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EFFECT OF STRAW AND GREEN MANURE ON BIOLOGICAL CONDITION SODDY-PODZOLIC SOILS

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Abstract

Estimation of changes of a biological condition (status) soddy-podzolic sandy soil under the influence of use of mineral fertilizers and biological resources (straw of a winter wheat and stubble green manure, separately and in a combination) was an objective of this research. Among the investigated kinds of fertilizers the strongest influence on the mortmass and mortmass carbon, number, activity of soil microflora and the content of soil microbial biomass have rendered straw in a combination with , postharverst green manure (intermediate culture), at the expense of increase in an input of the easily accessible for soil microflora organic matter. In this research mineral fertilizers without additives of organic materials essentially have not affected microbial activity

Key words*: biological activity, green manure, mortmass, nitrifying activity, number of microorganisms, soil microbial biomass, straw, soddy-podzolic sandy loam soils.*

INTRODUCTION

Under the conditions of a lack of manure and mineral fertilizers the most essential, annually completely renewed resource of organic matter and nutritious elements in arable soils are such biological resources of agrocoenosis - postharvest crop residue. In Russia it is annually made about 120 million т post-harvest residues of agricultural crops, to 80 % from them it is necessary on straw of grain and leguminous cultures. More than half residues real It is possible to use as fertilizer for retention and increasing the fertility of the arable soils. Thus in arable soils 36-90 kg nutrients (NPK) and 800-2000 kg of organic carbon counting on 1 ha-1 come back.

The green manure phytomass, including intermediate (stubble), grown up after cleaning of the basic winter grain culture (wheat, a rye or barley) can serve also as the important biological factor for improve of soils arable fertility.

The plant residues in agrocoenosis carry out various agroecological functions, including: serve as a substratum, a comfortable place of colonization, the basic accessible power material, a source of carbon and nutrients for soil microflora and are a major factor regulating microbiological activity in soils [1-5].

Results of scientific researches testify that inputs of phytomass of crop residues and green manure in soil improve biological, physical, agrochemical properties (are optimised), productivity of agricultural crops raises [6-8]. However in the scientific literature there are not enough the experimental data establishing quantitative parametres of changes of soil properties at use (entering) of straw in a combination with green fertilizers.

The work purpose - an estimation of changes of indicators of a biological condition of soddy-podzolic sandy soil at use on fertilizer of straw of a winter wheat and green manure biomass which has been grown up us stubble.

MATERIALS AND METHODS

The investigation took place in the long-term fertilization experiment located in Meshcherskaya Lowland (in the center of the East European Plain) (56° 03’ N, 40° 29’ E) at 150 m above sea level. The site is situated in the zone temperate continental climate,

average rainfall for the year - 599 mm, the average temperature for the year - 3.9° C. Soddy-podzolic sandy loam soil, are low in organic matter (C_{org} - 0.55-0.62 %) and nutrients, unstable water regime, acidity (pH_{kcl} - 4.5-4.9).

Researches spent in long-term field experience (in the practice ground of All-Russian Research Institute of Organic Fertilizers and Peat). Here (in this experience) since 1997 influence of application of straw of grain and leguminous cultures on reproduction of fertility of soddy-podzolic sandy soil and efficiency of cultures grain-row crop rotation is studied: a winter wheat - lupine - a potato - barley - annual grasses (lupine + oats).

In this article the experimental data received at carrying out of researches in a link of a crop rotation (3-rd rotation) discussed. Crop rotation: a winter wheat (*Triticum aestivum L.*) (2007-2008) - lupine (*Lupinus angustivolius L.*) (2008-2009). Harvesting of the grain winter wheat was spent in the beginning of August by means of the harvester Sampo-500 equipped with straw chopper, with crushing of straw till the length by of 7-10 cm, brought N30 (ammoniac saltpeter), disking with incorporation into soil of straw on depth 8-10 cm are spent and mustard white (*Sinapis alba*) are sowed. The vegetative period for mustard made 60-65 days. For this time the culture reached flowering phases. In the beginning of October made ploughing by a plough, thus the mustard phytomass together with winter wheat straw was in regular intervals distributed in a layer of earth 0-20 sm. Fertilizers brought under the scheme: 1. No treatment (0); 2. Mineral NPK-fertilizers (MF); 3. MF + winter wheat straw (WWS); 4. MF + WWS + postharverst green manure (GMa); 5. MF + WWS + GMs (in spring). Postharverst green manure brought in soil in a treatment with MF + WWS + GMa autumn before ploughing, in a treatment with MF + WWS + GMs - spring of next year.

Winter wheat straw and stubble green manure doses in are presented table 1. Mineral fertilizers (N30P60K60) brought in the spring, before seeding of lupine in the beginning of May.

Biological condition of investigated soil estimated on following parameters:to stocks mortmass (MM) - considered a decantation method, washing up of soil (from a layer of 0-20 cm) on a sieve of 0,25 mm [9]; number of the soil microorganisms participating in circulation of carbon and nitrogen - a crops and account method on nutrient mediums [10]; the microbial biomass C was measured by the rehydratation method based on the difference between C extracted with 0.5 M K2SO4 from dried soil at 65-700 C within 24 h and fresh soil samples with Kc coefficient of 0.25 [11]; nitrifying activity - on accumulation N-NO3 after 14 days incubation in laboratory conditions at optimum humidity of soil of 14 % (60 % WHC) and temperature 26 ° C.

For an estimation of a biological condition of soil counted also an integrated indicator of total biological activity **(TBA)** with use of a method of relative sizes: number of each group of microorganisms expressed in percentage, for 100 % accepted the maximum value. Relative values of variants and counted value of indicator **TBA** concerning a variant without fertilizers which accepted for 100 % are summarised. In tables and schedules in the samples of soil selected in 3 multiple frequencies from an arable layer (0-20 cm) from each allotment of experience average values of defined indicators are presented to two terms: in the spring before crops and in the autumn after harvesting.

Statistical analysis of experimental data and construction of schedules spent with use of computer programs Excel and Statistica 6,0.

RESULTS AND DISCUSSIONS

Incorporation into soil of winter wheat straw and mustard green manure has considerably increased receipt of organic substance and nutritious elements in soil (Table 1).

The quantity of the arrived vegetative material determines mortmass stocks in soil. Mortmass represents fossils of a vegetative, animal and microbial origin, fresh or initial transformation subjected. The considerable part of microbic populations, and also

character and intensity of biological processes, effective fertility and productivity is connected with this fraction biologically accessible nonhumicational organic substance [4].

Table 1. Receipt of organic substance and nutrient elements with a plant biomass into soil

Phyto-mass kind	C / N ratio	Inputs into soil				
		Dry substance, t ha^{-1}	C	N	P_2O_5	K_2O
			kg ha^{-1}			
Mustard biomass (elevated and roots)	16,2	2,48	950	58,7	24,8	61,4
Winter wheat straw	76,9	3,00	1200	15,6	5,8	20,7
Mustard biomass + winter wheat straw	28,9	5,48	2150	74,3	30,6	82,1

Agroecosystem security is defined by organic substance and energy sources mainly from mortmass stocks. Mineral fertilizers, increasing stocks of elements of a food in soil, cannot provide soil biota with necessary quantity of energy.

The received experimental data have shown high sensitivity of indicators of MM and C_{MM} to entering of straw and green manure. So, MM stocks in the arable layer of earth, made 3370 and 3040 kg ha^{-1} in treatment «0» and «MF» (accordingly), have increased to 5630 kg ha^{-1} at entering 3 t ha^{-1} WWS and to 6350 kg ha^{-1} in treatment «MF/WWS/GMa». The mortmass carbon stocks have increased approximately twice from entering of straw and stubble green manure (fig.1).

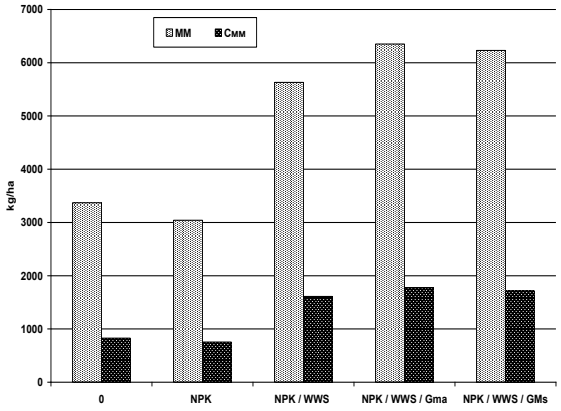

Fig.1. Mortmass stocks and C_{MM} in soil (0-20 cm)

The increase in stocks of easily transformed mortmass organic carbon at entering into soil of straw and green manure testifies security about to increase trophic resources, energy sources and humification in the soil biota. Winter wheat straw with wide parity C/N ratio =76,9 and mustard green with the high maintenance of nitrogenous connections represent contrast on biochemical structure and biological availability organic substrata. Taking into account it, use of straw of grain crops in a combination with green manure is more optimum in comparison with their separate entering. At a combination of straw with green manure and their joint applications the carbon and nitrogen parity in phytomass becomes more favorable (=28,9) for ability to live of soil microflora, therefore on the one hand - too high intensity of a mineralization green manure decreases, with another – difficultly decomposed lignino-cellulose complex in straw becomes more accessible to microflora.

Soil microorganisms are the major protagonists of organic matter decomposition and nutrient turnover in arable soils. It is known, that not only activity, but also number and a biomass of soil microorganisms can be essentially changed at addition of the plant residues in soil.

As a result of measurement of number of the soil microorganisms participating in transformation C - and N-containing connections, it is established, that after incorporation winter wheat straw into soil number agronomical useful groups of microorganisms has essentially raised: proteolitic - in 1,93 and 1,5; amilolitic - in 1,71 and 1,25; cellulolitic - in 1,94 and 1,57; nitrifying bacteria - in 1,88 and 1,38 times in comparison with a «0» treatment and «MF» treatment, respectively. Additional entering of mustard green manure, which characterised by higher maintenance of accessible organic substances with narrow parity C/N ratio as already it was mentioned above, has created more favorable conditions for soil saprophyte microflora. Therefore the soil was characterised by the maximum values of number of defined groups of microorganisms

and total biological activity (total relative biological activity) in a in a treatment with MF + WWS + GMa (in autumn before ploughing) (Table 2). The number increase anaerobe nitrogen fixation bacteria *Clostridium pasteurianum* in this variant in 10 times in comparison with nil treatment testifies that enrichment of an arable layer by organic substance of the vegetative rests in the form of straw and green manure promotes accumulation of biological nitrogen which can reach 2-15 kg on 1 т straw.

Stimulating action of straw and stubble green manure concerning microbiological processes and considerable growth anaerobe nitrogen fixation bacteria rivers *Clostridium* in vegetative and long-term field experiences on soddy-podzolic soils also observed Loshakov V. G et al (1995) and Emtsev V. T et al (1980) [13, 14]. Il'ina L.V.'s researches et al (1998) confirm value green manure as the factor providing interaction in communities of soil microorganisms in the course of decomposition of straw, and improving it fertilizing effect [6].

Decomposition of the vegetative residues in soil occurs to a mineralization of labile fractions of organic substance and microbial carbon formation [15].

Table 2. Parameters of a biological condition of soddy-podzolic soil at use on fertilizer WWS and GM

Variant of experience	CFU (Colony-forming unit), ths g^{-1} soils						TBA, %
	proteolitic	ammilolic	cellulolitic	micromicetes	nitrifying	Cl. pasteurianum	
0	5615	9700	19	58	8,2	175	100
MF	7200	13320	23	99	11,2	200	141
MF/WWS	10817	16584	36	83	15,4	508	175
MF/WWS/ GMa	13834	20308	42	106	21,0	1725	220
MF/WWS/ GMs	13484	19250	41 2.	100	20,7	950	213
LSD[1] 2800 3200 13 26 5,5 180							

(http://soilquality.org.au/factsheets/benefits-of-retaining-stubble-in-qld

Soil microbial biomass (bacteria, fungi and protozoa) is a measure of the mass of the living component of soil organic matter. The microbial biomass decomposed plant residues and soil organic matter to release carbon dioxide and plant available nutrients. Farming systems that increase plant residues tend to increase the microbial biomass).

The microbial biomass can serve as the important indicator characterized a biological condition of arable soils and representative diagnostic criterion of biological quality of soil organic matter [5].

As a result of the spent researches, content soil microbial biomass (C_{mic}) in a treatment «0» on the average for vegetative seasons of 2008-2009 of has made 312 μg g^{-1}. In our experiment application of mineral fertilizers was accompanied by insignificant growth C_{mic} to 348 μg g-1 (12 %). After entering of winter wheat straw C_{mic} has essentially increased on 68 μg g-1 (22 %). At joint entering winter wheat straw and green manure are noticed maximum in experience of value of the maintenance of a microbial biomass - 430 and 398 μg g^{-1}, that on 38 and 28 % above, in comparison with a nil treatment and treatment «MF», accordingly. The obtained data will be coordinated with results of researches in which substantial growth of microbial weight also is noted at entering of straw with full mineral fertilizer. In long-term field experiments in Denmark, Powlson et al. (1987) showed that straw manure could increase soil microbial biomass up to 45 % [5].

According to Fließbach A. et al (2000) if mineral fertilizers brought without carbon additives, they did not render positive influence on a microbial biomass whereas entering of straw in combination with mineral N-fertilizers has led to increase C_{mic} at 12 % in comparison with a background of alone mineral N-fertilizers [16].

Among the investigated fertilizer treatments, the combination of straw and green manure had the strongest impact on the microbial biomass. Similar data inform Kautz T. et al (2004) at entering of straw and green manure in sandy soils [17].

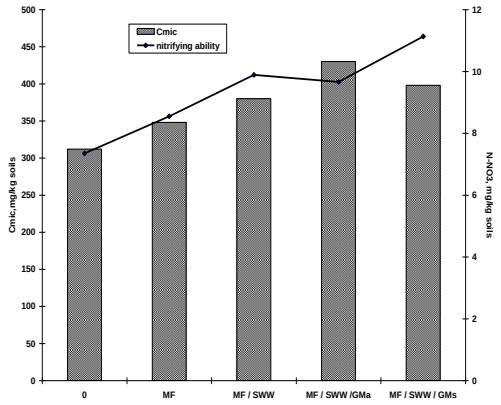

Fig.2. Content of a microbial biomass and nitrifying ability in an soil arable layer

Incorporation of straw into soil is often accompanied by such negative phenomenon, as decrease in ability of soil to nitrate formation as a result of an intensification biological nitrogen immobilization of the microorganisms, participating in its decomposition, especially in initial terms of decomposition.

In our researches, values nitrifying ability soils in the beginning of the vegetative period, before crops of cultures, in a «MF/WWS» treatment were above on 16 %, a treatment «MF / WWS / GMa» and «MF / WWS/GMs» - on 13 % and 30 % in comparison with a «MF» treatment (fig. 2). I.e. application of straw and stubble green manure has a little increased mobilization of nitric fund in soddy-podzolic sandy soil at the expense of additional receipt accessible nitrogen the containing organic substances and nitrifying bacteria activity.

CONCLUSIONS

Thus, use on fertilizer of straw of a winter wheat, separately and in a combination with stubble green manure entering at the expense of increase in an input and improvement of quality of the organic materials included in soil, has created more favorable conditions for soil microflora and substantially optimized a biological condition of soddy-podzolic sandy soil. soil. The mineral N-fertilization did not significantly effect biological properties of arable soils under this study.

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