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# CONSERVATION AGRICULTURE IN CHINA AND IMPACTS ON YIELDS OF MAIZE

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*Hongwen Li* earned his Ph.D. in agricultural mechanization from China Agricultural University, where he currently holds the post of professor and is a Changjiang Scholar. He is also head of the Conservation Tillage Research Centre at China's Ministry of Agriculture. He has 20 years' experience in conservation agriculture, has published more than 100 papers, owns more than 60 patents, and has won two national awards for his work in the area of conservation agriculture.

# ABSTRACT

China is one of the countries which have been seriously endangered and affected by desertification in the world. The soils in the dryland areas are severely suffered from degradation and desertification. Water and wind erosions are the main factors for the soil deterioration. The threat of water erosion in dryland areas is affected by the amount and intensity of rainfall, the type of irrigation, the erodibility of the soil, cropping and management factors, and erosion control practices. In recent decades, sand storms in China have also done great harms to the farmland. As affected by all the reasons mentioned above, the desertification of farmland finally caused the decline of productivity.

In Northeast China, spring maize is one of the most important grain crops where annual rainfall varies from 400 to 1,000mm and the average cumulative evaporation is about 1,800mm, which is about 4 times higher than the average total rainfall received during the growing stage of spring maize which causes low status of soil moisture in the root-zone usually limits productivity of spring maize. In North China Plain around Beijing, since 1980s the cropping system in this region has changed from a single to a double-cropping system (winter wheat-summer maize) where the annual cumulative evaporation hugely exceeds the annual rainfall. Therefore, the needed water for the plants is largely increased causing water scarcity. In farming-pastoral ecotone of Inner Mongolia large areas of grassland have been converted into cropland due to increased population and food demand. The conversion of grassland to cropland combined with insufficient rainfall and wind erosion have resulted in serious soil nutrient depletion and structural deterioration. In Northwest China areas where the average precipitation varies from 40 to 200mm, water shortage is definitely one of the major constraints to the production of spring wheat which is the major cereal crop of the region. Conventional tillage in dryland farming areas of China includes mouldboard ploughing to a depth of about 20cm, followed by harrowing, hoeing, rolling and levelling. All the residues in the fields are removed for animals or as fuel before ploughing. In some parts of northern China, particularly in North China Plain, burning crop residue has increased during the last decades. Long term mouldboard ploughing and residue removal/burning have increased the risks of wind and water erosion and the formation of hard pan in the deep soil layer. Also it has resulted in poor soil physical and chemical properties, high inputs of energy and labour which apparently leads to low farmer incomes. To solve all these problems, various kinds of Conservation Agriculture (CA) treatments are used in these dryland areas, such as the no/minimum tillage, controlled traffic tillage treatments and permanent raised beds (PRB).

This paper will talk about 20 years of conservation agriculture in China. Different kinds of CA machines were developed which made CA is possible in China; impacts of conservation agriculture on yields, environment are great which makes CA accepted, restraint of CA will be also mentioned.

## KEYWORDS

Conservation agriculture, dryland areas, no tillage, sustainable soil management, China

## REFERENCES

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- Jin He, Hongwen Li, et al., 2011: Soil & Tillage Research, 113, 48-54, Soil properties and crop yields after 11 years of no tillage farming in wheat maize cropping system in Northern China Plain.
- Jin He, Hongwen Li, et al., 2010: Annals of the New York Academy of Sciences, E96-E106.

**CONSERVATION AGRICULTURE IN CHINA  
AND IMPACTS ON YIELDS**

**Li Hongwen**

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Head, Conservation tillage Research Centre (CTRC), MOA

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**Conservation Tillage  
= Conservation Agriculture**

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**Outline**

**I. Why Conservation Agriculture Research**

**II. Conservation Agriculture in China**

Machines Development  
Benefits of CA  
History and Status of CA

**III. Achievements (Awards, Patents, Publication)**


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**I Why Conservation Tillage**

1. Draught and water shortage



- Dryland farm : 60% of total farmland
- Annual rainfall < 400 mm: 15 Provinces
- Draught : 60% of yield loss by natural disaster


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**II Why Conservation Tillage**

2. Severe soil and water loss



soil, water and nutrient loss

- Draught without rain
- Runoff while raining


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**Why Conservation Tillage**

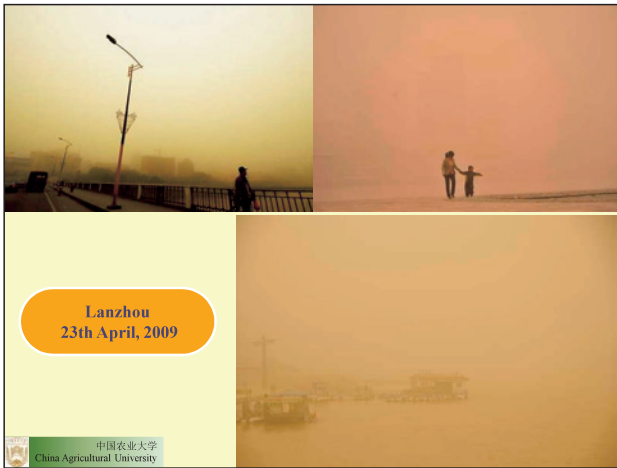
3. Soil erosion



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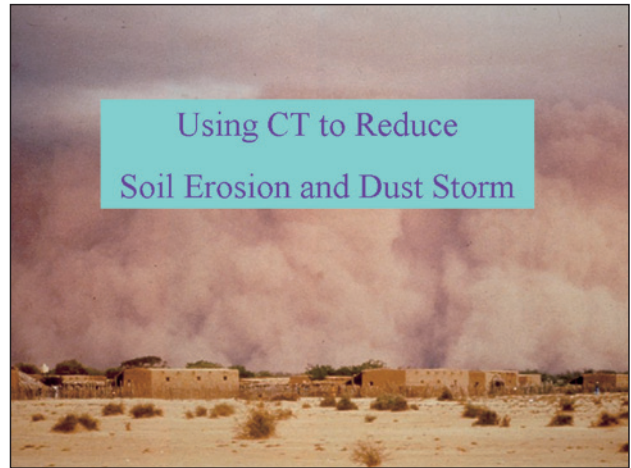
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Lanzhou  
23th April, 2009

7



Using CT to Reduce  
Soil Erosion and Dust Storm

8



### Dust Storm

9



### Why Conservation Tillage

#### 4. Residue burning

Resource waste and destruction

10



### Why Conservation Tillage

#### 5. Declining of groundwater level

Report on water situation in China

2002, volume 11

Hydropower and Water Resources Planning and Design General  
Institute, MEP

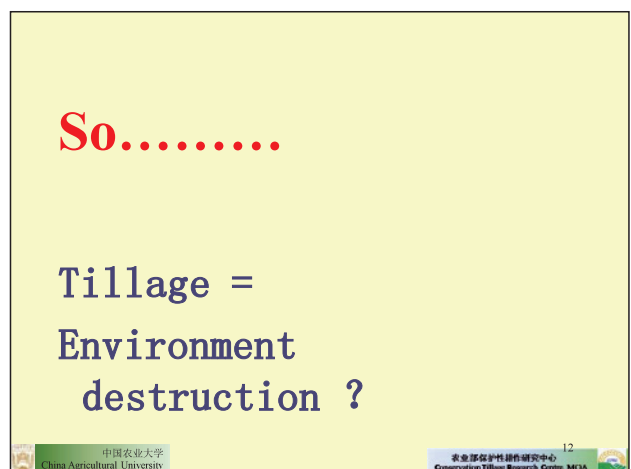
Continuous draught and water crisis in North China Plain

Academician Chen Zhikai

China Institute of Water Resources and Hydropower Research IWHR

**14 thousand km<sup>2</sup> funnel area due to declining of shallow groundwater in North China Plain around Beijing, Baoding, Shijianzhuang**

11



So.....

Tillage =  
Environment  
destruction ?

12

### Tillage Increase CO<sub>2</sub> Emission

Retosky

13

➤ Adverse effects of tillage:

- SOM loss
- Soil erosion
- Fuel consumption
- CO<sub>2</sub> emission
- Money
- Time

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## II Conservation Agriculture in China

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### Development of CT in China

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### Development of CT in China

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**Conservation Tillage Research Centre, MOA**  
农业部保护性耕作研究中心



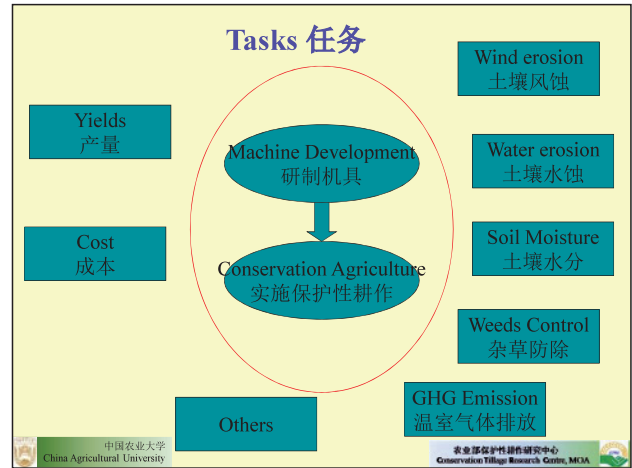
- The only organization specially on CT research in China; Locates in College of Engineering, China Agricultural University
- 专门从事保护性耕作研究的机构，挂靠中国农业大学工学院

[www.cn-ct.net](http://www.cn-ct.net)

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20

**Conservation Tillage Research Centre**  
**CTRC**




- Scientific Observing and Experimental Station of Arable Land Conservation, Ministry of Agriculture
- Longest conservation tillage experimental plot, 1992—
- 10 monitoring sites
- Haofeng Company: machines for 4 wheels tractor
- Yuncheng Company: machines for 2 wheels tractor
- Yunfan Company: Handle tools

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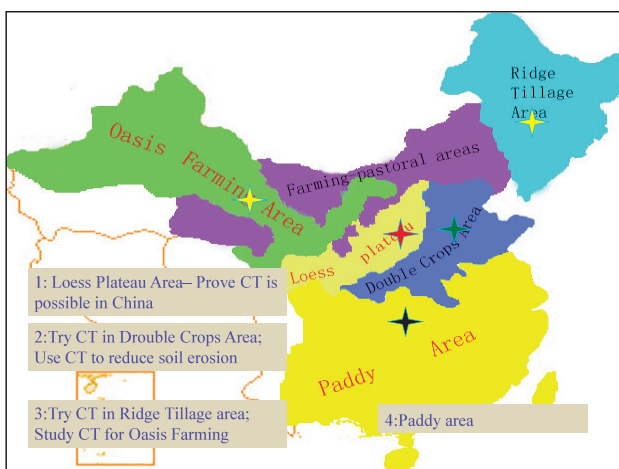
**Machine Production Base**

Huayin Harbin Company	Shandong Gongli Company	Liaoning Yuxian Company
For 4 wheels tractor	For 2 wheels tractor	Hand Seeder
		

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**Machinery**

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### Hand Planter



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### No till Seeder for 2 wheels tractor



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### Middle and Small No till Seeders

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### No Till Seeders with Power driven stubble Cleaning

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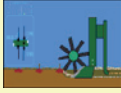
### Principles




Fast Rotating  
finger to stir  
stubble aside



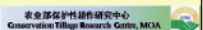
Driven Disk  
to cut stubble



Zone  
rotary hoe



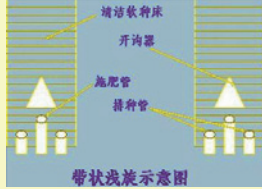
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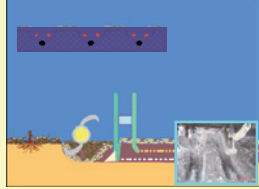
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### Strip Rotary Hoe to Make a Narrow Cleaning Zone

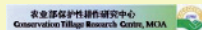


清洁软耢床  
开沟器  
施肥管  
播种管  
带状残茬示意图





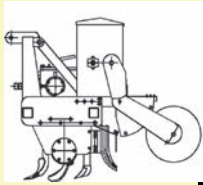
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32


### Wheat strip rotary hoe seeding



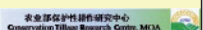








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### Rice strip rotary hoe transplanting










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### Strip Rotary Hoe Seeders Powered by 2WT



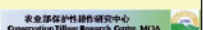








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### Strip Chopping



Y型秸秆粉碎刀  
防堵直刀  
开沟器





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### Vertiginating disk cut stubble and make a narrow furrow

a. 切断根  
茬中部

b. 切断根  
茬侧面

c. 未切到  
根茬

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**该船式旋耕埋草机机械作业可大幅度降低劳动强度，具有明显的省工节本增效优势。与耕整机、微耕机、手扶拖拉机、传统机耕船、大中型拖拉机相比。该船式旋耕埋草机适应性广，如对作物茬口要求和水田泥深度适应性强，秸秆埋覆还田效果比其他机械效率高、质量好。**

油菜秸秆地作业（油—稻制）

小麦秸秆地作业（麦—稻制）

早稻秸秆地作业（稻—稻制）

水稻机播、机插作业现场

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### Rape No till Planting into Wheat Stubble

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### Wheat into Rice Stubble

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## II Conservation Agriculture in China

43

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## Benefits 效益

- Increase Yields 增产
- Reduced Cost 降低成本
- Reduce Soil Water Erosion 减少土壤水蚀
- Reduce Soil Wind Erosion 减少土壤风蚀
- Reduce Fuel Consumption 降低油耗
- Reduce GHG Emission from Soil 减少农田温室气体排放
- .....

44

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### Benefit 1: Increase Yield 增加产量




Increase 5%~50%  
增产5%~50%

11% reports say conservation tillage reducing yield  
---Source: The Trends of Crop Yield Responses to Conservation Tillage in China

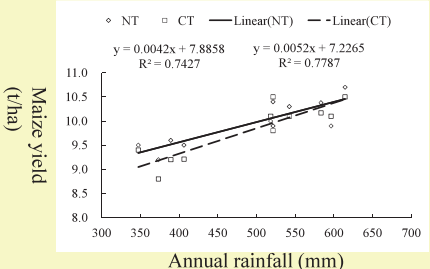
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### Long-term (10 years) experiment



Maize yield (t/ha)

Annual rainfall (mm)

Gaocheng, Hebei, North China Plain

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### Short-term experiment

Sites	Yield (t/ha)	
	Conservation Tillage(NT)	Conventional Tillage (CT)
Fuxin, Northeast China	12.0 (↑ 8.1)	11.1
Dingxing, North China Plain	10.1 (↑ 8.6)	9.3
Shouyang, Loess Plateau	4.1 (↑ 5.1)	3.9
Zhangye, Northwest China	12.3 (↑ 7.9%)	11.4

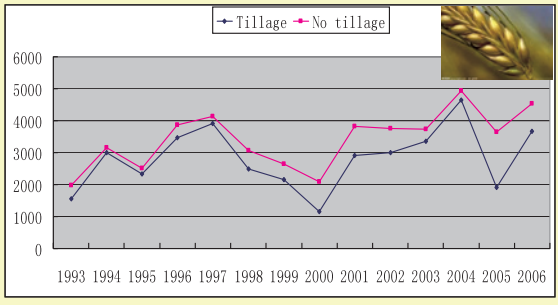
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### No tillage wheat yields from 1993 to 2006, Linfen, Shanxi, China



48

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### Saving Cost

<p>Conventional Tillage : &gt;9 operations:</p> <p>Stubble Chopping, <del>ploughing</del>, <del>Harrowing</del>, <del>leveling</del>, planting, Applying fertilizer, Weeding, Harvesting</p>	<p>Conservation Tillage : &lt;6 operations:</p> <p>Stubble Chopping, , , , planting, Applying fertilizer, Weeding, Harvesting</p>
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### More fertile soil

No earthworm before, 3~5 earthworm after 6 years;  
10~15 earthworm after 10 years







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## Conservation Tillage / Low Carbon Agriculture


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51


### Reduce Wind Erosion

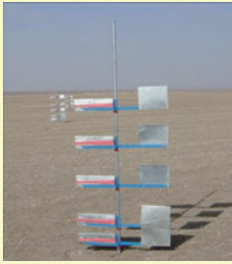


Duststorm in Northern China


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Self made Dust Sampler



Self made Wind Tunnel  
powered by tractor


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### Results


- Farm land is also a main resource of dust storm.
- Conservation tillage can reduce 30%~75% wind erosion

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### Reduce Water Erosion

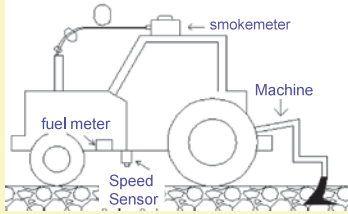



Runoff and soil loss can be reduced by 50%~80%

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### 3. Reduce Fuel Consumption





Reduce Fuel consumption 30%~40%, Hebei

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### 4. Effect of CT on GHG Emission from Field



Several experimental sites for GHG measurement

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### Results


1. Soil tillage increases CO<sub>2</sub> emission.
2. Conservation tillage can reduce CO<sub>2</sub> about 20kg/mu (300kg/ha)

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58

### Others

- Nearly 200 papers, among which 30 in English, download at [www.cn-ct.net](http://www.cn-ct.net)
- More than 60 patents
- 3 National Science & Technology Awards



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59

### Cartoon Book



综合版  
(基本版)


一年一熟版

一年两熟版

蒙汉对照版

企业版

English Version



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60



61



62

**Chairman Dr. Ryoichi Matsunaga:** Now, let's move onto the next presentation. The next presentation is by Prof. Hongwen Li, a professor and Changjiang Scholar of China Agricultural University. He is also the head of conservation tillage research center of the Ministry of Agriculture in China. He holds a Doctorate in Agricultural Mechanization from China Agricultural University. He has 20 years' experience on conservation agriculture, published more than 100 papers and own more than 60 patents on conservation agriculture, and won two national awards on conservation agriculture. He is a very prominent scientist and I am very happy to invite him to this presentation. So please start, Prof. Li.

**Prof. Hongwen Li:** Thank you Chairman for your introduction. Good morning, ladies and gentlemen. Firstly, I would like to suggest for this beautiful girl to sleep, and not count my time. I want also to say thanks to JIRCAS. It is my first time to Japan and to this city. Fifteen years ago I had a chance to study for a second Ph.D. degree at JIRCAS, but at that time I was only an assistant for my supervisor to do conservation agriculture. I think conservation agriculture is more important than a second Ph.D. Now, I will start my presentation.

Firstly, I should say that in China we do conservation agriculture but with the name "conservation tillage" in Chinese. Dr. Nagumo gave an excellent presentation about what conservation agriculture is, its principles and practices in Africa, so I can save some time by not repeating.

Why conservation tillage in China? As you know, in China and especially in northern China, dry land like this is more than 60% of the total farmland in China. Sometimes drought is very serious. For example, in Shanxi Province some farmers say that in 10 years they will have nine dry years. So you can imagine how serious drought is in China. Also there is serious soil and water loss, as this picture shows. After heavy rain, we often get logging like this and runoff and soil erosion.

Years ago some Japanese newspapers said that a dust storm came from China without a visa. It happened also in Lanzhou city and similarly happened in Beijing. Before 2008, for about six or seven years, every year in Beijing we got several times serious dust storms. As Dr. Nagumo says, in the 1930s the United States got a very serious dust storm. After that, America started no-tillage to try to control dust storms. In China, after 10 years of study on conservation tillage, we know that using conservation tillage we can reduce soil erosion and dust storms.

Also, residue burning happened everywhere in China after harvest. You can find very serious residue burning in many villages.

Declining of groundwater level: as you know, China has the largest population in the world; we need more and more food. So in many places, even in northern China, we grow two crops a year. It means that we must use more and more water for irrigation, otherwise the yields cannot be high enough for us. So we have to use more and more groundwater, which results in a very serious funnel area due to decline of shallow groundwater in northern China. I can tell you the story that Beijing groundwater declined about one meter per year. You can imagine what will happen after 100 years. So I think that tillage equals environmental destruction. Tillage increases CO<sub>2</sub> emission; tillage burns dollars; tillage burns soil; tillage burned many things. Tillage also makes more soil organic matter loss, soil erosion, fuel consumption, money and time.

Now I want to give some introduction about conservation agriculture in China. This is the website for the Conservation Tillage Research Centre of the Ministry of Agriculture. We in China started no-tillage research in the 1950s. From some papers I know that Japan also started no-tillage in the 1950s. But, China and Japan did not extend no-tillage into larger areas. Even now, no-tillage or conservation agriculture is not widespread in Japan. In China, until the end of the 1980s no-tillage has been studied in China for nearly 30 years but not extended, only happening in Sichuan Province, extended to small areas. The reason is that there is no equipment, no machinery.

Scientists publish many good papers showing that no-tillage can give good results to soil, to yield, but farmers

often ask, how can we do this? The answer is: by hand. Since social development and economic development, more farmers do not want to use their hands directly to do farming. So by the end of the 1980s, some scientists from China said that no-tillage is good but it is impossible in China, because we cannot supply suitable machinery for Chinese farmers. Since our farmland is very small and since our farmers are poor, we cannot buy or use big equipment like they do in America.

From 1992 we started such technology research with the term “conservation tillage,” not no-tillage, and we started from development of conservation tillage machinery, not just doing experiments in the field. After 10 years it was successful in Shanxi Province and we extended this technology in Shanxi Province. From 2002 the Ministry of Agriculture accepted this technology and started to extend conservation tilling in China.

In the first 10 years, the conservation tilling area increased very slowly. After 2002 it increased faster and faster. I am proud to say that the Conservation Tillage Research Center is the only organization in China which is doing special research on conservation tilling. The first task is machinery development. Then use machinery to do conservation agriculture, and then study what happens to conservation agriculture. In order to do such studies and such development, we have several companies to co-operate with us. I can say that in China we have many kinds of medium, small and hand conservation agriculture machinery. More than 50%, 60% or 70% of such conservation agriculture machinery is from prototypes designed by my team. Machinery can be like this: four-wheeled tractors, two-wheeled tractors and by hand. Conservation tillage has been applied in all provinces in northern China. The hand planter has been named by some friends last year in the WCCA in Australia as the “Li Seeder,” my name and the manufacturer’s name. It is interesting, the manufacturer’s name is also Li, the same as me, so it has been named the “Li Seeder.” You can find video and introduction of the Li Seeder from the FAO website.

For two-wheeled tractors, we also developed no-till seeders like this. For four-wheeled tractors like this, there are many kinds of no-till seeders from China. As you know, after harvesting we often get more and more stubble on the field. The stubble will block machinery; the machinery cannot work well, and the seed is often put on the stubble, not in the soil. So we found that in double-crop areas, such machinery cannot be well used. We devote a machine such as this one shown here to make a strip rotary hoe just like this. With a strip rotary hoe we do strip tillage here, no-tillage here, we plant seeds here and keep no-tillage here, just like semi-no-tillage. And it was successful. We also use this idea for rice transplanting. Transplanting can be done like this: strip rotary hoe and the furrow is like this, no-tillage here. For two-wheeled tractors, the machinery can also be similar like this. Strip chopping: after redeveloped the machinery, some scientists said that you destroy too much soil, so we modified it like this, not touching the soil, just cutting the stubble. And you can see much stubble still are here. But I have to tell you that we were successful with the machinery, no-till seeders, farmers do not like it. They think that after planting it looks so ugly that they do not want to use such a machine. Also from the idea of John Deere machine, they often use disks, but we found that medium-sized and small tractors, such an idea is impossible, so we tried to drive disk to rotor very quickly, to cut stubble and to cut soil. We also tried conservation agriculture in paddy areas for rice. The benefits have been shown by Dr. Nagumo so I shall not repeat it. Increased yield from 5% to 50% depending on different area, different soil differing rainfall. With long-term experiments in China we found that for maize in Heibei Province, the yield can be like this.

I will move on quickly. For wheat, it can also increase. This data comes from Linfen, with 20 years’ experiment. It shows that conservation tillage can give higher yield and it can save costs. I think you can imagine why it saves costs. The soil can be more fertile because the stubble returns to the soil and the soil is not disturbed. Reduced wind erosion: we use wind tunnels to measure what happens between conservation tillage and conventional tillage. Results show that conservation tillage can reduce wind erosion so much, by 30% to 75%, can reduce water erosion, reduce runoff, reduce fuel consumption and reduce CO<sub>2</sub> emissions. We measure what happens to greenhouse gas emissions from a conservation tillage field and a conventional tillage field. Results show that conservation tillage can reduce CO<sub>2</sub> by about 20kg/mu. Perhaps some people know that 15 mu are equal to one hectare.

The chairman introduced what we have done. Most people here are scientists. We often write books, papers with characters, with words. I think after years I have found that such papers can only be read by scientists, by researchers and by technicians, not by farmers. So in 2005 I edited cartoon books, with each page only having less than 100 characters. The whole book can be read by a farmer in 30 minutes. I am happy to say that more than 420,000 copies of this book have been published in China. Premiere Wen Jiabao is also interested in conservation tillage. He gave several speeches to say that China should do conservation tillage. He also tried to drive tractors to use no-tillage like this.

Thank you for your attention. Thank you for not making me go away.

**Chairman:** Thank you very much, Prof. Li. It is a very impressive presentation. I am deeply impressed to see your success story for conservation agriculture in China.