WAYS AND SOURCES OF ACCUMULATING NITROGEN IN THE ARRABLE SOILS OF THE REPUBLIC OF MOLDOVA

CĂILE ŞI SURSELE DE ACUMULARE A AZOTULUI ÎN SOLURILE ARABILE ALE REPUBLICII MOLDOVA

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Abstract. *The investigation focuses on the estimation and concretization of the values of molecular nitrogen accumulation from the atmosphere biologically and non-biologically. Biologically, the accumulation of nitrogen in the soil is done through symbiotic and non-symbiotic bacteria from vegetal wastes, secondary production, organic and green fertilizers. Non-biologically, nitrogen accumulates from atmospheric precipitation water, industrial fertilizers and other sources.*

Rezumat. *Obiectivul investigaţiilor rezidă în estimarea şi concretizarea valorilor de acumulare a azotului molecular din atmosferă pe calea biologică şi nebiologică. Pe calea biologică azotul în sol se acumulează prin intermediul bacteriilor simbiotice şi nesimbiotice din resturile vegetale, producţia secundară, îngrăşămintele organice şi verzi. Pe cale nebiologică azotul se acumulează în sol din apa precipitaţiilor atmosferice, din îngrăşămintele industriale cu azot şi din amendamente. S-au elaborat parametrii medii ai articolelor de venit ale bilanţului de azot din solurile Republicii Moldova.*

Nitrogen, similar to water, solar energy and organogenic elements (carbon, hydrogen), is an indispensable element of the biological circuit of chemical elements, manifested through accumulation and transformation processes in various organisms, soil and environment. Nitrogen components found in soil serve as nutrition sources for plants and microorganisms. Without soil nutritive nitrogen, the vegetal pigment cannot be formed. Chlorophyll provides the natural development of photosynthesis processes, the growth and the development of plants, as well as the formation of main and secondary production. The value and the harvest quality of different cultures depend, to a great extend, on the level of providing the plants with accessible nitrogen in soil.

At present, there are known two main ways of accumulating nitrogen in soil: biological and non-biological. The non-biological molecular nitrogen accumulation from the atmospheric air in soil, which constitutes 78.06% of the volume and 75 % of the weight, is produced when the nitrogen molecule (N≡N) gets into direct contact with hot air currents. This thermal energy equal to 225 kkal and appears in the warm period of the year when the clouds charged with opposite electric charges collide. In such conditions, the tight links between atoms

weaken and the nitrogen molecule begins to disintegrate coming into reaction with the hydrogen found in the precipitation water according to the following reactions:

1) $N_2 \xrightarrow{+225kkal} + 3\ H_2 = 3\ NH_3$ 2) $NH_3 + H_20 = NH_4OH$

In the Republic of Moldova, the value of accumulation of the nitrogen in soil caused by precipitations per an agricultural year constitutes in average: 15 kg/ha in the Northern pedo-climacteric zone, 13 – in the Center and 11 kg/ha in the Southern zone (Table 1).

This principle is also used when producing industrial fertilizers containing nitrogen from molecular nitrogen of the atmospheric air. The most wide spread chemical fertilizers in the Republic of Moldova are ammonium nitrate, carbomid, amophos, nitrophosc, ammonium anhydride, ammonia water and complex liquid fertilizers (N-8-10; P_20_5-28-34).

In a 75-year period (1930-2005), 2938.6 thousand tons of nitrogen mineral fertilizers were incorporated into the soil. The largest quantity was applied in the period 1980-1990, when each hectare of ploughed land received 66-70 kg of nitrogen (Table 2). This contributed to the creation of a positive balance of nitrogen in soil. At present, the level of application of nitrogen mineral fertilizers is of 1.4-21.0 kg/ha, the average - 11 kg/ha, which is insufficient in order to form a balanced equilibrium of nitrogen in soil.

Table 1

Dynamics of applying mineral fertilizers containing nitrogen as active substance in the arable soils of the Republic of Moldova

Investigated period	were applied			
	kg/ha	thousand tons on the whole agricultural surface		
	In average per year	Annual average	thousand ha	thousand tons
1930-1950 (20 years)	1.9	3.2	1684.2	64.0
1951-1960 (10 years)	2.0	3.6	1800.0	36.0
1961-1965 (5 years)	6.2	13.0	2096.8	65.0
1966-1970 (5 years)	15.7	33.8	2152.9	169.0
1971-1975 (5 years)	35.4	75.6	2135.6	377.0
1976-1980 (5 years)	46.6	99.6	2137.3	498.0
1981-1985 (5 years)	70.4	148.2	2105.1	741.0
1986-1990 (5 years)	66.2	138.0	2084.6	690.0
1991	40.0	87.0	2175.0	87.0
1992	30.0	65.0	2166.6	65.0
1993	9.0	20.0	2222.2	20.0
1994	4.0	9.0	2250.0	9.0
1995	11.0	9.6	872.7	9.6
1996	6.0	13.0	2166.7	13.0
1997	4.3	9.4	2186.0	9.4
1998	3.1	6.8	2193.5	6.8
1999	1.4	3.0	2142.8	3.0
2000	3.4	7.6	2235.3	7.6

2001	15.0	11.2	746.0	11.2
2002	18.0	14.7	817.7	14.7
2003	19.0	13.3	700.0	13.3
2004	19.0	14.2	747.4	14.2
2005	21.0	14.8	704.8	14.8
Average (1930-2005)	19.5	35.4	1580.6	2938.6

The biological way of accumulating nitrogen in soil includes: symbiotic and non-symbiotic fixation of nitrogen, vegetal remains, secondary production, organic fertilizers of different origin, green fertilizers, organogenic remains and residue, alluvial soil, mud, lacustrine sludge and other sources.

Symbiotic and non-symbiotic nitrogen fixation has a significant quota in the income articles of nitrogen in arable soils and constitutes in average 69.9 kg/ha of arable land (Table 2).

Vegetal remains and only 1/3 of the secondary production entirely used can compensate 50 % of the nitrogen consumed in the main production, mineralization and other non-productive nitrogen losses in soil. 48 kg/ha of nitrogen can yearly be returned into the soil with the help of vegetal remains and 1/3 of the secondary production.

Table 2

Biologic nitrogen fixation potential in the cultivation of agricultural plants in the conditions of the Republic of Moldova

Culture	Yield/ ha	Parameters of accumulation in soil through bacteria				total biologic nitrogen fixation potential, kg/ha
		symbiotic		non-symbiotic		
		kg/t*	kg/ha	kg/t*	kg/ha	
Peas	2.0	37.0	74.0	8.3	16.3	**90.3**
Vetch	1.5	43.3	65.0	7.9	11.8	**76.8**
Soya	1.5	48.0	72.0	8.5	12.8	**84.8**
Beans	1.2	16.7	20.0	8.1	9.7	**29.7**
Hungarian vetch (hay)	3.5	12.3	43.0	5.5	19.2	**105.2**
Clover (hay)	5.0	13.0	63.0	9.5	47.5	**110.5**
Onobrychis caputgalli (cocks head) (hay)	6.0	21.0	126.0	10.0	60.0	**186**
Alfalfa (hay)	7.0	27.0	190.0	10.7	74.9	**264.9**
Cereals (grains)	3.5	-	-	4.1	14.4	**14.4**
corn	4.0	-	-	1.9	7.6	**7.6**
Beet (roots)	35.0	-	-	0.9	31.5	**31.5**
Sun flower	2.0	-	-	8.0	16.0	**16.0**
Tobacco	2.0	-	-	8.2	16.4	**16.4**
Vegetables and potatoes	22.0	-	-	0.5	11.0	**11.0**
Tree and vine strings and branches	9.0	-	-	0.3	2.7	**2.7**
Average	-	27.3	46.4	6.2	23.5	**69.9**

Note: kg/t of main production

Table 3

Nitrogen accumulation potential in soil through vegetal remains and 1/3 of secondary production in cultivating various cultures

Culture	Yield t/ha	Accumulation (kg/ha N):				Average multiannual surface, thousand ha	Accumulation potential in soil, thousand tons N
		1/3 secondary production	Stubble field and other vegetal wastes	Roots in 0.6 m layer	total, kg/ha		
Vegetables (grains)	1.5	-	16.6	20.8	37.4	90	3.4
Autumn cereals (wheat, barley)	3.0	5.4	21.0	22.8	49.2	390	19.2
Spring cereals (barley, oats)	2.5	4.1	15.0	17.9	37.0	80	3.0
Corn (grains)	3.5	17.3	14.8	20.5	52.6	310	16.3
Sun-flower	1.5	15.6	56.2	16.4	88.2	100	8.8
Tobacco	2.0	-	75.5	42.6	110.1	30	3.5
Sugar beetroot	30.0	33.0	18.0	13.6	64.5	80	5.2
Fodder beetroot	50.0	25.0	30.0	22.5	77.5	10	0.8
Corn (silo)	15.0	-	23.9	39.5	63.4	60	3.8
Hungarian vetch	12.0	-	34.6	47.4	82.0	40	3.3
Perennial grasses	7.0	-	37.8	103.7	141.5	80	11.3
Vegetables and potatoes	15.0	-	74.7	26.8	101.5	110	11.2
Vine yards	5.0	-	21.6	8.1	29.7	210	6.2
Orchards	8.0	-	34.6	13.0	47.6	180	8.6
Other cultures	2.8*	5.1	19.6	21.3	46.0	330	15.2
Average		**15.1**	**32.9**	**29.1**	**77.1**	**2100****	**119.8**

*in cereals units; ** total thousand ha of agricultural land

The recovering of nitrogen in soil through the application of organic fertilizers is the most important compensation source of nitrogen in soil (Table 4).

If the accumulation and utilization of these organic sources were well organized, then more than 276,000 hectares of arable soil could be fertilized at a norm of 40-50 t/ha, thus recovering 28-36 kg/ha of nitrogen in soil annually (Table 4).

Table 4

Nitrogen contents in organic fertilizers and the possibility of soil enrichment with this element through them (generalized data)

Component	N contents, kg/t gross mass	Application norm– annual average for crop rotation, t/ha	Restoring potential and fertilization per year	
			Accumulation of N in soil, tons	Can be fertilized, ha
Cattle manure				
with cover	5.6	5.7 (40)	19197	85701
without cover	3.9	8.6 (60)	12644	54034
semi-liquid	2.0	14.3 (100)	471	2355
fluid	2.2	28.6 (200)	8492	19300

Pig manure				
with cover	8.2	4.3 (30)	6560	26667
without cover	5.7	5.7 (40)	5569	24425
fluid	2.3	28.6 (200)	5175	11250
Bird droppings				
with cover	22.2	1.4 (10)	2065	9301
without cover	16.3	2.1 (15)	1516	6200
fluid	1.4	28.6 (200)	7508	26814
Ovine manure				
with cover	9.5	3.6 (25)	2594	10922
without cover	9.2	4.3 (30)	920	3333
Average for all types and forms				
with cover	11.4*	3.8* (26)	30416	132595
without cover	8.8*	5.2* (36)	20649	87992
semi-liquid	2.0*	14.3* (100)	471	2355
fluid	2.0*	26.6* (200)	21175	53364
Total			**72711**	**276306**

* Average content of nitrogen and the average application norm of different types and forms of manure; in brackets is indicated the norm of fertilizer, t/ha in rotation once in 7 years

The sources for nitrogen recovering in soil with the help of organogenic remains, mud, alluvial soil, and from different constructions are presented in Table 5.

An additional source of nitrogen accumulation in arable soils could be green fertilizers, which can be produced in the Republic of Moldova on a total surface of 8,000 – 10,000 hectares, accumulating more than 175,000 tons of nitrogen or 20-20 kg/ha per year.

Table 5

Nitrogen potential contents and reserves accumulated from various oganogenic residues in alluvial soil and in lacustrine mud

Material	total volume, thousand tons	Contents of N, kg/t	Application norm – annual average, t/ha	Total nitrogen contained tons	Can be fertilized, hectares per year
Hydrolytic residuum	5.0	16.3	15	81.5	333
Hydrolytic lignine	14.4	1.4	24	6.15	600
Mud originating from water purification	1200	12.0	40	14400	30000
Defecation mud	1000	3.1	40	3100	2500
Lacustrine mud	538000	1.9	100	17350	5300
Soil removed from construction sites	150	2.1	150	3150	100
Alluvial soil (0-50 cm)	90000	1.7	200	35294	4500
Total	**630369**	**5.5 (average)**	**81**	**73382**	**16333**

CONCLUSIONS

So, the nitrogen income articles in the agricultural soils of the Republic of Moldova are multiple and have different volumes. According to importance and origin, these can be conventionally arranged in the following way: crop rotations with perennial grasses and vegetable cultures; all vegetal remains from surface and roots; secondary production of different cultures; non-symbiotic nitrogen fixation in the cultivation of non-vegetable cultures; nitrogen from seeds and planting materials; nitrogen accumulated from precipitations;; green vine strings and branches of fruit trees remained after clipping; wastes from industrial enterprises and communal households; mud from lakes and ponds; alluvial soils from valleys and meadows for the amelioration of eroded soils; the fertile stratum from construction sites.

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