ECOLOGICAL JUSTIFICATION OF STABILIZATION METHODS OF N2O DIRECT EMISSIONS FROM MANAGED SOILS IN UKRAINE

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This paper presentsthe dependence between direct nitrous oxide emissions from agricultural soils and application of mineral N fertilizers. There were founded that almost one third of the total volume of N2O emissions from agricultural soils in Ukraine comes from the application of mineral nitrogen fertilizers. It is shown the necessity of the development the set of measures aimed at reducing emissions of nitrous oxide as one of the main greenhouse gases through the rational application of mineral fertilizers.

INTRODUCTION

The economic, political, social, ecological problems, as well as the climate change challenge the future of humanity; its economic and political development fully depends on the solution of this problem [1]. The continuous greenhouse gases emission (hereinafter − GHGs) will be the reason of the further warming and changes of every climate system element. Climate change means that the average air temperature values will be changing all over the planet, the sea level will rise, the frequency of extreme weather conditions will rise as well.In order to restrict these changes, sufficient and uninterrupted reduction of greenhouse gases emission shall be reached [2].

The effects of climate changes may be complex for Ukraine. Nevertheless, the adaptation process to the climate change will not be easy and gratuitous. Many Ukrainian researchers consider that soon the global climate changes will have higher impact on agriculture, namely due to worsening of general conditions for the agrarian production, growth of frequency and number of extreme weathers phenomena, particularly droughts, as well as changes of vegetation period of crops, spatial redistribution and change of precipitations amount and other adverse conditions [3, 4].

According to National Cadastre of Anthropogenic Emission from Sources and Absorption by Greenhouse Gases Absorbers in Ukraine [5] the main contribution into general emissions in the agricultural sector of the state is made by categories “Methane Emissions from Enteric Fermentation “ and “Managed soils”. That was respectively 33,7 and 55,9 % of total emission in the sector in 2013.

As the agriculture is one of the main sources of greenhouse gases emission to the atmosphere, it also has a significant potential for efficient easing of consequences of climate change. Because of that the reasoning of events directed to decrease or to stabilize the emission of GHGs, particularly nitrous oxide in the agrarian sector is extremely actual.

OBJECTIVES AND METHODS

The general methodology used in estimation of GHGs emission in agriculture is in accordance with 2006 IPCC Guidelines [6] with some national adaptations. The methodology for estimating N2O from application of synthetic N fertilizers is in accordance with Ukraine National Inventory Report [5] but also default emission factors from IPCC Good Practice Guidance [7] were used.

Emission from N fertilizers was calculated as:

Emissions = NFERT • (1 - FracGASF) • EF• 44/28

where NFERTis the total amount of fertilizer, expressed as nitrogen, consumed annually; FracGASFis the amount of gaseous nitrogen losses in the formNH3andNOx;EFis the fraction that volatilizes as ammonia (= 0,1); the fraction 44/28 is included in order to consider the molar weight of N2O.

Library materials on the State Statistics Service of Ukraine (form № 9-b-agr.) reporting form, scientific publications, as well as the additional sources were used as the sources for raw information obtaining aiming at research performance. In order to formalize the research results, the graphical method with the use of Microsoft Excel was applied.

RESULTS AND ANALYSIS

The intensification of the natural greenhouse effect caused by greenhouse gases emission to the atmosphere in the result of anthropogenic activities, including agricultural

activities is considered to be the most significant reason of the present global warming. The rise of global concentration of carbon dioxide caused, primarily, by use of fossil fuels and by changes in land-use.

Moreover, the changes in methane and nitrous oxide concentrations, first of all, connected with the agricultural activity. In accordance with the conclusion of the Intergovernmental Panel on Climate Change (IPCC), the agriculture is one of the main sources of gas delivery to the atmosphere causing the thermal effect: CO2, CH4, NxO, Nox, NH3 [8].

Despite the fact that N2O at the table of natural greenhouse gases is on the fourth place its contribution directly into intensification of atmosphere greenhouse effect became so significant nowadays that according to the data of Inter-governmental expert group on climate change it has passed to the third place from the point of anthropogenic thermal regime of our planet [9].

Nitrous oxide is naturally created in the soils in the way of microbial process of nitrification and denitrification. In the result of different kinds of agricultural activity nitrogen is added to the soil.

The amount of nitrogen (N) for nitrification and denitrification increases and in the end the volume of N2O emission also enlarges. Emission of nitrous oxide as the result of anthropogenic addition of N happens both directly (that is directly from the soil where N is added) and from two indirect sources (because of fast evaporation in the form of NH3 and NOx and further repeated precipitation and because of wash-out and drainage) [6].

Direct emission of nitrous oxide from managed soils is calculated according to following sources: 1) application of nitrogen fertilizers; 2) introduction of organic fertilizers; 3) plant residues, including nitrogen fixation; 4) cultivation of organic (turfy) soil.

Gaseous losses of nitrogen in mineral fertilizers (carbamide, ammonium nitrate) happen mainly as a result of nitrification according to the scheme:

AMIDES → AMMONIA → NITRATES → NITRITES → FREE NITROGEN.

Gaseous losses mainly depend on soil-and-climate conditions, kind of fertilizer, terms of its introduction and way of plant sowing. At the main use of nitrogen fertilizers the gaseous losses can achieve maximum rates (25−50 %). In Ukraine for an area of sufficient humidification rather popular practice is introduction of nitrogen fertilizers during spring cultivation before sowing because nitrogen introduced in autumn is washed out in nitrate form. On introduction of fertilizers directly under plants the gaseous losses are within the limits of 5−24 % [5].

For determination of share of direct emission of nitrous oxide from introduction of mineral nitrogen fertilizers we have calculated summary direct emissions of N2O from arable lands in general in Ukraine (Fig. 1).

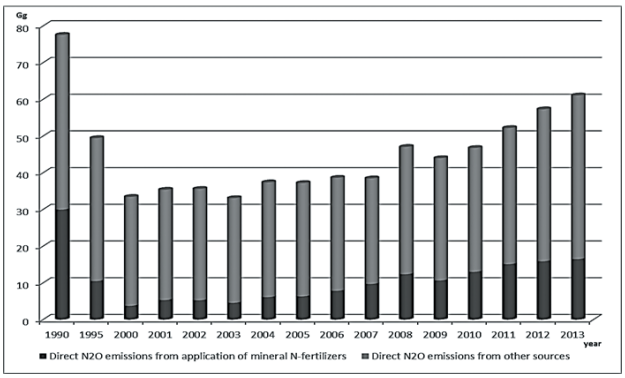

Fig. 1. *Dynamics of direct emissions of N_2O from managed soils in Ukraine*

It is specifically determined that the biggest introduction (38.65 %) into total volume of direct emissions of nitrous oxide from agricultural soils the volume of introduction of mineral fertilizers was made in 1990 and the smallest one − in 2000 (11,23 %).

It is surely connected with the decline of agricultural manufacturing after the start of a land reform and a penetration of market relations in the agrarian sector of economics. It is also confirmed by the dynamics of use of mineral nitrogen fertilizers (Fig. 2).

Since 2001 the share of direct emissions of nitrous oxide as the result of use of nitrogen fertilizers has been steadily increased except a little decrease in 2009 (as a consequence of the economic crisis of 2007−2008).Nowadays almost the third part (29 %) of total volume of N2O emission from the arable soil happens because of use of mineral nitrogen fertilizers.

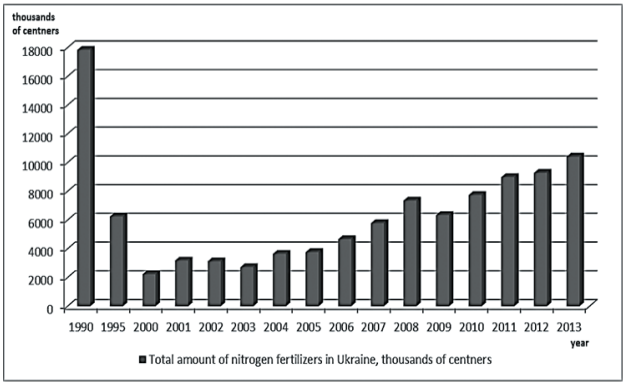

Fig. 2.*Dynamics of use of nitrogen fertilizers in Ukraine, thousands of centners*

This certifies the necessity of development of the set of measures oriented to decrease the emission of nitrous oxide in the way of ecologically grounded use of mineral fertilizers.

The main principle of use of mineral fertilizers, especially nitrogen ones is “reasonable efficiency” that secures permanent productivity of plant cultivation and safe condition of the environment.

Rational methods of nitrogen fertilizers introduction to decrease the emission of nitrous oxide as the result of agricultural activity are following: local and belt introduction of nitrogen fertilizers during the sowing or extranutrition; refusal from the introduction of nitrogen fertilizers in autumn; the introduction of anhydrous liquid ammonia into the soil to the depth of 10−18 cm with the purpose to avoid nitrogen losses; the introduction of nitrogen fertilizers after previous mulching of the soil surface with the plant residues.

With the purpose of involving atmospheric nitrogen into the biological cycle, legume crops use is of key importance. According to our research, perennial legume grasses (clover, medic) accumulate in biomass up to 200−300 kg/ha of nitrogen out of the air, annual legume grasses – 60−100 kg/ha [9]. Using them in farming rotation (20−30 %) can make it possible to significantly reduce their efficiency up to 25−50 %.

CONCLUSION

Summarizing, we may say that the most probable reason of the present global warming is the intensification of the natural greenhouse effect caused by greenhouse gases emissions to the atmosphere (carbon dioxide, methane, nitrous oxide etc.) in the result of business and agricultural activity. The prevailing source of nitrous oxide emissions in Ukraine is the agricultural soils.

As it is evident from the analysis of dynamics regarding amount of mineral nitrogenous fertilizers application and amount of direct nitrous oxide emissions in the result of its application in Ukraine, there is the direct correlation between them, i.e. the more the nitrogenous fertilizers are applied, the greater the gaseous nitrogen decline out of cultivated soils is.

This indicates of the necessity of implementation of the ecologically grounded methods of use of the mineral nitrogen fertilizers in the way that in case of increase of their introduction the emissions of the nitrous oxide do not enlarge.

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ЭКОЛОГИЧЕСКОЕ ОБОСНОВАНИЕ МЕТОДОВ СТАБИЛИЗАЦИИ ПРЯМЫХ ВЫБРОСОВ N2O ИЗ ОБРАБАТЫВАЕМЫХ ПОЧВ НА УКРАИНЕ

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В работе рассматривается зависимость между прямыми выбросами закиси азота от сельскохозяйственных почв и объемами применения минеральных азотных удобрений. Показано, что причиной почти трети от общего объема выбросов N2O от сельскохозяйственных почв в Украине является применение минеральных азотных удобрений. Показана необходимость разработки комплекса мер, направленных на стабилизацию и сокращение выбросов закиси азота, как одного из основных парниковых газов, путем рационального применения минеральных удобрений.