J. Agr. Sci. Tech. (2016) Vol. 18: 845-854

Conservation Practices and Management in Ukrainian Mollisols

Y. S. Kravchenko[1,2], Q. Chen [2,4], X. Liu[1], S. J. Herbert[3], and X. Zhang[1,*]

ABSTRACT

This study focused on soil degradation of Ukrainian Mollisols and investigated the effect of conservation practices on soil physical, chemical, and biological properties over the past 50 years. And the policies and relevant legislation are also outlined in this paper. The results showed conversion from plow-tillage to minimum tillage and no-till improved infiltration rate, pH, and Soil Organic Matter (SOM) in 0-10 cm layer and led to carbon accumulation in fulvic acids and humins. No significant differences in SOM storage were observed among tillage systems in the 0-100 cm layer. The five crop rotation increased 0.8, 0.71, and 0.94 t ha^{-1} yield of cereals and 5.8, 1.0, and 4.2 t ha^{-1} sugar beet under conventional tillage, deep minimum tillage, and reduced minimum tillage, respectively. Application of fertilizer in conservation agriculture, including NPK and manure, was 12 t ha^{-1} in the humid zone, 10-12 t ha^{1} manure in semi-humid zone and 8-10 t ha^{-1} manure in the Mollisols region of semi-arid zone. Green manure, cover crops, and inter crops increased crop yield by 2-10% on Forest-Steppe and Steppe Mollisols. The combination of strip cropping, contour farming, contour bunds, and terracing are particularly recommended for the sloping farmland in order to reduce soil erosion. In conclusion, soil conservation practices should be applied in Ukraine to prevent soil degradation.

Keywords: Conservation tillage, Degradation, Erosion, Fertilizers, Soil organic carbon.

INTRODUCTION

Ukraine, the granary of Europe, witnessed a significant rise in crop production due to the intensive land use during the first decade of the new millennium. The exported wheat, corn, and barley were listed in the eighth, third, and first place in the world grain market in 2011, respectively (Potiha, 2011). However, agricultural system in Ukraine has affected 35-40% of the total environmental degradation (Sutton *et al.,* 2007). It is estimated that over 8-10 million ha of farmland or 24.6-30.8% of arable land has been degraded, and 4.5 million ha of farmland are in the state of moderate- and severe-erosion. The agricultural land subjected to water erosion is approximately 13.3 million ha (including 10.6 million ha of arable land). Over 1.9 million ha of these soils have been identified as poorly drained. Irrigated land area decreased by 15% over the past 15 years (Anisimova *et al.,* 2009). More than 500,000 gullies are spread out on the land of 140,000 ha in Ukraine. Annually, 600,000 ha land are affected by wind erosion, and wind erosion area increased to 20 million ha in the dust storm periods (Zubets, 2010).

To prevent soil losses and improve soil fertility, the Ukraine government enacted regulations of soil conservation at the end of

[1] Key Laboratory of Mollisols Agroecology, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Harbin, 150081, People's Republic of China.
* Corresponding author, email: zhangxy@iga.ac.cn
[2] Soil Science and Soil Conservation Department, National University of Life and Environmental Sciences of Ukraine, Kyiv, 03041, Ukraine.
[3] Center for Agriculture, University of Massachusetts, Amherst, 01003, MA, USA.
[4] University of Chinese Academy of Sciences, Beijing, 100049, People Republic's of China.

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

the 19th century, while legislative conservation policies and field trials were implemented in 1954. According to the government directives, 851 benchmark sites were set up in all soil-climatic zones. The interest in adopting soil conservation technologies in the middle 1950s appeared simultaneously with the rising wind erosion processes and soil degradation in Steppe regions of the former Soviet Union. It was estimated that annual loss value of humus was 10-15 million t, nitrogen 0.3-0.9 million t, phosphorus 0.7-0.9 million t, and potassium 6-12 million t with a reduction in crop yield by 20-60% on eroded land in Ukraine (Zubets, 2008). All these problems are driven by human activities. Therefore, to be sustainable, the food-producing system should not undermine the natural resources on food products, which depend on soil properties.

In Ukraine, the primary soil type is Mollisols, which occupy 62% of all agricultural lands and approximately 78% of these soils have been cultivated. Agricultural management has a strong influence on soil properties, so, the assessment of agricultural management on Ukrainian Mollisols could identify the degree of soil degradation and then give advice for policy-makers and stakeholders on how to take appropriate practices and guidelines. This paper summarizes the effects of conservation tillage, cropping systems, fertilization and strip-cropping on soil physical, chemical, and biological properties in Ukraine over the past 50 years. The policies and relevant legislation on field management in Ukraine are also outlined.

MATERIALS AND METHODS

Mollisols Distribution, Topography, Climate, and Vegetation in Ukraine

Ukrainian Mollisols are known in other soil classification systems as Chernozems (Ukraine, Russia, FAO), Kastanozems and Phaeozems (FAO, WRB), Mollisols (USA), Isohumosols or Black Soils (China). For the purpose of this overview, the terms ‘‘Black Soils’’, ‘‘Chernozems’’ and ‘‘Mollisols’’ are used as synonyms.

Ukrainian Mollisols are located in a 737 km north–south zone occurring from lat. 51° 18´ N to 44° 41´ N and an 1,144-km-long east–west zone located from long. 24° 18´ E to 40° 12 ´E (Liu *et al*., 2012). The Podzolized and leached Mollisols are distributed across the well-drained uplands of the Forest–Steppe and watersheds. Typical Mollisols are widespread on upland plateaus between river valleys and terraces. Ordinary Mollisols occur everywhere in the northern subzone of the Steppe, covering the watershed plateaus. Southern Mollisols are common across the Black Sea lowlands and mid-Crimean peninsula, as well as being found on the flat plateaus of the South Steppe.

Ukrainian Mollisols are formed in a temperate short with a relatively brief freezing period. In general, the climate of the Mollisols area is humid in the northwest, semi-humid in the middle and the semi-arid in the southern region, respectively. The vegetation type of Mollisols area in Ukraine is oak-maple-lime-hornbeam forests with grasslands and meadows in the north, and meadow, fescue, and needle grasses with greater xerophytic and halophytic species towards the south.

Study Site and Experimental Design

Our experimental site is located on a Typical Mollisols area in the Forest-Steppe zone of Ukraine near the town of Velykosnyatynka, in the Kyiv region (lat. 50° 5′ N, long. 30° 2′ E). The study was conducted by the Soil Science and Soil Conservation Department of the National University of Life and Environmental Sciences of Ukraine. The average annual temperature is 7.9 and 12.7°C in the growing period. The local climate can be defined as temperate with annual precipitation about 588 mm (291 mm in the growing period).

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

Tillage treatments included Conventional Tillage (CT) based on deep plowing (25-30 cm), and two soil conservation tillage based on the Deep minimum Tillage (DT) to a depth of 25-30 cm, Reduced minimum Tillage (RT) to a depth of 10-12 cm, and minimized soil disturbance using a Rotary Harrow (RH) to 6-7 cm depth. The fertilizers are applied at rates of $N_{50}P_{45}K_{45}$ ha^{-1} coupled with annual application of cattle manure at a rate of 12 t ha^{-1}. Corn was grown in crop rotation made up of five fields.

Sampling and Measurement

Composite soil samples (five cores per composite samples) were taken by using a core sampler (diameter of 6.0 cm) in the 0-10 cm layer. Soil samples were air dried and ground to pass through a 1 mm sieve. Soil moisture was determined by drying subsamples at 105°C for 24 hours. A portion of each sample was ground to pass through 150 μm sieve to determine the SOC content. Humus composition was analyzed according to the method of Kononova (1963). Humic substances were extracted with a mixture of 0.1M $Na_4P_2O_7$ +0.1N NaOH (pH= 12.5). Then, the extract was separated into Humic Acids (HA) and Fulvic Acids (FA) by the addition of H_2SO_4 until the solution reached pH 1.3-1.5. The total carbon and carbon of HA from 0.1M $Na_4P_2O_7$ +0.1N NaOH soil extractions were determined by wet combustion (Tyurin, 1937). For other analyses, the gel HA was washed free of salts by using a dialysis membrane with a pore size of 2.5 to 3 nm and then freeze-dried. Analysis of the HA molecular mass composition was performed by the method of analytical gradient centrifugation for 5 h at 30,000 rpm with ρNaCl density gradient i.e. 1.05 to 1.20 g cm^{-3}, and solution volume of 5 mL (Votselko *et al*., 1993). Dextrin and polyethylene glycol with Mw of 13.5 15, 20, 40, 70, 110, 600, and 1,500 kDa were used as markers. Soil pH was determined on a 1:2.5 (V/V) soil/water mixture and measured then with a pH meter. Bulk density was determined on an oven dry basis by the core method. The undisturbed soil cores were taken at soil depths of 0–10 cm in early July. Infiltration of water into the soil was determined by the double ring infiltrometer (Bouwer, 1986), with a 20 cm inner diameter and a 40 cm outer diameter cylinder. For the review purposes, the data in the Table 2 and Figure 1 were adopted from other sources.

RESULTS AND DISCUSSION

Conservation Tillage

Conventional Tillage (CT) in Ukraine often involves two major operations. The basic and primary operations involved include hoeing plough, disc-harrows, and/or chisel type cultivators, and moldboard plow in burying and placing fertilizers, manure, as well as crop residues. The secondary operation used spring-tooth harrows, seedbed levelers, packers, seedbed cultivators, star-wheeled rollers and other types of machinery (Ghudz *et al.,* 2010). However, primary and secondary tillage varied as soil properties changed. Gilley and Doran

Table 1. Tillage effects on a Haplick Mollisols properties in upper 0-10 cm layer.[a]

Tillage	Bulk density (g cm^{-3})	Compaction (kg cm^{-2})	Infiltration rate (mm h^{-1})	pH	SOC (g kg^{-1})	HA (%)	FA (%)	HA Mw (kDa)
RT	1.20 a	2.7 a	64.5 a	6.97 a	24.1 a	1 bc	0.39 ef	405053 a
DT	1.17 b	2.5 ab	41.8 b	6.82 b	22.9 b	0.98 cd	0.38 ef	367156 b
CT	1.17 b	2.2 b	41.2 b	6.57 c	22.2 b	0.96 d	0.34 f	275961 c

[a] Different letters indicate significant differences (α= 0.05 level) in soil properties between tillage treatments. HA: Humic Acids, FA: Fulvic Acids.

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

Table 2. Crop yields (t ha^{-1}) in tillage systems and crop rotations (Demidenko, 2012).[a]

	Cereals (t ha^{-1})		Sugar beet (t ha^{-1})	
	Number of crop years between the same crop in the cropping system			
	5	3	5	3
Plowing 22-25 cm	6.02 a	5.22 ab	58.2 a	52.4 a
Minimum tillage 22-25 cm	6.00 a	5.29 a	53.5 b	52.5 a
Minimum tillage 8-12 cm	5.95 a	5.01 b	51.4 c	47.2 b

[a] Different letters indicate significant differences (α= 0.05 level) in crop yields between tillage treatments.

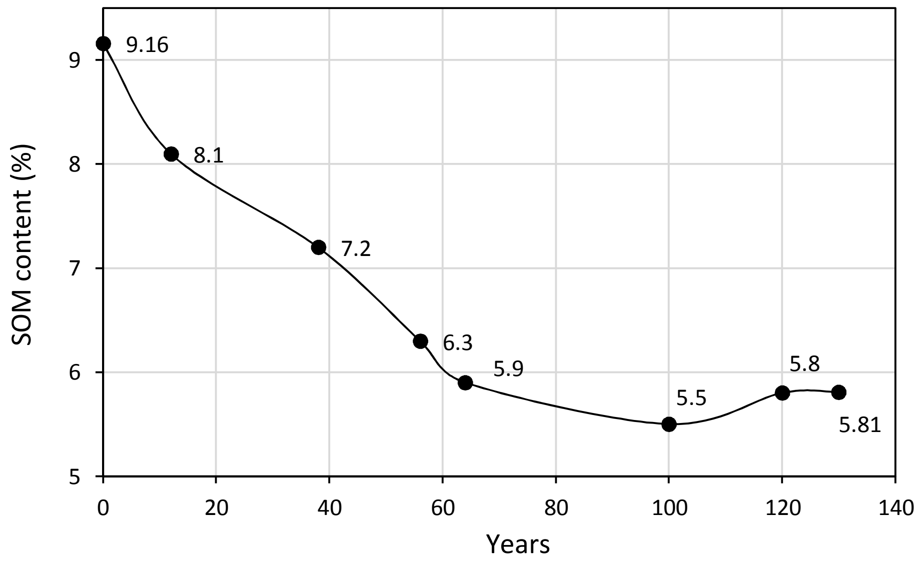

Figure 1. Effect of long-term cultivation of Typical Mollisols on SOM content (adapted from reference of Degtyarov, 2011).

(1997) found continuous tillage led to soil degradation, including loss of organic matter and deterioration in soil structure. The major cultivation factors in CT were seedbed preparation and weed control. Plowing treatment could improve soil aeration, decrease bulk density, and compaction, and increase water percolation at soil surface layer. These advantages are important for farmers to make decisions to implement CT.

Numerous studies have proved that conservation tillage has a positive effect in controlling soil erosion (Liu *et al.,* 2011). The adoption of conservation tillage under winter crops in the South and South-East regions of Ukraine is successful, and about 50% of arable land use is now under no-till, and minimum tillage. Conventional tillage is prevalent on Spodosols and Alfisols in the humid and semi-humid regions of Ukraine (Sayko, 2007). Our study showed minimum tillage could decrease bulk density and improve soil compaction, infiltration rate, pH, Soil Organic Carbon (SOC) content, carbon of Humic Acids (HA), carbon of Fulvic Acids (FA), and molecular weight fractions of Humic Acids (HA Mw) (Table 1). However, minimum tillage had a higher proportion of Soil Organic Carbon

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

Labile (SOCL), a lower ratio of carbon in humic acids and fulvic acids, and greater humic acids with molecular masses from 110 to 2,000 kDa.

Minimum tillage always accumulates organic matter in the topsoil, which lead to carbon vertical stratification. Our research, conducted on a Typical Chernozem in the Forest-Steppe zone of Ukraine over a period of 10 years (Kravchenko *et al.,* 2012), found a significant increase in SOM concentration in the 0-15 cm layer under three conservational tillage practices; SOM concentration under Reduced Minimum Tillage (RMT), Deep Minimum Tillage (DMT) and Rotary Harrow (RH) were 0.28, 0.30, and 0.34 g 100 g^{-1} greater than Conventional Tillage (CT), respectively. However, no difference was observed between RMT, DMT and CT in the 15-30 cm layer. The difference in SOM content among tillage systems gradually diminished from 45 cm depth downward. Our 10-year management of Chernozem, which involved annual NPK fertilization coupled with 12 t ha^{-1} yr^{-1} of manure, increased the SOM storage by 15.9 to 19.4 t ha^{-1} in the 0-100 cm layer in all treatments, regardless of tillage systems. SOM storage was 438.3, 437.7, 438.6, and 441.2 t ha^{-1} 100 cm^{-1} under CT, DMT, RMT, and RH, respectively.

Crop Rotation

Crop rotation in Ukraine is made up of eight–ten crops. The crop sequence in a typical forest-steppe rotation is: (1) Green manure fallow or grain legume; (2) Winter wheat; (3) Sugar beet (*Beta vulgaris* L.); (4) Spring barley (*Hordeum vulgare L.*) with perennial grasses; (5) Perennial grasses; (6) Winter wheat *(Triticum aestivum* L.); (7) Sugar beet or corn (*Zea mays* L.); (8) Pea (*Pisum sativum* L.); (9) Winter wheat, and (10) Sunflower (*Helianthus annuus* L.). However, crop rotation has been reduced to three or four crops at the current time, owing to economic considerations. Crop rotation is classified into field, fodder, vegetable, and special types. Crop rotation can improve soil properties and increase crop production. A long-term experiment by Gangu *et al.* (2011) showed that yield of continuous sugar beet was 8.9-10.7 t ha^{-1} less than that of rotation system. However, 932,000 hectares of arable lands in Ukraine are in monoculture (FAO, 2013). The data in the Table 2 shows that 5-yr crop rotation had a higher yield of cereals and sugar beet than 3-yr crop rotation (Demidenko, 2012).

Fertilization

The commonly recommended fertilization rates (kg ha^{-1}) in typical Mollisols of Ukraine are: $N_{80}P_{70}K_{60}$ for winter wheat, $N_{80-120}P_{90-120}K_{120}$+manure 30 t ha^{-1} for corn, $N_{60}P_{60}K_{40}$ for barley, $N_{90-120}P_{70-90}K_{40-60}$+manure 20-40 t ha^{-1} for rice, $N_{60-80}P_{60-80}K_{40-60}$ for buckwheat, $N_{30-45}P_{45}K_{45}$ for soybean, $N_{160}P_{170}K_{150}$+manure 30-50 t ha^{-1} for sugar beet, $N_{60}P_{60}K_{60}$ for sunflower, $N_{45-90}P_{60}K_{60-120}$+manure 30 t ha^{-1} for potato, and $N_{90-120}P_{40-60}K_{80-120}$+manure 20-30 t ha^{-1} for rape (Marchuk *et al*., 2011). Application of mineral fertilizers may increase soil acidity (all forms) and enhance the leaching of exchangeable bases.

SOM loss is one major characteristic of soil degradation in Ukraine. Figure 1 shows SOM content declined steadily in the first 60 years cultivation from the virgin Mollisols, and then maintained a relatively stable level (Degtyarov, 2011). SOC can be changed by application of cattle/pig/poultry manure, compost, peat, green manure and plant residues. Meanwhile, the effectiveness of mulching on reducing soil erosion was observed in the field experiment in Ukraine. Minimal tillage with 2.5 t ha^{-1} mulching in the eroded Mollisols area could save some available water, reduce runoff up to 3.8 m^{-3} ha^{-1} and improve spring barley yield by 1.6 t ha^{-1}. According to Hospodarenko *et al.* (2012), application of 45-year manure noticeably increased percentage of base saturation and available nutrients content, improved soil aggregation. Increasing annual average solid manure rate from 9 to 13.5 t ha^{-1}, resulted in

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

increased SOM content from 32.4 to 34.3 g kg^{-1}, whereas annual rate of 18 t ha^{-1} manure application led to a less pronounced increase in SOM content (to 34.9 g kg^{-1}). Greatest values of total porosity (0.58 m^3 m^{-3}) and infiltration rate (23.85 mm hr^{-1}) were observed by Nazeer and Malik (2011) in the treatment of Farm Manure (FM) at the rate of 40 t ha^{-1}, followed by FM rate of 20 t ha^{-1} (0.41 m^3 m^{-3}, 15.00 mm hr^{-1}) and without FM (0.36 m^3 m^{-3}, 12.00 mm hr^{-1}).

Over the past several decades, intensive crop cultivation has led to a higher demand for trace elements. A fundamental difference in traditionally used salt (ionic) form of fertilizers is a nano form of mineral nutrients. The 10–150 nm sized nano fraction, followed by the vapor phase, has a particular biological functionality and it can be applied in plant growing. The use of pre-treatment of wheat seeds with colloidal solutions makes a positive effect on crop growth in calcareous and saline soils. The use of metal colloids normalized the osmotic properties of cells, since it stimulated the swelling and seed germination (Kravchenko *et al*., 2015).

Strip Cropping

Strip cropping is a method to minimize soil erosion, which is often applied in slopes exceeding 2° steepness or/and 150-200 m length. Deep heavy-rooted plants in this arrangement should alternate with loosely-rooted plants. The strip width on 3° slopes is usually about 60-70 m for corn/rape/sunflower, and 70-150 m for spring-winter cereals. Nearby the strip, it need to build a buffer area, which was made up with grasses and legumes. Its width should be no less than 4-6 m on 3°slope and 8-10 m on 3-7°slopes (Tarariko, 2006).

For the field with 1-3° slope, common practices are: plowing along the lines of the contours, 1-3 m buffer strips comprised of buckwheat, phacelia (Phacelia), oats, annual legumes planted at intervals of 60-80 m; 6-8 m wide forest belts along the field margins and perpendicular to the wind direction; contour ridges or channels established at 160 m intervals; mulching no less than 65 per cent of the soil surface; establishment of permanent vegetation barriers; multiple crops for use in rotations, and application of an additional 10-15% chemical fertilizers. For the field with 3-7° slope, recommended practices are: alternative strips across the slope parallel to each other in breadth of 60-80 m under annual grasses mixed with cereals or 20-40 m under corn-legumes mixtures; crop rotations with 40% cereals and 60% legumes; forest belts mixed with bushes 8-10 m wide at an intervals of 200 m; mulching cover no less than 75% in the soil surface; additional 15-20% fertilizers applied. For steeper slopes with erodible Mollisols, the top priority practices are: growing perennial forage and pasture crops. The benefits of contour farming could be enhanced by combination with the other relevant conservation practices, which were suitable to local soil, relief/geology and climate conditions (Balyuk and Tovazhnyanskiy, 2010).

Contour bunds, suitable for slopes 1-7°, are 1.5-2 m wide and 0.25-0.4 m high, spaced at 18-50 m intervals, which are built across the slope to form a water storage area on their upslope side and frequently used in a strip-cropping systems covered by vineyards, gardens, and shrubs. Ivanytska (2010) found the earth bunds increased the effective volume of plum roots to 515 m^{-3}, as compared to 347 m^{-3} on the slopes without the bunds. Soil total porosity increased to 55%, compared with 49% on the slopes without the bunds, and soil bulk density improved to 1.23 g cm^{-3}, as compared to 1.33 g cm^{-3} on the slopes without bunds.

Terracing the sloping land can reduce surface runoff and soil erosion. Three classes of terraces are employed in Ukraine: diversion, retention, and bench. The common ground terraces are normally used on slopes less than 7°, with the embankment up to 1 m high and 3-12 m width (Dzhamal and Shelyakin, 1986). Terracing and slope steepness could affect the Mollisols

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

morphological features. Svitlichniy and Chorniy (2007) reported that terracing on sloping lands reduced loss of nitrogen, phosphorus, potassium, and calcium when compared with non-terraced sloping lands.

Policy and Legislation in Ukraine

The National Ukrainian legislation takes into account interrelationships between soil friendly practices to decrease soil degradation and direct policy measures. The Land Code of Ukraine is the most advanced and closest to European legislative norms. It defines legislative codification and summarizes the rules regulating land relations into a coherent system, built upon unified principles, taking into account the world experience and requirements regarding harmonization of Ukraine's legislation with legislation of the European Union. Some norms of this act contain direct guidance for land protection, use, reclamation, recovering of contaminated and damaged soils, restoration of soil fertility, standards in land protection, and state oversight of land use and conservation.

All agricultural lands in Ukraine, according to the President Decree №1118/95 and Directive №536 must possess an agrochemical identity certificate. The certificate includes common soil parameters (SOM and its distribution downwards soil profile, soil texture, storage capacity of available water for plants, acidity, salinity, soil nutrients and microelements content) as well as the concentrations of the soil contaminants determined by the regulations № 4433-87 "Sanitary code of MPC (Maximum Permissible Concentration) of chemical substances in soils". The sanitary condition of the Ukrainian soils is also determined by the State Standard №17.4.2.01-81 "Nature Protection Soils". Nomenclature of sanitary condition indices" (Dzhygirey, 2006). According to the law "On State Control over Use and Protections of Lands", the control of land use and protection is carried out by the authorized body of The State Agency of Land Resources. The control of the observance of laws for soil protection is fulfilled by the authorized body of Ministry of Ecology and Natural Resources, and the monitoring of soil fertility is fulfilled by the authorized body of Ministry of Agrarian Policy and Food (VVR, 2003).

The Ukrainian government is keen to address all recognized soil degradation by legislation. However, policies relevant to soil conservation are few or do not address soil degradation, and even if they do, they are not oriented towards specific results of improved soil quality with appropriate farm management. Overall, all of these policies and measures have broad scopes of action, but are not sufficient to ensure an adequate level of soil management. Obviously, further development of conservation agriculture in Ukraine should be based on updated government policies, strategies, and integrated programs to encourage voluntary adoption by the farmers and other land managers in both crop production and the preservation (conservation) of sustainable environment.

CONCLUSIONS

According to our findings, no-till and minimum tillage with the application of 2.5 t ha^{-1} of shredded cereal straw resulted in 1.31-1.67 t ha^{-1} added yield of sugar beet, reducing surface runoff by 3.8 m^{-3} ha^{-1}, and improvement in SOM concentration, infiltration rate, and pH. This effect is enhanced by the use of a rotation of eight to ten field crops, enriched by small grain crops and leguminous forages. The commonly applied fertilizers in conservation agriculture include full NPK rates plus 12 t ha^{-1} of manure in the humid zone, 10-12 t ha^{1} manure in semi-humid zone, and 8-10 t ha^{-1} manure in the semi-arid zone of the Mollisol region. Green manure, cover crops, and inter crops increased crop yield by 2-10% on Forest-Steppe and Steppe Mollisols. The combination of strip cropping, contour farming, contour bunds, and terracing are particularly recommended for sloping lands in order to minimize soil erosion, to reduce water losses, and provide sustainable management practices on sloping farmland. Obviously, conservation agriculture should be widely applied in Ukraine and it needs government policies, strategies, and integrated programs to encourage farmers to adopt soil conservation practices and to prevent soil degradation.

ACKNOWLEDGEMENTS

This study was financially supported by the Bureau of International Cooperation of the Chinese Academy of Sciences, foundation item: CAS-China, Ukraine and Belarus Cooperation Program, and the project of National Natural Science Foundation of China (NO: 41171230 and 41071201).

REFERENCES

1. Anisimova, L. B., Grytsan, N. P. and Kharytonov, M. M. 2009. Land Distribution and Assessment in the Ukrainian Steppe within the Dnepropetrovsk Region. Regional Aspects of Climate-Terrestrial-Hydrologic Interactions in Non-Boreal Eastern Europe. NATO Science for Peace and Security. Springer Netherlands, PP. 201–210.
2. Balyuk, S. and Tovazhnyanskiy, L. 2010. *Scientific Principles of Soil Conservation from Erosion.* NTU KNU Press, Kharkiv. (in Ukrainian)
3. Bouwer, H. 1986. Intake Rate: Cylinder Infiltrometer. In: "*Methods of Soil Analysis*", (Ed.): Klute, A.. ASA, Madison, WI, PP. 825-843.
4. Degtyarov, V. 2011. *Humus of Ukrainian Forest-Steppe and Steppe Chernozems.* Maydan Press, Kharkiv. (in Ukrainian)
5. Demidenko, O. 2012. Crop Rotation Effect on Physics and Chemical Properties of Forest-steppe Mollisols. Proceedings of International Scientific-practical Conference Devoted to the 90^{th} Anniversary of the Soil Science and Soil Conservation Department. Modern Soil Science: Scientific Issues and Teaching Methodology. Interservice Press, Kyiv, PP. 59–62. (in Ukrainian)
6. Dzhamal, V. and Shelyakin, M. 1986. *Soil Erosion Conservation*. Urozhay Press, Kyiv. (in Ukrainian)
7. Dzhygirey, V. 2006. *Ecology and Environmental Protection.* Znannya Press, Kyiv. (in Ukrainian)
8. FAO (Food and Agriculture Organization). 1993. *Soil Tillage in Africa: Needs and Challenges*. Journal of Natural Resources Management and Environment Department, *FAO Soils Bull.,* **69**.
9. Gangu, V., Brazhenko, I. and Kramarenko, I. 2011. The Sugar Beet Productivity Assessment under Long-Term Continues Growing versus Crop rotation. *VDDAU*, **1:** 12–15. (in Ukrainian)
10. Ghudz, V., Prymak, I. and Budyonniy, Y. 2010. *Soil Tillage Systems.* 2nd Edition, Textbook Center Press, Kyiv. (in Ukrainian)
11. Gilley, J. and Doran, J. 1997. Tillage Effects on Soil Erosion Potential and Soil Quality of a Former Conservation Reserve Program Site. *Soil. Water Conserv.,* **52:** 184–188.
12. Hospodarenko, H., Trus, O., and Prokopchuk, I. 2012. Humus Conservation Conditions in a Field Crop Rotation. *Biological Syst.,* **4:** 31–34. (in Ukrainian)
13. Ivanytska, V. 2010. Soil Conservation Systems and Plum Roots Development on the Terraces. *JNFU,* 20: 21–27. (in Ukrainian)
14. Kononova, M. 1963. *Soil Organic Matter*. Nauka, Moskow, 313 PP. (in Russian)
15. Kravchenko, Y., Rogovska, N., Petrenko, L., Zhang, X. Y., Song, C. Y. and Chen, Y. 2012. Quality and Dynamics of Soil Organic Matter in a Typical Chernozem of Ukraine under Different Long-term Tillage Systems. *Can. J. Soil. Sci.,* **92:** 429-438.
16. Kravchenko Y., Lopatko K., Aftodiliants Y., Trach V. 2015. The Effect of Colloidal Nanoparticles on Plant Grows, Phytotoxicity and Crop Yields. Fertiliser Technology I. Syntesis. Studium Press LLC., USA, **1:** 408-443.
17. Liu, X. B., Zhang, S. L., Zhang, X. Y., Ding, G. W. and Cruse, R. M. 2011. Soil Erosion Control Practices in Northeast China: A Mini-review. *Soil Till. Res.,* **117:** 44–48.
18. Liu, X., Burras, L., Kravchenko, Y., Duran, A., Huffman, T., Morras, H., Studdert, G., Zhang, X., Cruse, R., Yuan, X. 2012. Overview of Mollisols in the World:

Distribution, Land Use and Management. *Can. J. Soil Sci*., **92:** 383-402. .
19. Marchuk, I., Makarenko, V. and Rozstalniy, V. 2011. *Fertilizers Management.* Aristey Press, Kyiv. (in Ukrainian)
20. Nazeer, S. and Malik, A. 2011. Effect of Tillage Systems and Farm Manure on Various Properties of Soil and Nutrient's Concentration. *Russ. Agr. Sci.,* **37:** 232–238.
21. Potiha, A. 2011. Yanukovich: Ukraine Sealed the Leading Power in a Grain Production in the World. *Ukraine Events Facts Review,* **23:** 24–29. (in Ukrainian)
22. Sayko, V. 2007. *Systems of Soil Tillage in Ukraine.* VD EKMO Press, Kyiv. (in Ukrainian)
23. Sutton, W., Whitford, P., Stephens, E. M., Galinato, S. P., Nevel, B., Plonka, B. and Karamete, E. 2007. Integrating Environment into Agriculture and Forestry: Progress and Prospects in Eastern Europe and Central Asia. Volume II. Ukraine Country Review. World Bank, Washington, DC, 20 PP.
24. Svitlichniy, O. and Chorniy, S. 2007. *Basics of Erosion.* University Book Press, Sumy. (in Ukrainian)
25. Tarariko, O. 2006. Modern Soil Conservation Model Based on Contour–ameliorative Land Management. *BKNAU Serie. Soil Sci.,* **1:** 130–135. (in Ukrainian)
26. Tyurin, I. 1937. *Soil Organic Matter and Its Role in Pedogenesis*. Humus Doctrine, M. K. Selhozizdat, 287 PP. (in Russian)
27. Votselko, S. K., Pirog, T. P., Malashenko, Y. R. and Grinberg, T. A. 1993. A Method for Determining the Mass-molecular Composition of Microbial Exopolysaccharides. *J. Microbiol. Meth*., **18:** 349-356. (in Russian)
28. VVR (Vidomosty of Verkhovna Rada).2003. *On State Control over Use and Protections of Lands.* Official Publication, VVR, Ukraine. **39:** 350. (in Ukrainian)
29. Zubets, M. 2008. Soil Erosion is a Fertility Hazard. *Soil Sci.,* **9:** 5–8. (in Ukrainian)
30. Zubets, M. 2010. *Scientific Approaches of Crop Production in Ukrainian Steppe.* Agricultural Science Press, Kyiv. (in Ukrainian).

عملیات حفاظتی و مدیریت در خاک های مولی سولز در اکراین

ی. س. کراوچنکو، ک. چن، ز. لیو، س. ج. هربرت، و ز. ژانگ

چکیده

هدف این مطالعه بررسی تخریب خاک های مولی سولز در اکراین و تعیین اثر عملیات حفاظتی روی ویژگی های فیزیکی، شیمیایی، و زیستی این خاک ها طی ۵۰ سال گذشته بود. در این مقاله رئوس سیاست ها و مقررات قانونی نیز گنجانده شده است. نتایج بررسی نشان داد که تبدیل خاکورزی با شخم (plow-tillage) به خاکورزی کمینه و بی خاکورزی(no-tillage)منجر به بهبود سرعت نفوذ آب به خاک، اسیدیته(pH) و مواد آلی خاک(SOM) در لایه ۱۰-۰ سانتی متری و تجمع کربن در اسیدهای فلویک و هومینزها (humins) شد. در لایه ۱۰۰-۰ سانتی متری، از نظر انباشت SOM هیچ تفاوت معنی داری بین سامانه های خاکورزی مشاهده نشد. تناوب پنج محصولی در سه سامانه خاکورزی شامل خاکورزی رایج، خاکورزی کمینه عمیق، و خاکورزی کمینه کاهش یافته(reduced minimum tillage) موجب افزایش تولید غلات به ترتیب برابر ۰/۸ ، ۰/۷۱، و۰/۹۴ تن در هکتار و در چغندر قند

[DOR: 20.1001.1.16807073.2016.18.3.21.3]

به ترتیب ۵/۸، ۱/۰ و ۴/۲ تن در هکتار شد. افزودن کود در کشاورزی حفاظتی شامل مصرف NPK و کود حیوانی (۱۲ تن در هکتار در مناطق مرطوب ، ۱۲-۱۰ در مناطق نیمه خشک و ۱۰-۸ تن در هکتاردر مناطق دارای خاک های مولی سولز مناطق نیمه خشک) بود. همچنین، کار برد کود سبز، گیاهان پوششی، و کشت مخلوط (inter crops) باعث افزایش عملکردی برابر ۱۰-۲٪ روی خاک های مولی سولز جنگلی استپ و مولی سولز استپی شد. برای کاهش فرسایش خاک در مزارع واقع در اراضی شیب دار، ترکیب کاشت نواری (strip cropping)، کشت روی خط تراز، پشته بندی روی خط تراز و تراس بندی به طور مؤکدی توصیه می شود. در جمعبندی باید گفت که برای جلوگیری از تخریب خاک در اکراین، اجرای عملیات حفاظت خاک ضروری است.

[DOR: 20.1001.1.16807073.2016.18.3.21.3]