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CHEMICAL COMPOSITION AND BIOLOGICAL ACTIVITY OF COMPOUNDS BASED ON DEFECATE

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Influence of chemical contents from defecation mud-based mixtures with phosphatic acid and defecation mud with bischofite saline solution on plants growth (rye, lentil) was researched in laboratory environment. Optimum concentrations of mud-based mixtures with phosphatic acid and defecation mud with bischofite saline solution, promoting rye crops were identified. We have proven the possibility of artificial defecation mud mineralization in order to increase the effects of its positive influence towards plants growth.

Introduction. Defecation mud from sugar production which forms at the factories at the amount of 9–11 % from total processed sugar mass, constitutes approximately 30 thousand tons per one factory.

Usually this type of waste is used for soil deoxidization [1–5], it also is a significant source of replenishing the soil with microelements (Cuprum, Zink, Manganese), partially – with Potassium, Phosphorus and Nitrogen, as well as biologically active organic substances [6–8]. Researches of defecation mud influence on soils, performed by different scientists, show that such approach promotes the soul structure, decreases their acidity, promotes the ability of plants to absorb Potassium, Phosphorus and Nitrogen [9,10] increases humus contents [11,12], and as a result promotes the crop yield of root and grain varieties.

Literature also contains data about using defecation mud as an addition to raw slurry in cement [13], asphalt topping [14], adsorbents for cleansing the water from dyes [15] and toxic metals, as a chemical filling component in order to receive modified Calcium molybdate and wolframate [16].

This project [17] shows that the field of defecation mud application can be significantly extended as a result of receiving quantity characteristics of this object complex research by different physical-chemical methods.

Brief analysis of the published research shows that the most massive application of defecation mud is found in the role of chemical ameliorant, effectiveness of which is increased after applying NPK-fertilizer or along with this fertilizer. As of present data [1] 15 tons of defecation mud per hectare increases the crop yield of winter barley for approximately 40%; and $N_{60}P_{60}K_{60}$ mineral fertilizer dose for 53 %; combined power of

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defecation mud and this fertilizer – 94,4 %. For Adretta class potato, combined power of defecation mud and $N_{60}P_{60}K_{60}$ mineral fertilizer, resulted in 100% crop yield increase, summer wheat crop yield increased 141 %, winter wheat crop yield increased 97 % and triticale crop yield – 127,5 %.

Application of defecation mud at the amount 9,0–9,5 tons per hectare against the ammophos $N_{120}P_{120}K_{120}$ background, resulted in 77,4 increase of sugar beet crop yield [18].

The most effective performance of defecation mud as a chemical meliorant is set on research soils which complied to the following levels: strongly acid (pH<4,5); medium acid (pH = 4,6–5,0) and weak acid (pH = 5,1–5,5); this type of waste has the feeble effect on soils close to neutral (pH = 5,6–6,0), [19].

Therefore, defecation mud is an effective soil ameliorant, proven so by different researchers. Notwithstanding, biological effect of defecation mud, processed by chemical reagents or enriched with special natural minerals is not yet studied. So the purpose of this work is to research the biological effect of mixtures (defecation mud with bischofite saline solution, or the defecate mud itself, processed by phosphatic acid, which results in development of mixture, containing different metals phosphates in the content of received products).

Experimental part and results discussion. Research mixtures were received by the following methods. Air-dried sugar manufacture defecation mud with contents of $CaCO_3$ (51–58 mass %) (Kapitanivskyi sugar plant, Kirovograd region), was mixed with phosphatic acid of "technical" qualification (ω = 73,5 mass %, ρ = 1,617 g/cm^3), taken in the content of outlet mixture at the amount 7,15–51,00 mass %.

Effectiveness of stimulation action of the received mixtures was identified on research crops of rye and lentil.

Research were performed in June–September 2012 at the land plot №75 of "Zoria" gardening community (Plakhtianka village of Makariv district, Kyiv region) under the sunshade, without influence of direct sun air on local sandy-loam soil, contained in wooden boxes (box with rye with dimensions 58 × 38,5 × 15 cm^3 and box with lentil – 60 × 30 × 15 cm^3).

Rye before sowing was put in water for 1 hour, ditches were made in the soil where 4 grams of mixture were put at first, then the seeds were planted to approx. 10 mm depth. After that soil was put on top of seeds (11 seeds per row with distance between seeds – approx. 25–30 mm, and distance between rows – approx. 55–56 mm.) According to calculations, biologically active mixture consumption reached approx. 14,5 kg per 100 m^2 of the soil surface.

Lens after 30 minutes of presoaking, was planted in ditches to approx. 15 mm depth, 1 row contained 11 seeds and 20 grams of yellow earth was put into ditches under the seeds, and 4 grams of biologically active mixture – atop the seeds. Distance between lens seeds was approx. 25 mm and distance between rows – approx. 45 mm.

Young crops of rye and lentil after sowing and during first 3,5 weeks since sowing were sprinkled with 200–300 ml of water in the morning and evening from the sprinkler (each 1–2 days); after 3,5 weeks since sowing were periodically (not every day) sprinkled with 0,6–0,7 l of water in the morning and in the evening.

Table 1 shows the results of biologically active mixture, received by the offered method to the young crops of lens, planted on 17.06.12. Table 2 contains results of such mixture influence to bare crops, planted on 29.06.12.

Tables 1, 2 show that the content of phosphatic acid in the outlet mixture with calciumcarbonate residue from sugar manufacture 7,15–36,20 mass %, gives positive

results. Therefore, defecation mud and phosphatic acid give biologically active mixture which increases germinating ability of crops, increases average height of crops in a row (38,7–64,0 % for lentil and 10,3–27,5 % for rye), increases the sickness of plant stems, leaf width, and better tilling capacity (of rye); earlier emersion and quantity increase of pods, third, fourth, sixth leaf and flower buds (for lentil) which provides a possibility of using it to stimulate plant growth in the agrarian sector [20].

Other series of experiments, bischofite saline solution at the amount of 8,3–31,3 mass % and the process of heating the exit mixture of the mentioned content of the named content is performed at 105–115 °C during 1–2 hours.

Bischofite saline solution had the density of $\rho = 1{,}19$ g/cm^3 and molar concentration of magnesium chloride $C_M = 0{,}07$ mol/l. Used phosphatic acid was of "technical" qualification, its density $\rho = 1{,}617$ g/cm^3, contents of pure phosphatic acid in which $\omega = 73{,}5$ mass %. Instead of phosphatic acid of used qualification, the proposed method can employ its industrial wastes, but then they are to be controlled according to the contents of fluoride-, chloride-, sulphate-ions, as well as toxic metals. In order to assess the activity of only bischofite saline solution, at first, only the influence of separately taken clear soil samples, the defecate mud and soil with admixture of 6,79 mass % bischofite saline solution.

Rye seeds were planted to loamy soil on 17.10.12. As of 25.10.12 and on 31.10.2012 was proven that the influence of the tested substances in all tests is similar (sprouts height and germinating ability of rye).

Figure 1 shows that bischofite in mixture with defecation mud has no positive effect

Table 1. Results of the research of the influence of the chemical composition of mixtures on stairs of lentils, planted 17.06.12

№ p/n samples	The weight of the initial mixture defecate and phosphoric acid, g	Content of H_3PO_4 in the initial mixture, mass.%	Grains sown in the line item, p	Date and number of stairs, p								The height of the stairs in a row, as of 18.07.12., mm	The similarity in a row as of 27.06.12p., %	Note (on 18.07.12.)
				21.06.12	22.06.12	23.06.12	24.06.12	27.06.12	05.07.12	08.07.12	18.07.12			
1	4 (pure defecate)	0	11	The appearance of the first hoots	0	3	4	6	6	6	5*	62	54	Background
2	4	7,15	11		4	6	6	6	6	6	6	101,7	54	I
3	4	14,40	11		6	6	6	6	6	6	5*	98	54	
4	4	21,60	11		6	8	8	8	7*	6*	6*	92,3	72,7	
5	4	28,60	11		2	4	5	6	6	4*	4*	86	54	
6	4	36,20	11		7	7	7	8	8	8	8	90,6	72,7	
7	4	43,40	11		1	2	3	4	4	2*	1*	65	36,3	II
8	4	51,00	11		0	0	1	1	1	0	0*	0	9	

I – increased growth (increased height, width sheet); II – growth inhibition stairs (reduced height, narrow leaf).

Table 2. Results of the research of the influence of the chemical composition of mixtures on stairs of ryes, planted 29.06.12

№ p/n samples	Mass of defeca-te or mixtu-re, g	Content of H_3PO_4 in the initial mixture, mass.%	Sown grains in the row, p	Date and number of stairs, p						The height of the east line of ± 2 mm, as of 18.07.12.	Germination, % (in the row) as of 8.07.12.	Note (state of stairs 18.07.12)
				6^{30}, 02.07.12 p.	13^{30}, 03.07.12	19^{30}, 03.07.12	9^{00}, 04.07.12	05.07.12	08.07.12	18.07.12			
1	4	0	11	Stairway nowhere	3	4	8	9	9	9	191,9	81,8	Background
2	4	7,15	11		4	7	8	9	9	7*	232	81,8	I
3	4	14,40	11		5	6	8	8	11	9*	211,7	100	
4	4	21,60	11		5	8	8	8	8	7*	224,3	72,7	
5	4	28,96	11		7	10	10	11	11	10*	244,6	100	
6	4	36,20	11		4	4	9	9	9	9	216,2	81,8	
7	4	43,40	11		0	0	0	1	5	5	261,2	44,4	II
8	4	51,00	11		0	0	0	0	0	0	0	0	
9	0	0	11		10	10	10	10	10	10	205	90,9	III

* - drying some stairs from lack of irrigation; I - similarity in average ranks № 2 № 6 is 86,9 mm; stairs strong, thick stems ~ 2,2 ±0,1 mm broad leaves; II - depressed growth of stairs; III - weak shoots, stem thickness ~ 1,4 ±0,1 mm, narrow leaves.

towards the plants growth during first two weeks after seeding, and in concentration over 9,53 mass%, even inhibits the growth. So it is necessary to define the biological effect of mixtures, containing defecation mud and bischofite, processed by given quantities of phosphatic acid upon prior heating.

Likewise, mixtures of bischofite and defecation mud show the same indices if the contents of bischofite lies within 3,64–9,53 mass % limits. Upon bischofite more 9,53 % (verified mixtures 11,94 and 14,08 mass %), a significant decrease of average sprouts height is detected (approx. 50 %). Therefore, the mixtures of bischofite and defecation mud have no stimulating effect on the rye growth.

So in order to study the effective stimulation activity, biologically active mixture is

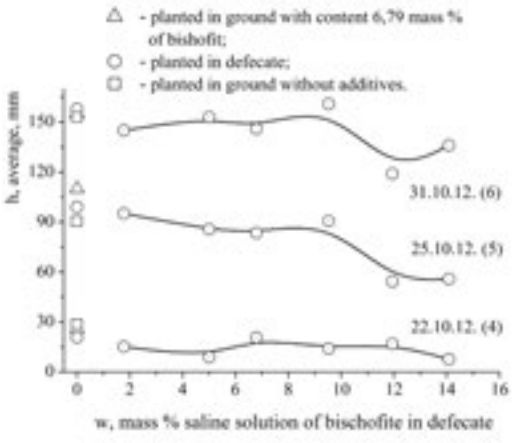

Fig. 1. The dependence of the average height of stairs rye (h) from content of saline solution of bischofite (mass %) in the mix with defecate (planted 17.10.12.), (curves 4, 5, 6)

prepared on the basis of sugar production defecation mud, bischofite saline solution and phosphatic acid.

In such a manner this work has a purpose of finding an optimum content of bischofite saline solution in exit mixture, in order to define the concentration interval which provides an increased biological action of the received end products.

It is defined that in the tests on loamy soil, concentration of clean phosphatic acid, corresponding to the formula H_3PO_4, in exit mixture is less than 12,0 mass %, and bischofite solution – less than 22,2 mass %, than the received product has a less stimulating effect towards plants (rye) growth, Upon concentration of clean phosphatic acid in the exit mixture more than 29,4 mass %, the received product has an inhibiting effect on plants growth and germination.

Therefore in the tests performed on loamy soil, only the contents in exit mixture (defecation mud – phosphatic acid – bischofite) from natural bischofite solution in quantity of 22,3–31,3 mass %, homogeneization and heating the exit mixture upon 105–115 °C during 2 hours, provides an increased stimulation biological activity of end product towards the plant growth.

For tests performed on loamy soil: stimulation of plant growth (rye) by means of biologically active mixture, the later was received by means of air drying sugar production defecation mud with contents of $CaCO_3$ 51–58 mass. % (Kapitanivskyi sugar plant, Kirovograd region), which was taken as a part of mixture in quantity of 57,6–32,7 mass % and mixed with bischofite, taken as a part of exit mixture in quantity 34,0–19,3 mass %, and mixed with phosphatic acid (ρ = 1,617 g/cm^3, ω = 73,5 mass % of pure phosphatic acid), taken in quantity 6,2–35,0 mass % (in calculation to pure H_3PO_4 acid). Mixture of three named ingredients (weighting was performed on technical scales with tolerance up to ±0,02 grams), were blended in porcelain jar till receiving homogenous mass which was poured into porcelain crucibles and heated at 105–115 °C during two hours. Received (after cooling) a free-flowing end product powder. Ingredient content in the end mixture for tests on loamy soil (before heating) is specified in table 3.

While blending the exit mixture and the following period, reaction between magnesium chloride of bischofite saline solution and calciumcarbonate residue with phosphatic acid, accompanied by creation of chloride acid and carbon dioxide gas release, we received viscous mixture after blending. This mixture was poured into porcelain crucibles, which were then put into drying cabinet at 105–115 °C and kept there for 2 hours (loamy soil). This operation provides extraction of chloride acid from the mixture (harmful acid for the soil).

Mixture stimulating effect was identified on research rye crops in laboratory environment. First series of tests were performed since 8.10.12 till 20.02.13 in G-713 laboratory of NUFT on the windowsill, without direct sunlight influence on local loamy soils (with upper layer of digested plant leaves), poured into carton box with dimensions 46 × 27,5 × 13,5 cm^3. Soil layer was 11 cm in sickness. In the soil of the box, walls and bottom of which were covered with triple layer of polyethylene foil in order to provide water-tightness, holes with 10 mm diameter were made and 0,3 g of dried mixture from the named three ingredients was applied. Rye seeds were planted in the middle of the mixture, left approx. 0,5 cm of free space and poured the soil atop of the seeds. After covering the seeds with soil, a small hole was made to where water was poured. Each row had 8 or 9 seeds. Distance between each seeds of the row was approx. 40 mm, distance between the rows – 30–35 mm. Rows were separated from each other by means of wooden walls, placed in the soil 80 mm deep. Seeds and sprouts of rye right after sowing, and in further – during first three weeks

Table 3. The composition of the initial mixtures of defecate, saline solution of bischofite and phosphoric acid (before heating) to produce of biological activity mixture; planted in loamy soil

№ s/n samples	Mass % of defecate	Mass % solution of bischofite	Mass % 73,5 %-st H_3PO_4, ρ = 1,617 g/cm^3	Mass % of pure H_3PO_4	Mass of mixture in the row, g
1	57,57	33,98	8,45	6,20	3,50
2	53,02	31,29	16,37	11,94	3,75
3	47,85	28,24	23,91	17,60	3,50
4	42,40	25,02	32,58	23,95	3,00
5	37,75	22,28	39,97	29,40	3,50
6	32,75	19,33	47,92	34,96	3,50
7	76,04	0	23,95	17,60	4,00

since sowing, were sprinkled with 200–300 ml of water in the morning and in evening (from sprinkler unit).

Table 4 shows research results of mixture with bischofite (increased effectiveness), received by means of suggested method on rye crops growth, sowed in loamy soil on 8.11.12.

Table 4 shows that the content of bischofite solution (22,3–31,3 mass %) provides rye cropping at 75–88,9 % and increases the average sprouts height up to 209–277 mm (27.11.12). As of 6.12.12, stimulating capacity of enhanced biological activity mixture was observed only in samples № 2–№ 5, and in samples № 1, № 2 and № 7 such effect was completely absent. If the bischofite was not used in mixture (sample № 7), then germination capacity constituted only 44,4 % and average sprouts height constituted only 171 mm (27.12.12).

Figure 2 reflects the dependency of average sprouts height (h, mm) and germination capacity (figure 3) of bere from the content of phosphatic acid in mixtures: saline bischofite

Table 4. Results of the research of the effect of biological activity mixture of increased efficiency which obtained by the proposed method on the stairs of rye, planted in loamy soil on 8.11.12

№ s/n samples	Sown grains in the row, p	Mass of dry mixture in the cell, (±0,02 g)	Content of saline solution of bischofite, mass %	Germination, % 16.11.12.	The height of the stairs in the row, mm (±1 mm)	
					27.11.12.	6.12.12.
1	8	0,3	33,98	75,0	209	227
2	9	0,3	31,29	77,8	247	267
3	9	0,3	28,24	88,9	228	279
4	9	0,3	25,02	75,0	234	244
5	9	0,3	22,88	88,9	213	240
6	9	0,3	19,33	55,0	186	235
7	9	0,3 (without bischofite)	0	44,4	171	233

(33,98–19,2 mass %) – defecate (remainder), (planted 8.11.12). Figure 2 shows the dependency of phosphatic acid with more than 24 mass %, and in this research, stimulated rye growth, but even upon concentration increase up to 34,96 mass %, mixtures from these three ingredients after 19 days have more effect in promoting rye growth than the background contents: defecation mud and 17,6 mass % of phosphatic acid (without bischofite). Figure 3 shows that the contents of phosphatic acid more than 30 mass %, inhibits rye growth.

Upon increased contents of phosphatic acid in exit mixtures, namely: 34,96 mass %, germinating capacity of rye constituted 55,5 % and average crop height reached 186 mm (27.11.12). Rye growth observations allowed making a conclusion that the mixture received from incgredients free of bischofite – is inefficient and the mixture, where bischofite saline solution is equal to 34,0 mass % also has low effectiveness.

Therefore, only the content of saline bischofite solution in exit mixture 22,3–31,3 mass % (loamy soil), and its following homogenization and heating up to 105–115 °C during 2 hours, provides a possibility of receiving dry, free-flowing product with increased effectiveness, which may be added to the soil.

6.03.13, a second series of research was performed. Dry white sand was used instead of loamy soil. Researched exit mixture was heated at 105–115 °C during 1 hour. Before forming nests for the mixture, the sand surface in the box was sprinkled with 0,2 l of water in order to allow making holes in the sand. These holes had a conic shape with average diameter approx. 14 mm, and approx. 20 mm depth. Distance between centers of such holes were approx. 35–40 mm, distance between the rows – approx. 36–40 mm. Each nest was filled with 0,8 g of mixture from three previously prepared ingredients, and one rye seed was placed atop of the mixture and filled the nest with soil in a manner to leave a 3 mm deep hole in the soil. Afterwards, each hole was sprinkled with water from a sprinkler to create a wet sand layer above the seeds. Then the sand surface was equally sprinkled with 1,1 l of water. Depth of sand layer in the box – 110 mm.

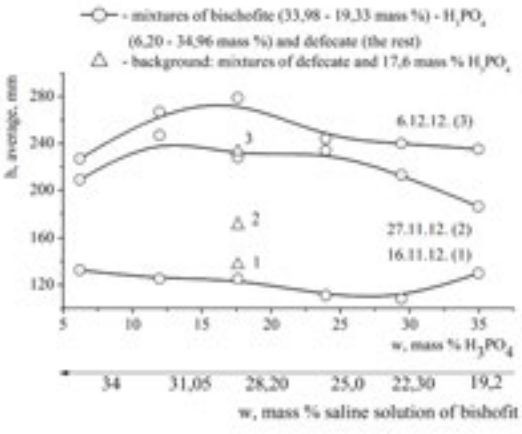

Fig. 2. The dependence of the average height of stairs rye (h) from content in mixture (defecate —biscofite — phosphatic acid) of bischofite and phosphatic acid, (planted 8.11.12.)

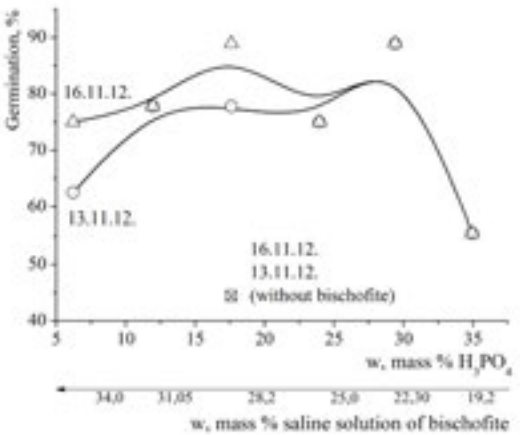

Fig. 3. The dependence of germination of rye from content of phosphatic acid in mixtures defecate — solution of bischofite — phosphatic acid, planted 8.11.12.

Table 5. Results of the research of the effect of biological activity mixture which obtained in other proportions of ingredients on the stairs of rye, planted

№ s/n samples	Sown grains in the row, p	Mass of dry mixture in the cell, g	Mass % ingredient in mixture before heating			The height of the stairs (±1 mm)	
			Defecate	Saline solution of bischofite	H_3PO_4 (pure)	14.03.13.	19.08.13.
1	11	0,8	78,53	10,81	7,83	57,2	130,1
2	11	0,8	73,06	10,05	12,40	48,2	108,1
3	11	0,8	69,28	9,40	16,38	60,6	131,9
4	11	0,8	64,14	8,83	19,86	42,6	109,9
5	11	0,8	60,44	8,32	22,95	42,8	114,1
6	11	0,8	57,15	7,86	25,7	30,2	93,0
7	11	0,8	77,94	0	16,21	32,3	61,2

Table 5 reflects the contents of exit mixtures and results of their influence on the seeds growth, planted in pure sand.

Germination for each sample (row), constituted 91 % and the increased effectiveness of biological activity was observed only upon contents of bischofite saline solution at 8,3–10,8 mass %.

By comparing average height of rye young crops planted in loamy soil (first series of tests) and in pure sand, we discovered that in 8 days after sowing, sprouts from first series of tests were two times higher than sprouts planted in pure sand. Although the crops planted in pure sand also showed the increased effectiveness of biologically active mixtures. But it is obvious that the best results were received on loamy soil [21].

Conclusion

We have experimentally proven a possibility of receiving biologically active mixtures with optimum chemical composition, based on defecation mud, phosphatic acid and bischofite saline solution in order to increase agricultural plants (rye and lentil) without application of phosphatic fertilizers.

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АНОТАЦІЯ

Перепелиця О.П., Петренко Т.В., Іщенко В.М. *Хімічний склад і біологічна активність сумішей на основі дефекату // Біоресурси і природокористування. – 2015. – 7, № 3–4. – С. 40–48.*

У лабораторних умовах досліджено вплив хімічного складу сумішей дефекату з фосфатною кислотою та дефекату з фосфатною кислотою і сольовим розчином бішофіту на ріст рослин (жито, сочевиця). Встановлено оптимальні концентрації фосфатної кислоти і розчину бішофіту, які посилюють ріст рослин жита в посівах. Доведено можливість штучної мінералізації дефекату для посилення ефекту його позитивного впливу на ріст рослин.

АННОТАЦИЯ

Перепелица А.П., Петренко Т.В., Ищенко В.Н. *Химический состав и биологическая активность смесей на основе дефеката // Биоресурсы и природопользование. – 2015. – 7, № 3–4. – Р. 40–48.*

В лабораторных условиях исследовано влияние химического состава смесей дефеката с фосфатной кислотой и дефеката с фосфатной кислотой и солевым раствором бишофита на рост растений (рожь, чечевица). Установлены оптимальные концентрации фосфатной кислоты и раствора бишофита, которые усиливают рост растений ржи в посевах. Доказана возможность искусственной минерализации дефеката для увеличения эффекта его позитивного влияния на рост растений.