THE PLANT GROWTH DYNAMICS DURING LAYERED DOUBLE HYDROXIDES (LDH) ACTION

DINAMICA DEZVOLTĂRII PLANTELOR SUB ACȚIUNEA LDH

OANCEA Servilia, PĂDUREANU Silvica
University of Agricultural Sciences and Veterinary Medicine Iasi, Romania

Abstract. *Layered double hydroxides (LDHs) known as anionic clays are an important class of ionic lamellar solids. The anionic clays exhibit anion sorption, anion diffusion and exchange properties together with surface basicity making them materials of importance for many modern applications. The LDHs clays are useful in agriculture due their physical and chemical properties, in order to obtain organic products. In this work, a study concerning the plant growth dynamics of corn plant during the LDH action. Seeds of wheat were put into Petri dishes on double filter paper together with suspensions from some anionic clay and they were kept here for 3 days. The dynamic of germination and the growth during the first phenophase of growth has been monitorized. After that the germinated seeds were planted in soil where they continued to growth. The content of photosynthetic pigments was obtained spectrophotometrically. Our results showed that the anionic clays could modify the plant growth, the clay containing magnetite having the most important effect on plant growth. A slow release of the active substance from nanocomposite material could be exploited for control release formulation of some pesticide or plant growth stimulator; this means the intercalation of pesticides or plant growth stimulator into layers of LDH is a feasible solution.*

Key words: LDH, magnetite, salicilic acid, photosynthetic pigments

Rezumat. *LDH, cunoscute ca argile anionice sunt o clasa importanta de solide ionice lamelare. Argilele anionice prezintă proprietăți de sorbție a anionilor, de difuzie a anionilor şi de schimb şi datorită bazicității superficiale sunt materiale cu importanță şi aplicații în domenii moderne. Aceste argile pot fi folosite in agricultură datorită proprietăților fizice şi chimice cu scopul obținerii unor produse agricole organice. In această lucrare este prezentat un studiu privind dinamica cresterii plantelor de grau sub actiunea argilelor anionice. Semințele de grau au fost puse în sticle Petri cu hârtie de filtru şi suspensia de argilă şi au fost ținute aici timp de 3 zile. Apoi semintele germinate au fost plantate in sol unde au continuat sa creasca. A fost monitorizată dinamica germinației şi creşterea plantelor în timpul primelor fenofaze. Rezultatele noastre arată că argilele anionice pot modifica dezvoltarea plantelor, argila continand magnetita avand cel mai important efect in cresterea acestora. O eliberare lenta a substantei active din nanocompozita poate fi folosita pentru eliberarea controlata a unui pesticid sau a unui regulator de crestere; aceasta inseamna ca intercalarea unui pesticid sau a unui regulator de crestere in lamelele LDH este o solutie fezabila.*

Cuvinte cheie: LDH, magnetite, acid salicilic, pigmenti fotosintetici

INTRODUCTION

Minerals that reversibly fix ions, in particular NO_3^- can be used as fertilizers and soil conditioners, as well as for the purification and treatment of water, particularly for the elimination of nitrate. Layered double hydroxides (LDHs) contain exchangeable fixed anions in the intermediary layers. Therefore methods for producing anion-exchanging minerals, particularly suitable LDHs, and usage them as fertilizers or soil conditioners and for the purification and treatment of water have been reported.

Layered double hydroxides (LDHs) known as anionic clays are an important class of ionic lamellar solids. LDH structure is described with formula $[M^{2+}_{1-x}M^{3+}_{x}(OH)_2][A^{n-}_{x/n}.zH_2O]$, where M^2 is a divalent metal ion such as Mg^{2+}, Ca^{2+}, Zn^{2+}, etc, M^3 is a trivalent ion such as Al^{3+}, Cr^{3+}, Fe^{3+}, Co^{3+} and A is an anion such as Cl^-, CO_3^{2-},NO_3^- ,etc.

The anionic clays exhibit anion sorption, anion diffusion and exchange properties together with surface basicity making them materials of importance for many modern applications (1), (2), (9), (14), (19). Anionic clays, have attracted increasing interest as nanovehicles for delivering genes, drugs, and bio-active molecules into cells. Due their capacity of ion exchangers, anionic clays have been used to remove the toxic compounds from water as arsenite (18) or chromate (7). Recent reports on the advantages of mesoporous materials as drug delivery vehicles have imposed research in novel applications and several materials with this purpose have been reported (15). The LDHs clays are useful in agriculture due their physical and chemical properties, in order to obtain organic products (10), (16). Luis Dorante presents evaluation of LDHs as a nitrate exchanger in soil in (5).

In this paper, the comparative effects of two composites containing anionic clay (MgAlLDH) and salicylic acid and Fe_3O_4 + salicylic acide (sal) on germination rate, root elongation, stem dimension and growth of *Triticum sativum* have been analyzed. Germination rate and root elongation, as a rapid phytotoxicity test method, possess several advantages, such as sensitivity, simplicity, low cost and suitability for unstable chemicals or samples (17).

MATERIAL AND METHODS

To study the effect of anionic clays on plant growth, many clays have been prepared (3), (4), but here we sorted the following variants:

1. control;
2. MgAl LDH+sal;
3. MgAl LDH+sal+Fe_3O_4;

100 seeds of wheat were put into Petri dishes on double filter paper together with 5 mL treatment solution (a suspension that contains 0.5g of clay and 50mL bidistilled water). Here the seeds have been kept in dark and at optimal temperature (20-23^{0}C) for three days. Every day we poured bidistilled water for control and treatment solution for the other variants to determine seed germination. After that the germinated seed were planted in soil where they developed in optimal conditions.

The soil was prepared from celery soil in proportion of ¾ and red peat (produced by Kekkilä Ozi from Tuusula, Finland) in proportion of ¼. The dynamic of

germination and the growth has been monitorized during the first phenophase of growth.

Photosynthetic pigments were extracted in acetone (6), (13), measured spectrophotometrically using a spectrophotometer SPECORD 200 produced by Analytik Iena and calculated according to Lichtenthaler formula (11).

RESULTS AND DISCUSSIONS

Figure 1 shows the wheat seed germination dynamics after 3 days and figure 2 the root dimension after 3 days.

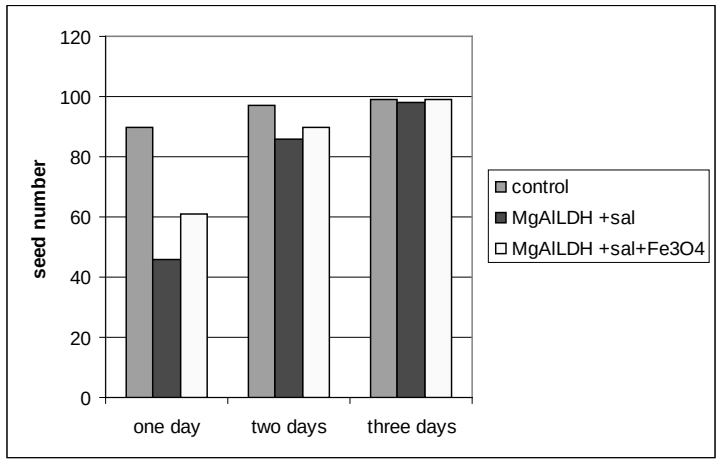

Fig.1. Wheat seed germination after 3 days of anionic clay treatments

Figure 1 shows that the control seeds germinated faster that the treated seeds but after three days the number of germinated seeds is the same.

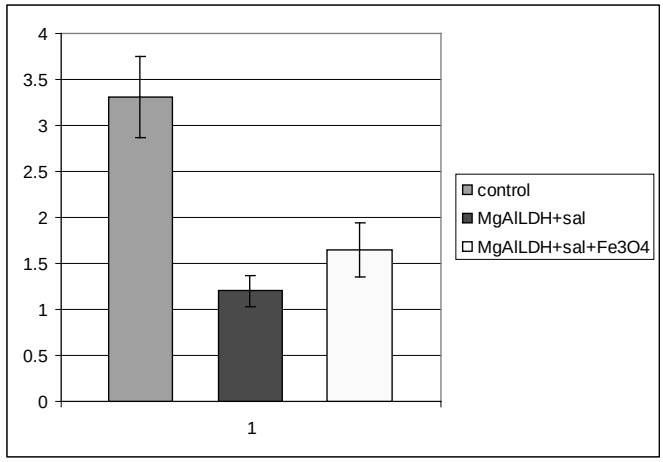

Fig.2. Wheat root dimensions after 3 days of anionic clay treatments. Error bars are confidence intervals (n=50) (12)

From figure 2 we can see that the wheat root of the control plants are better developed than the treated seeds but the root dimensions of treated plants with

composite containing magnetite are higher than those treated with anionic clay containing only salicylic acid.

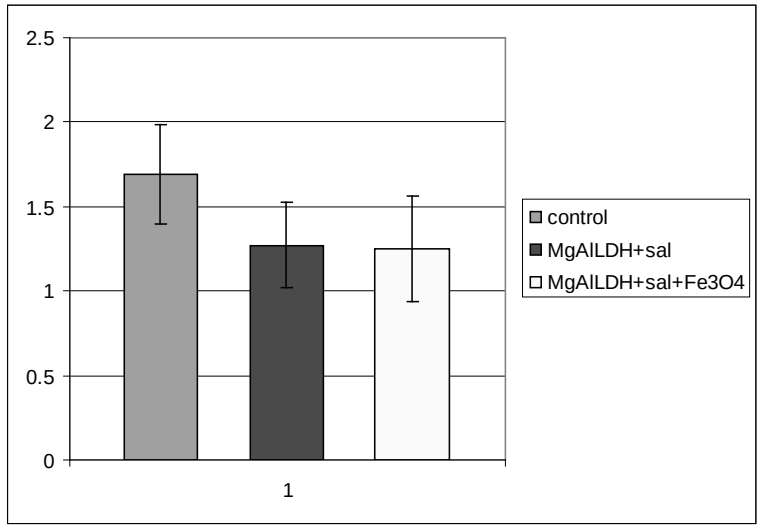

Fig.3. The stem dimensions, after 3 days of treatment with anionic clays

As the figure 3 shows, the wheat stems of the control plants are better developed than the treated plants.

Content of photosynthetic pigments, chlorophyll a (Chla), clorophyls b (Chlb) and carotenoids (Car) from corn leaves are given in figure 4.

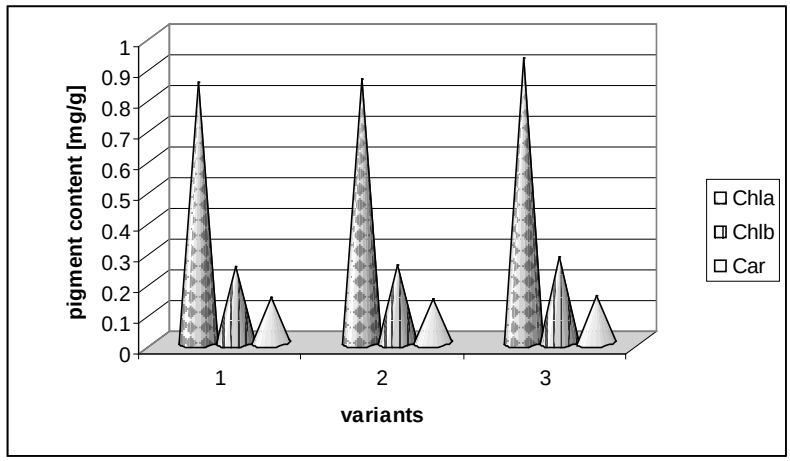

Fig. 4. The content of photosynthetic pigments (mg/g fresh tissue) from wheat leaves

From figure 4 we can see that the content of chlorophyl a (the most important photosynthetic pigment), for treated plant is meaningful higher than the control plant leaves, the content of chlorophyl b slightly increases and the carotenoid content remains the the same.

CONCLUSIONS

The anionic clays are useful in agriculture due their physical and chemical properties. Our results prove that there are differences between control plants and those treated with anionic clay suspensions. The best anionic clay from point of view of plant growth was the composite containing magnetite; despite the fact that the germination was faster for the control than the other variants, the content of the photosynthetic pigment for the treated plants was higher than the control plants. This means that the structure of LDH offers a good and controlled release of some active substances from nanocomposites to the plant cell. Our results are in concordance with C. Jiao et al. work, which recently reported the synergistic effects of Fe_2O_3 with layered double hydroxides (8).

Because are not toxic they can be materials of great interest especially in organic agriculture. Therefore, they can substitute some fertilizers or plant growth stimulators, (especially toxic chemical compounds) in order to obtain organic products.

REFERENCES

1. **Auerbach S. M., Carrado K. A., Dutta P. K., 2004** - *Handbook of Layered Materials*. 261-311, New York
2. **Carrado K.A.; Marshall C.L.; Brenner J.R.; Song K., 1998 -** *Materials with controlled mesoporosity derived from synthetic polyvinylpyrrolidone-clay composites*. Microporous and Mesoporous Materials, 20(1-3), 17-26
3. **Chiriac H., Oancea S., Gaburici M., Lupu N., 2008 -** *Layered double hydroxide (LDH) as potentiasl plant growth stimulator*. 7-th Int. Conf. on Global research and Education Inter-Academia, 2008, Sept. 15-18, Hungary, 87-93
4. **Chiriac H., Lupu N., Gaburici M., Oancea S., 2008 -** *Synthesis and Characterization of Layered Double Hydroxides With Induced Magnetic properties*. Proc.of Joint Int. Conf. Materials for Electrical Engineering, Bucharest, June 16th-17th, 221-224
5. **Dorante L.O.T., 2007 -** *Evaluation of a Layered Double Hydroxide (LDH) mineral as a long-term nitrate exchanger in soil*. Cuvillier Verlag.
6. **Foca N., Oancea S., Condurache D., 2004 -** *Growth and photosynthetic activity for tomato plants treated with different cations.* Molecular crystals and Liquid crystals Journal, 418, 971-981
7. **Houri B., Legrouri A., Barrou A., Forano C., Besse J. P., 1999 -** *Removal of Chromate Ions from Water by Anionic Clays.* J. Chim. Phys., 96 (3), 455-463
8. **Jiao C., Chen X., Zhang J., 2009 -** *Synergistic Effects of Fe_2O_3 with Layered Double Hydroxides in EVA/LDH Composites*. Journal of Fire Sciences, Vol. 27, No. 5, 465-479
9. **Kloprogge J. T., Komarneni S., Amonette J. E., 1999** - *Synthesis of smectite clay minerals: a critical review.* Clays and Clay Minerals, 47(5), 529-55
10. **Lakraimi M., Legrouri A., Barroug A., De Roy A., Besse J-P., 1999 -** *Removal of Pesticides from Water by Anionic Clays*. J. Chim. Phys., 96 (3), 470-478

11. **Lichtenthaler H.K., Wellburn A.R., 1983 -** *Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents*. Biochemical Society Transactions, 11, 591 - 592.
12. **Oancea S., 2007 -** *Ghid de prelucrare rapidă a datelor experimentale*. Editura Performantica, Iasi
13. **Oancea S., Foca N., Airinei A., 2005** - *Effects of heavy metals on plant growth and photosynthetic activity.* Analele Univ. Al. I. Cuza, Tom I, s, Biofizica, Fizică medicală şi Fizica mediului, 107-110
14. **Saber O., Tagaya H., 2005 -** *Preparation of new layered double hydroxide*. Rev. Adv. Mater. Sci, 10, 59-63
15. **Salonen J., Laitinen L., Kaukonen A.M., Tuura J., Björkqvist M., Heikkilä T., Vähä-Heikkilä K, Hirvonen J. , Lehto V.-P., 2005** - *Mesoporous silicon microparticles for oral drug delivery: Loading and release of five model drugs*. Journal of Controlled Release 108, 362– 374
16. **Tsai W. T., Chen C. H., Yang J. M., 2002 -** *Adsorption of paraquat on the physically activated bleaching earth waste from soybean oil processing plant***.** Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes, 37(5), 453-463
17. **Wang X., Sun C., Gao S., Wang L., Shuokui H., 2001** - *Validation of germination rate and root elongation as indicator to assess phytotoxicity with Cucumis sativus.* Chemosphere, 44(8), 1711-1721
18. **You Y.W., Zhao H.T., Vance G.F., 2001** - *Removal of arsenite from aqueous solutions by anionic clays.* Environ Technol**,** 22(12), 1447-1457
19. **Zhang J., Zhang F., Ren L., Evans D.G., Duan X., 2004** - *Synthesis of layered double hydroxide anionic clays intercalated by carboxylate anions.* Materials Chemistry and Physics, 85, 207-214