REGULATION OF INTENSITY SOIL EROSION IN CONDITIONS OF CONTOUR AGRICULTURE

F.N. Lisetskii, L.G. Smirnova, O.A. Chepelev, A.G. Shaydurova
Department of Nature Using and Land Cadastre, Belgorod State University, 308015, Belgorod, Russia.
Tel: 7(4722)301176, Fax: 7(4722)301012, E-mail: liset@bsu.edu.ru

Abstract
Results of soil-erosive monitoring according to a system effectiveness of contour agriculture (Russia, Belgorod region, a watershed of the small river) are submitted. The system of adaptive-landscape agriculture provides a number of measures on prevention of water erosion on slopes, to restoration of fertility of soils, increase of efficiency and rationalization of their use. Such measures are construction of hydrotechnical structures, planting of forest belts, a continuous aforestation of gullies.
Modern methods of land maintenance of erosive monitoring of boundaries of regulation (the shaft-gutters combined with forest belts), geoinformation systems (GIS), thematic mapping and remote sensing are used at carrying out on a field stationary and laboratory researches. Materials of long-term supervision which speeds of spring erosional losses of soil in system of contour agriculture assess, can be useful to calibration erosional models. Prospects of closer coordination of design decisions on soil conservation and ecological arrangement of agrolandscape with positionally-dynamic landscape structures of reservoirs are shown. It is developed model dependence of the deepness of the humus horizon on the time for definitions of soil loss tolerance level. It has allowed to reveal dependence of intensity and a direction of horizontal materially-power streams, in particular soil erosion, from a complex of an environment. It is shown, that a task of maintenance of reproduction soils and their fertility is considered in a context of reorganization agrolandscapes and the adjacent lands with it.

Keywords: water erosion, soil conservation, contour agriculture, geoinformation systems

INTRODUCTION

Indispensable condition for steady rise of productivity of agricultural cultures becomes ecological and biological intensification processes, and a stability condition of systems of agriculture (with planned-economic, agrotechnical, reclamation and ecological inter-systems) and steady development of a countryside should become the strategy of spatial and temporal adapting of economic effects to frame and development of nature and anthropogenic landscape systems.

A macro level of spatial adapting of plant-growing is the usage of a zonal principle in a specialization, in last 25 years was supplemented by diverse hierarchical levels: meso level (agroecological demarcation) and topological (landscape) level of “device” (accommodating) of agriculture to abiotic factors of environment. At intralandscape differentiation of agrotechnics: its useful to orientate the intrusion “of precise agriculture” on an objective function, which one, in our judgment, can become resource saving (first of all, in the attitude of land resources) and environment forming function.

The experience of an intrusion of landscape-ecosystems of agriculture convinces, that the problem of security of reproduction both soil conservation and their fertility cannot be independent. It should become an integral part of the surrounding program of function reorganization of rural locality. We excrete nine milestones of such reorganization [Lisetskii, Zissman, 2003].

For last 25 years for system of adaptive-landscape agriculture research groups of Russia and Ukraine at participation and under the direction of one of authors develop theory, some new conceptual development, models which are used in development of settlement methods of modelling, and also the experimental substantiation of normative base of soil-protective designing in agrolandscape is lead [Lisetskii, 1991; Kashtanov et. al., 1994; Lisetskiy, 1996; Kravtsov et. al., 2006].

OBJECT OF INVESTIGATION

In definition antierosion and agroecological efficiency of introduction of adaptive-landscape system of agriculture which has been introduced 15 years ago in a skilled-industrial facilities "Belgorodskoje" (Russia, Belgorod region, a watershed of the small river) the basic purpose of the researches carried out by us consist (fig. 1).

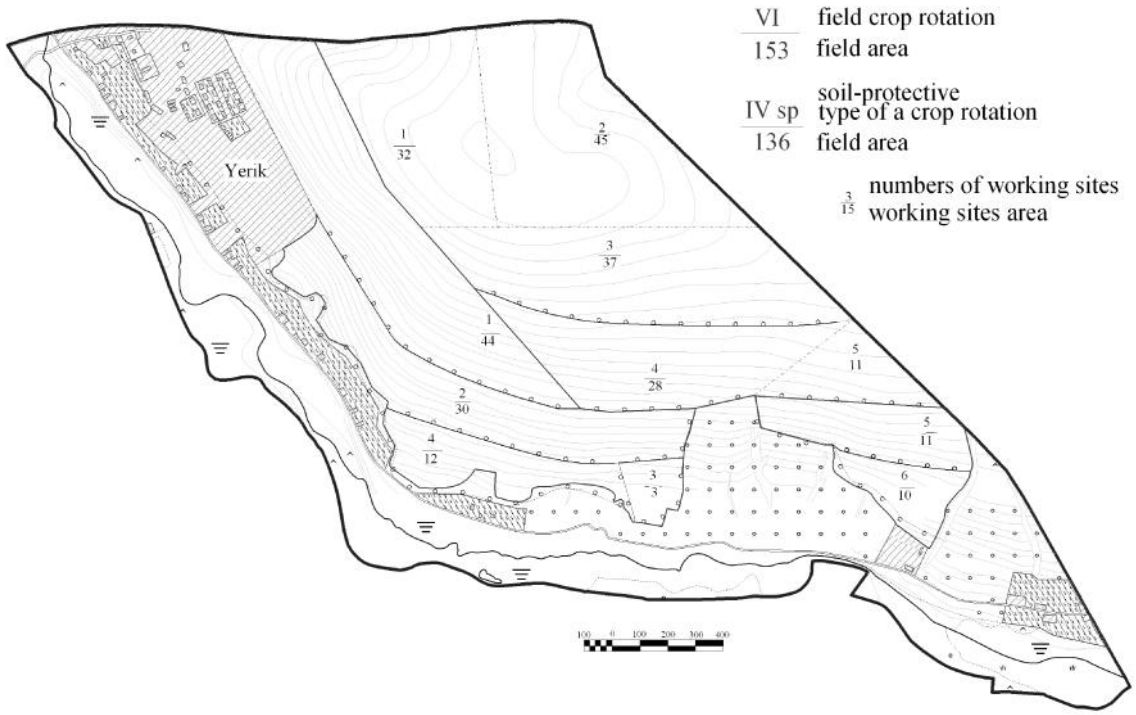

Figure 1. The project of interfarm land management for the IV and VI fields.

The economy is typical for forest-steppe landscapes of the Belgorod area: a climate here moderate-continental, the mid-annual temperature of air here makes +6,3 ^{o}C, mid-annual amount of deposits – 530 mm.

INVESTIGATION OF THE INTERFARM LAND MANAGEMENT PROJECT

The project of interfarm land management on a landscape basis with the contour-meliorative organization of territory has been developed by the land managemental enterprise for the specified economy in 1988. And works on removal of the project in a nature have been finished in 1991: the arable land has been transformed, construction of shaft-ditch has been started, wood strips which could adjust a superficial drain of water on a reservoir have been planted. Wood strips after a construction of boundaries had the following parameters: a wood strip from a poplar - detaining water ditch on section as a trapeze (the width made 1 m, design depth reached up to 1,5 m) - a wood strip from a birch - a shaft detaining water (the width of the basis made 2,2 m) - a wood strip from a poplar. The width between rows made 3 m. Along a wood strip from northern side are located strips of abandoned land which young growths for today are used as technological road (their width changes from 6 m up to 8 m). Thus, the general width of a boundary reaches 13-18 m.

The research range for realization agroecological monitoring in system of landscape agriculture represents a slope of a southern exposition a steepness from 1 up to 5º the area 2716 ha. The slope is divided into two a agrolandscape contour as which borders forest belts

from three lines located on distance of 3 m serve, with 20 water-retaining shaft and gutters (depth of 1,5 m and width 0,8 m). The system of adaptive-landscape agriculture provides a number of measures on prevention of water erosion on slopes, to restoration of fertility of soils, increase of efficiency and rationalization of their use. Such measures are construction of hydrotechnical structures, planting of forest belts, a continuous aforestation of gullies.

The equipment design on construction of hydrotechnical constructions is made on materials of a scheduled cartographical basis (scale 1:10000), materials of a soil reconnaissance and a mapping (scale 1:2000). On the basis of shooting by Topcon Electronic Total Station GTS-236N it has been created Digital Elevation Model (DEM).

The modern Geographic information systems (GIS-technologies) serve as an informational basis to intensity agricultural industry. Databases of cartographical and analytical information were formed with the help of BelGIS software: the cartographical editor MapProj and the data bases control system NetBase. For this purpose BelGIS has a lot of possibilities to enter and edit graphic elements of the maps, and to form and enter the parametrical information for each element in the form of database.

So vector maps which were made with the help of the software are characterized by the high accuracy and informative level. We used a system of agreed signs according to the standard of digital and polygraphical cartography. It gave the opportunity to make a cartographical data base which can be used as an informational and reference system and be printed with the usage of digital apparatuses.

The data on design distribution of the lands on gradation of expositions and steepnesses of slopes for each working site have been received by us by means of the module of the statistical analysis of maps of program MapProj (tab. 1-2).

Table 1. Design distribution of working sites of crop rotations on an exposition, ha

Exposition	Type of a crop rotation										
	field (VI field)					soil-protective (IV field)					
	numbers of working sites					numbers of working sites					
	1	2	3	4	5	1	2	3	4	5	6
flat interfluve	17,0	44,4	5,6	0,8	1,2	-	-	-	-	-	-
northern	2,6	-	-	-	-	0,0	-	-	-	-	-
northwest	2,8	-	-	-	-	0,0	0,8	-	-	-	-
western	2,5	-	-	-	-	5,4	1,6	-	-	-	-
southwest	6,9	-	2,9	-	-	30,2	11,5	-	0,7	-	-
southern	0,2	0,6	28,5	27,2	9,8	7,6	16,9	3,0	11,3	11,0	10,0
in total	32,0	45,0	37,0	28,0	11,0	44,0	30,0	3,0	12,0	11,0	10,0

Table 2. Design distribution of working sites of crop rotations on steepness, ha

Slope, degrees	Type of a crop rotation										
	field (VI field)					soil-protective (IV field)					
	numbers of working sites					numbers of working sites					
	1	2	3	4	5	1	2	3	4	5	6
0-1	8,6	17,0	-	-	-	-	-	-	-	-	-
1-3	20,4	28,0	31,0	9,0	6,7	2,8	-	-	-	-	-
3-5	3,0	-	6,0	19,0	4,3	25,6	11,5	3,0	8,9	9,3	4,1
5-7	0,0	-	-	-	-	10,8	16,7	-	3,1	1,7	5,9
more7	0,0	-	-	-	-	4,8	1,8	-	-	-	-
in total	32,0	45,0	37,0	28,0	11,0	44,0	30,0	3,0	12,0	11,0	10,0

On the basis of the analysis of cartograms of distribution in agrolandscapes expositions and steepnesses of slopes it is established, that the researched territory is located on slopes mainly southern (47,9 %) and southwest (19,9 %) expositions with biases from 0 up

to 9° (0-1° – 9,8 %, 1-3° – 37,3 %, 3-5° - 35,4 %, 5-7° – 14,9 %, more than 7° – 2,6 %).

By actions on the land device the territory is divided by actions into two agrolandscape a contour as which borders serve field road in the west and a wood strip in the south. The average length of a line of a current of the top contour makes 900 m and an average steepness – 2°. The bottom part of a slope is divided by wood strips which are placed on a boundary 3° and 5°. The top part of a slope up to 3° – cross-section - convex and longitudinal - convex, and bottom – with a steepness more than 3° – cross-section - convex longitudinal - direct also differs presence of microhollows.

The data of tables 1-2 show, that in one agrolandscape contour there are sites with different biases: on 3 and 4 working sites of VI field of a field crop rotation accordingly 16 % and 70 % of the lands are located on biases more than 3°.

The first working site of a field crop rotation contains the areas with expositions on the parties of light which are contrast on thermal security (northern and southern). From here it is possible to draw a conclusion that usual (componental) the analysis of territory when in design works only the relief on topographical maps and soil, as a rule, is taken into account, is insufficient for real reflection in the project of landscape features of land tenure.

The complex of field researches (spring of 2006) which put the purpose of studying of modern functioning of landscape system of agriculture in a basic economy - in a skilled-industrial facilities "Belgorodskoje", has been carried out by us. At the initial stage with use of the data of remote sensing by us specification of boundaries which have been born in a nature at introduction of the project of land management is made. Thus it was found out, that at a stage of carrying out of the project in a nature some deviations have been allowed. In particular, borders of some sites have been displaced downhill on 54-149 m. Therefore now in researched territory the amount of working sites has essentially changed. For new working sites with help GIS-technologies the data on real distribution of the lands on gradation of expositions and steepness have been received. It is necessary for the organization of the future monitoring researches.

INVESTIGATION OF THE LINEAR ANTIEROSION BOUNDARIES

As it was possible to reveal, some defects in designing have been in part eliminated at a stage of realization of the project that has found fastening in position of boundaries of regulation of system of land management.

Initial survey of has shown, that as a whole they are in a satisfactory status, however there is a necessity of a deepening gutters (their depth was reduced up to 0,65 m), raisings of scheduled marks of shaft, clearings of wood strips. Thus hydromeliorative and woodmeliorative receptions as a whole cope with the functions assigned to them. However the length of a line of a drain (on the average 900 m) does not meet design requirements and should be located above on 150-200 m. In some cases at a bookmark of shaft-gutters and planting of forest belts features of a microrelief that has resulted on some sites to almost full silting gutters and levelling of shaft of antierosion boundaries have not been taken into account. We investigate a site of a three-row forest belt between 3 and 4 working site of VI field of a field crop rotation (under the project) with hydraulic engineering constructions and the crosspiece – overgrowing a water-current for reset of a part noregulated flow. On object detailed geodetic shooting by electronic station Topcon is lead, constructional features of antierosion boundaries are described. With use of systems BelGIS and Surfer it is constructed DEM an antierosion boundary and adjoining territories, allocation of lines of a current is made (fig. 2). Lines of a current mark a site of a hollow above on a slope from an antierosion boundary. In this zone there is a concentration of a flow that has not been taken into account at a design of a boundary and has resulted in his destruction.

Modern methods of land maintenance of erosive monitoring of boundaries of regulation (the shaft-gutters combined with forest belts), geoinformation systems (GIS), thematic mapping and remote sensing are used at carrying out on a field stationary and laboratory researches. Materials of long-term supervision which speeds of spring erosional losses of soil in system of contour agriculture assess, can be useful to calibration erosional models. Prospects of closer coordination of design decisions on soil conservation and ecological arrangement of agrolandscape with positionally-dynamic landscape structures of reservoirs are shown. It is developed model dependence of the deepness of the humus horizon on the time for definitions of soil loss tolerance level. It has allowed to reveal dependence of intensity and a direction of horizontal materially-power streams, in particular soil erosion, from a complex of an environment. It is shown, that a task of maintenance of reproduction soils and their fertility is considered in a context of reorganization agrolandscapes and the adjacent lands with it.

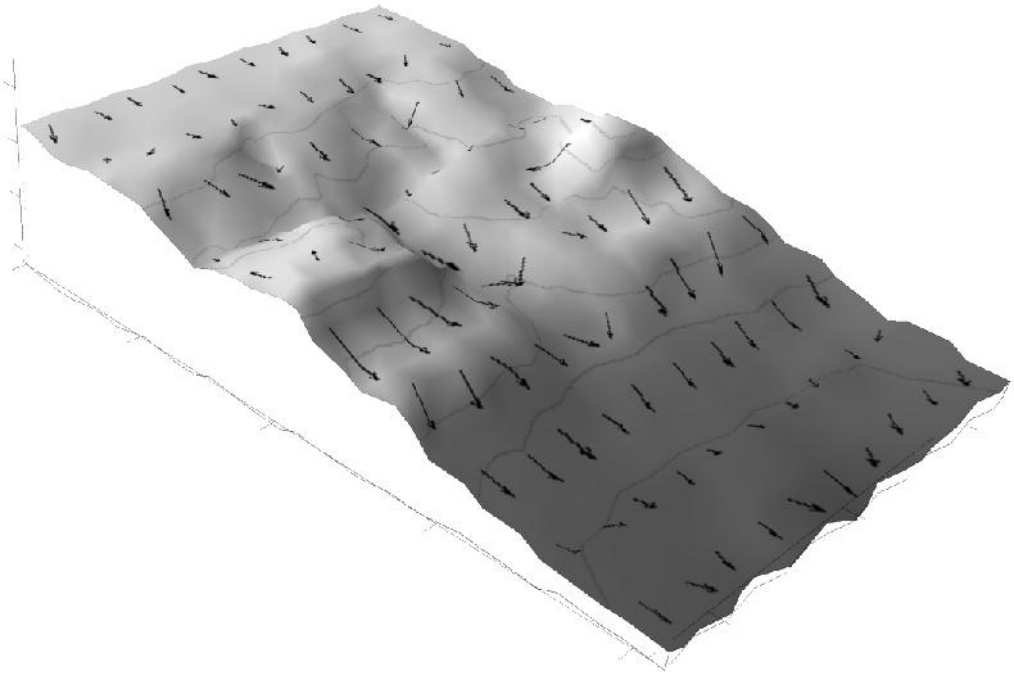

Figure 2. Digital elevation model with the automated allocation of stream lines in a zone of an antierosion boundary break.

Antierosion boundaries as a whole successfully carry out the functions during 15 years. Them silting and washout are observed in the single instances quite predicted at the analysis of conditions of formation of a flow and an erosive situation. At planning accommodation of antierosion boundaries it was necessary to take into account the form of a slope and position of microhollows. The specified lacks are caused by that, that during designing methods of geoinformatics which allow to reflect more adequately not only water erosion but also microlandscape preconditions of functioning agrolandscapes were not used. Modern computer technologies allow to take into account influence of a microrelief at designing landscape systems of agriculture.

The differentiated approach to definition of the sizes of shaft and depths water-retaining ditch would allow to lower expenses for a bookmark of boundaries and to avoid their destruction in zones of concentration of a flow. On occasion, for sites with low erosive potential of a relief, it was possible to refuse in general a construction of shaft-ditch due to expansion overgrowing spillways.

SOIL INVESTIGATION

For a rating of influence of the contour-meliorative organization of territory on change of soil properties and resources of soil fertility we studied morphological, physical and agrochemical parameters of soils. Materials of the previous soil inspection have been used thus. For 15 years in the majority of soil structures attributes gleying are found out. Their wide circulation in investigated soils testifies to increase of hydromorphic soils. As is known, occurrence and development gley formations is characterized of leaching carbonates, occurrence of cold colouring and specific concretions.

Depth of boiling up from a hydrochloric acid after the fifteen-year period became lower in comparison with the previous inspection. On the average on a slope with a steepness 1-3º it has made 60,5 sm, and in a forest belt – 62,5 sm, on a slope with a steepness 3-5º – 68,5 sm. The basic concretions in soils a skilled site are carbonates. Basically it pseudomicella, impregnation, strikes, streaks, white spots of lime in soil. Ferruterous new formations in soils to researched territory are submitted fine concretions, stains and inclusions, but meet as layers and concretions in diameter from less 0,5 up to 1 sm.

As a result of soil inspection it is determined, that among chernozems of a researched site the sort of deep-gleyic chernozems making up to 50 % of structures surveyed soils prevails.

CONCLUSIONS

Not only soil-protective and antierosion criteria should be taken into account at introduction of landscape and ecological systems of agriculture, but also economic expenses. At formation of farms on slopes (the area about 70 ha) selection of the most effective but also less exrensive on execution of systems of the antierosion control becomes very actual. In our opinion, perspective would be to isolate originally such land tenure within the framework of the general antierosion organization of territory of small river pools (for public funds). And allocation of the lands for new farms to carry out under obligations of a periodic leaving of boundaries of regulation due to means of the proprietor of the land.

ACKNOWLEDGEMENTS

Work is executed at support of the grant RFBR 06-05-90871-Mol_a.

REFERENCES

Kashtanov, A.N., Lisetskii, F.N. and Shvebs, G.I., 1994. *Osnovy Landshaftno-ekologicheskogo Zemledeliia*, Moscow: Kolos, 125 p. (in Russian).

Kravtsov, S.V., Lisetskii, F.N. and Martsinevskaja, L.V., 2006. Efficiency of landscape-ecological systems of agriculture in the decision of problems on protection soils // *Scientific Articles. Ecology 2006*. Part I. ISBN 954-9368-16-5, pp. 79-92 (in Russian).

Lisetskii, F.N., 1991. Soil conservation and ecological arrangement of agrolandscapes // *Papers and lectures of International conference "Youth and ecology"*. Vol. 1. Moldova: Ecological Projects Center, pp. 60-69.

Lisetskiy, F.N., 1996. Soil-water conservational arrangement of the agrolandscapes: Conception, methods, standard basis // *ESSC Second International. Congress. Development and Implementation of Soil Conservation Strategies for Sustainable Land Use. Abstracts.* Freising-Weihenstephan, Germany, p. 95.

Lisetskii, F.N. and Zissman, A.I., 2003. Geoinformation security of control by land resources // *Actual issues of land reform development in Ukraine: state and prospects. Collection of scientific arti*cle. Cherson, pp. 202-204.