Introduction of CA Techniques in DPR Korea

Kim Kyong Il[1]

ABSTRACT

The achievement of food security is of utmost importance and target in DPR Korea's agriculture. The country continuously suffered from severe floods and drought in the 1990s, which resulted in 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 systems recovering the infrastructure and production capacity in the agricultural sector that has been destroyed by natural disasters and calls for farmers and the whole country to concentrate efforts in this regard.

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

This paper aims to evaluate the urgent need to adopt measures for soil protection and to analyze the advantages of CA techniques as good options for the quick recovery and maintenance of nutrients in the cultivated soil and systematic and gradual improvement of its fertility.

CA was implemented during the last five years both in paddy and upland soils. Comparisons were made with traditional farming in terms of yield and other economic parameters/inputs such as labour, materials, fuel, etc.

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[1] 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

1. BACKGROUND

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

Majority of the upland field are in sloping areas with granite soils, thus, making it prone to erosion. Average annual rainfall ranges between 1,000 to 1,200 mm. Due to the torrential rains in humid July and August, about $30m^3$ soil per ha is lost on sloping lands. Therefore, soil depth in upland field is limited to 30-50 cm and structure of soil particles is mainly sandy loam.

In the past ten years, sufficient quantity of nutrients such as minerals and natural fertilizers for high cereal production was not available, resulting in serious imbalance of nutrients in the soil. Thus, the expected yields were not attained.

Considering the fact that major upland areas were situated in slopes of 5-10 per cent, different kinds of research on the slopes and its protection against rainfall and wind erosion were developed through the adoption of terrace, strip, planting of shrubs, and minimum tillage.

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 per cent to 1.6 per cent during the recent ten years. As a result, the 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 the last ten 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 sloping lands is a big problem. According to research results in 2006, soil depth in upland decreased to 4.9 cm compared with that of 1990 and loss of soil particles in the land with gradient of 15 amounted from 40 to 100 tons per ha.

If this trend continues, crops will have limited root development. The soil would have very low levels of water and nutrients retention capacity. Even the nutrients applied may be lost; those dissolved in the water or attached to soil particles could be washed off.

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

Table 1.Yield decrease by 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 prevented with the improvement of tillage methods and adoption of soil cover system. With the passing of years, physical characteristics including porosity, bulk density, moisture, and structure of the soil could even be improved.

The concept of CA is understood and tested recently in the 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 in 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 increasing 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 fields consisted of combinations of mixed or intercropped green manure-maize, wheat-soybean, maize-soybean, etc. In the paddy fields, crops for rotation were wheat followed by rice.

The Ministry of Agriculture and Academy of Agricultural Sciences formulated the design of the trials and guidelines, and implemented technical training for the staff of pilot farms before the trials. Technical teams were fielded frequently to the farms analyzing and evaluating the trial results.

Trials in uplands determined the suitable rotation or intercropping of crops between green manure-maize, wheat–soybean, and maize-soybean; in paddy, trials determined the land rotation of wheat and paddy. It strictly adhered to the technical requirements of CA practices focusing in no-till, residue mulching, and appropriate rotation and weeding by herbicide.

Trial plot sizes were divided into 50 ㎡, 100 ㎡, 10000 ㎡ dimensions and separated by small, medium and field demonstration types. CA has been expanded to 16 farms in 2006.

3. RESEARCH RESULTS

3.1 Evaluation of Soil Fertility

3.1.1 Soil Humus and Available Nutrients

No-till mulch system helps in the systematic increase of soil fertility. Based on a three-year research on continuous mulching of 5 tons of straw/ha, soil pH did not change drastically. It was noticeable however, that the soil became loose and darker with humus.

Compared with traditional tillage, CA has generally increased the organic matter (OM) and available nutrient contents in the soil. Trials in the sandy loam plots in Songmun Farm, Samsok District, Pyongyang City, showed an increase of soil nutrients: OM by 0.2 per cent; 2.2 mg of N; 2.9 mg of P; and 1.2 mg of K per 100g (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 nutrient contents in the soil as follow: within 3 years OM and available N, P, K contents have been lowered up to 0.02 per cent and 0.3 mg, 0.5 mg and 0.6 mg respectively per 100 g of soil.

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

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 -5 cm 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)

In trials implemented in upland clay plots of Ryongchon farm, Hwangju County, CA has contributed to increase by 0.2 per cent of OM and 1.1 mg, 1.8 mg and 2.0 mg per 100g soil with available N, P, K nutrients, respectively (Table 3).

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

Leguminous crops (Hairy vetch) planted as first crop and treated with herbicides resulted in good effects of mulching for maize.

Farmers in Jungsan Up Farm sowed green manure crop in autumn and followed with maize in next spring May and obtained an increase of OM and available N, P nutrient contents by 0.3 per cent and 1.8 mg and 2 mg, respectively.

Putrefaction of green manure helped to cover soil surface with sufficient organic matter, thus impeding the survival of weeds, making the soil softer favouring 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

3.1.2 Soil Organisms

Mulching of soil with crop residues or green manure provides favourable conditions for the improvement of soil structures through the quick multiplication of useful organisms such frogs, spiders, 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, the number of worms has increased in all trial plots. In particular, CA plots in Songmun farms where mulching with green manure and maize were applied continuously for two years had 200 more worms.

CA improves the physical properties of the soil increasing the moisture content capacity. This is due to the fact that mulching preserves the water within the soil. Table 6 shows that CA helps to increase by 3.2-4 per cent soil moisture after crop sowing, providing favourable conditions for germination. Mulching impedes the evaporation of the soil water and the straws absorb 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

3.1.3 Improvement of Soil Bulk Density

CA improves soil bulk density.

Mulching preserves water in the soil and protects it from direct sunrays, reducing the danger of compacting top soils, and providing favourable conditions for the root penetration due to the low bulk density of the soil.

Table 7. Change of soil bulk density by different farming systems (g/㎤)

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 could be noted from Table 7 that soil bulk density was considerably improved under CA conditions than the traditional one, and in paddy conditions rather than in upland plots. As shown in the table, it maintains 1.20g/cm^3 level in general except after sowing.

It implies that traditional tillage results in change of soil bulk density by 1.24-1.33 due to the summer heavy rainfall and strong sunshine. However, CA contributes to maintain secure structured soil during the crop's growth period.

3.1.4 Reduction of Soil Erosion

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

Table 8.Rainwater runoff by different tilling systems (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 uplands impeding the runoff of soil particles by rainfall during the main rainy season.

Table 9.Runoff of soil particles by rainwater runoff

	Rainfall

Type of farming	Kg/ha	Difference	%
Traditional	22.0	-	0
Conservation	6.0	16.0	72.7

Same conditions as in Table 13

Mulching with crop residues prevents the fine particles on the surface of the soil to be split and run off by the force of rainfall drops. If wheat is directly seeded on the straws of wheat left in the field after harvest, soil washing out can be reduced by 70 per cent during the main rainy season.

_CA provides a good perspective for the establishment of appropriate cropping and rotation systems in the country.

No-till mulching in paddy under double cropping can contribute to increase in yields and soil fertility, leaving a lot of residues from the first crop and reduces tilling and levelling processes for the preparation of the field for the second crop.

Table 10. Change of yield according to different DC systems 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 a total yield of 7.6 mt/ha between wheat and rice. Under the no-till mulching system, this yield went up to 8.8 tons. It also saved tillage and field preparation processes after the wheat harvest.

Farmers in Yaksu, Kangso County, obtained an increase of 7 tons of potato as first crop and 200 kg per ha during the second crop of rice compared with traditional tilling method. They practiced CA system where they placed potato seeds on the no-tilled paddy and covered it with humus and rice straws.

CA in paddy is a good choice in a double cropping due to the high possibility of the use of rice straws, savings in labour and fuel in spring, increased soil fertility and higher economic benefits resulting from the system.

The introduction of CA in an upland double cropping (wheat-soybean, wheat-maize, green manure-maize, etc.) has also the advantage to improve germination rates in spring, resolve problems related with soil mulching, and increase in yield (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

Comparing the yields, CA gives an increase of 1, 1.5 and 1.5 tons in crop combination systems of wheat-soybean, wheat-maize and green manure-maize, respectively.

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

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

3.1.5 Economical and Technical Efficiency of CA

CA can reduce the tillage and harrowing processes in farming 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 (%)
	TA	72	-	12	-

Paddy	CA	28	44	2	600
Upland	TA	35	-	12	-
	CA	19	16	2	600

Songmun, Ryongchon, Jungsan Farms

4. CONCLUSION

First, CA constitutes a very efficient cultivation system that guarantees secure agricultural productivity due to the improvement of humus and available nutrients in the soil. CA does not require the application of humus or organic fertilizers. It favours the growth of useful soil organisms, including worms.

Second, CA provides favourable physical environment of the soil for better crop growth. Mulching with crop residues or green manure contributes to increased water retention capacity of the soil contributing to better seed germination, lower volume density, and secured soil structure during the vegetative period of crops.

Third, mulching with crop residues or green manure can help control soil erosion. Traditional tillage may cause soil erosion as a result of the rainfall in July and August, but CA can help contain much water in the soil and reduce the loss of soil particles caused by raindrops.

Fourth, CA provides the possibility to establish better crop rotation and cultivation systems in DPR Korea.

Fifth, CA is very efficient farming method with high economical and technical advantages. It does not need the process of tillage or harrowing of the soil before sowing; results in savings in time and labour in double cropping systems.

5. REFERENCES

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