Scientific Papers. Series A. Agronomy, Vol. LXII, No. 1, 2019
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PEDOFUNCTIONAL EFFECTS INDUCED BY ALGALIZATION OF TYPICAL CHERNOZEM HUMUS MODERATED WITH CYANOPHYTA ALGAE NITROGEN FIXATORS UNDER IRRIGATION

Victor ȘALARU, Gheorghe JIGĂU, Elena TOFAN, Sergiu DOBROJAN, Nina PLĂCINTĂ, Eugeniu CIOBANU

Moldova State University, 60 Alexe Mateevici Street, Chisinau, MD-2009 Republic of Moldova

Corresponding author email: salaruvictor@yahoo.com

Abstract

Algalization - administration procedure in the soil of living algal cultures in order to restore trophic chains within soil microbiocenoses, which have a beneficial impact on all levels of soil ecosystem organization. At the lower levels (bio-cellular, ionic-mineral and elementary particle) involves biochemical processes and organic-mineral with the formation of active substances which determines the structural-aggregate organization of soil mass which involves several evolutionary stages: 1. Elementary particle $\frac{algae}{microbiota}$ *elementary particle → microaggregates (< 0.25 mm); 2. Microaggregates* $\frac{algae}{microbiota}$ *elementary particle → aggregate (1-0.25 mm); 3. Aggregate (1-0.25 mm)* $\frac{humic}{substances}$ *aggregate (1-0.25 mm) → aggregate 7-1 mm. Within these processes three groups of structural aggregates with different pedogenetic stability and functions are formed.*

Key words*: algalization, structural-aggregate organization, pedogenetic stability.*

INTRODUCTION

In the literature, the place and role of algae in pedogenesis is more frequently examined in the context of the early stages of pedogenesis process. In this sense, algae are assigned the role of principal source of organic matter necessary for the operation of microbial “biocenoses”. Recent research, however, has shown that, as the pedogenesis process and soils evolve the role of algae does not decrease but on contrary increases. In this context, it was established that algae directly participate in several biochemical and physical processes that occur in soils: the accumulation of organic substances and nitrogen fixation from the atmosphere, decomposition of primary and secondary minerals, redistribution and accumulation of biophile elements and aggregation - structuration. Mechanisms and quantitative expression of these processes are less studied.

This implies the need for systematic studies in the field. In light of above this paper aims to study the pedofunctional effects induced by alagalization of typical chernozem humus moderated with cynophyta algae nitrogen fixators under irrigation.

MATERIALS AND METHODS

Research was conducted during 2016-2018 in the central area of Moldova. Soils within experimental land are represented through typical chernozems humus moderated loam clay with relatively high potential for aggregation. Irrigation method used is drip irrigation.

The water source is conventionally suitable for irrigation. Experience scheme:

1. Control;
2. Algogenic preparation *Nostoc flagelliforme* (3 kg/ha);
3. Algogenic preparation *Anabaena minima* (3 kg/ha).

Structural-aggregation analysis was performed by Savvinov method. For calculating the quality indices of structural-aggregate have been applied relations:

$$Ks = \frac{A}{B} \quad (1)$$

where:

Ks - coefficient of structure;

A - aggregates content with dimensions 10-0.25 mm;

B - summary content of aggregates > 10 mm and < 0.25 mm.

$$Kafi = \frac{A}{B} \quad (2)$$

where:

Kafi - coefficient of structure;

A - aggregates content with dimensions 7-1 mm;

B - summary content of aggregates > 7 mm and < 1 mm.

$$Kc = \frac{A}{B} \quad (3)$$

where:

Kc - aggregate stability index;

A - aggregates content 1-0.5 mm fractionated in water;

B - aggregates content 1-0.5 mm dry fractionation.

RESULTS AND DISCUSSIONS

Algalization-soil administration procedure in the soil of living algal cultures in order to restore trophic chains in soil biocenosis and support for pedofunctional processes has come to the attention in the relatively recent research (Lupascu & Jigau, 1998; Jigau, 2009; Jigau et al., 2018 a; 2018 b.; Dobrojan et al., 2016).

The specified research has shown that algalization has impact on pedofunctional processes at all levels of structural-functional of soil ecosystem.

At bio-cellular level cyanophyta algae nitrogen fixators in their capacity as nucleus of cyano-bacterial coenoses lead to the formation of organisms responsible for decomposition of various groups of organic substances (geno-metabolic chains), which decompose the consecutive organic residues by enriching organic matter with nitrogen in a closed circuit of substances and energy.

At ionic-molecular level algae-bacterial coenoses creates a vital environment which favours starting the humification processes of algae-bacteria dead mass with the formation of active organic substances represented by macromolecular organic compounds and pseudohumic substances.

Elementary particle level involves organic-mineral reactions with the formation of organic-mineral compounds (Figure 1).

Processes specified quantitatively and qualitatively materialize in the "aggregate" hierarchical level, which involves two groups of structural-aggregate organization:

a) Direct - binding of elementary particles and microaggregates by means of agglutinated substances secreted in the algae activity process (gels and coagulants);
b) Indirect - are interleaved with algae activity within the carbon circuit in the system: external biocoenosis (upper plants) and internal biocoenosis (soil biota).

Through this prism of ideas cyanophyta algae provide carbon and nitrogen circuits in the soil:

1. Short duration - within biological circuit of chemical elements in the trophic chain algae - microbiota - algae.
2. Long duration - in the process of formation and humus accumulation.

The circuit ensures development of plant root system and enhancing its role in the soil mass structure with the formation of bullet aggregates (7-3 mm).

In the long duration circuit, humic substances forming with the cations of metals and clay minerals stable compounds that are associated in grain structural formations (3-0.5 mm). Within these mechanisms, the grain structural aggregates are produced in situ formed with participation of soil internal biocoenosis.

This is intensive in the layer 0-30 cm. This implies that the aggregation activity of internal biocoenosis is intercorrelated with the activity of structuration of root system plants. The interaction between plants and algae in this process has direct character algae - plants or indirect plant - algae - microbiota - algae - plant. The role of algae in this sense implies stimulation of microbial activity, part of humification process. In this respect, organic substances in the soil follows to be perceived as bio-organic substances which include non-specific organic matter (organic residues) in various decomposition phases, specific organic substances (humic substances) and microbiota associated with these two groups of substances (Jigau et al., 2018).

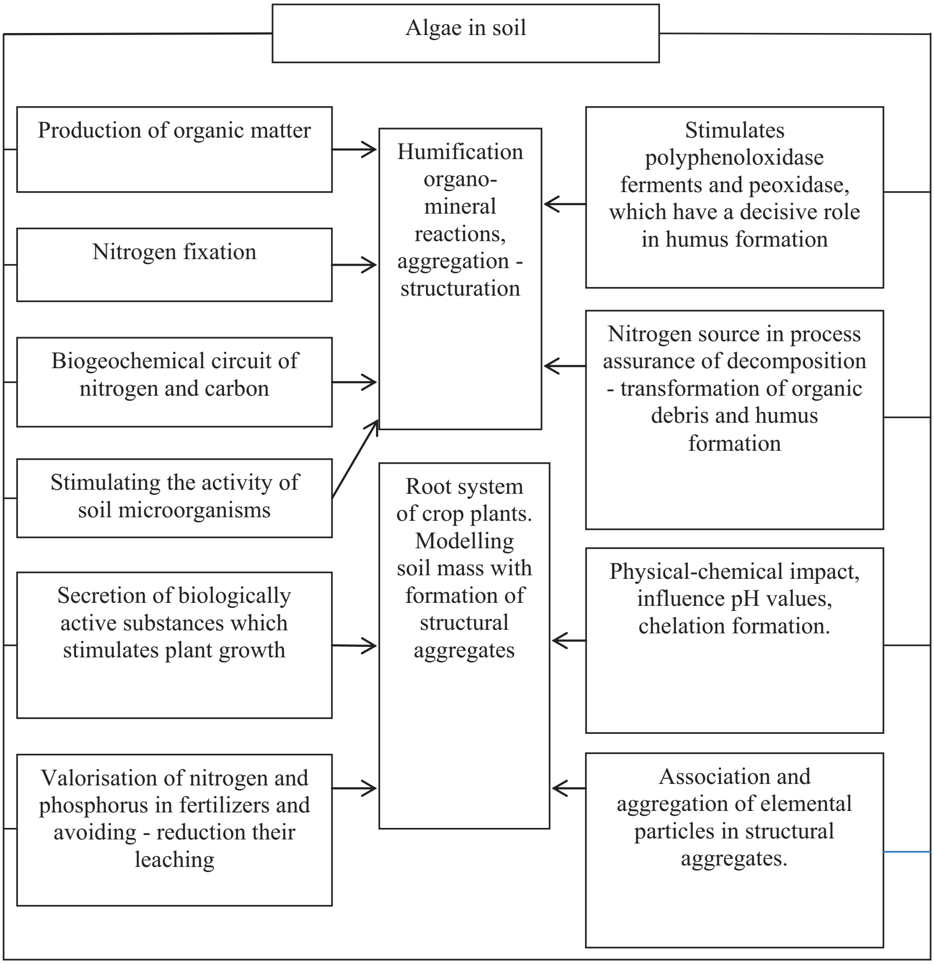

Figure 1. Place of algae in aggregation structure of soils

The biocoagulation of structural-aggregation process of pedomatrix with participation of algae includes several evolutionary stages:

1. Elementary particle $\frac{algae}{microbiota}$ elementary particle → microaggregates (< 0.25 mm);

2. Microaggregates $\frac{algae}{microbiota}$ elementary particle → aggregate (1-0.25 mm);

3. Aggregates (1-0.25 mm) $\frac{humic}{substances}$ aggregates (1-0.25 mm) → aggregates 7-1 mm.

Within these processes three groups of structural aggregates are formed:

a) Low stability - 7-5 mm;
b) With moderate stability - 5-1 mm;
c) With increased stability - 1-0.25 mm.

Through this prism of ideas aggregates > 7 mm have an abiotic origin. Their formation is determined by physico-mechanical processes. Intensification of formation processes and humus accumulation contributes to the intensification of soil invertebrate's mesofauna biological activity, and respectively of coprogenic structuring processes, increasing over time (Table 1).

Table 1. Post-action of algal preparations on invertebrate mesophane activity in typical chernozem humus moderated (irrigated regime), mean values, layer 0-50 cm (un/m^2)

Version	Year											
	Beginning of growing season						End of growing season					
	2016		2017		2018		2016		2017		2018	
	Copr	Cerv	Copr	Cerv	Copr	Cerv	Copr	Cerv	Copr	Cerv	Copr	Cerv
Control	29	37	28	38	27	35	33	42	36	41	33	39
Nostoc flageliforme	32	39	33	43	35	45	39	49	40	52	47	58
Anabaena minima	36	43	35	41	37	44	65	77	67	80	76	94

According to Kovda (1973) the formation and reproduction of humus reserves in soil involves intercalated action mechanisms of invertebrate's mezofauna and soil microbiomes. The earthworms assimilate preferentially soluble humic substances and slightly subject to mineralization of organic matter in various stages of decomposition and forming coprolites enriched in carbon and nitrogen. This is due the overlap, in time of biological activity of earthworms and microbiomes responsible for formation processes and humus accumulation: during the active nutrition of earthworms in soil, microbiological activity is intensified. This leads to the formation of intermediate products which are framed in the resynthesis process and humification.

The data presented in Table 1 highlights the intensification of intervertebrate mesofauna activity both in the administration of *Nostoc flagelliforme* culture as well as in the case of culture with *Anabaena minima*. An increase in time of this index allows us to consider the soil slowly the trophic chains are restored algae microbiomes materialized in the intensification of formation and humus accumulation. The decisive role in the structuration - aggregation of soil mass returns to biocoagulant processes determinate intercalating action of root system and coagulation processes.

From Table 2 we find that in the early stages of growing season agronomical valuable aggregate content (10-0.25 mm) in all three investigates variants is excellent. However, already at this stage we find the positive influence of algae microflora on the structural-aggregation process. The maximum effect of this process is within *Nostoc flagelliforme* version, both with aggregate content 10-0.25 mm and 5-1 mm. During vegetation, this variant stands out strongly by the Control version through content of these groups of aggregates. The effects of aggregation structure determined by *Anabaena minima* species are later; these are intensifying over time and presenting excellent values at the end of growing season. In the *Nostoc flagelliforme* version in the aggregates composition 10-0.25 mm predominates 5-1 mm. Their content makes up 54.32 % of soil mass or 64.47 % of agronomic valuable aggregates. In the case of *Anabaena minima* version the aggregate content 5-1 mm does not differ essentially from the Control variant.

Table 2. Dynamics of structural quality indices of typical chernozem humus moderated under algalization conditions (Irrigated regime) (Mean values, layer 0-50 cm)

Terms of sampling	Version	Agronomical valuable aggregate content (10-0.25 mm)	Precious agronomic aggregate content (5-1 mm)	Coefficient of structure (Ks)	Coefficient of structure (Kafi)	Aggregate stability index (Kc) %
May	Control	80.34	46.54	4.38	1.35	318
	Nostoc flagelliforme	85.58	54.32	8.12	2.05	492
	Anabaena minima	87.73	46.42	5.71	1.45	347
June	Control	72.33	39.56	3.95	1.37	426
	Nostoc flagelliforme	80.06	50.33	4.63	1.68	542
	Anabaena minima	73.50	42.73	2.96	1.23	411
July	Control	72.07	37.85	3.30	1.13	396
	Nostoc flagelliforme	79.75	47.91	4.44	1.16	458
	Anabaena minima	77.13	41.85	4.03	1.18	387
August	Control	71.80	36.14	2.65	0.88	306
	Nostoc flagelliforme	79.45	45.49	4.24	1.09	375
	Anabaena minima	80.76	40.98	5.09	1.13	363

Table 3. Dynamics of aggregate content > 7 and 7-1 mm in the aggregate composition of typical chernozem humus moderated under algalization conditions (Irrigated regime) (Mean values, layer 0-50 cm)

Terms of sampling	Version	Aggregate content > 7 mm	Aggregate content 7-1 mm	
			7-1 mm	% from ∑ 10-0.25 mm
May	Control	28.39	58.95	73.21
	Nostoc flagelliforme	24.02	64.89	75.82
	Anabaena minima	26.04	58.41	72.30
June	Control	28.19	55.43	70.44
	Nostoc flagelliforme	21.65	60.23	74.86
	Anabaena minima	31.55	53.29	72.57
July	Control	29.50	50.87	69.65
	Nostoc flagelliforme	20.82	54.43	71.37
	Anabaena minima	30.05	53.09	69.08
Augu st	Control	30.81	46.31	68.85
	Nostoc flagelliforme	19.99	55.57	67.88
	Anabaena minima	28.55	52.89	65.59

During the vegetation period in all variants in the structural - aggregate composition predominated 7-1 mm. With maximum capacity of their formation is characterized
Nostoc flagelliforme where their content in the first half of vegetation periods makes up (75.82-74.84 %).

Anabaena minima version through the content of these aggregates differs insignificantly from Control version. In the second half of vegetation period, aggregate content 7-1 mm is reduced to all variants. However, for algalized variants their content is higher than Control version. This allows us to conclude that aggregates 7-1 mm formed with participation of cyanophyta algae have greater aggregate stability. In support of this assertion it's coming Aggregate Stability Index (Kc) and dynamic indices of aggregate stability (Table 4).

From the last we find that in case of algalized versions there are attested hydrostatic aggregates with a diameter 7-5 mm throughout the whole vegetation period, their content, however, ranging from 2-4%.

As the aggregate diameter is reduced their hidrostability increases in all variants.

Table 4. Dynamics of aggregate stability of typical chernozem humus moderated under algalization conditions (Irrigated regime) (Mean values, layer 0-50 cm)

Terms of sampling	Version	Hydrostabile aggregate content, %				
		Aggregate content. mm				
		7-5	5-1	1-0.25	> 0.25	< 0.25
May	Control	-	17.34	41.43	58.77	41.23
	Nostoc flagelliforme	3.62	18.19	42.13	63.30	36.70
	Anabaena minima	3.33	19.74	43.32	65.45	34.55
June	Control	-	17.82	32.48	51.56	48.44
	Nostoc flagelliforme	3.89	20.94	47.28	72.11	27.89
	Anabaena minima	2.36	20.12	38.08	60.56	39.44
July	Control	-	15.31	32.61	47.92	52.08
	Nostoc flagelliforme	2.33	25.73	44.31	72.13	24.87
	Anabaena minima	2.32	19.12	39.76	31.20	38.80
August	Control	-	16.94	32.16	49.10	50.90
	Nostoc flagelliforme	2.23	27.53	45.81	75.57	24.43
	Anabaena minima	1.97	18.83	40.51	62.31	37.69

With maximum hidrostability is characterized aggregates 1-0.5 mm which make up the active reserves for aggregation process. Based on their content we find that maximum structural potential characterizes *Nostoc flagelliforme*.

CONCLUSIONS

Algalization intensifies the entire chain processes and soil functioning mechanisms which materializes in the aggregation of soil mass structure. It is necessary to distinguish two stages intercalated:

Processes and mechanism carried out at lower levels (bio-cellular, ionic-molecular, elementary particle) to organize the soil ecosystem with the formation of active substances;

Processes and mechanisms of structural-aggregate organization.

Structural aggregation with the participation of algae leads to the formation of three groups of structural aggregates with aggregate stability and different pedofunctional functions.

REFERENCES

Dobrojan, S., Salaru, V., Melnic, V. (2016). *Cultivarea algelor*. CEP USM, 172.

Jigau, G. (2009). *Geneza si fizica solurilor*. CEP USM, 164.

Jigau, G., Salaru, V., Dobrojan, S., Tofan, E., Blidari, A., Placinta, N. (2018a). Place of cynophyta algae in support and achievement of the structural – aggregation processes of humifer moderated typical chermozems. *Factori si Procese Pedogenetice din Zona Temperata, Iasi, Al. I. Cuza University.*

Jigau, G., Salaru, V., Blidari, A., Dobrojan, S., Tofan, E., Gatman G., Placinta, N. (2018). Vision on the structural – aggregation mechanisms with the participation of cyanophyta alegae. *Seria Agronomie, Iasi.*

Lupascu, G., Jigau G., Verlan, M. (1998). *Pedologie Generala*. Iasi, 298.

Kovda, V.A. (1973). *Osnovi ucenia o pocvah*. Moskva: Nauka, 468.