CARBON SEQUESTRATION IN AGRICULTURAL SOILS OF DIFFERENT NATURAL FERTILITY UNDER NITROGEN USAGE

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ABSTRACT

The influence of nitrogen fertilizing on carbon accumulation and decomposition in arable soils of different fertility – gray forest soil and chernozem was investigated in greenhouse experiment with corn. Growing of plants without N application on rich chernozem favored the considerable (about 1% of C_{org}) C growth, and on poor gray forest soil contributed to C decrease. Soil organic matter (SOM) decomposition in both soils under unfertilized plants was the same. N usage on gray forest soil resulted in increase of C accumulation due to the substantial increase of C input with roots of fertilized plants and as organic matter active phase of this soil was stable against decomposition under N. N application on chernozem in reverse significantly increased SOM decomposition and affected plant productivity to a lesser degree. Thus, N fertilizing favors C sink in arable soils of low fertility and can reduce soil C accumulation in arable soils of high fertility.

INTRODUCTION

C sequestration in agricultural soils under conventional land use that include tillage, mineral fertilizing and removal of crops production, is to a great extent determined by i) accumulation of roots in soil after harvesting and ii) ability of SOM to decomposition. N fertilizers on the one hand favor the intensification of CO_2 plant uptake from atmosphere and increase of C sink into the soil but, on the other hand can stimulate or reduce SOM decomposition. Effects of N fertilization on C sequestration in agricultural soils of different natural fertility with dissimilar SOM decomposability is not investigated enough. The aim of this work was to evaluate N fertilization effects on accumulation and decomposition of SOM in gray forest soil and chernozem.

MATERIALS AND METHODS

Gray forest soil (Moscow region, Russia) and chernozem (Tula region, Russia) were sampled from long-term arable plots. To the beginning of the experiment the two soils had following characteristics: gray forest soil– C_{org} – 1.0%, N_{total} – 0.10%, $N_{mineral}$ - 17 mg kg^{-1}; chernozem – C_{org} – 3.4%, N_{total} – 0.29%, $N_{mineral}$ - 65 mg. $Ca(NO_3)_2$ was applied as at the rate of 80 mg kg^{-1} soil. Greenhouse experiment with planted (corn) and unplanted soil lasted 75 days. SOM decomposition was evaluated by CO_2 emission after separation of root respiration by root-exclusion technique. Growth of C content in soils was calculated as a difference between accumulation of C in plant roots and SOM decomposition.

RESULTS AND DISCUSSION

Difference in natural fertility of gray forest soil and chernozem cause the ability of these soils to sequester C: in the unfertilized control on the gray forest soil plant biomass was in 3.4 times smaller than on chernozem (Table 1), and as SOM decomposition in the both soils was almost equal, C input into gray forest soil did not cover its losses while in chernozem considerable growth of C was established. N usage substantially changed sizes of C input into soil and soil C losses. Under N fertilization plant biomass on gray forest soil increased in the comparison with unfertilized control in 3.3 times, and SOM decomposition remained constant. On chernozem N fertilizer favors SOM decomposition intensification in 1.6 times, and C input increased only for 1.5 times in comparison with no-N variant. As a result N application promote C accumulation increase in poor gray forest soil to the level of C accumulation in rich unfertilized chernozem. N usage on chernozem led to some decrease of C growth in soil. Mentioned above differences in N influence on SOM decomposition in gray forest soil and chernozem are confirmed by direct evaluation of microbial pool sizes of these soils. $C_{microbial}$ content in initial gray forest soil consisted 253 mg mg kg^{-1}, at the end of the experiment under unfertilized plants– 251, under fertilized plants - 262 mg kg^{-1}. Chernozem initially contained 435 mg kg^{-1} of $C_{microbial}$, under unfertilized plants - 150 mg kg^{-1}, under fertilized plants - 30 mg kg^{-1}. It is obvious that microbial biomass, which to a great extent define SOM active phase [*Semenov et al*., 2001], in gray forest soil was more stable against decomposition in comparison with microbial biomass of chernozem.

Table 1. Influence of N fertilizing on plant productivity, rate of soil organic matter decomposition and growth of C in gray forest soil and chernozem.

Soil	Plant productivity at the end of the experiment, g pot $^{-1}$ (shoots + roots)		Rate of SOM decomposition, mg C-CO_2 kg soil $^{-1}$ day $^{-1}$ (mean)		Growth of C in soil at the end of the experiment, mg kg^{-1}	
	Without N	With N	Without N	With N	Without N	With N
Gray forest soil	14.0	46.5	3.9	4.0	-28	357
Chernozem	48.1	71.6	4.2	6.9	345	308

Several authors also mentioned, that "limiting the addition of N fertilizer can play a role in reducing soil C content, if the soil is not N-saturated" [*Freibauer at al.,* 2004]. As we concluded before [(*Tulina et al*., 2004; *Tulina and Stavrova*, 2005], strong positive correlation (r=0.941) between crop yields and C_{org} content in extremely poor soddy-podzolic sandy soil (Bryansk region, Russia) was established in the long-term field experiment. In this soil SOM decomposition decreased for 1.2 times under fertilization and since N increased C input and suppressed C output, C_{org} content in soil increased on average of 25 years by 240 kg ha^{-1} year^{-1} in comparison with unfertilized control. Our results agree with studies of other authors used field, laboratory and pattern data [*Buyanovsky and Wagner*, 1998; *Schlesinger*, 1999; *Kucharik et al.,* 2001], demonstrated that agricultural soils could be a C sink if the productivity of agroecosystems is of the adequate high level. Natural fertility of rich arable soils is evidently enough to ensure proper productivity level, and in poor soils N fertilizing can be appropriate tool.

CONCLUSIONS

Thus, N fertilizer usage on the soils of low fertility not only substantially increases yields, but also favors C sequestration. N application on more fertile soils much less influence crop yields and can reduce soil C content and intensify CO_2 emission.

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REFERENCES

Buyanovsky, G.A., and Wagner, G.H. (1998), Changing role of cultivated land in the global carbon cycle, *Biology and Fertility of Soils, 27*, 242-245.

Freibauer, A., Rounsevell, M.D.A., Smith P., and Verhagen J. (2004), Carbon sequestration in the agricultural soils of Europe, *Geoderma, 122,* 1-23.

Kucharik, C.J., Brye, K.R., Norman, J.M., Foley, J.A., Gower, S.T., and Bundy, L.G. (2001), Measurements and modeling of Carbon and Nitrogen cycling in agroecosystems of Southern Wisconsin: potential for SOC sequestration during the next 50 years, *Ecosystems, 4,* 237-258.

Schlesinger, W.H. (1999), Carbon sequestration in soils, *Science, 284*, 2950.

Semenov, V.M., Ivannikova, L.A., Kuznetsova, T.V., Tulina, A.S. and Kudeyarov, V.N. (2001), Kinetic analysis of the decomposition and mineralization of plant residues in gray forest soil, *Eurasian Soil Science*, *34*(5), 503-511.

Tulina, A.S., Kuzyakov, Y.V., Stavrova, N.G., Kuznetsova, T.V., and Semenov V.M. (2004), Soil carbon sequestration: role of mineral fertilizers, in *Agroecological Optimization of Land Use*, Kursk, 480-482 (in Russian).

Tulina, A.S., and Stavrova, N.G. (2005), Organic compounds of carbon and nitrogen in soil: role of long-term using of mineral and organic fertilizers, paper presented at Int. Conference on Practical Solutions for Managing Optimum C and N content in Agricultural Soils III, Prague, June 22-24.