

AGRICULTURE SYSTEM IMPACT ON HUMUS BALANCE ON PLOWED SOILS FROM THE REPUBLIC OF MOLDOVA

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Abstract

It was stated balance of humus in soils of Moldova, which occupies an area of 1786 thousand ha. There is, practically, no application of fertilizers over the past two decades. Balance humus remains deeply negative, being characterized by an annual deficit of 2.212 thousand t or 1.24 t/ha. For slowing continuous decrease in soil fertility with annual plants sown area of 1500 hectares of land is proposed to reduce weeding crops with 256 thousand hectares, from 65% to 52%, stabilizing at approximately equal proportions between row crops and those sowed in dense rows. The largest expansion will be for the soils with perennial herb up to 15% (220 000 ha). And land with perennial crops will be grassed up to 88% of the surface. It will increase more than eight times that of the production of fodder and manure from 3.9 million t to 7.2 million t per hectare for plowing and return by 4.0 t/year of manure. Making the best use of manure will increase annual crop production by about 716,000 t of conventional wheat and approximately the same will be for the mass of humus in the soil. Additional humus synthesized from modification of sowing the crops and the application of manure will reduce annual losses of humus in soils show a 59%, making the balance to be with minus 0.51 t/ha. It will achieve an annual profit of about 1270 lei/ha with the return of 50%.

Keywords: Balance of humus, soil fertility, structure of cultivated crops.

It is unanimously known that organic matter from soil (humus) is the most important factor of soil fertility. A fertile soil means, first and foremost, a soil rich in humus. Humus has a beneficial influence on physical, chemical and biological indices of soil being in a close and direct correlation with plant productivity. Although humus is relatively stable complex, it is a and sustainable organic substances under the action of microorganisms which is subject to continuous decay and resynthesizing, serving them as nutritive material and energy source. Under perennial grasses, that leave annually in the soil a huge amount of plant debris, it dominates the process of humus accumulation, and under annual crops - the mineralization, including the previously accumulated humus. In sowed soils with annual row crops or those under perennial crops, where the soil is in a black field maintenance mode, there are always prevailing the processes of humus decomposition, od reducing the fertility of soils and therefore the productivity of cultivated plants. The latestare in only approximately 90% are represented by manure. The objective of given work is to describe quantitative balance of humus in soils show in Moldova and arguing some measures to improve it.

MATERIAL AND METHOD

There was achieved the appreciation of humus balance by calculating the difference between items of income and loss of interest. As items of income served the hummus intake from vegetable crop residues and manure mass that was produced annually, considering that the entire mass is incorporated into the soil. Normative indices used in the calculations are borrowed from his research Al.Donos, S.Andrieș (2001) (Table 1).

Article of humus losses were calculated by the sum of consumption of nitrogen for the formation of yields and losses through ammonification, denitrification and leaching, subtracting from this sum the contribution by symbiotic and non-symbiotic fixation of this item. Net consumption of nitrogen obtained from the respective crop was multiplied to the adjusting coefficient of the transformation processes of nitrogen in soil texture and soil tillage technology in every culture. In this regard the following factors were used to determine the soil texture by prof. A. Lakov (1985): loamy clays - 0.8, clays - 1.0, sandy clays - 1.2, clayey sands - 1.4, sands - 1.8. For groups of crops and agro-technical ones for the maintenance of soil were used the following coefficients: perennial grasses - 1.0, row crops densely sowed - 1.2, weeding crops - 1.8, black soil - 2.2.

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Since the soil texture after being sowed in Moldova has a representation of 60% of being loamy clays, the calculated consumption of nitrogen was multiplied by the coefficient 0.8. Then nitrogen consumption was recalculated in humus by multiplying to

the coefficient 19. Being obtained in such a way the total losses of humus through mineralization decreased from its synthesized contribution of vegetative losses, being established the humus balance for each of the crops taken under evaluation.

Table 1

Optimum indexes used in calculating the humus balance

Plant cultivated	Main production with natural humidity, t/ha		Coefficient of determining the dry mass of crop losses from main production	Coefficient of humification of crop losses	Coefficient of mineralization of humus from soil for main productivity unit formation	
	current, on average on 2003-2010 yrs	planned, in the conditions of structure improvements and manure high application				
		Model 1, with 16% perennial herbs				Model 2, with 26% perennial herbs
1. Wheat	2,14	2,48	2,57	1,40	0,12	0,66
2. Barley	1,70	1,97	2,04	1,40	0,12	0,64
3. Maize grains	2,83	3,28	3,40	1,00	0,12	0,82
4. Leguminous grains	1,11	1,29	1,33	1,14	0,21	0,14
5. Miliium, sorghum	2,00	2,32	2,40	1,10	0,17	0,66
6. Sun flower	1,26	1,46	1,51	4,24	0,14	1,38
7. Soya	1,50	1,74	1,80	1,14	0,21	0,38
8. Sugar beet	26,24	30,44	31,49	0,09	0,16	0,13
9. Tobacco	1,47	1,71	1,76	4,98	0,13	0,99
10. Brassica rape	1,70	1,97	2,04	4,24	0,13	1,59
11. Legumes, inclusively potatoes	9,06	10,51	10,87	0,11	0,15	0,21
12. Fodder root vegetabeles	23,44	27,19	28,13	0,07	0,17	0,08
13. Table green maize	10,21	11,84	12,25	0,14	0,13	0,11
14. Annual herbs, green mass	9,32	10,81	11,18	0,29	0,21	0,04
15. Perennial herbs, green mass	14,00	16,24	16,80	0,34	0,21	0,02
16. Orchards on black soil	4,53	5,25	5,44	0,80	0,06	0,30
17. Grassy orchards	5,25	6,09	6,30	1,23	0,13	0,11
18. Vineyards on black soil	3,51	4,07	4,21	1,11	0,07	0,46
19. Grassy vineyards	4,07	4,72	4,88	1,90	0,11	0,20
20. Herbs form orchards and vineyards	10,00	11,60	12,00	0,29	0,21	0,03

In the production of fodder crops it was calculated the nutrient content by multiplying its units to the respective coefficients. For fodder beet the coefficient of calculation the nutritional content is 0.12 units for maize green mass - 0.15, for green mass of *Vicia pannonica* from annual gramens and legumes - 0.21 and the green mass of the mixture of alfalfa and *Bromus non-aristatus* - 0.24. Then by comparing the daily nutritional doze of units required for maintaining livestock with a unit of the amount of manure, it has been estimated that on average 1 ton units nutrients, passing through the animal body, formed 3 t of partially fermented stable manure with litter. There were taken from the Statistical Yearbook /2011/ there were taken average data on eight years on the area planted with different crops. There were included in the surfaces plowed both land sown with annual crops and perennial plantings ones. There were also borrowed from this source the indexes of average production per hectare of crops and their cost price.

RESULTS AND DISCUSSION

Calculations made according to the parameters and methodology described showed that humus balance is negative for most crops. Plants with the highest consumption of fertility and humus deficit of over 1 t/ha per year formed following descending series: sugar beet, maize, *Brassica* rape, potatoes, fodder beet, vines, working the soil as black soil. With the exception of *Brassica* rape, they are weeding crops to keep the soil loose, thus stimulating mineralization of organic matter. Group weeding crops with relatively low humus deficiency is characterized tobacco, leaving a mass of over 7 t/ha of crop residues which summarizes approximately 950 kg of humus. Frankly speaking, *Brassica* rape leaves plant residues about as plant debris, but if it is compared to tobacco it consumes over 2.7 times more nitrogen to the crop formation (139.4: 52.5) and therefore wasteful of humus influences.

Modest requirements regarding the nitrogen and humus from the soil is shown by soya, peas, beans and other legumes, with the acquisition of fixing nitrogen in the air. From the soil the plant consumes little nitrogen, for 8 to 30 kg/ha, and respectively, not much humus, that is 158-564 kg/ha. Under annual legumes is created a relatively equilibrated balance of humus, which ranges from minus to plus 200 kg 100 kg/ha. Therefore, the cultivated plant are affecting the balance humus of crops in two ways: a) by the amount of nitrogen in the soil required to achieve the production potential and b) the mass of the residue remaining in the soil after crop harvest. From the range of plants grown in Moldova, large masses of plant debris, from 4.8 to 7.8 t/ha, leave the sunflower, tobacco, Brassica rape and perennial grasses.

In this regard, perennial grasses deserve a special attention because they had a positive impact through a triple action on humus. Perennial grasses, especially those sown in mixtures of gramens and legumes, not only leave many plant debris, but also make a contribution to the soil more than 100 kg/ha nitrogen fixed symbiotically, and by way of growth of continuous vegetation cover reduces by minimum the loss of nitrogen and organic matter, making it dominate the accumulation of these elements in the soil. The potential for accumulation of humus under perennial grasses sown exceeds three times more the consumption, forming an annual increase of over 700 kg/ha.

This storage phenomenon of humus is manifested conclusively in occupied soils with fruit growing and viticulture cultures. The soils here are

maintained in two variants opposite the humus dynamics. At present most soils with these cultures are maintained under a black soil where the annual intake of plant debris humus is very low, 470-787 kg/ha. Balance here remains deeply negative, characterized by an annual deficit of 640-1130 kg/ha. While the alternative with grassing of every third interval between rows (24-32% from the surface) increases by 1.4-1.6 times the mass of plant debris and increases the supply of humus from 1.6 to 1.8 times. They increased with more than 15% of fruit and grapes yields. The soil is fully insured in terms of anti-erosion being more than 10 times the risk (Erosion ..., 2004). In the fruit growing and viticulture plantations the perennial grass is reduced by 2.0 to 2.3 times or the loss of humus by mineralization setting a slightly positive balance of its rated at 280-380 kg/ha per year.

The actual structure of plowed soil in Moldova to 68% is made up of weeding and planting perennial crops, the soil where it is worked according to the agrotechnics of black soil (Table 2). These cultures, and, even more, the loose soil in which they grow, are causing great loss of humus. It was stated that in an annual cycle of the plowed surface it was shown of 1.786 million are mineralized 3.035 million t of humus, compensating it with crop residues 822 000 t - only 27 percent of the annual demand for balanced humus. There are required radical measures that would improve the humus situation of soil plowed, their fertility status. To achieve this goal it is necessary to

Table 2

Humus balance on arable soils of Republic of Moldova on different structures of cultivated crops

Cultivated crop	Actual structure with 2% perennial herbs and 69% row crops. Average on 2003-2010 yrs							Perspective model, with 26% perennial herbs and 46% row crops						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1.Wheat	324	18,1	693	971	117	458	-341	250	14,0	643	900	10	424	-316
2.Barley	122	6,8	207	290	35	133	-98	135	7,5	275	386	46	176	-130
3.Maize grains	471	26,4	1333	1333	160	1093	-933	240	13,5	816	816	98	669	-571
4.Peas, beans	38	2,1	42	48	10	6	+4	100	5,6	133	152	32	19	+13
5.Milum, sorghum	16	0,9	32	35	6	21	-15	10	0,6	24	26	5	16	-11
6.Sun flower	266	14,9	335	1421	199	463	-264	120	6,7	181	768	108	250	-142
7.Soya	41	2,3	62	70	15	23	-8	30	1,7	54	62	13	21	-8
8.Sugar beet	32	1,8	840	76	13	109	-97	60	3,4	1889	170	27	246	-219
9.Tobacco	4	0,2	6	29	4	6	-2	35	2,0	62	256	33	51	-18
10. Brassica rape	30	1,7	51	216	28	81	-53	30	1,7	61	260	34	97	-63
11.Legumes, potatoes	82	4,6	743	82	12	156	-144	110	6,2	1196	132	20	251	-231
12.Fodder beet	6	0,3	141	10	2	11	-9	40	2,2	1125	79	13	90	-77
13.Maize green mass	45	2,5	460	64	8	49	-41	90	5,0	1103	154	20	121	-101
14.Annual herbs	10	0,6	93	27	6	4	+2	30	1,7	335	97	20	13	+7
15.Perennial herbs	13	0,7	182	62	13	4	+9	220	12,3	3696	1257	264	74	+190
16.Orchards black soil	120	6,8	440	352	56	133	-77	20	1,1	73	59	9	22	-13
17.Grassy orchards	13	0,7	55	62	11	6	+5	113	6,3	481	539	97	54	+43
18.Vineyards black soil	138	7,7	575	639	109	265	-156	15	0,8	63	69	12	29	-17
19.Grassy vineyards	15	0,9	73	98	19	14	+5	138	7,7	668	902	171	133	+38
TOTAL	1786	100,0	-	5885	823	3035	-2212	1786	100,0	-	7084	1130	2756	-1626

Remarque: 1 – cultivated surface, thousand ha; 2 – cultivated surface, %; 3 – main production, thousand tone; 4 – vegetal residues, dry mass, thousand tone; 5 - Humus synthesized from vegetal residues, thousand tone; 6 - Humus mineralized from soil, thousand tone; 7 – humus balance, thousand tone.

improve, primarily spatial structure of crops. As indicators of cultivated areas with main cultures with major crops, there were taken the recommendations of Prof. B. Boincean (2005). Compared to existing surfaces cultivated with crops, it provides 49-55 percent reduction of soles cultivated with sunflower and corn grain. In their turn there will be expanded the fodder cultures up to 316 000 ha/year. Of course, the more pronounced will evolve perennial grasses. It is forecasted to expand the area cultivated with tobacco and legumes. Also, it will be expanded to a technological maximum the perennial plantations grassing.

The proposed changes in the structure of the cultivated plants in the soil humus will act beneficially in two ways. Directly, through massive intake of humus synthesized from plant debris and, indirectly, by sensitively reducing the intensity of mineralization previously deposited in soil humus. Compared to the current structure of cultivated plants in the model structure with 26% of perennial crops and 46% row crops, the annual input of humus will increase by about 37% $[(1130-823) \times 100: 823]$, and mineralization intensity will decrease by more than 9% $[(3035-2756) \times 100: 3035]$ (Table 3). Thus, development of proposals for improving the structure of plants would complete annual deficit of humus in soils show the country with 586 000 t or per unit of land, with 0.33 t/ha, thus compensating up to 27% of the current annual deficit humus.

There are appreciated as excessive the soils seeded with wheat, maize and sun flower. It is suggested to gradually reduce them with 74 thsnd ha, with 231 thsand ha and respectively, with 146 thsnd ha. There is an exaggerated area covered with these crops that do not allow organizing certain crop rotations to be more or less reasonable. They create as well overproduction and, with the exception of wheat, are great consumers of fertility.

There is an appreciation of the fact that as a result of seeded surface with wheat there will be no 158 thsnd tons of grains evaluated at a price cost of 281714 thsnd lei. As a result of seeded surface with maize there will be no 654 thsnd tons of grains evaluated at a price cost of 1166082 thsnd lei. Also as a result of seeded surface with sun flower there will be no 184 thsnd tons of grains evaluated at a price cost of 837568 thsnd lei. Per total the selling production of these three crops, that will be territorially limited, is estimated at a price of 2,28 biln lei MD/year or 136,8 mil EUR. This sum is, from the calculations made, appreciated as losses, due to decreasing the total area of seeded land with crops mentioned above, where the given production will not be obtained. There are foreseen, as well, expenses of about 2,5 billion

lei/year (7158 thsnd t x 350 lei/t) for production and application of stable manure. There is a great need of considerable financial investments in order to maintain the biofile elements of the entire annual mass of stable manure in the economic circuit and to recover the fertility of tilled soils. These investments, though, will be recovered with profit from increases in vegetative production. It is forecasted that the yield of all cultivated plants will raise to at least 20 per cent in comparison with the current one.

On the reduced land with wheat, maize and sun flower, of about 450 thsnd ha, they will extend up to 300 thsnd ha of seeded land with forage crops.

Of these the largest share of growth will have perennial grasses as unique plants accumulate humus soil and restore its structure. Compared to today's modest areas (13 000 ha), is expected sole with perennial grasses will increase by about 17 times, up to 220 mi ha. Area multilateral reasoned and strongly recommended patriarch our agronomy, Acad. M. Lupașcu (1996). Calculate the amount of land with annual crops, the perennial grasses will form 15% $(220 \times 100: 1500)$. And the share of perennial grass plantings will increase to 88%. The future structure of crops will also increase the share of land with vegetables and legumes, sugar beet, tobacco and other species that provide high profits per unit of land. The annual mass of forage will be sufficient for a zoo-technical production estimated to a value of 3,1 mil lei (1315 thsnd t u. n. x 0,11 t alive meat/t u. n. x 21469 lei/t alive meat). And because in our country the natural forage isn't widely expanded as goods, when calculating the monetary equivalent of zoo-technical production, it has started from the point where the relation of 1 t of nutritive units (n. u.) used as fodder assures an increase in body mass (alive meat) of cattle of about 0,11 t. And the price cost of alive meat goods constituted on average 21469 lei/t in 2003-2010 years. They will increase with about 60 thsnd ha the area seeded with peas, beans and other leguminous annual plants that, besides the fact they favorably influence the soil fertility and, lately, they are more and more demanded on the market, increasing the efficiency of their cultivation. Given that the proposed cultural structures will increase by 3.8 to 5.1 times the land planted with forage will increase or table feed and livestock production, including manure. The model with 26% perennial grasses annual amount of manure will increase by more than 3.7 mln t practically doubling the currently accumulated mass of the fertilizer. The capitalization of the entire mass of household 7.158 thousand t manure, not only will get an

impressive increase plant production estimated at 716 000 t wheat conventional but equally pretty and inflows will increase soil humus from manure. Together with humus synthesized from plant debris will succeed in reducing the annual

deficit of humus soils show the country of 2.212 thousand t to 910 000 t you say, the actual losses will reduce uncompensated humus than twice (1822 : 910).

Table 3

Sources and possibilities of recovering the humus in plowed soils of the Republic of Moldova

Specification	Structure of cultivated plants					
	actual, 2% perennial herbs, 60% row crops		of perspective, 16% perennial herbs, 57% weeding crops		of perspective, 26% perennial herbs, 46% weeding crops	
	mii t	t/ha	mii t	t/ha	mii t	t/ha
1. are formed vegetal residues	5885	3,30	6637	3,72	7084	3,97
2. is synthesized humus of vegetal residues	823	0,46	1009	0,56	1130	0,63
3. is mineralized humus from soil under cultivated plants	3035	1,70	3011	1,69	2756	1,54
4. Humus balance from modification of the structure of cultivated plants (row 2 - row 3)	-2212	-1,24	-2002	1,13	-1626	-0,91
5. it will be produced conventional stable manure of cultivated fodder plants	463	0,26	2565	1,44	3718	2,08
6. it will be produced the conventional stable manure per total [(3903-463) + row 5]	3903	2,19	6005	3,36	7158	4,01
7. Quantity of humus from stable manure that can be synthesized used as a fertilizer (row 6 x 0,1)	390	0,22	600	0,34	716	0,40
8. it will be accumulated per total humus in the soil from vegetal residues and stable manure. (row 2 + row 7)	1213	0,68	1609	0,90	1846	1,03
9. Balance of humus from soil on superior using of stable manure (row 3 - row 8)	-1822	-1,02	-1402	-0,78	-910	-0,51

As mentioned, look to improve soil fertility will be achieved through modification of crops and maximum use of organic fertilizers. Both tasks will require sacrifices, but worth pursuing gradually achieve these goals not only of strategic principles of maintaining soil fertility for future generations but also purely economic considerations of the moment. About the necessity and effectiveness of organic fertilizers known quite well (Lixandru, Filipov, 2012; Rusu et al., 2012). Less about the agronomic and economic effectiveness of different types of structure of crops.

The economic analysis of the future structure model of cultivated plants with 26% of perennial herbs in comparison with the existent one demonstrated that the total value of the obtained agricultural production from the modification of existing structure is estimated to 6,78 billion lei. The amount of crop losses that are expected to be reduced and the costs for the preparation and application of manure can rise to 4.51 billion lei. The difference of these figures shows that the cultivated land change in meaning and parameters mentioned, as also capitalizing manure as fertilizer, will bring an annual income estimated at 2.27 billion lei, or 136.5 million euros. Based on 1 ha of arable land in 1270 lei income will be, characterized by a return of 50%.

CONCLUSIONS

1. It was determined that today in an annual cycle of soils show the country of 1.786 million hectares and 3.035 million tons mineralized humus, compensating it with plant debris only 823 000 tones or 27 percent of the requirement for a balanced balance. Over the past two decades the inputs of organic matter in the soil with fertilizers practically realized. Humus remains deeply negative balance characterized by an annual deficit of 2.212 million t or 1.24 t/ha. The large losses of organic matter soil fertility decreases continuously, and with it crops and overall profitability of agriculture.

2. For soil fertility remedy the situation deplorable annual plants sown land is proposed to reduce weeding crops with 256 thousand hectares, from 65% today to 48% in future structure of sown areas. Thus the model of the structure future half of the area to be cultivated row crops and other plants half often drill, which is characterized by a reduced consumption of humus. Among them, priority will be given to the cultivation of perennial grasses in crop rotation - as the only plant species that enrich the soil with humus and restore its structure. It is expected that field and vegetable crop rotations with perennial grasses

Sole share will gradually increase to 15% and perennial crops will fully grassed up to 88% of the surface. Therefore, by modifying the structure of annual plants and perennial crop row spacing grassing the annual deficit of humus in soils show the country could be reduced from 1.24 t to 0.91 t/ha, or 27%.

3. In comparison with the current structure of plants grown in the proposed will increase from 150 thousand tons to 1.27 million tons/year, or 8.4 times the calculated mass production of feed dry which will ensure that growth of livestock production and the annual mass of manure. Annual mass of manure will increase from 3.9 million t at present to 7.2 million t in the future structure, or about twice. Plowing and return per hectare of 4.01 t/year of manure. Making the most of the mass of waste as fertilizer mentioned will increase crop production by about 716,000 t while conventional wheat and about the same as the mass of humus in soils show.

4. Of superior application of manure shall be compensated with 32% annual deficit of humus. Together with humus synthesized from plant debris location of the new structure of crops (27%), humus annual deficit could be compensated at 59% annual loss steadfastness to 0.51 t/ha or 41%, compared with the show the current in the soil. These losses of humus could be further reduced by increasing the share of crops in crop rotations generating humus, as well as the integration aside other sources of organic fertilizers.

5. Amelioration agronomic structure grassing land sown with spaces in orchards and

vineyards, as well as better use of manure as fertilizer to increase agricultural production provides a country-wide estimate to 6.78 billion MD/year (136, 5 million euros) and net income of 2.27 billion / year, increasing to 50% return on these works. Based on 1 ha of arable land will be income in 1270 lei/year and one lion will recover spent 1.5 lei.

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