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

Introduction of CA Techniques in DPR Korea

Submitted to

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

24-26 October 2007, Zhengzhou, China

By

Kim Kyong Il[1]

[1] Mr. Kim Kyong Il, Agronomist, Ministry of Agriculture, DPR Korea
Jungsong-Dong, Sungri Street, Central District Ryong Yang, DPR Korea
Tel: 00850-2-1811-381 8278 Fax: 00850-2-3814401, Email:moaecd@silibank.com

Abstract

The achievement of the food security is of the utmost importance and target in DPR Korea's Agriculture. The country suffered continuously severe floods and drought in 1990's, which resulted low agricultural production thus insufficient provision of food for the people.

The Government of DPR Korea puts forward the policy and programme to build sustainable food security system recovering the infrastructure and production capacity in agricultural sector that has been destroyed by natural disasters and calls for farmers and whole country to concentrate efforts in this regard.

In order to preserve the soil fertility, main agricultural production potentiality, achieve the high efficiency of the investment and protect the agro-ecological system of the country, the Ministry of Agriculture (MoA) and the Korean Academy of Agricultural Sciences (KAAS), with close collaboration with FAO, have organized from year 2003 research work and trials aimed to introduce conservation farming techniques in the crop production and attained noticeable successes. Based on experiences gained, CA is now expanding to other farms at national level.

This paper aims to evaluate the urgent need to adopt measure for soil protection and to analyse the advantages of the conservation agriculture techniques as good option for the quick recovery and maintenance of nutrients in the cultivated soil and systematic and gradual improvement of its fertility.

CA was implemented during last 5 years' period both in paddy and upland soil and through the research comparison was made with the traditional farming in terms of yield and some other economic parameters/input such as labour, materials, fuel, etc.

1. Background

Soil fertility in DPR Korea, where 80 % of its territorial land is covered by mountains, is generally poor or moderate. In particular its cultivated land has long history in use, resulting in low contents of organic matter of 1.5~ 1.7 %.

Majority of the upland field is made of soils derived from granite and is located in slope land, thus, making prone to severe erosion. Average annual rainfall ranges between 1,000 to 1,200 mm, and it is estimated that due to the torrential rains in humid July and August about 30 ㎥ soil per ha lost on sloping land. Therefore soil depth in upland field is limited up to 30 or 50cm and its structure of the soil particles is mainly made by sandy loam.

In past 10 years, sufficient quantity of nutrients such as mineral and natural fertilizers for high cereal production level was not provided, resulting in serious imbalance of nutrients in the soil, thus making difficult the better use of chemical fertilizers to get expected yield.

Considering the fact that major upland soil in our country is situated in slope with 5 to 10 grade, different kind of research work on the slope soil protection against the rainfall and wind erosion is developed through the adoption of terrace, strip, planting of shrubs, minimum tillage, etc.

Research shows that during the main rainy season the cultivated land is considerably washed out making big gullies. Through this erosion process by rainfall or soil moving, a lot of nutrients are wasted, for example, 25.7 kg of N, 42 kg of P, 169 kg of K, 38.9 kg of Mg in the first case, and 27 kg of N, 12 kg of P, 158 kg of Ca, 170 kg of K and 81 kg of Mg in the second case.

Soil organic matter content as main factor of fertility is becoming lower from 1.8 % to 1.6% during recent 10 years. As the result, quantity of available N and P in the soil decreases. Available N lowered from 6.9 mg to 6.2 mg per 100 g soil in paddy and 7.4 mg to 6.1 mg in upland.

During last 10 years, the available P in the soil decreased from 4.7 mg to 3.8 mg in paddy and 5.5 mg to 4.4 mg in upland field.

Erosion in slope land is presented as big problem. According to the research in 2006, soil depth in upland lowered to 4.9 cm comparing with the figure of 1990 and loss of soil particles in land with gradient of 15 amounted up to 40 to 100 tons per ha.

If this trend continues, crop will have limited root development and the soil possesses very low level of water and nutrients contention capacity. Even the nutrients applied may be lost; dissolved into water or attached to soil particles washed off.

Soil erosion decreases considerably the crop yield impoverishing the land resources. Research shows that soil erosion can lead to decrease of yield of maize to 3.2 t, even to 2.8 t according to its severity compared with 4.6 t yield in plot of low erosion.

Table 1.Yield decrease by the soil erosion(t/ha)

Erosion / Plot selected (ha)	Low		medium		severe		Too severe	
	No. of plots	Average yield	1	2	1	2	1	2

29871	757	4.6	517	3.9	622	3.2	649	2.8

This huge loss of soil nutrients can be surely prevented with the improvement of tillage method and adoption of soil cover system. With passing years physical characteristics including porosity, bulk density, moisture, structure of the soil could even be improved.

The concept of Conservation Agriculture is understood and tested recently in our country. Practically it expresses the new farming system where the sowing is introduced under the condition of no tillage combined with mulching of green manure or crop residues on the field. It needs to establish appropriate crop rotation system, overcome the damage from the monoculture improving the physical structure of the soil and finally to increase the soil fertility and yield.

2. CA demonstration and methodology

From 2003 three cooperative farms (Ryongchon, Jungsan Up and Songmun) have been selected as demonstration farms of CA introduction under the FAO TCP project. Modules for the trials in upland field consisted of appropriate combination of mixed or intercropped of green manure-maize, wheat-soybean, maize-soybean, etc. and in paddy the crops for rotation were wheat followed by rice.

Ministry of Agriculture and Academy of Agricultural Sciences formulated the design of trial and guideline, implemented technical training for the staff of pilot farms before the trial and the technical team fielded frequently the farms analysing and evaluating the trial result.
Trial in upland was the suitable rotation or intercropping of crops between green manure-maize, wheat – soybean, maize-soybean and in paddy land rotation of wheat and paddy was implemented. It strictly adheres to the technical requirement of CA practices focussing in no-till, residue mulching, and appropriate rotation and weeding by herbicide.

Trial plot size was divided into 50 ㎡, 100 ㎡, 10000 ㎡ of dimension and separated by small, medium and field demonstration types. Conservation Agriculture has been expanded to another 16 farms in 2006.

3. Research result

Evaluation of soil fertility

- Soil humus and available nutrients

No-till mulch system helps with systematic increase of soil fertility.

According to the analyse conducted after three years of continuous mulching of 5 tons of straws per ha, soil pH didn't change drastically. But it was noticeable that the soil became loose and darker with humus.

Compared with traditional tillage, CA has generally increased the OM and available nutrient contents. According to the sampling of sandy loam plot in Songmun Farm, Samsok District, Pyongyang City, it was found an increase of soil nutrients: OM by 0.2 %, 2.2 mg of N, 2.9 mg of P and 1.2 mg of K per 100g.(See table 2)

Table 2. Change of agro-chemical properties of sandy loam soil

Items	Year	TA	CA
PH (Kcl)	2004	5.5	5.5
	2005	5.5	5.5
	2006	5.5	5.4
Organic Matter Content (%)	2004	1.5	1.5
	2005	1.5	1.5
	2006	1.5	1.7
Available N (mg/100g soil)	2004	6.5	6.5
	2005	6.4	7.7
	2006	6.4	8.7
Available P (mg/100g soil)	2004	15.8	15.8
	2005	15.6	17.6
	2006	15.8	18.7
Available K (mg/100g soil)	2004	14.5	15.5
	2005	15.5	16.3
	2006	15.5	16.8

0 ~ 5 cm soil depth

Site: Songmun Farm, Samsok District, Pyongyang.

2004-wheat-soybean (covered with 4t of wheat straw and 2t of soybean straw)

2005-wheat-soybean (covered with 4t of wheat straw and 1.5t of soybean straw)

2006-maize (covered with 5t of maize straw)

No-till direct seeding without mulching with green manure or other crops residue can not prevent the compaction of soil surface and washing out of nutritional elements, leading gradually to the low level of available nutrients contents in the soil as following: within 3 years OM and available N,P, K contents have been lowered up to 0.02 % and 0.3 mg, 0.5 mg and 0.6 mg respectively per 100 g of soil.

In particular it is noticed that in no-mulched soil the weed occurrence was more frequent than in the mulched one, and after the rain its topsoil was more hardened.

Table 3. Change of agro-chemical characteristics of clay soil

Item	Year	TT	CA	CA, No mulch
PH(kcl)	2004	6.5	6.5	6.5
	2005	6.5	6.5	6.5
	2006	6.5	6.5	6.5
Organic Matter Contents(%)	2004	1.7	1.7	1.7
	2005	1.7	1.8	1.7
	2006	1.68	1.9	1.6
Available N (mg/100g soil)	2004	8.8	8.8	8.8
	2005	8.5	9.5	8.6
	2006	8.2	9.9	8.5
Available P (mg/100g soil)	2004	15.0	15.0	15.0
	2005	15.6	16.7	15.0
	2006	15.7	16.8	13.0
Available K (mg/100g soil)	2004	12.8	12.8	12.8
	2005	13.0	14.4	13.3
	2006	13.0	14.8	12.5

0 ~ 5cm soil depth

site: Ryongchon Farm, Hwangju County

2004 - Intercropping of wheat and maize (2.5t of wheat straw and 5t of maize straw)

2005 –double cropping of wheat and soybean (4t of wheat straw and 2.5t of soybean)

2006 –double cropping of wheat and soybean (4t of wheat straw and 2.5t of soybean)

Trial implemented in upland clay plot of Ryongchon farm, Hwangju County, CA has contributed to increase by 0.2 % of OM and 1.1 mg, 1.8 mg and 2.0 mg per 100g soil with available N, P, K nutrients respectively. (See table 3)

It is observed that without the mulching under the no till condition, decrease of OM and available nutrient contents in the clay soil was evident in same farm.

Leguminous crops (Hairy vetch) planted as first crop and treated with herbicide gave good effect of mulching for the following crops such as maize.

Jungsan Up farm farmers sowed green manure crop in autumn and followed with maize in next spring May and get more increase of OM and available N, P nutrient contents by 0.3% and 1.8 mg , 2 mg respectively.

Putrefaction of green manure helped to cover soil surface with sufficient organic matters, thus impeding the survival of weeds, making softer the soil and favoured the existence of soil microorganism and worms.

Table 4.Change of soil fertility by green manure mulching

Farming method	OMC	N	P2O5	K2O
20cm tilling	1.5	5.7	8.8	20.9
CA	1.8	7.5	10.9	21.1

2005- Jungsan farm 15 t /ha of hair vetch applied

- *Soil animals*

Mulching of soil with crop residue or green manure provides favourable condition for the improvement of soil structure through the quick multiplication of useful animals such frog, spider and worms.

Table 5. Number of worms in CA plot

Site	CA	TA
Somun	236	36
Ryongchon	194	24
Jungsan	76	28

2005- Jungsan farm (mulched with green manure)

* No of worm per 1 ㎡

As shown in table 5, number of worms has increased in all trial plots. In particular CA plot in Songmun farm where the mulching with green manure and maize during 2 years continuously had 200 more worms.

CA improves the physical property of the soil increasing the moisture contention capacity of the soil. This is because the mulching preserves the water within the soil. Table 6 shows that CA helps to increase by 3.2 ~ 4% of soil moisture after the sowing giving favourable condition for the germination. Mulching impedes the evaporation of the soil water and straws absorbs the vapour coming from micropores.

Table 6. Change of soil moisture by farming system (0~10cm soil depth)

Type of soil	Farming system	Soil moisture (%)			
		Pre-sowing	After sowing	mid-July	After harvest
Paddy	Traditional	16.1	30.6	32.7	21.5
	Conservation	19.5	34.3	32.5	23.5
Upland	Traditional	14.3	13.6	26.5	16.3
	Conservation	17.5	15.8	28.9	16.8

Year 2005 – Songmun Farm

- *Improvement of soil bulk density*

Conservation Agriculture improves also the soil bulk density.

Mulching preserves of water in the soil and protects it from direct sunrays, reducing the danger of compacting top soils, and giving favourable condition for the root penetration thanks to low bulk density of soil

Table 7. Change of soil bulk density by different farming system(g/cm^3)

Type of soil	Method of farming	Soil bulk density			
		Pre-sowing	After sowing	Mid-July	After harvest
Paddy	Traditional	1.28	1.02	1.20	1.31
	Conservation	1.26	1.08	1.21	1.30
Dryland	Traditional	1.24	1.18	1.23	1.33
	Conservation	1.20	1.20	1.15	1.20

2006 Songmun farm soil depth-0~10cm

It can be noticed from table 7 that soil bulk density was considerable improved under the CA condition than the traditional one, and in paddy rather than in upland plot. As shown it maintains securely 1.20g/cm3 level in general except after the sowing.

It means that traditional tillage results in change of soil bulk density by 1.24~1.33 due to the summer heavy rainfall and strong sunshine, but CA contributes to maintain secure structured soil during all crop living period.

- *Reduction of soil erosion*

Mulching of soil with crop residues increases the effect of prevention of soil erosion. During the main rainy season CA method can reduce by half the water runoff comparing with traditional tillage.

Table 8.Rainwater runoff by different tilling system(M^3/ha)

type of farming.	Rainfall		
	runoff	difference	Protection rate(%)
Traditional	31.5	-	0
Conservation	15.2	16.3	51.7

Rainfall in 6 July– 110 mm slope of 14.5^o Kumhung Farm, Sukchon County

With the introduction of CA farmers can reduce the erosion in upland impeding the runoff of soil particles by rainfall in main rainy season.

Table 9.Runoff of soil particles by rainwater runoff

type of farming	Rainfall		
	Kg/ha	difference	%
Traditional	22.0	-	0
Conservation	6.0	16.0	72.7

Same condition as table 13

Mulching with crop residue prevents the fine particles on the surface of the soil to be split and run off by the force of drop of rainfall. If left straws of wheat harvested in the field and seeded directly on it, soil washing out can be reduced by 70% during the main rainy season.

CA gives good perspective for the establishment of appropriate cropping and rotation system in our country.

- No-till mulching in paddy under double cropping can contribute to increase the yield and soil fertility leaving a lot of residues of first crop and reduce tilling and levelling process for the preparation of the field for second crop.

TABLE 10.CHANGE OF YIELD ACCORDING TO DIFFERENT DC SYSTEM IN PADDY

Type of Farming	Yield(t/ha)	
	Wheat – paddy rice	Potato - paddy rice

	Wheat	Rice	potato	Rice
Traditional	2.6	5.0	18.5	5.8
Conservation	3.5	5.3	25.0	6.0

2006, Komhung Farm and Yaksu Farm

Traditional tillage system gave total yield of 7.6 mt/ha between wheat and rice, meanwhile under the no-till mulching system this yield went up to 8.8 tons in total. Also it saves the tillage and field preparation process after the wheat harvest.

Farmers in Yaksu, Kangso County, got increase of 7 t of potato as first crop and 200 kg per ha in second crop of rice comparing with traditional tilling method. They practiced CA system where they put potato seed on the no-tilled paddy and covered it with humus and rice straws.

CA in paddy sounds good choice in double cropping, because of high possibility of the use of rice straws, saving of labour and fuel in spring, increased soil fertility and huge economic aspect the system has.

- CA introduction in upland double cropping (wheat-soybean, wheat-maize, green manure-maize, etc.) has also advantage to improve germination rate in spring, resolve problem for soil mulching and increase the yield as shown in table 11.

Table 11. Yield according to different DC system in upland

Type	Yield(t/ha)		
	wheat-soybean	wheat - maize	GM-maize
Traditional	3 t -2.5 t	3 t – 6 t	7
Conservation	3.5 t –3 t	4 t - 6.5 t	8.5

Compare the yield between conservation and the traditional farming system. CA gives the increase of 1, 1.5 and 1.5 ton in crops combination systems of wheat-soybean, wheat-maize and green manure-maize respectively.

It is obviously efficient to adopt double cropping of wheat-soybean system in CA because it provides sufficient quantity of mulching residues and produces nitrogen by the N fixing action of the soybean crop.

Green manure cultivation in maize field helps to produce 10 ton of high quality organic matter, making possible to good mulching. It is one of best types of rotation for the improvement of soil fertility with more proliferation of useful soil microorganisms.

-economical and technical efficiency of CA

CA can reduces tillage and harrowing process in farming because and saves considerable amount of fuel, labour and materials.

Table 12. Economical and technical efficiency of CA compared with TA

Type of soil	Farming system	Fuel consumed (kg/ha)		Time for preparation of soil before sowing	
		Total fuel consumption	Saving	Working hours (hour/ha)	Productivity (%)
Paddy	TA	72	-	12	-
	CA	28	44	2	600
Upland	TA	35	-	12	-
	CA	19	16	2	600

Songmun, Ryongchon, Jungsan farms

4. Conclusion

1st - CA constitutes very efficient cultivation system that guarantees the secure agricultural productivity thanks to the improvement of humus and available nutrients in the soil. CA doesn't need to apply humus or organic fertilizers for the increase of organic matter and available nutrient content in the soil and favours the living of useful soil animals including worms.

2nd CA provides good physical environment of the soil for the better crop growing.
Mulching with crop residue or green manure contributes to increase the water contention capacity of the soil contributing to better seed germination, lower volume density and secure soil structure during all vegetative period of the crops.

3rd Mulching with crop residue or green manure can help to control the soil erosion. Traditional tillage may cause loss of soil erosion by the rainfall in July and August, but CA can help to contain much water in the soil and reduce the lost soil particles by raindrops.

4th CA provides possibility to establish better crop rotation and cultivation system in DPR of Korea.

5th CA is very efficient farming method with high economical and technical advantages. It doesn't need the process of tillage or harrowing of the soil before the sowing, saving a lot of time and labour under the double cropping system.

References:

- Jo Il Son and Pak Byong Hyu, 2007, -Management of slope land and conservation agriculture.
- Dr. Pr.Ri Gun Haeng, 2006, -Research on foundation and effect of no-till rice farming.

Central Information Agency of Science and Technology, 1997,- Rice cultivation under the no till system - (bulletin – technical news)

- Iwajawa Novoo, 2003, - To grow rice without tilling the soil.
- Gao Huanwen.2004. - Conservation tillage and Sustainable Farming