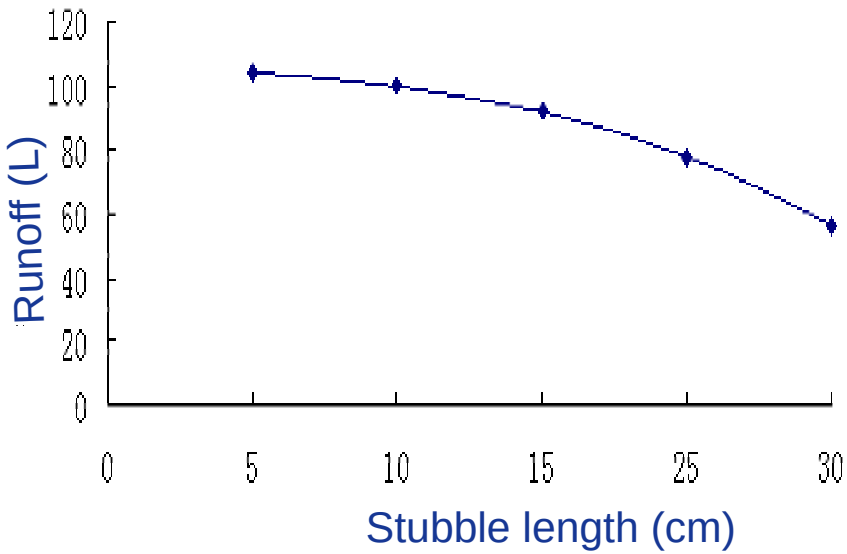
Fig4 Sediment changes with different coverage rate

When coverage rate was 40%, runoff decreased by 4%, sediment reduction was about 50%; And when the ratio was 60-80%, runoff decreased by 10-30%; When the ratio became 100%, the runoff reduced by 40%, sediment yield decreased about 80%. In conclusion, when coverage less than 40%, the sediment increased rapidly, and it was useless to control soil erosion

5. Effect on runoff and sediment production by different stubble length

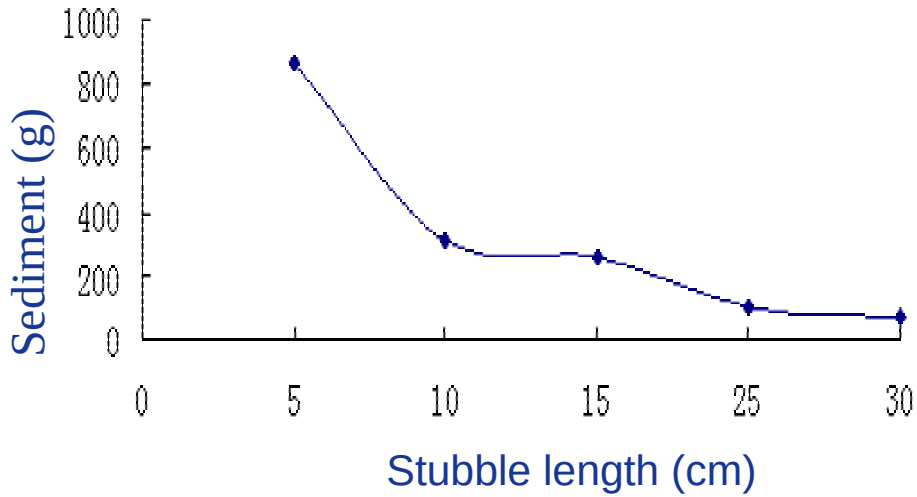
5.1 Runoff changes under the condition of different stubble length

The cumulative runoff reduced with stubble height has been increased. When the height was 10 cm, the runoff decreased by 3.6%. When the height was 15 cm, it was reduced by 11.3%. the height of 25 cm or 30 cm, the runoff reduction was 25.3% or 45.8%.



5.2 Changes of sediment concentration under the condition of different stubble length

Sediment yield increased with straw height reduction. When stubble length was less than 10 cm, sediment increased dramatically. 10 cm was critical for soil erosion control, soil erosion were controlled effectively only when stubble length above it.

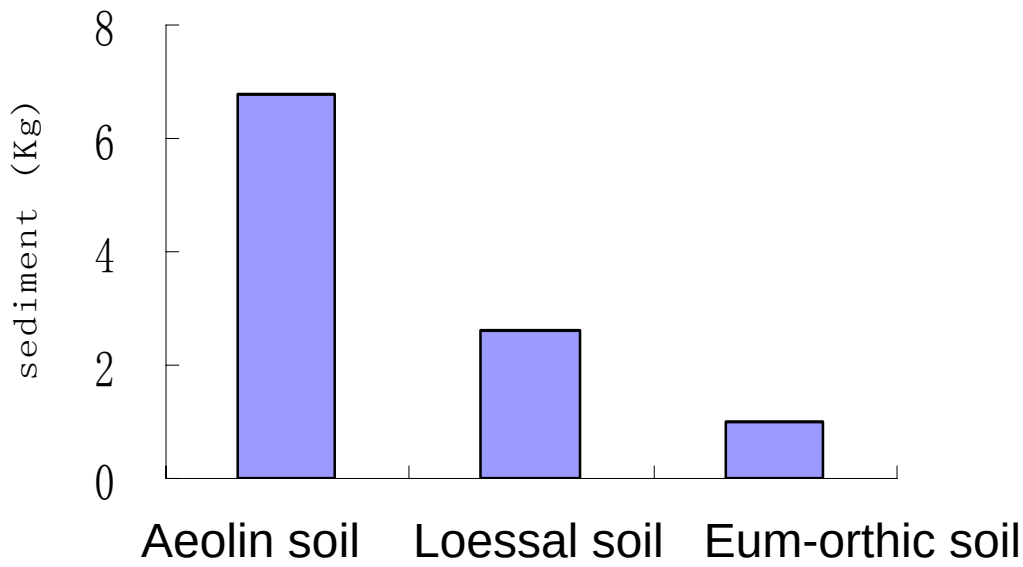


Different stubble length

6.Changes of infiltration capacity and erosion resistance in different soil groups

6.1Changes of erosion resistance in different soil groups

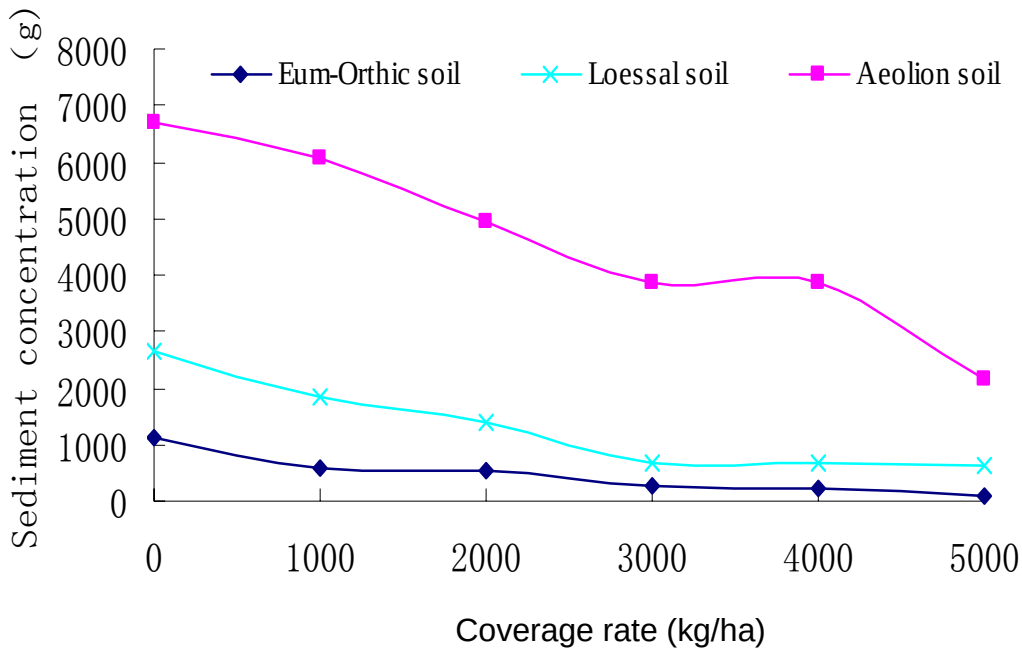
During the rainfall process, infiltration intensity of Aeolian soil was the largest, Loessal soil followed, and the Eum-Orthic soil was the lowest one. The sediment concentration change was same to the infiltration intensity. And the erosion resistance was reverse to infiltration intensity or sediment concentration.



Changes of sediment in different soil groups

6.2 Effects of coverage rate in different soil groups

When the soil was covered, the sediment reduced with the coverage rate became bigger. The sediment production of different soil groups were changed in the same way.



Sediment changes in the condition of different coverag

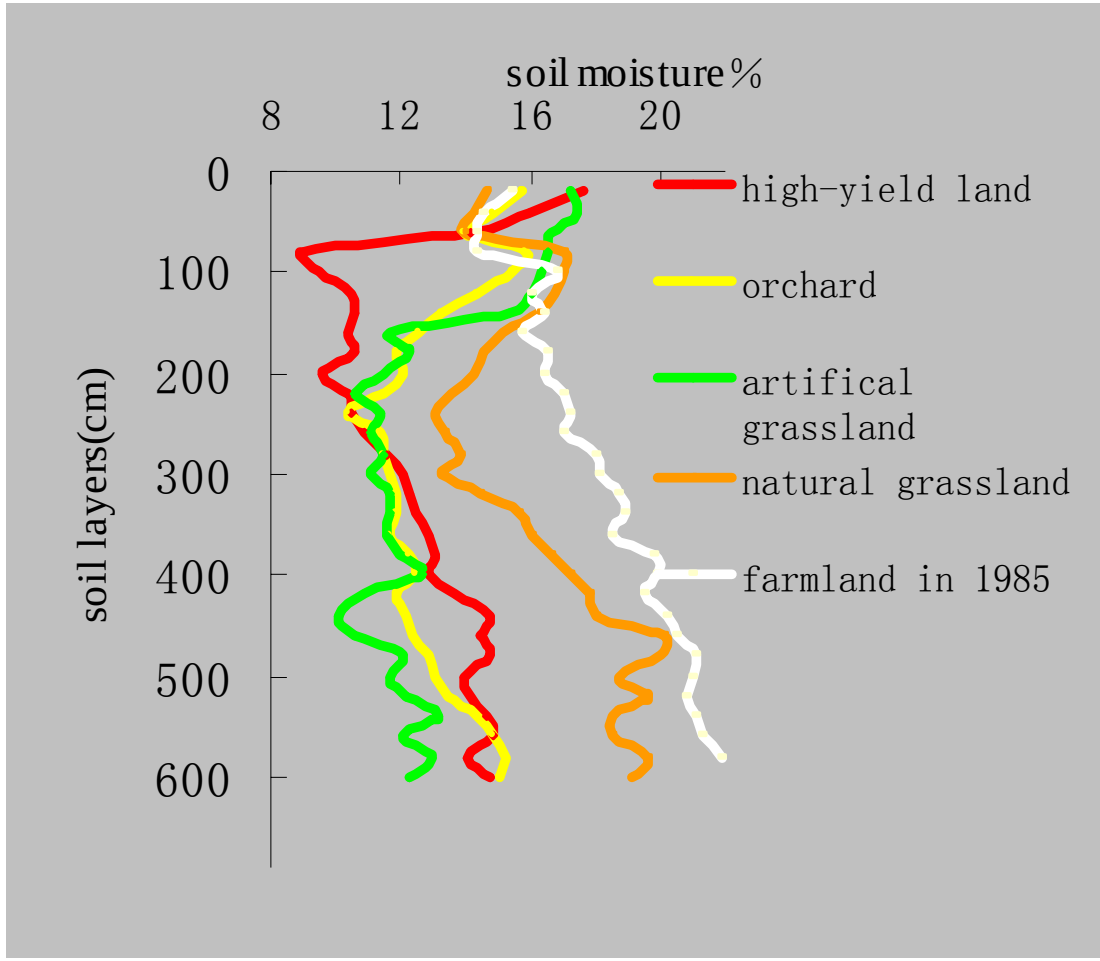
The new issues emerges of dryland farming on Loess Plateau

1.The potential of dryland farming technologies move closer to the limit in Loess Plateau.

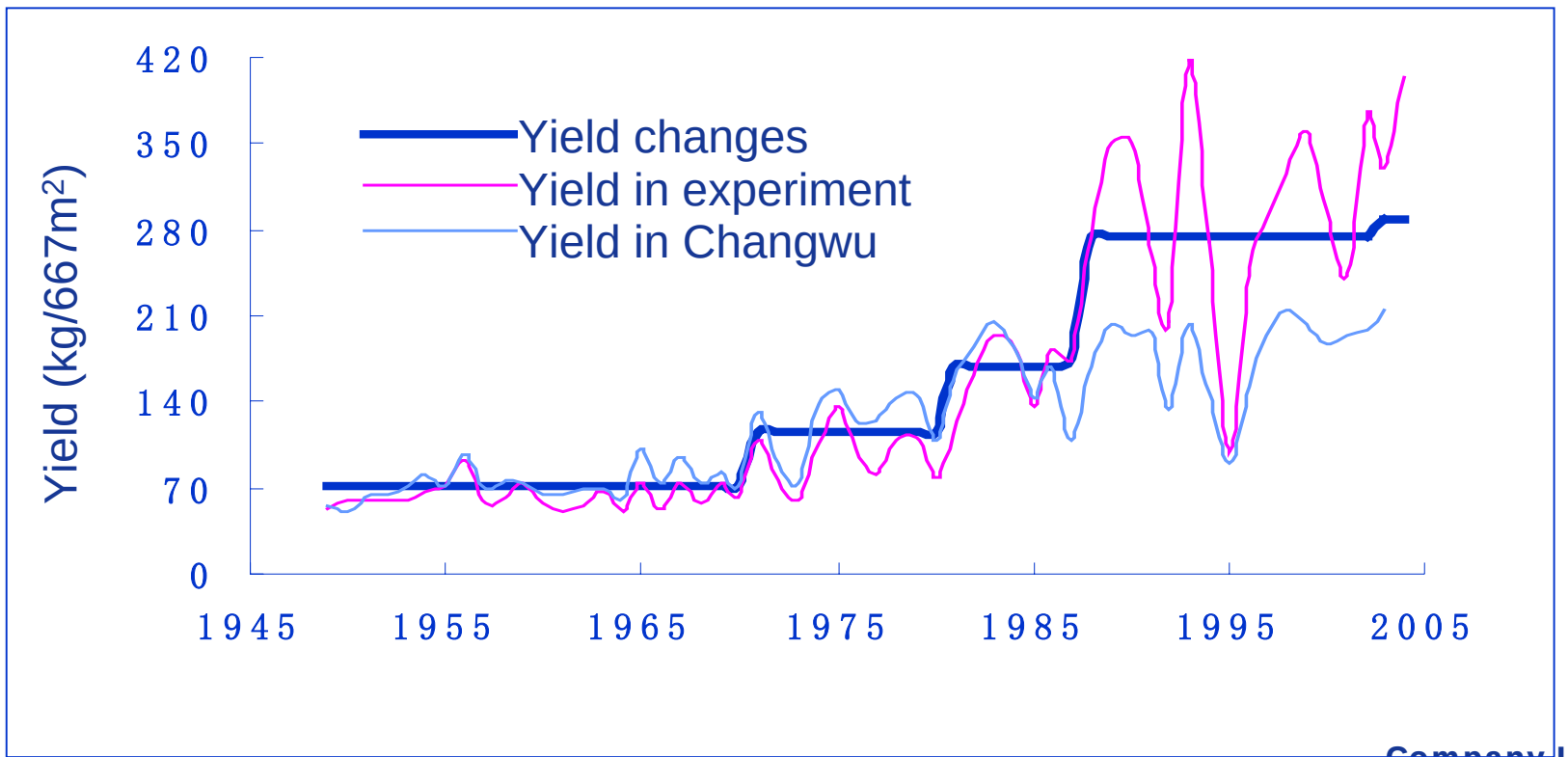
- The capacity of drought resistance in this area was about 85%, most area has been entered high-yield stages. With the continuous productivity improved, agricultural production has already been in a stage which were enslaved to agriculture weather condition, not limited by material and energy, but the narrowed rainfall resources. The deficient water supply was the main factor which influenced crop yield in the dry land. How to make full use of the limited rainfall recourses was the breakthrough in dryland farming.

2. Soil moisture, fertilizer and soil environment

- Deep soil desiccations
- Ability to regulate the soil reservoir weakened,
- Large fluctuations in productivity,
- The quality of agricultural products decreased,
- Waste of resources,
- Soil eco- environment deteriorated



3.Productivity fluctuations in dryland farming comes from the annual and seasonal precipitation changes. Precipitation and soil reservoir regulation determined soil productivity directly. Technologies in dryland farming could not eliminate its fluctuation, and the yield waved at a high level.



Experiments on conservation tillage technology of rainfall-collecting and mulching

1. Dualistic mulching technology

Film mulching could increase water use efficiency by 7.2%, increase wheat yield by 15% above, film and straw dualistic mulching technology could increase wheat yield by 15% compared to film mulching.

2.Wheat mulching for whole growing process

Wheat yield changes in different mulching modes

Treatment	Average yield (kg/hm^2)	Increased yield (kg/hm^2)	Increase rate (%)
Control	4155	—	—
film mulching for whole growing process	5980.5	1825.5	43.9
Film mulching during summer fallow	5074.5	919.5	22.2
Straw mulching for whole growing process	4854	699	16.8
Straw mulching during summer fallow	4593	438	10.5

3. Micro-water collecting technology of double ridges-furrow maize planting

Plowing two furrows on the ridge, mulching film before seeding, keep furrows stay as original. Furrows and holes formed a micro catchment landform which collected rainfall on the film surface and keep water in seeding furrows. It could increase soil moisture significantly, and also enhanced validity of rainfall and water use efficiency.

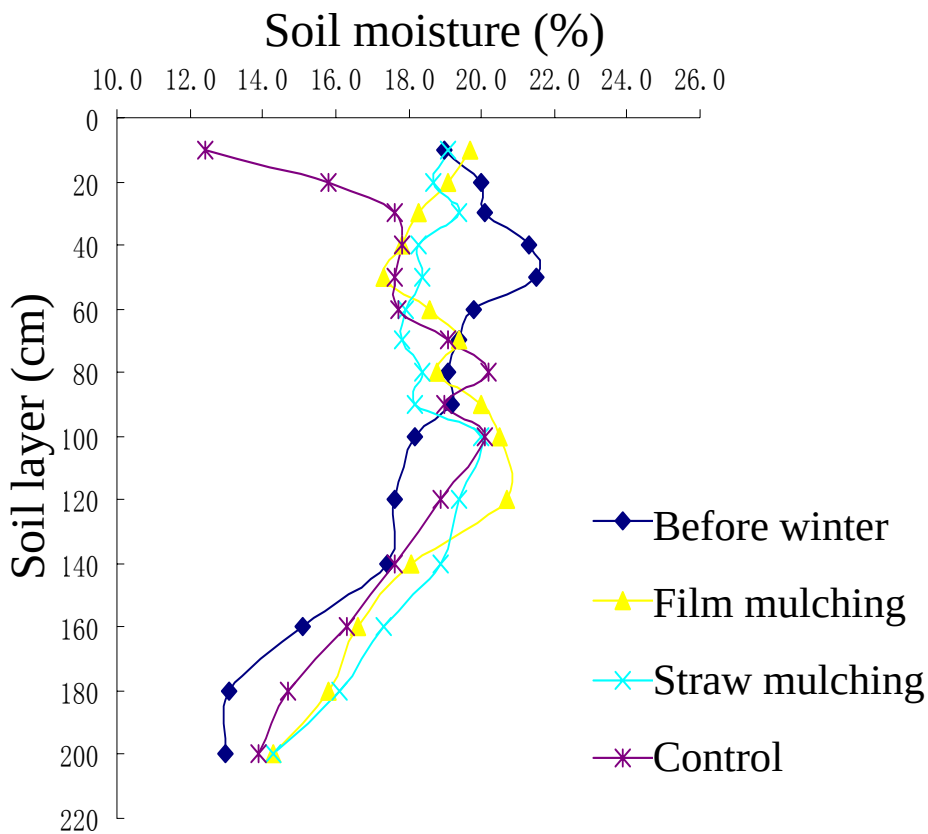
4. Mulching technology during summer or winter fallow

4.1 Plant winter wheat with mulching during summer fallow

	normal	Straw mulching	Straw and film mulching	Film mulching
deposited water	68.35	73.94	96.51	120.06
rainfall deposited rate %	45.7	49.4	64.5	80.2%

4.2 Mulching technology during winter fallow

Soil moisture increased by 11.8%，and it was in favor of increasing wheat seeding rate in spring.



Plant spring maize with mulching during winter fallow

5. Orchard mulching technology

Under the condition of straw mulching, Sod-mulching and film mulching, the soil water content in the 0-60cm soil layer increased by 23.1%, 5.0% and 32.1% compared to the control, mulching technologies could increase soil moisture significantly. Clover mulching in orchard could increase soil moisture unremarkably.

Setting up Conservation System with Loess Plateau Characteristic

1. Popularize Mechanized Conservation Tillage Technology in large areas

According to crop species, finish the work of ditching-fertilizing-sowing-ridging-mulching at one time, popularize some mechanized technologies which can cut down the cost while increase efficiency such as mechanized subsoiling and deep loosing, returning straw to the land. It was to bring along the combination of single technologies.

2. Set up conservation tillage technology system of collecting rainfall to drought resistance in farmland

Based on the micro-water collecting systems of “furrow alternated with ridge, ridge mulching, furrow sowing, runoff on the ridge, gathering water in furrows”, set up technologies to use collected rainfall efficiently.

3. Set up conservation tillage technology system of film and straw mulching

Popularize technologies such as high stubble mulch of winter wheat, straw mulching, corn straw returning to the land, sowing in furrows and mulching on ridge, Sod-mulching. Then consummate conservation tillage technology of furrow or ridge planting system accompanied by mulching which adapt to the technology of increasing soil moisture by gathering runoff.

Company
LOGO

Email:mdhao@iswc.ac.cn