https://doi.org/10.31489/2024BMG4/70-76

UDC 504.54.062.4 Received: 20 August 2024 | Accepted: 19 September 2024

E.N. Martynova[1], S.E. Dadyka[2], I.A. Safronova[2], A.Zh. Abyurov[2], D.V. Ageev[3], A.K. Ramazanov[3,*]

[1]*JSC "Shubarkol komir", Moscow, Russian Federation;*
[2]*LLP "ERG Research Engineering Center", Pavlodar, Kazakhstan;*
[3]*Karaganda Buketov University, Karaganda, Kazakhstan*
[*]*Corresponding author: kairidenovich_rak@mail.ru*

Assessment of the effect of humates produced by "Shubarkol Komir" JSC on germination of vegetable seeds

Humic preparations are valuable sources of humic acids, which increase soil fertility and have growth-regulating activity on agricultural crops. Application of new humic preparations from local weathered coals allows providing agricultural producers with domestic preparations. To identify the optimal doses of application, we conducted a series of experiments on germination of vegetable seeds to increase their germination. The results of the study showed that humic preparations in different concentrations may not have the same activity on the seeds of plants of different species. The best germination rates are as follows: for white cabbage seeds after soaking in a solution of potassium humate at a concentration of 0.005 %, for eggplant seeds — a mixture of potassium and sodium humate at a concentration of 0.5 %, for tomato seeds — potassium humate 0.005 %, for sweet pepper seeds — a mixture of potassium and sodium humate 0.005 %, for cucumber seeds — a mixture of potassium and sodium humate 0.01 %. The results can be used for agricultural and greenhouse applications.

Keywords: humic preparations, seed material, vegetable crops, pre-sowing soaking, germination, germination energy.

Introduction

Humic substances (or humates) are high-molecular polymers of irregular structure, which are formed in nature (soil, peat areas, coals, bottom sediments, etc.) as a result of transformation of dead biomass of plants and animals. Biological activity of humates was discovered in the late XIX century [1]. Humate production is carried out from a wide range of raw materials: coals, peats, soil extracts, composts, sapropels, wastes of organic origin [2].

Humic preparations are used as organic fertilizers, natural stimulants to activate seed germination and plant growth, to improve soil fertility, for remediation of contaminated soils, as feed additives for farm animals and birds [3–5]. The possibility of using humic preparations for detoxification of oil products and salts of heavy metals is known [6, 7]. Given the diversity of processes for obtaining humic substances, sources of organic raw materials for their production, humates themselves may differ in structure and biological activity.

Based on the prospects of their widespread use in agriculture and environmental protection, there is a need for comprehensive testing of new humic preparations to determine their biological activity, develop principles of agro-system management and biosafety assessment.

An important advantage of humic substances is their relatively low cost and the availability of large reserves of raw materials (including weathered coal), which allows for the production and use of preparations based on them in agricultural and environmental technologies.

In Central Kazakhstan, "Shubarkol Komir" JSC has developed fertilizers based on humates from weathered coals from the Shubarkol deposit, which can be used in agriculture and vegetable growing, in particular, to increase the germination of vegetable seeds.

The purpose of our work was to study the effect of humates produced by "Shubarkol Komir" JSC on germination of seeds of some vegetable plants.

Experimental

The objects of research were humates provided by "Shubarkol Komir" LLP: potassium humate, a mixture of potassium humate and sodium humate (2:1 ratio), distilled water served as a control. The tested humates were diluted in concentrations of 0.1 %, 0.01 %, 0.5 %, 0.05 % and 0.005 %.

Seeds of the following vegetable crops were taken in the experiment: white cabbage, eggplant, tomatoes, cucumbers and sweet pepper.

Experiments to assess seed germination were conducted in laboratory conditions based on standard methods [8–10]. Germination was carried out on Petri dishes on 2-layer filter paper (Fig.) in 4-fold repetition. Plant seeds were soaked for 24 hours in appropriate humate solutions.

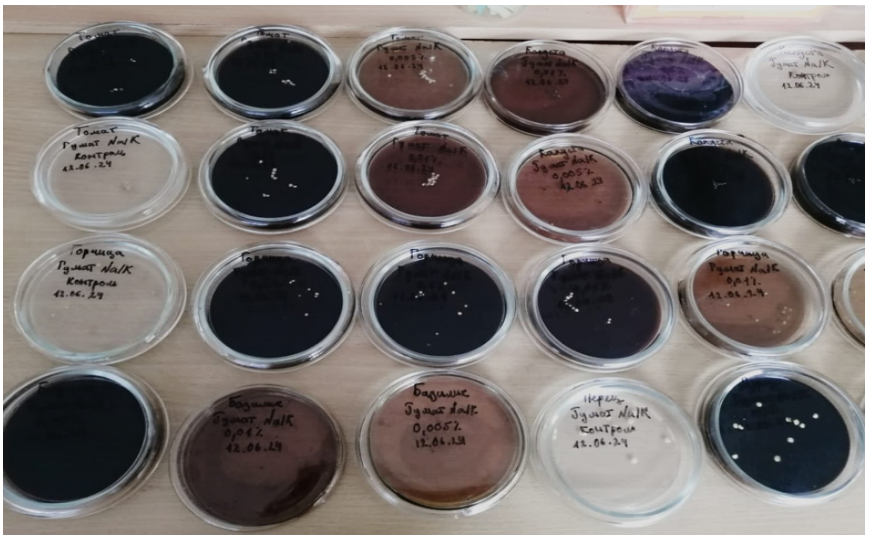

Figure 1: Pre-sowing soaking of vegetable seeds in humate solutions

Statistical processing of data was carried out using the online calculator https://medstatistic.ru/ and Excel program, the mean germination rates and germination energy with deviation were estimated, the reliability of the results was evaluated on the basis of Student's criterion.

Results and Discussion

The analysis of germination indices on the background of potassium humate and a mixture of potassium humate and sodium humate for different crops were not the same. Thus, for white cabbage seeds, the best germination indices were observed on the background of potassium humate at a concentration of 0.005 % (Table 1); in this variant, seed germination was 63.4 %, germination energy — 51.2 %, as well as for the same type of humate at a concentration of 0.01 %. Germination and germination energy amounted to 60.8 and 41.2 %, respectively. For the other variants, the viability indicators were significantly lower than the control values, or at the level of the control — preliminary soaking in water.

Table 1

Indices of germination and germination energy of white cabbage seeds on the background of application of different concentrations of humic preparations

Experiment variant	Germination energy,%	Germination,%
Control (water)	30,5±0,6	38,5±0,8
0.5 % humate K	11,4±0,2*	13,5±0,1*
0.1 % humate K	10,0±0,3*	20,8±0,4*
0.01 % humate K	41,2±1,1	60,8±3,6*
0.05 % humate K	8,9±0,1*	12,0±0,3*
0.005 % humate K	51,2±3,0*	63,4±2,7*
0.1 % K-Na humate	20,0±0,4*	32,0±0,5
0.01 % K-Na humate	20,0±0,4*	22,3±0,5
0.5 % K-Na humate	0	0
0.05 % K-Na humate	29,8±0,6	31,2±0,9
0.005 % K-Na humate	30,7±0,6	32,3±1,2
*Note – Significance of differences of indicators from control at P≤0.05		

Combined application of potassium and sodium humate at a concentration of 0.5 % resulted in the absence of cabbage seed germination.

The germination efficiency of eggplant seeds was at a rather low level. The best germination indices were recorded on the background of potassium and sodium humate mixture in concentration of 0.5 %, in this variant of the experiment germination was 90.0 %, germination energy — 40.6 % (Table 2), which significantly exceeded similar indices for the control variant. Lower indicators were observed for the humate mixture at a concentration of 0.1 %, germination and germination energy were 60.0 and 52.5 %, respectively.

Table 2

Indices of germination and germination energy of eggplant seeds on the background of application of different concentrations of humic preparations

Experiment variant	Germination energy,%	Germination,%
Control	10,5±0,1	40,8±1,2
0.5 % humate K	11,2±0,2	51,5±2,3*
0.1 % humate K	41,4±0,9*	44,6±1,3
0.01 % humate K	20,3±0,4	23,4±0,5*
0.05 % humate K	43,2±1,0*	45,8±0,8
0.005 % humate K	20,0±0,6	23,5±0,2*
0.1 % K-Na humate	52,5±2,7*	60,0±3,2*
0.01 % K-Na humate	10,0±0,2	11,3±0,2*
0.5 % K-Na humate	40,6±1,8*	90,0±4,1*
0.05 % K-Na humate	21,2±0,4	30,4±0,6*
0.005 % K-Na humate	10,0±0,1	18,2±0,3*
*Note – Significance of differences of indicators from control at P≤0.05		

The optimal concentration for potassium humate is 0.5 %, which increased germination up to 51.5 %. The other variants exceeded the control values, but were significantly lower than the specified concentrations.

Tomato seeds showed good germination rates. Practically all variants, except for potassium humate 0.5 %, showed germination rates above or at the level of control parameters. Maximum germination values were obtained on the background of potassium humate at a concentration of 0.005 %. Seed germination was 90.3 %, germination energy 70.0 % (Table 3).

Table 3

Indicators of germination and germination energy of tomato seeds on the background of application of different concentrations of humic preparations

Experiment variant	Germination energy,%	Germination,%
Control	40,6±0,9	45,6±0,8
0.5 % humate K	11,5±0,2*	20,7±0,2*
0.1 % humate K	52,4±1,8	55,2±1,5*
0.01 % humate K	41,5±0,6	44,6±0,7
0.05 % humate K	51,6±1,8*	55,0±1,7*
0.005 % humate K	70,0±2,5*	90,3±4,1*
0.1 % K-Na humate	53,2±1,4*	51,9±2,2
0.01 % K-Na humate	70,3±2,9*	82,0±3,3*
0.5 % K-Na humate	70,8±2,3*	70,1±3,8*
0.05 % K-Na humate	40,4±0,5	60,8±3,0*
0.005 % K-Na humate	30,0±0,5*	41,2±1,0
*Note – Significance of differences of indicators from control at P≤0.05		

For the mixture of potassium and sodium humate, the highest germination rates were observed for the concentration of 0.01 %, at which germination was 82.0 % and germination energy 70.3 %.

The seed material of sweet pepper confirmed the data made on the previous crop. Potassium humate at concentrations of 0.5 % and 0.01 % had a depressing effect on germination, as seed germination in these variants of experiments was significantly lower than the control values (Table 4).

Table 4

Indices of germination and germination energy of sweet pepper seeds on the background of application of different concentrations of humic preparations

Experiment variant	Germination energy,%	Germination,%
Control	70,4±2,5	80,8±3,6
0.5 % potassium humate	61,6±2,2	65,4±2,3*
0.1 % potassium humate	80,5±3,3*	91,5±4,1*
0.01 % potassium humate	51,0±1,2	54,2±2,5*
0.05 % potassium humate	80,0±3,1*	90,5±3,4*
0.005 % potassium humate	72,8±2,7	81,9±2,6
0.1 % K-Na humate	71,0±2,0	80,5±3,0
0.01 % K-Na humate	74,3±2,6	78,4±2,2
0.5 % K-Na humate	62,4±2,0	83,4±2,6
0.05 % K-Na humate	54,5±2,0*	70,0±2,2
0.005 % K-Na humate	72,3±2,4	93,4±3,1*
*Note – Significance of differences of indicators from control at P≤0.05		

Significantly higher germination indices were obtained in the variant of application of potassium and sodium humate mixture at a concentration of 0.005 %, at which germination was 93.4 % and germination energy 72.3 %; and for potassium humate at a concentration of 0.05 % — germination was estimated at 90.5 %, germination energy 80.0 %.

When testing humic preparations on cucumber seeds, an insignificant difference was established in comparison with the control (Table 5). Significant excess over the control was observed on the background of presowing soaking seeds in the solution of potassium and sodium humate mixture at a concentration of 0.01 %. Germination and germination energy in this variant amounted to 100 %.

Table 5

Indices of germination and germination energy of cucumber seeds on the background of application of different concentrations of humic preparations

Experiment variant	Germination energy,%	Germination,%
Control	90,4±4,2	92,5±3,8
0.5 % humate K	90,0±3,3	96,4±4,2
0.1 % humate K	92,5±3,8	95,0±3,6
0.01 % humate K	71,6±2,4*	72,5±2,7*
0.05 % humate K	90,7±1,9	92,8±4,1
0.005 % humate K	82,6±2,5	85,6±3,3
0.1 % K-Na humate	93,3±2,9	94,8±3,0
0.01 % K-Na humate	100±0,0*	100±0,0*
0.5 % K-Na humate	92,5±2,4	95,6±4,0
0.05 % K-Na humate	91,8±2,2	92,3±2,5
0.005 % K-Na humate	94,0±3,1	95,3±3,0
*Note – Significance of differences of indicators from control at P≤0.05		

On the contrary, the concentration of potassium humate 0.01 % had an inhibitory effect on the germination of cucumber seeds.

Conclusion

Thus, pre-sowing soaking of vegetable seeds in solutions of humates produced by “Shubarkol Komir” JSC allows to significantly increase germination and germination energy. The best germination indices were observed for white cabbage seeds after soaking in potassium humate solution at a concentration of 0.005 %, for eggplant seeds — potassium and sodium humate mixture at a concentration of 0.5 %, for tomato seeds — potassium humate 0.005 %, for sweet pepper seeds — potassium and sodium humate mixture 0.005 %, for cucumber seeds — potassium and sodium humate mixture 0.01 %.

Acknowledgements

The research was carried out within the framework of the contractual theme “Laboratory and field evaluation of the effectiveness of organic fertilizer potassium humate on the basis of weathered coals” of JSC “Shubarkol Komir” (2024).

References

1 Lobartini J.C. The geochemical nature and agricultural importance of commercial humic matter / J.C. Lobartini, K.H. Tan, J.A. Rema, A.R. Gingle, C. Pape, D.S. Himmelsbach // Science of the total environment. — 1992. — Vol. 113 (1-2). — P. 1–15. https://doi.org/10.1016/0048-9697(92)90013-1

2 Wang R. Production of artificial humic acid from rice straw for fertilizer production and soil improvement / R. Wang, D. Li, F. Deng, Zh. Cao, G. Zheng // Science of total environment. — 2024. — Vol. 906(1). — Article ID 167548. https://doi.org/10.1016/j.scitotenv.2023.167548

3 Rose M.T. A meta-analysis and review of plant-growth response to humic substances / M.T. Rosa, A.F. Patti, K.R. Little, A.L. Brown, W.R. Jackson, T.R. Cavagnaro // In Advances in Agronomy, ed. D.L. Sparks. — Amsterdam: Elsevier, 2014. — P. 37–89. https://doi.org/10.1016/B978-0-12-800138-7.00002-4

4 Li Y. Humic acid fertilizer improves soil properties and soil microbial diversity of continuous cropping peanut: a three-year experiment / Y. Li, F. Fang, J. Wei, X. Wu, R. Cui, G. Li, F. Zheng, D. Tan // Scientific Report. — 2019. — Vol. 9. — P. 1–9. https://doi.org/10.1038/s41598-019-48620-46

5 Arif M. Humic acids as a feed addictive in poultry diets: a review / M. Arif, M. Alagawany, M.E. Abd El-Hack, M. Saeed, M.A. Arain, S.S. Elnesr // Iran J Vet Res. — 2019. — Vol. 20(3). — P. 167–172.

6 Savelyeva A.V. Detoxication of oil-contaminated soils by using humic acids / A.V. Savelyeva, E.V. Linkevich, N.V. Yudina, N. Nebogina // IOP Conference. Series Materials Science and Engineering. — 2019. — Vol. 597(1). — Article ID 012020. https://doi.org/10.1088/1757-899X/597/1/012020

7 Tang W.W. Impact of humic/fulvic acid on the removal of heave metals from aqueous solutions using nanomaterials: a review / W.W. Tang, G.-M. Zeng, J.-L. Gong, J. Liang, P. Xu, Ch. Zhang, B.-B. Huang // Sci Total Inviron. — 2014. — Vol. 15(468-469). — P. 1014–1027. https://doi.org/10.1016/j.scitotenv.2013.09.044

8 Зорина М.С. Определение семенной продуктивности и качества семян интродуцентов / М.С. Зорина, С.П. Кабанов // Методики интродукционных исследований в Казахстане. — Алма-Ата: Наука, 1986. — С. 75–85.

9 Мальцева М.В. Пособие по определению посевных качеств семян лекарственных растений / М.В. Мальцева. — М., 1950. — 56 с.

10 Методические указания по семеноведению интродуцентов. — М.: Наука, 1980. — 64 с.

Е.Н. Мартынова, С.Е. Дадыка, И.А. Сафронова, А.Ж. Абюров,
Д.В. Агеев, А.К. Рамазанов

«Шұбаркөл Көмір» АҚ өндірген гуматтардың көкөніс өсімдіктері тұқымдарының өнуіне әсерін бағалау

Гуминді препараттар топырақ құнарлығын арттыратын және ауылшаруашылық дақылдарының өсуін реттейтін белсенділігі бар гумин қышқылдарының құнды көзі. Жергілікті морыған көмірлерден жаңа гуминді препараттарды қолдану ауыл шаруашылығы тауарын өндірушілерді отандық препараттармен қамтамасыз етуге мүмкіндік береді. Қолданудың оңтайлы дозаларын анықтау үшін біз көкөніс тұқымдарының өнгіштігін арттыру үшін бірнеше тәжірибелер жүргіздік. Зерттеу нәтижелері әртүрлі концентрациядағы гуминді препараттардың әртүрлі түрдегі өсімдіктердің тұқымдарында бірдей белсенділікке ие болмауы мүмкін екенін көрсетті. Ақ қырыққабат тұқымы 0,005% концентрациядағы калий гуматының ерітіндісіне, баклажан тұқымы — 0,5% концентрациядағы калий мен натрий гуматтарының қоспасына, қызанақ тұқымдары — 0,005% калий гуматына, тәтті бұрыш тұқымдары — 0,005% калий мен натрий гуматының қоспасына, қияр дәндері — 0,01% калий гуматының қоспасына және натрийге батырылғаннан кейін ең жақсы өну көрсеткіштерін көрсетті.

Кілт сөздер: гуминдік препараттар, тұқым материалы, көкөніс дақылдары, егу алдындағы сіңіру, өну, өну энергиясы.

Е.Н. Мартынова, С.Е. Дадыка, И.А. Сафронова, А.Ж. Абюров,
Д.В. Агеев, А.К. Рамазанов

Оценка эффекта гуматов производства АО «Шубарколь комир» на прорастание семян овощных растений

Гуминовые препараты являются ценными источниками гуминовых кислот, которые повышают плодородие почвы, оказывают рост-регулирующую активность на сельскохозяйственные культуры. Использование новых гуминовых препаратов из местных выветрелых углей позволяет обеспечить сельскохозяйственных производителей отечественными препаратами. Для выявления оптимальных доз применения нами проведен ряд опытов по прорастанию семян овощных культур для повышения их прорастания. Результаты исследования показали, что гуминовые препараты в разных концентрациях могут оказывать неодинаковую активность на семена растений разных видов. Лучшие показатели прорастания следующие: для семян капусты белокочанной после замачивания в растворе гумата калия в концентрации 0,005 %, для семян баклажанов — смесь гуматов калия и натрия в концентрации 0,5 %, для семян томатов — гумат калия 0,005 %, для семян перца сладкого — смесь гумата калия и натрия 0,005 %, для семян огурцов — смесь гумата калия и натрия 0,01 %. Результаты могут использоваться для применения в сельском и тепличном хозяйствах.

Ключевые слова: гуминовые препараты, семенной материал, овощные культуры, предпосевное замачивание, всхожесть, энергия прорастания.

References

1 Lobartini, J.C., Tan, K.H., Rema, J.A., Gingle, A. R., Pape, C., & Himmelsbach, D.S. (1992). The geochemical nature and agricultural importance of commercial humic matter. *Science of the total environment, 113* (1-2), 1–15. https://doi.org/10.1016/0048-9697(92)90013-1

2 Wang, R., Li, D., Deng, F., Cao, Zh., & Zheng, G. (2024). Production of artificial humic acid from rice straw for fertilizer production and soil improvement. *Science of total environment, 906*(1), 167548. https://doi.org/10.1016/j.scitotenv.2023.167548

3 Rose, M.T., Patti, A.F., Little, K.R., Brown, A.L., Jackson, W.R., & Cavagnaro, T.R. (2014). A meta-analysis and review of plant-growth response to humic substances. In *Advances in Agronomy*, Ed. D.L. Sparks. Amsterdam: Elsevier, 37–89. https://doi.org/10.1016/B978-0-12-800138-7.00002-4

4 Li, Y., Fang, F., Wei, J., Wu, X., Cui, R., Li, G., Zheng, F., & Tan, D. (2019). Humic acid fertilizer improves soil properties and soil microbial diversity of continuous cropping peanut: a three-year experiment. *Scientific Report, 9*, 1–9. https://doi.org/10.1038/s41598-019-48620-46

5 Arif, M., Alagawany, M., Abd El-Hack, M.E., Saeed, M., Arain, M.A., & Elnesr, S.S. (2019). Humic acids as a feed addictive in poultry diets: a review. *Iran J Vet Res., 20*(3), 167–172.

6 Savelyeva, A.V., Linkevich, E.V., Yudina, N.V., & Nebogina, N. (2019). Detoxication of oil-contaminated soils by using humic acids. *IOP Conference. Series Materials Science and Engineering, 597*(1), 012020. https://doi.org/10.1088/1757-899X/597/1/012020

7 Tang, W.W., Zeng, G.-M., Gong, J.-L., Liang, J., Xu, P., Zhang, Ch., & Huang, B.-B. (2014). Impact of humic/fulvic acid on the removal of heave metals from aqueous solutions using nanomaterials: a review. *Sci Total Inviron., 15*(468-469), 1014–1027. https://doi.org/10.1016/j.scitotenv.2013.09.044

8 Zorina, M.S. & Kabanov, S.P. (1986). Opredelenie semennoi produktivnosti i kachestva semian introdutsentov [Determination of sees productivity and seed quality of introduced plants]. *Metodiki introduktsionnykh issledovanii v Kazakhstane — Methodology for introduction study in Kazakhstan.* Alma-Ata: Nauka [in Russian].

9 Maltseva, M.V. (1950). *Posobie po opredeleniiu posevnykh kachestv semian lekarstvennykh rastenii [Manual for determination of sowing qualities of seeds of medicinal plants]*. Moscow [in Russian].

10 (1980). *Metodicheskie ukazaniia po semenovedeniiu introdutsentov [Methodological instructions on seed science of introducers]*. Moscow: Nauka [in Russian].

Information about the authors

Martynova Elena Nikolayevna — Manager of Research and Development Department, JSC "Shubarkol komir", Karaganda, Kazakhstan; e-mail: *yelena.martynova@erg.kz;*

Dadyka Sergey Evgenievich — Manager for Coal Chemistry, LLP "ERG Research Engineering Center", Pavlodar, Kazakhstan; e-mail: *sergey.dadyka@erg.kz;*

Safronova Inessa A. — Head of the Laboratory of Coal Chemistry, LLP "ERG Research Engineering Center", Pavlodar, Kazakhstan;

Abyurov Arman Zhumagaliyevich — Engineer-technologist, Coal Chemistry Laboratory, LLP "ERG Research Engineering Center", Pavlodar, Kazakhstan; e-mail: arman.abyurov@erg.kz;

Ageev Dmitry Vladimirovich — Master of biology, Junior researcher of the Faculty of Biology and Geography, Karaganda Buketov University, Karaganda, Kazakhstan; e-mail: ageevdimon88@mail.ru;

Ramazanov Alibek Kairidenovich — PhD-student, Researcher of the Faculty of Biology and Geography, Karaganda Buketov University, Karaganda, Kazakhstan; e-mail: kairidenovich_rak@mail.ru.