UNITED NATIONS - NATIONS UNIES
ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

ASIAN AND PACIFIC CENTRE FOR AGRICULTURAL ENGINEERING AND MACHINERY (APCAEM)
A-7/F, China International Science and Technology Convention Centre
No. 12, Yumin Road, Chaoyang District, Beijing 100029, P.R. China

The Impacts of Conservation Tillage on Atmosphere Warming, Dust Storm and Soil Deterioration in North China[1]

Submitted to

International Seminar on Enhancing Extension of Conservation Agriculture Techniques in Asia and the Pacific

24-26 October 2007, Zhengzhou, China

By

Huanwen GAO[2]

[1] This report was prepared in 2006 by Dr. J.N. Tullberg, a contracted consultant of APCAEM.

[2] Mr. Gao Huanwen, Member of the Expert Committee of the Misnistry of Agriculture of China, Professor, Conservation Tillage Research Center, MOA, China Agricultural University, Qinghua Donglu Beijing 100083, China, Tel: 86-10-62737630, Fax: 86-10-62737630 Email: ghwbgs@cau.edu.cn

Preface

More people, insufficient resources and environment deterioration are heavy challenge to the human being. China is an even more people, less crop land and environment fragility country, especially the problems of serious drought, dust storm and soil deterioration have been limited the social economy development and human living improvement.

Many researches and practices in North China and the world have approved that CT (conservation tillage) besides has productive benefits of yield increasing and cost reducing, more importantly, has social benefits like depressing wind erosion, Green House Gas emission, improving soil fertility. Because of the great profitable from CT to the whole society, government planning and both sectors of governmental and private supporting are necessary.

Key words: Conservation Tillage, Environment Protection, Resource Saving

1. Depress Dust Storm

Dust storm has been a big environment problem in North China. From statistics, the dust storms happened in China was 5 times annually at 1950', 6 times at 1960',13 times at 1970',14 times at 1980'and 23 times at 1990'in last century. Dust storm did not only result soil desertification, but also directly influence people live.

Most of soil dusts are larger particles with rolling or jumping forward on the ground, those articles could damage crop and field. The fine particles can be suspended in the sky and moving to thousands miles away, specially the diameter less than 10 μm (PM10) mote, can entry human lung, harm human health and the amount of mote is a major monitoring index in atmosphere environment control. The PM10 mainly come from crop land.

CAU (China Agricultural University) measured the PM10 production from different soil surfaces under the wind speed 12 m/s at table 1.

The rule of total amount of PM10 production is: Plow field >short stubble cover >chopped stalk cover> chopped stalk plus high stubble cover. Comparing to plow

Table 1 Measured PM_{10} amount unit: g

Soil Surface	Growth weight	Paper weight	PM_{10} weight
Plow field	2.65	2.4386	0.2114

Short stubble	2.5633	2.4386	0.1247
Chopped stalk	2.5037	2.4386	0.0651
High stubble + Chopped stalk	2.4862	2.4386	0.0476

field, short stubble cover (other stalk move out of field) has less 41%，chopped stalk cover (all stalk left in field) has less 69.21%，chopped stalk plus high stubble cover (all stalk left in field) has less 77.48% of PM10 produced.

PM10 mote is only small percentage in wind erosion, for example, average 1.4% in Beijing，but to large area, the whole amount of PM10 also can be quite large. If all crop land plowed in Beijing, it could produce 84,000 t of PM10 annually. Each Beijing people would share 7 kg of PM10 mote. Adoption of CT can efficiently reduce soil dust and PM10, while adoption of CT in whole Beijing with 6t/hm2 residue cover，PM10 could be reduce to 19,000t only.

20t/hm2(wind erosion in moldboard plowed land) * 1.4% *300000hm2= 84000t

2. CT Reduce GHG

GHG (Green House Gases) mainly are CO2, CH4 and N2O, their contributions to atmosphere warming are 60%, 20% and 6% in the world. China is a big GHG production country, produced 13% CO2 and 10% N2O of the world, thus has heavy duty to reduce. Large percentage of N2O and CO2 come from agriculture, therefore, it is very important to reduce N2O and CO2 emission through Conservation tillage.

2.1 Reduce CO_2

CO2 come from burning coal, fossil oil, plant biomass, and escaping of soil carbon. Traditional mechanized agriculture did produce CO2 into atmosphere, through burning stalk, burning fuel in machine operation, manufacture chemical fertilizer, herbicide and machinery, as well soil carbon escaped as moldboard plowing.

The adoption of CT, can stop burning stalk, reduce fuel consumption and cut down soil C escaping.

CT can largely cut down tillage and transportation operations (moving crop stalks out of field and transport organic manure into field). From typical investigation, saving 30 kg/hm2 of fuel or 40% of fuel consumption in one crop a year region and 78 kg/hm2 of fuel in double cropping region in NC could be expected through adoption of CT system.

While CT adopted on 70% of crop land in NC, the total fossil fuel saving could be 1.924Mt each year.

One crop a year area 50M hm2 * 0.7 * 30 kg/hm2 = 1.05 Mt fuel saved
Double cropping area 16M hm2* 0.7 * 78 kg/hm2= 0.873 Mt fuel saved

Fossil fuel reduction represents the Greenhouse gas reduction from the engine of farm machinery, the amount of gas is estimated approximately 3.2 kg of CO2 or 0.01kg of N2O for 1 kg of fuel burning. (1)

Assume Fossil fuel produce 70% CO2 and 30% N2O emission, thus, the CO2 emission could be produced 93.3 kg/hm2 and 4.31Mt in NC.

1.924Mt * 0.7 * 3.2 = 4.31Mt

Many observations from US, Canada in long term (hundred years), and from China in Short term (15 years) shown that, traditional tillage (moldboard plow) lose Soil Organic Matter (SOM), and increased CO2 emission into atmosphere. Reversely, OM increased in soil & CO2 decreased in atmosphere during CT period. Taken an average figure from NC that no-tillage can increase SOM 0.01% per year, CT could story 240kg/hm2of C in the soil, or reduce 878kg/hm2 of CO2 emission into atmosphere. While 70% of NC crop land adopted CT, the direct CO2 emission reduction is 45Mt from reducing fuel consumption and soil C escaping, which is about 1.2% of total CO2 emission in China.

66Mhm2 *0.7*(93.3 + 878) kg/hm2 = 44.9Mt

It is clearly CT can reduce CO2 emission and mainly from story more C in the soil, at same time, story C in the soil would be much useful to improve soil fertility, structure, and water infiltration, increase ground water and reduce soil compaction. Many scientists believe that the contribution of CT on soil C storage would not be less than on the crop production, thus, should be supported by government.

2.1 Reduce N_2O

The potential of N2O emission warming atmosphere is greater 290～310 times than CO2 , 10 times than CH4, therefore it is specially concerned in protect of environment.

The total annual N2O emissions are 3.6 Mt in the world and 0.31～0.398Mt in China, 90% of N2O emissions comes from farming land, with about 75% from dry land and 25% from paddy field.

Many experimental researches and producive practices in China and other countries have shown the follow advantages of CT related to the reduction of soil N2O emission:

1) Reduce soil wind erosion
2) Reduce soil water erosion

3) Avoid burning crop residue

4) Reduce fossil fuel consumption
5) Improve soil structure
6) Improve soil fertility

1) Reduce soil wind erosion

China is a serious soil erosion country, wind erosion area is approximately 1.6 Mkm2 in total and about 12～14 Mhm2 is farmland mainly located in North and West of China. The wind erosion losses in farm land are 10～20 t/hm2 and the "wind collection" has contained 1.2～2.3 times higher of OM and 1.3～1.7 times of N fertilizer than top soil, respectively. (table 2)

Taking the soil wind erosion 10～20 t/hm2, with 0.17% of full N content in wind collection, a 17～34 kg/hm2 of full N loss from wind erosion can be estimated.

The reduction of wind erosion from TT to CT system is 60% in average, whereas, the change of TT to CT can reduce 10.2～20.4 kg/hm2 of full N loss. Employ the IPCC default factor that 1.25% of applied N fertilizer can be transformed to N2O emission, then, all the wind area change tillage system from TT to CT can reduce 2001～6024 t of N_2O emission through reduction of wind erosion.

Table 2. The nutrition contents in top soil and "wind collection" Unite: %

Place & Time		Soil OM	Total N	Total P	Total K	Method of measure
Fengnin county, Hebei,2002	Top Soil (5cm)	1.3	0.096	0.014	1.83	Field Sampler
	Wind Collection	3.016	0.167	0.038	1.99	
	Concentrate rate	2.32	1.74	2.70	1.09	
Zhenlan Banner, Inner Mongolia, 2003	Top Soil (5cm)	1.38	0.103	0.016	1.82	Portable Wind tunnel
	Wind Collection	3.01	0.179	0.038	1.96	
	Concentrate rate	2.18	1.74	2.38	1.08	

$12～14\ Mhm^2 * 10.2～20.4\ kg/hm^2 * 1.57 * 1.25\% = 2001～6024t$

Note: Consider the atomic weight of nitrogen is 14 and oxygen 16, then, 1 kg of N is converted to (14+14+16)/(14+14) = 1.57kg of N_2O emission.

2) Reduce soil water erosion

Take Shanxi province as an example, the average water erosion was about 15 t/hm2, among eroded soil, there were 50kg/hm2 of full N and 25kg/hm2 of full P fertilizer.

Soil water erosion could be reduced 80% on 4～5% slope field by adoption of CT system, which slope is typical in Yellow river basin. As taken 80% of water erosion reduction, CT would reduce about 40kg/hm2 of full N loss in approximately 10～13 Mhm2. Thus, a total reduction of 0.32～0.4Mt full N loss can be calculated from water erosion. Using the same transform rate of 1.25% of N2O emission to N fertilizer, the total reduction of N2O emission from water erosion reduced in Yellow river basin are 7850～10200t,

$40Kg/\ hm^2 * 1.57 * 1.25\% * 10～13\ Mhm^2 = 7850～10200t$

3) Avoid burning crop residue

Approximately 600Mt of crop stalks are produced each year in China, it contains 3Mt of N, 0.7 Mt of P, 7 Mt of K fertilizers. Currently 25% of crop residue is burned in china, those would produce 0.0075Mt of N2O emission, 0.379Mt of CH4 emission and less of CO2 emission.. If through adoption of CT system to stop 10% of crop stalks burning, thus, 3000t of N2O emission and 151,000t of CH4 emission could be eliminated.

4) Reduce Fossil Fuel consumption

CT can cut down fuel consumption 41.6kg/hm2 in NC, comparing to TT system. While CT adopted on 70% of crop land in North of China, the total fossil fuel saving could be 1.924Mt each year.

Assume 30% of fossil fuel emission is N2O emission, thus, 5772t of N2O emission could be reduced.

1.924Mt * 0.01* 0.3 = 5772t of N_2O emission

Analysis of above 4 aspects, they have immediate and indirect influences with reduction of 12851～24996t N2O emission or 3.6～7.1% of whole N2O emission in China.

Other 2 aspects have direct influence, which means the N2O emission change can be measured directly from cropland using “close chamber method”, but lack of scientific figures to show the influence clearly at the moment.

From positive side, the improvement of soil fertility and structure would be useful to reduce the amount of N fertilizer application, then, reduce N2O emission. However, the rich soil base would produce more N2O emission itself. Some research mentioned that the frequent exchange of soil dry and wet condition would induce N2O emission production, soil water logging easy to create anaerobic environment, thus produce more N2O emission. The situation is rather complex and uncertainty. Dr. Johan Six in California university of US concluded that the CT system can directly offset the GHG emissions (CO2, N2O, and CH4), only in longer-term adoption, say, adoption of CT system 10 years in paddy field (humid area), the fluxes GWP ((global warming potential) becomes negative, means reduction of GHG and 20 years in paddy and dry land areas both show negative GWP fluxes. In the short term of CT application, the GHG may be less, may be more, this is the true situation.

3. CT Improve Soil Productivity

Soil productivity has been declining in most of NC crop land, it shows that the SOM reduced from 4-5% to 2-3% in North-East area with block soil become yellow soil, reduced from 2% to 1% more in central China, further more many crop land total lose productivity by desertification and desolation. Soil deterioration has become a major factor to limit the crop production capability in China. The reasons of soil productivity reduction are soil erosion and over utilization. China is a serious soil erosion country, annual soil erosion reached 5 Bt, among it 3.3Bt come from crop land, which equivalent to loss top soil 2.5mm each year. Wind erosion is the major in North-West China and water erosion is the major in loess tableland and North-East China.

3.1 Wind Erosion

Since 1990'of last century, Chinese water & soil conservancy staffs have done a lot of Measuring works on wind erosion, the results show that the wind erosion is between 10-80 t/hm2 and cropland concentrated in 10-20 t/hm2 (Table 3).

The soil nutrition in wind dust is higher than in the top soil, CAU has measured the top soil and wind collection materials in Hebei and Inner Mongolia , the results can be seen at table 2. Take the wind dust 10-20t/hm2 with contain2-3% of OM and 0.17% of full N, then, the soil nutrition loss by wind erosion are 200-600 kg/hm2 of OM and 17-34 kg/hm2 of full N, which would decrease the soil OM content 0.008-0.025% annually. Without moldboard plow, soil fine articles would gradually be depressed in top soil and wind

No	Land type/Region	climate	Soil Type l	Amount of W.E (t/hm^2)	Method Of measure	Measure time
1	Farmland/ Beijing	Semi-Humid	loam	11.28	Set pole	2005
2	Farmland/Shanxi	Semi-Humid	loess	13.7	Set Pole	1990
3	Farmland/Shandong	Semi- Humid	Sand-loam	21	Set pole	1992
4	Farmland/Shaanxi	Semi-Humid	Loess	18.9	Modeling	1998
5	Sand/Hebei	Semi-arid	sandy	96	Set pole	2002
6	Sand/Inner Mongolia.	Semi-arid	Windy sand	80	Set pole	1993
7	Farmland/Inner Mongolia	Semi-arid	Sand Soil	21.6	Trap Collection	2002
8	Farm & Grass land/ Qinghai	Arid	Sand Soil	7.5～43	Cs-137 label	2000
9	Farm & Grass land/ Xinjiang	Arid	Sand Soil	31-60	Cs-137 label	1998

Table 3 Wind erosion measuring results in North of China

erosion intensity would reduced until stop, but moldboard plow turns bottom soil up, makes new fine articles available and erosion continuing. If continuous moldboard plowing for100 year and soil fallow in bare condition, wind erosion would make soil

OM 0.4-1.25% depression, rich soil become poor soil, poor soil become totally no productivity.

Table 4. The comparison of soil wind erosion from TT and CT fields

No	Place of Measure	Soil type	Amount of Wind erosion			Method of measure	Time of measure
			TT	CT	Reduce Rate (%)		
1	Fengnin,Hebei	Sand Soil	11.7	2.81	76	Field Sampler	2002
2	Zhangbei, Hebei	Sand Soil	10.6	3.6	66	Field Sampler	2002
3	Zhenglan Banner, Inner Mongolia	Sand Soil	5.7	3.37	41	Field Sampler	2003

The reduction of wind erosion from TT change to CT is 41～76%, with 60% in average at table 4. Whereas, the change of TT to CT can reduce the losses of OM 120～360kg, N 10.2～20.4 kg, P 2.28～4.56kg and K 118～236kg per hm2 per year.

3.2 Water Erosion

In Yellow river basin, water erosion makes 1.6Bt soil into the sea each year, the average water erosion is above 15 t/hm2. It is more serious in slop land, water erosion on 150 slop land is higher 5 times than 5o slop land measured by Shanxi Agricultural University.

CT turn off moldboard plow, left residue on soil ground, thus, largely reduce soil erosion and protect soil productivity. CAU and other units have measured the soil erosion in TT and CT system, the results shown that CT can reduce wind erosion 60% and water erosion 80% in average.（Table 5）。

It is same with wind erosion, CT can reduce large amount of soil OM, N, P, K losses from water erosion.

Table 5 Water erosion comparison between TT and CT

Place /measure Unit	Field slop	Water erosion			Method	Time
		TT	CT	+- (%)		
Shouyang of Shanxi/ CAU	5°	7.34 (t/hm^2)	1.45 (t/hm^2)	-80	Run-off Plot, Tipping Bucket	1998-1999
Henan/ Academy of Luoyang Ag. Science	0°	0.525 (t/hm^2)	0.123 (t/hm^2)	-76	Soil Bin Rainfall simulate	2000-2001
Shixian of Shanxi /Shanxi Ag. University	5°	0.454 (g/s)	0.048 (g/s)	-88	Artificial Slop Rainfall Simulate	1999
	10°	3.327	1.154	-65		
	15°	6.046	3.543	-41		

Besides reduce soil erosion, CT put tons of crop residues into the field would increase soil fertility and improve the structure, CT cut down tillage operations specially rotary hoeing, can save soil organism like worth worm. CAU measured a CT plots in Linfen city of Shanxi province, where a wheat CT experiment plots has passed through 15 years. The SOM in CT field from 0.89% at 1992 increased to 1.31% at 2005, every year increased 0.03% and 13 years raised one grade from poor to middle grade. There was no earth worm in the experiment plots at beginning(1992), had 3-5 heads/m2 of earth worms in CT plots after 6 years and 10-15 heads after 10years, but no earth worm in TT plots at same time.

For torsion of soil productivity decline, speed up the CT extension is necessary and It is better to have enough residue cover the field surface all the time and have soil less disturbing as much as possible.

Reference:

Gao Huanwen ，Construction of Energy saving system of Agricultural Mechanization，《Extension of Farm Machinery Science & Technology》，9 issue of 2005

Gao Huanwen, Raise soil productivity by development of conservation tillage, China Agricultural Mechanization Herald, 04/July/2005

Zangying, Gao Huanwen, A Study of Soil Wind Erosion Model for dryland Conservation Tillage, <Dryland Farming Research>，No2，Vol 22，March 2006，P1-P7 .

Gao Huanwen, Li Hongwen, Li wenying，Experiment Study of Conservation Tillage in North of China, <Conservation Tillage & Sustainable Farming> , China Agriculrural Sience & Technology Press，P265-274，October 2004.

Zhang Yuming, Hu Chunsheng, and so on, The influencing factors of production and emission of N2O from agricultural soil and estimation of total N2O emission, Chinese Journal of Eco-Agriculture, Chinese Journal of Eco-Agriculture，Vol.12, No3, July 2004, P 119～123

Johansix, Stephenm. Oglew , F. Jaybreidtz, Richt. Conantw etc, The potential to mitigate global warming with no-tillage management is only realized when practiced in the long term, Global Change Biology (2004) 10, P155–160

D.C.Reicosky (USDA-ARS, North central Soil Conservation Research Lab),Agronomic quantification of potential soil organic matter increase with direct seeding in Ukraine, 2nd International No Till Conference in Ukraine,17-20 August 2005