Content of labile forms and plant residues in cultivated soils

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Abstract

The quick decrease of organic matter is a direct result of the sharp reduction of the biomass entering into the soil and quick mineralization of the organic matter in consequence of soil aeration after plowing. The rate of organic matter mineralization decreases till creation of an equilibrium state between the main processes – synthesis – decomposition.

The influence of farming production and plant output on the content of labile forms and the need for plant residues to conserve and increase soil fertility of alluvial meadow soil (Eutric sandy and loamy), calcareous (Calcic chernozems (CHcc), leached chernozem (Haplic chernozems (Chha) and pseudopodzolic soil (Planosols (PL) cropped with wheat, maize and lucerne was studied in the 2000-2004 period in the Institute of Forage Crops. The obtained results were compared with those of virgin analogues of these soils.

There is a marked tendency to increase of plant residues by 50-80% in all soils at both depths and detritus content by 40-60% in lucerne, as compared to wheat and maize, approximating and equalizing to that of virgin soil.

Among the studied crops, lucerne conditions the lowest values of the C:N ratio in soils and in this connection it could be affirmed that it improves not only the humus composition, but also the nitrogen balance in all soils. The formation of higher fertility of the soils, on which lucerne is grown, is obvious.

Key words: plant residues, organic matter, cultivated soils, labile forms

Introduction

Recently, stubble burning after harvesting has established itself as a practice in farming. The soil remaining after firing has worse physico - chemical properties. A part of organic matter on the surface burnt out, which is a prerequisite for decrease of fertility and yields. The burning destroys many useful predators and parasites, which leads to heavy increase of very dangerous pests, such as aphids, thrips, wireworms etc.

The quick decrease of organic matter is a direct result of the sharp reduction of the biomass entering into the soil and quick mineralization of the organic matter in consequence of soil aeration after plowing. After depletion of easily decomposable substances, soil microflora begins to attack the more resistant plant components and under certain conditions, some humus fractions. The rate of organic matter mineralization decreases till creation of an equilibrium state between the main processes – synthesis – decomposition (Juma and. al., 1984, Sallins and al., 1984). Several decades are needed to reach that state.

The objective of our study was to determine the influence of farming production and plant output on the content of labile forms and the need for plant residues to conserve and increase soil fertility.

Material and methods

The influence of farming production and plant output on the content of labile forms and the need for plant residues to conserve and increase soil fertility of alluvial meadow soil, calcareous, leached chernozem and pseudopodzolic soil cropped with wheat, maize and

lucerne was studied in the 2000-2004 period in the Institute of Forage Crops. The obtained results were compared with those of virgin analogues of these soils.

True humus substances and detritus were determined by the method of Springer (cited after Laktionov) and plant residue quantity by the method of Ganzhara.

Results and discussion

In fact the methods of analytical determination of C and N in soils determine C and N of soil humus. In our analytical scheme, the soil humus is divided into true humus substances and detritus. The C quantity in plant residues is determined separately. The full scheme of subdivision of the soil organic matter is: 1) true humus substances, 2) detritus, 3) plant residues.

The losses of organic (humus) C are the greatest in alluvial meadow soil (Eutric sandy and loamy) - 32% on average. They are higher, as compared to the other studied soils (Table 1) by 6 to 16%. At first sight, this seems to be rather illogical from the point of view of scientific logic for alluvial meadow soil. It has high content of clay minerals of the montmorillonite group, which as it is known, is rather good protection of organic matter from degradation processes, including mineralization. The true humus substances in plowing layer are conserved, as compared to virgin soil and detritus quantity falls to 20-37% of that in virgin soil.

In calcareous chernozem (Calcic chernozems (CHcc) the decrease of organic C in plowing layer is 26% on average.

Table 1. Variation in group composition of soil organic matter after plowing the virgin soils

Soils	Way of use	True humus substances in % of:		Detritus in % of:		Plant residues in % of:	
		Soil	Virgin soil	Soil	Virgin soil	Soil	Virgin soil
Alluvial meadow	Virgin soil	3.98	100	3.31	100	1.34	100
	field in crop	3.83-4.13	96-104	0.65-1.23	20-37	0.29-0.67	22-50
Calcareous chernozem	Virgin soil	2.71	100	2.17	100	1.97	100
	field in crop	1.72-1.75	63-65	1.73-2.19	80-101	0.95-1-62	48-82
Leached chernozem	Virgin soil	1.95	100	2.70	100	1.63	100
	field in crop	1.60-1.75	82-90	1.65-2.55	61-94	1.28-1.44	79-88
Pseudo-podzolic	Virgin soil	1.10	100	1.39	100	0.64	100
	field in crop	0.95-1.29	86-117	0.66-1.36	47-98	0.50-0.62	78-97

It is about 10% greater than that of leached chernozem and pseudopodzolic soil and about 6% lower than the reduction found for the alluvial meadow one. The true humus substances greatly decreased to 63-65% in comparison with the plowing layer. That confirms the supposition for a possible oxidative decomposition to a great extent. As for detritus, its absolute quantities also decrease, but to a considerably smaller extent, as compared to those of true humus substances. The reduction is 19 and 20% for wheat and maize, respectively and only 1% for lucerne. That can be explained by relatively light mechanical composition of calcareous chernozems of the Danubian province and predominance of silt fraction. The considerable decrease of the true humus substances leads to great and intensive degradation of soil structure, known as pulverization. This results in the often-observed dust storms and intensive wind erosion in these regions.

The leached chernozem (Haplic chernozems (CHha) is least liable to changes in the content of true humus substances during plowing of virgin soils. After plowing, these substances decrease only by 16%. In this respect, the leached chernozem occupies the lowest place among the studied soils. That is due to the combination of rather favourable factors of formation and accumulation of humus substances, resistant to degradation processes. These factors include, as follows: texture, mineralogical composition, high degree of saturation with bases of sorption capacity, favourable water-physical properties, heat and water regime. The true humus substances are 82-90% in plowing layers in comparison with virgin soils. The detritus content is very high, 61-90%. All that points to a very well balanced and stable composition of soil organic matter.

The pseudopodzolic (Planosols (PL) soil, with regard to the true humus substances, belongs to the group of leached chernozem – only a 17% decrease of organic carbon after plowing of virgin soil. The true humus substances in the plowing layers vary between 86 and 117 % of the virgin analogues and the detritus is within the range of 47 to 98%. The wide variation range in content of both true humus substances and detritus is an indicator of some instability of the system. The low values of degradation, though unexpected, can find their logical explanation based on the information about these soils. It is known that they have mainly fulvic composition and humic acids, if any, are represented by compounds with low relative participation of an aromatic nucleus in them, i.e. they have low aromatization, which confirms the studies of Krastanov (1968).

One of the most important functions of organic matter is to provide the plants with nitrogen. It was found in many studies that about 50% of the necessary nitrogen to plants is obtained to the expense of soil humus. Moreover, the role of the different fractions in plant nutrition is not equal; it is determined mainly by their mineralization capacity. The labile (quickly decomposable) forms of organic matter, which include leaf and grass fall in forest and virgin soils, post-harvesting residues in plowing analogues and intermediate products of their decomposition, detritus, are most actively liable to mineralization.

The content of labile forms of organic matter in plowing layers varies from 0.1 to 1.5 - 2.0% of soil weight and depends on the input of after-harvesting residues and the technology of crop growing (Pachev, 1997).

The C:N ratio in plant residue composition varies from 15 to 60 according to decomposition degree and with increase of humification degree, this ratio narrows to the range of soil humus (Table 2).

At C:N above 25, the mineralization processes are very intensive and predominate over the conservation processes, expressed as humification. The reason for this is that the building material to build the bodies of microorganisms is in shortage, as for nitrogen and in excess, as for energy material, carbon. In this situation, in order to provide themselves with the necessary nitrogen, the microorganisms process large quantities of organic residues, mineralizing them to CO_2 with high losses of organic matter. Addition of mineral N in quantities that reduce the C:N ratio to less than 25 accelerates the decomposition process and modifies it into formation of a pre-humus products of proteinaceous nature. At the same time, the fraction of pre-humus products is also enriched with lignin fragments – residues of plant tissues. Thus, the absolute and relative detritus quantities in soil are maintained at a high optimum level. It, in its turn, improves water-air properties of soil and maintains continuous nitrogen flow into soil solution. The result of this is a favourable nutritive regime and normal nutrition of grown plants. Through regulation of plant residue quantity and correction of the C:N ratio in them, we are able to exert a substantial influence on the water-air and nutritive regime in soils and on the level of soil fertility.

Table 2. Content of carbon, nitrogen, C:N ratio, labile forms of nitrogen, phosphorus and calcium

Soil	Crop	Depth cm	C	N	C:N	Labile forms		
						NO_3:N mg/ 1000g	P_2O_5 mg/100g	K_2O mg/100g
Alluvial meadow	Virgin soil	0-20	4.22	0.400	10.55	4.20	4.01	24.30
		20-40	2.22	0.231	9.61	1.40	5.03	24.30
	Wheat	0-20	2.98	0.308	9.67	4.20	28.11	48.60
		20-40	2.40	0.268	8.95	2.90	11.56	37.80
	Maize	0-20	2.59	0.312	8.30	3.50	21.93	48.60
		20-40	1.72	0.237	7.25	2.80	10.77	37.80
	Lucerne	0-20	3.02	0.407	7.42	2.80	11.6	35.10
		20-40	2.36	0.237	7.21	3.50	6.08	29.70
Calcareous chernozem	Virgin soil	0-20	2.89	0.158	10.56	4.40	9.45	35.10
		20-40	2.10	0.154	9.87	3.90	2.30	27.00
	Wheat	0-20	2.02	0.208	9.71	4.90	20.95	43.20
		20-40	1.76	0.201	8.71	2.80	9.86	29.70
	Maize	0-20	2.02	0.226	8.93	5.60	12.13	37.80
		20-40	1.84	0.196	7.55	4.20	3.53	43.20
	Lucerne	0-20	2.28	0.275	8.29	4.20	4.56	36.45
		20-40	1.83	0.202	9.05	3.50	4.16	28.35
Leached chernozem	Virgin soil	0-20	2.69	0.180	11.72	3.50	5.18	26.65
		20-40	1.79	0.102	11.96	4.20	4.75	18.00
	Wheat	0-20	1.97	0.194	10.15	2.80	30.47	64.80
		20-40	1.42	0.147	9.65	2.80	11.93	51.30
	Maize	0-20	2.38	0.246	9.67	5.60	15.29	35.00
		20-40	2.07	0.222	9.32	4.20	3.51	24.80
	Lucerne	0-20	2.47	0.250	9.88	4.90	44.10	75.60
		20-40	1.72	0.187	9.19	4.90	40.10	79.65
Pseudo podzolic soil	Virgin soil	0-20	1.44	0.102	14.11	3.50	15.63	18.80
		20-40	1.17	0.074	5.81	4.20	2.64	9.72
	Wheat	0-20	1.07	0.092	11.63	3.50	3.75	23.25
		20-40	0.75	0.071	10.56	3.20	1.63	20.60
	Maize	0-20	1.13	0.107	10.56	4.20	3.85	24.30
		20-40	0.83	0.085	9.76	2.80	0.34	21.60
	Lucerne	0-20	1.39	0.144	9.65	2.80	3.34	35.10
		20-40	1.04	0.117	8.88	2.80	1.58	29.70

Conclusions

There is a marked tendency of plant residues increase by 50-80% in all soils at both depths and detritus content by 40-60% in soil after alfalfa, as compared to wheat and maize, approximating and equalizing to that of virgin soil.

Among the studied crops, alfalfa conditions the lowest values of the C:N ratio in soils and in this connection it could be affirmed that it improves not only the humus composition, but also the nitrogen balance in all soils. The formation of higher fertility of the soils, on which alfalfa is grown, is obvious.

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